SD EPSCoR

RESEARCH. EDUCATION. ECONOMIC DEVELOPMENT.

8th Annual

Research Symposium

featuring **Undergraduates in South Dakota**

Thursday, July 29, on Gather.town

Undergraduate STEM students, faculty and industry experts from institutions across the state gather virtually on Thursday, July 29, to participate in the eighth annual SD EPSCoR Undergraduate Research Symposium.

The symposium will bring together undergraduate students involved in the NSF EPSCoR RII Track-1 project and the undergraduate students representing South Dakota's public, private and tribal universities who participated in the Research Experiences for Undergraduates (REU) summer research program.

GATHER.TOWN

JULY 29, 2021

About

SD EPSCOR

The National Science Foundation (NSF) created the Established (formerly Experimental) Program to Stimulate Competitive Research (EPSCoR) in 1979 because Congress recognized the uneven distribution of federal research and development grants. After World War II, federally funded academic research grew dramatically, but national science policy at the time tended to funnel resources to a small number of centers of excellence. This status quo ignored the dramatic growth in regional educational and research institutions. In every state, talented young people aspired to careers in science, technology, engineering and mathematics, but the nation wasn't profiting fully from the wealth of ingenuity and skill embedded across the country. EPSCoR provided a solution and is now a federal-wide initiative spanning five agencies including NASA, DOE, DoD, NIH and NSF.

South Dakota's current $20 million NSF Research Infrastructure Improvement Program is a multidisciplinary project focused on biofilm research, development of diverse STEM workforce, K-12 STEM education and technology-based economic development.

Current goals of South Dakota EPSCoR include:

- Increase South Dakota's science and technology research capacity
- Provide educational opportunities for K-12, undergraduate, and graduate students
- Promote science-based economic development for South Dakota

Visit sdepscor.org for more information.

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SD EPSCoR

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Schedule

Thursday, July 29

10 - 10:50 a.m. CDT	First group presents in Gather.Town **Room A**
11 - 11:50 a.m. CDT	Second group presents in Gather.Town **Room B**
12 - 12:50 p.m. CDT	Third group presents in Gather.Town **Room C**

The Symposium Gather Space will remain open for a month following these presentations.

Partners

REU

The National Science Foundation (NSF) funds a large number of research opportunities for undergraduate students through its Research Experiences for Undergraduates (REU) program. Undergraduate student participants in either REU Sites or REU Supplements must be U.S. citizens, U.S. nationals, or permanent residents of the United States. An REU Site may be at either a US or foreign location. Visit nsf.org for more information.

Current South Dakota REU Awards:

- Multidisciplinary Underground Science at the Sanford Underground Research Facility: 1852575 (**BHSU**)
- IoT Security: 1852145 (**DSU**)
- Cellular and Molecular Biology at Sanford Research: 1756912 (**Sanford Research**)
- Back to the Future: 1757799 (**SDSMT**)
- Security Printing and Anti-Counterfeiting Technology: 1852336 (**SDSMT**)
- Security Printing and Anti-Counterfeiting Technologies: 1852177 (**SDSU**)
- Interdisciplinary Research for Undergraduates in the Plant Sciences: Genomes, Phenomes and Landscapes: 1950503 (**SDSU**)
- Promoting Leadership in Advanced-Research-Computing for INterdisciplinary Sectors (PLAINS): 1950448 (**SDSU**)
- Security Printing and Anti-Counterfeiting Technology: 1852306, (**USD**)
- Undergraduate Research in Fluorine Chemistry: 1757652 (**USD**)

Use **#ResearchSymposium** on Social posts.

Presenters

Aitchison, Alysha — B01
Alba Garcia, Monica — A01, C01
Almiron Solano, Yulia — A02
Arner, Jaden — C02
Arnold, Ryan — C03
Asrari, Hasti — A03
Baker, Gavin — B02
Bass, Jordyn — B03
Baumeister, Jordan — A04
Bayliss, Bennet — A05
Beall, Faith — B04
Bhat, Shankar — B05, C04
Blacksmith, Cheryl — B06
Booth, Jacob — C05
Bordeaux, Caitlin — B07
Butzin, Rachel — B08
Carman, Joseph — C06
Cerritelli, John — A06
Cook, Elizabethann — C07
Crespo Maldonado, Sofia — B09
Dahlen, Nicholas — C08
Davis, Devin — C09
Delwiche, Maia — A07
Devlin, Layla — B10
Driesen, Marissa — A08, C10
Drummond, Samuel — C11
Eide, Hunter — B11
Elston, D'Nia — A09
Engel, Rachel — B12
Flesche, Matt — C12
Frank, Turner — A10
Frede, Nicholas — B13
Gehrer, Mallory — C13
Gentry, Paolo — A11
Giles, Jenni — A29
Hanka, Janean — B14
Harrison, Keegan — A12
Harroun, Paycen — A13
Hartman, Tim — A14
Hastings, Ian — B15
Heath, Paxson — B16
Henderson, Alethia — C14
Ickler, Adam — C15
Ingram, Jacob — B17
Johnson, Jennifer — A15
Keller, Elliott — B18
Kleekamp, Kelly — A16
Kleindienst, Joe — B19
Knutson, Ava — C17
Kreisa, Dallas — B20
Kulm, Alexis — B21
Lafferty, Erica — C18
Lankisch, Julia — A17, B22
Larsen, Jake — A18
Leftwich, Blaine — A19
Lincoln, Joe — B23
Lindholm, Madisen — A20
Loutsch, Nathan — C19
Lueth, Amanda — B24
Maloney, Christina — C20
McConnell, Evan — C21
McIntyre, Isabel — B26, C22, A27, B25
Miller, Cyle — A21
Nguyen, Hoang Thien Ngan — A22
Okamoto, Tatum — C23
Ormé, Emily — B27
Palomino-Alonso, Brandon — B28
Patron, Neal — B29
Peery, Joseph — A23
Peitz, Solomon — C24
Pfaffenberger, Kyle — A24
Philips, Kate — A25, C25
Pierce, Grant — B30
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Pomarleau, Wiyaka — B31
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Saucerman, Emma — C28
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Schnetzer, Erin — A31
Schultz, Maycie — C30
Seffrood, Morgan — C31
Showers, Jesiah — A32
Skelly, Elizabeth — A33
Smith, Alexandra — B34
Soto, Max — B35
Speck, Elizabeth — B36
Stanislawski, Noam — C07
Stone, Cory — B38
Suh, James — C32
Summers, Bali — C33
Taylor, Austin — C34
Teeslink, Kennedy — C35
Thaler, Conner — A34
Than, Wai — A35
Tian, Yuan — A36
Tordsen, Conner — A37
Torres Irizarry, Naomi — C37
Ullrich, Connor — C38
Vanden Berge, Kalista — C39
Vasek, Patrisse — B39
Wild, Katherine — A38
Williams, Tyler — A39
Wysong, Jax — B40
Yox, Rebecca — A40
Zaug, Jacob — B37

Abstracts

Authenticating Lakota Artifacts — B01 — 11 a.m.
Alysha Aitchison

Abstract: This research investigated the authenticating of Lakota artifacts and artwork. Scientific analyses and discussions with local artists, elders and scientific content experts were used throughout the investigation. This research is significant because it brings awareness on the importance of authentic historical art and how counterfeits harm not only the native culture but also the artist's livelihood. The artifact in question was a knife presumably from the 1890s. However, there was minimal supporting evidence associated with this date. A ledger art piece purportedly from this same time period was also examined, also without evidence to substantiate its date. Specific analyses conducted included x-ray fluorescence spectroscopy, infrared spectroscopy and optical microscopy.

REU South Dakota Mines
Advisor(s): Grant Crawford, Jon Kellar

Plant beneficial qualities of selected Bradyrhizobium strains — A01 — 10 a.m.
Monica Alba Garcia, Jesus Loya

Abstract: Bradyrhizobacterium spp are slow growing nitrogen fixing bacteria that form symbiotic associations with soybean and some other legumes. The symbiosis results in root nodules where biological nitrogen fixation occurs. Recent studies have suggested that repeat inoculations with Bradyrhizobia result in increased nitrogen fixation and grain yield in soybean. Surprisingly, Bradyrhizobium strains defective in nitrogen fixation also result in increased grain yields in soybean. The goal in this project was to evaluate other plant growth promoting qualities of selected Bradyrhizobium strains to determine additional benefits offered through repeat inoculations. USDA 6, 13, 20, 26, 83, 110, 126, 140, and 3384 Bradyrhizobium strains were evaluated for IAA production, phosphate solubilization, and the presence of ACC deaminase gene. Pikovskaya's agar medium was used to examine the strain's ability to solubilize phosphate. Bradyrhizobium strains were inoculated onto yeast extract mannitol medium supplemented with L-tryptophan to measure IAA production. Results from these experiments will be presented and the implications will be discussed.

REU South Dakota State University
Advisor(s): Sen Subramanian

Assembling the transcriptome of Field Horsetail (Equisetum Arvense) — C01 — 12 p.m.
David Peery, Brandon Palomino-Alonso, Monica Antonieta Alba Garcia, Michael Robben, Anne Fennel, and Jose Gonzalez

Abstract: Field Horsetail (Equisetum Arvense) is a perennial non-flowering weed that evolved 400 million years ago during the Paleozoic era. Currently, it is being investigated for its medicinal value in pharmacology research, as it serves as an immunomodulator that treats inflammatory disorders. We assembled the transcriptome of field horsetail for the first time using RNA-seq data and the Trinity bioinformatics package. We identified more than 38,000 genes and predicted the function of these genes using NCBI's blast tool. Assembling the transcriptome of Field Horsetail lays the foundation for additional studies to further understand the biology of the plant, such as the plant's specific cell types, mechanisms of its cells and how modifying its genes may help the advancement of pharmacology.

REU South Dakota State University
Advisor(s): Sen Subramanian

Drug delivery properties of novel materials for dentinal desensitization — A02 — 10 a.m.
Yulia Almiron Solano, Abu Ahammadullah

Abstract: Good oral health is one of the major importance for general health and well-being all around the world. Two of the most predominant diseases that contributes to the dental loss are the periodontal (a chronic inflammatory disease that is triggered by bacterial microorganisms) and endodontic diseases (an inflammation of the dental pulp as well as affection in the nerves and tissue in and around the tooth root). There has been a lot of research to create conventional dosage forms for local treatment for the oral cavity. In every single traditional method, there has been found that the is a low oral cavity retention which results in an inferior therapeutic impact. In this research project, we will explore the dentinal occlusive particles like hydroxyapatite nanoneedles, calcium carbonate microspheres and calcium carbonate coated with hydroxyapatite microplatelets and their conjugates as controlled drug delivery systems both to the surface and inside of dentin using eugenol as a model drug. We are using human teeth samples with a shape of (2.5mm x 2.5mm) and a thickness of 0.5mm. Hydroxyapatite was used because it is one of the most biocompatible materials as well as has a similar mineral comparison as human hard tissues like teeth and bone, and in our case, we are going to use teeth. And is also the most thermodynamically stable compound under physiological conditions like pH or temperature. While eugenol was used because it is used for the relief of insignificant dental pain, including in the form of a sedative dentinal dressing with zinc oxide. We used casein as a blocker to hold the drug molecules inside the particles. Lastly, we used particles of calcium citrate, a mineral that are found in naturally foods and used to prevent and to treat calcium deficiencies. We loaded the drug and the release drug, then we used the standard curve to figure out the amount of eugenol and with the at UV-Vis spectrophotometer we scanned the solution. Our future work will consist of drug delivery from the dentin samples by other particles, and we will develop a new HPLC method for the determination of eugenol.

REU University of South Dakota
Advisor(s): Grigoriy Sereda

Temperature profile of ultrasonic spot welding — C02 — 12 p.m.

Jaden Arner, Cassandra Birrenkott

Abstract: Ultrasonic spot welding (USSW) is the process of rapidly joining plastic materials together with the use of high-frequency vibrations to melt the interface between two parts, creating a bond. This process has led to high potential for innovative technology in areas including the use of race cars, airplanes, and military vehicles. USSW decreases weight compared to traditional metallic welding and increases stiffness due to the material. The project will focus on measuring the temperatures reached during the welding process. Temperature measurement tests using polyetherimide (PEI) will be carried out to verify background research and simulation results. Thermocouples and a thermal camera will be used to measure and confirm temperature data. The goal of this work is to use knowledge of the temperature changes during the USSW process to better understand what specifications need to be changed on the welder for the best welds while avoiding degradation of the polymer. Factors such as time, the amplitude of the welding horn, pressure, energy, and voltage affect the temperature throughout the welding process. Understanding the temperature throughout the welding process may lead to better control over welding parameters, as well as help optimize the final weld.

REU South Dakota Mines
Advisor(s): Prasoon Diwakar

Metal-Organic Supercontainers for Direct Capture of CO2 from Air — C03 — 12 p.m.

Ryan Arnold (Peru State College), Hanying Li, and Shrijana Dc

Abstract: The amount of greenhouse gases, especially carbon dioxide, has sharply increased in the atmosphere due to continued fossil fuel use, causing a rise in global air temperature. To mitigate the effects of global warming, a number of carbon capture strategies, including a chemical sequestration approach based on amine solutions and a physical adsorption approach based on nanoporous materials, are under investigation. However, these methods typically require a high CO2 concentration and are efficient for carbon capture at abundant sources such as power plants. Direct removal of CO2 from the air, known as “direct air capture” (DAC), provides a more effective approach to reducing global atmospheric CO2 concentration. However, development of DAC technology is challenging due to the more dilute nature of CO2 in the atmosphere.

In this presentation, a promising DAC approach based on a new class of nanostructured molecules known as metal-organic supercontainers (MOSCs) is discussed. MOSCs are supramolecular host molecules containing endo- and exo- cavities suitable for selectively binding small molecules and ions. One particular MOSC, obtained from the assembly of zinc(II) and lanthanide(III) ions bridged by hydroxamate and pyridyl linkers, shows an encouraging capacity to capture CO2 directly from the air. Nuclear magnetic resonance (NMR) studies suggest that the MOSC dissolved in a dimethyl sulfoxide (DMSO) solution binds 4~5 equivalents of CO2 from the atmosphere in the bicarbonate (HCO3-) ion form. A proposed three-step mechanism for the DAC process follows: physical adsorption of CO2 by the MOSC occurs, then, a MOSC-catalyzed chemical conversion of CO2 to HCO3-, and finally, HCO3- ion recognition by the MOSC. Therefore, this MOSC-based DAC method combines characteristics of chemical and physical sequestration approaches and has the potential to overcome their respective limitations. Future studies will focus on determining the exact carbon capture mechanism and improving the DAC efficiency of the MOSCs.

REU University of South Dakota
Advisor(s): Rick Wang

Comparison and Characterization of "Cave Silver" Biofilms at Three Different Elevations of the Sanford Underground Research Facility — A03 — 10 a.m.
Hasti Asrari (Arizona State University)

Abstract: On the rock walls of the former gold mine in South Dakota, USA, the Sanford Underground Research Facility (SURF) harbors thin, whitish, microbial biofilms on rocks, called "cave silver." These biofilms are similar in appearance to those found in caves but little is known of their origin and metabolism in the subsurface environment. We utilized Illumina MiSeq sequencing of 16S rRNA gene libraries to compare the "cave silver" biofilms at the 244, 518, and 1478 m levels of SURF. We also collected bacterial 16S rRNA data from the air in SURF, surface rocks, and surface soils to determine the possible origin of the cave silver. Samples from rocks and cave silver from SURF were cultured on low-nutrient media and analyzed under a light microscope. High diversity and abundance of microbial colonies were seen on the cultured rock surface samples at the 1478 m level, while the "cave silver" samples were dominated by whitish, mycelial colonies, apparently Actinobacteria. Additionally, various microbial cell shapes were observed in Scanning Electron Microscopy images of representative cave silver and rock samples. A better understanding of the potential origin of these underground biofilms will provide clues on how environmental conditions can influence microbial colonization of novel, nutrient-poor, subterranean habitats.

REU Black Hills State University
Advisor(s): Dave Bergmann

Electronic Band Structure and Magnetism of CoFeV0.5Mn0.5Si — B02 — 11 a.m.
Gavin Baker, Matthew Flesche, and Pavel Lukashev (University of Northern Iowa)

Abstract: Half-metallic Heusler alloys have attracted much attention due to their potential application in spin-transport-based devices. We have synthesized one such alloy CoFeV0.5Mn0.5Si using arc melting and high-vacuum annealing. The vacuum annealing was done at 600oC for 24 hours. First principles calculation indicates that CoFeV0.5Mn0.5Si shows nearly half-metallic band structure with the degree of spin polarization of about 93%. The room temperature x-ray diffraction patterns are indexed with the cubic crystal structure without disorder and secondary phases. The annealed sample show ferromagnetic order with the Curie temperature well above room temperature (Tc = 657 K) and the high-field (3T) magnetization at room temperature is about 83 emu/g. Figure 1 below shows the magnetization as a function of temperature of CoFeV0.5Mn0.5Si measured at 1 kOe which shows a smooth magnetic transition at the Curie temperature. The calculated electronic band structure and the observed magnetic properties indicate that CoFeV0.5Mn0.5Si has potential for room temperature spin-transport-based devices.

REU South Dakota State University
Advisor(s): Parashu Kharel

High Purity Gamma Ray Spectroscopy for Rare Event Searches — B03 — 11 a.m.
Jordyn Bass

Abstract: Rare event searches at the Sanford Underground Research Facility (SURF) require ultra radiopure materials. High Purity Germanium (HPGe) gamma ray spectroscopy systems, located on the 4850' level of in the Davis Campus at SURF, screen materials for these searches to aid in the selection of materials as well as to inform background analyses. This poster will describe the construction of one of these HPGe systems as well as the analysis of ultra-low background samples.

REU Black Hills State University
Advisor(s): Brianna Mount

Modeling Illicit Networks Through Dynamic Graphs and Multilinear Time-Series Forecasting — A04 — 10 a.m.
Jordan Baumeister, Kyle Caudle, Jackson Cates

Abstract: Developing reliable mathematical models for dynamic graphs has broad implications and applications in the modern world. From representing social dynamics to modeling criminal networks, graph-based abstractions are common among computer science and mathematical modelers. The current work aims to develop mathematical models of such networks by re-casting the problem from an algebraic framework to a multilinear algebraic framework. In particular, we combine elements of algebraic graph theory and multilinear systems theory to develop multilinear time-series models of the graph evolution. Such models can then be used for understanding community structure within a network, learn network interactions, understand how information diffuses through the network, detect anomalous behavior, and forecast the network to anticipate future events.

REU South Dakota Mines
Advisor(s): Randy Hoover

Exploring How Changes in Copper Concentration Affect PHB productivity in Methylocystis sp. NLS7 — A05 — 10 a.m.
Bennet Bayliss (Montana State University), Rajesh Sani

Abstract: This study is attempting to explore the relationship between the range of copper concentration and amount of polyhydroxyalkanoates (PHAs) synthesised. The detailed role of varying copper concentrations on the rates of microbial growth, and enzymatic efficiency will also be determined.

REU South Dakota Mines
Advisor(s): Eleni Moutsoglou

Assay of Radioactivity Content of Cavern Walls for the Deep Underground Neutrino Experiment (DUNE) at Sanford Lab — B04 — 11 a.m.

Faith Beall, James Haiston, Layne Tieszen, Madan Timalsina, and Serenity Engel

Abstract: As the underground excavation for DUNE at Sanford Lab has commenced in 2021, it is paramount to assay, control and map out the ambient background radiation in the cavern walls for DUNE to achieve all of its physics goals. Despite 40,000 tonnes of liquid argon as active detector mass, neutrino interactions will still be relative rare events, whose signals could be easily overwhelmed by radioactive background from the more than 2 x 120 meters long parallel twin caverns. Radioactivity assays of rock, shotcrete, concrete, cryostat and detector samples are performed using gamma-ray spectroscopy with a germanium detector at Dr. Reichenbacher's lab located at nearby South Dakota School of Mines and Technology. As the excavation and detector installation at Sanford Lab will take many years, having a very stable germanium detector response will greatly speed up the turnaround time of assays of many hundreds of material samples. A detailed study of existing germanium detector data, recorded over the past two years, has been conducted using the ambient K-40 gamma-ray line as tracer to characterize the time dependent stability of the germanium detector's electronic signals. The germanium detector's response has been found to be stable at the subpercent level. However, a detailed statistical signal and background band analysis of the K-40 line still revealed that an o(0.1%) relative small time dependent signal correction should be applied to avoid having the analysis code continuously adjusted for each sample assay over the next years. Rock samples are analyzed/re-analyzed to verify the time dependent data correction. Further, improvements to the liquid nitrogen filling station for the cooling of the germanium detector have been made to simplify continuous operation. Together with the performed data study this will enable a high throughput of assays to control and understand radioactive backgrounds in detail for a successful DUNE project.

REU South Dakota Mines
Advisor(s): Juergen Reichenbacher

Vitis riparia Transcriptomic Response to Decreasing Daylength — B05 — 11 a.m.

Shankar Bhat, Prakriti Sharma, and Michael Robben

Abstract: Vitis riparia is one of the most common grape species in North America and is frequently used in breeding cold climate grapes. With this project we seek to analyze differential gene expression relevant to decreasing daylength induced shoot tip/leaf senescence. Leaf senescence is a visual sign of the onset of dormancy, which is an essential trait to woody species living in cold climate regions. This trait is hypothesized to be ancient and highly conserved as it is seen in disparate species ranging from the Ginkgo genus to the Vitis genus. In this study, samples were taken from plants exposed to either a long photoperiod (15 hrs) or short photoperiod (13 hrs). Three samples each were taken from the plants at the 7 day stage and the 21 day stage yielding four treatments and twelve total samples. Illumina short reads were trimmed of excess using Trimmomatic on Galaxy. The reads were then mapped to a Vitis vinifera reference genome from Canaguier et al. 2017 using HISAT2 with a V. vinifera annotation file. Differential gene expression analysis will be performed in R followed by Gene Set Enrichment Analysis (GSEA). This study will answer questions about which genes specifically are differentiated in response to different photoperiods and at different growth stages. This study can have significant implications for the cold climate wine industry in North America and beyond as dormancy is essential for winter survival of grapevines. Commercial vineyards need high survival rates of grapevines to yield high profits. With studies like this expanding on our knowledge of dormancy, breeders can identify new grapevine cultivars adapted to cold climate regions.

REU South Dakota State University
Advisor(s): Anne Fennell

Viola pedatifida Genomic Assembly from Illumina and Nanopore Sequencing — C04 — 12 p.m.
Shankar Bhat, Isabel McIntyre, Rebecca Yox, and Lan Xu

Abstract: Viola pedatifida, more commonly known as prairie violet, belongs to the Viola genus of approximately 500-600 species. V. pedatifida, a native, C3, perennial flowering plant, reproduces both sexually and asexually and is widespread in prairies. Furthermore, V. pedatifida is unique in that it does not have a complete genome due to its particularly large size. Our research aims to begin the creation of the first complete genome for V. pedatifida. The plant used for this project was germinated from a sample collected in Brule County, South Dakota and was grown for six months before tissue was collected. Then, genetic analysis began with pre-trimmed Illumina sequence reads that were run through Trinity. The transcriptome assembly has an N50 of 988 bps, largest contig length of 9,036 bps, and total length of 857,958 bps. Nanopore sequence reads will be included in order to supplement the Illumina generated data. The transcriptome will then be annotated against the NCBI DNA sequences database using BLAST. Following annotation, the transcriptome will be compared to transcriptomes of other species that may be related to V. pedatifida or to that of a model species such as Arabidopsis. Aiding in the construction of the V. pedatifida genome will be greatly beneficial in understanding its important ecosystem service as larval hosts for several butterfly species, particularly for Speyeria idalia which is classified as a Federal Species of Concern, Endangered in Wisconsin, and Species of Greatest Conservation Need in South Dakota. Furthering the transcriptome of V. pedatifida could aid in the development of critical increases in this species' seed production and population establishment, thus overall improving pollinator's habitats as a whole.

REU South Dakota State University
Advisor(s): Jose Gonzalez, Sen Subramanian

Plant Diversity Within Southwestern South Dakota — B06 — 11 a.m.
Cheryl Blacksmith, Stephanie Two Crow

Abstract: This observation study will be conducted in this area to see how the present variables impact the growth of plant life. The drought like conditions and the various weather mixtures seem to speed up the readiness of certain wild fruits and medicinal plants while drying up other plant life. Surrounding animals and insects are also invading the wild fruit plants or shrubs.

REU Oglala Lakota College
Advisor(s): Dana Gehring

Overview of the LUX ZEPLIN (LZ) Dark matter experiment — C05 — 12 p.m.
Jacob Booth (Lycoming College), Jax Wysong

Abstract: The LUX-ZEPLIN (LZ) is an ongoing project being completed at the Sanford Underground Research Facility (SURF) in Lead, SD. It is hosted approximately 1 mile underground in the Davis Campus. This experiment attempts to directly detect Weakly Interacting Massive Particles (WIMPs) in order to find evidence of dark matter. The heart of the LZ detector is a liquid xenon time projection chamber (TPC) containing 7 tonnes of active liquid xenon. The TPC sits inside of a 25' diameter, 20' tall water tank to shield the TPC from external gamma radiation. In the TPC, WIMPs will collide with the xenon nuclei and produce scintillation light which will be detected by photomultiplier tubes. To assist with the rejection of background radiation, the TPC is surrounded by a liquid scintillator loaded with gadolinium which will tag neutrons that interact in the TPC, and would otherwise mimic a WIMP signal. With the water tank, this system is collectively known as the outer detector. In this slide show, we will give an overview of the LZ project as well as present some work that we did to help commissioning of the outer detector, xenon handling, and the calibration systems.

REU Black Hills State University
Advisor(s): David Woodward

Engineering the Future with 3D Printing — B07 — 11 a.m.
Caitlin Bordeaux, Rumuyan Okiyan Moves Camp, Kanyen Mousseaux-Begay, and Luta Keegan

Abstract: The goal of this research is for students to create an understanding of the nature of engineering by engaging them in hands-on experiences with CAD and 3D printers. Students will use their own indigenous way of knowing and have the creative freedom to design a component showing their understanding of engineering.

NSF EPSCoR Track-1 at Lakota Tech High School
Advisor(s): Katrina Donovan, Caitlin Bordeaux

Indigenous Plants of the Missouri River Valley connecting Native American Youth with their culture and science — B08 — 11 a.m.

Rachel Butzin, MyKenzie Rouiland, Aralyn Defender, and Lael Middletent

Abstract:
Chii Miigwitch Gizhe Manido.
Gimiigwechiwigom zaakiiyig noojimo'iyaang Gaye ashamiyaang.
Gimiigwechiwigon ininatig, wiigwaas,giizhik, Gaye zhiingwaak , naadamawiyaang ji-minobimaadiziyaang.
Gimiigwechiwigon mashkosiwag memindage wiingashk ji-okaadenmaang.
I'iw nama'ewinan, Kaaba asemaa, miinwaa n'ode' gda-bagidinimaagom.
Miigwitch manidoog iyaajig Noodining, iyaajig nibiing, iyaajig shkodeng miinwa iyaajig akiing.
Chii Miigwitch Gizhe Manido.

Thank you Great Spirit.
We all thank you plants for healing and feeding us.
We all thank you maples, birch, cedar, and pine for helping us live well.
We all thank you grasses, especially the sweet grass we braid.
We offer our prayers, tobacco, and our hearts.
Thank you spirits of the winds, water, fire and earth.
Thank you Great Spirit.

As Annishnabbe, whenever collecting plants I always begin with a prayer to thank the plants and let them know they will be used in a good way. I would like to begin in this way. In education, we view students as the future, as hope. My hope for this project is to create a better understanding of plants and the natural world for my students in a way they feel truly connected and can take ownership over their own learning. Creating "hope that lives in contingency with the past—one that trusts the beliefs and understandings of our ancestors as well as the power of traditional knowledge" (Grande 2004)

For this research I will be collecting and mapping plant data for several locations within the Missouri River Basin. Connecting western scientific methodology with traditional Native American knowledge to create culturally relevant curriculum for Dakota/ Lakota student demographic.

The purpose of this research is connecting historical as well as modern Native American art with plants and their uses, that are native to the Missouri River Basin. Indigenous education is self-determined; engages distinctive Indigenous methods, structures, and content; and encourages respect for Indigenous knowledges and self-reliance and self-respect of Indigenous peoples (Hampton 1995)
It addresses the social, cultural, pedagogic, and epis- temological needs of Indigenous communities and explores Indigenous collective heritage and contributions to global education (Cajete, 1994)

REU University of South Dakota
Advisor(s): Bree Oatman

Characterization of Microstructure in Fe-Mn-Ga Shape Memory Alloys — C06 — 12 p.m.
Joseph Carman (Roanoke College), Nana Adoo

Abstract: Certain off-stoichiometric Fe-Mn-Ga Heusler alloys have recently become materials of interest, due to the irreversible low-temperature martensitic transformations. Fe-Mn-Ga shape memory alloys (SMAs) can exhibit the shape memory effect, superelasticity, magnetic exchange bias, and low martensitic transformation temperatures making them suitable alloys for applications in cold environments. Additionally, Fe-based SMAs can possess favorable mechanical properties, including higher ductility, when compared with other NiMn-based SMAs. Prior research has shown that Fe-based SMAs exhibit large hysteresis that inhibits the reversibility of the martensitic transformations. Identifying the cause of this energy loss, requires further investigation. Here we investigate the microstructure of Fe-Mn-Ga SMAs to determine possible causes of large thermal hysteresis. X-ray diffraction (XRD), optical and scanning electron microscopy (SEM), and differential scanning calorimetry (DSC) will be employed to characterize the crystal structure, morphology, and thermal hysteresis, respectively, of novel Fe-based SMAs. Ensuing results shall indicate the distinctive features present in Fe-Mn-Ga SMAs with large thermal hysteresis.

REU South Dakota Mines
Advisor(s): Nickolaus Bruno

Reaction with fluoride anion, methyl cation, and o-cresol with (picolin-2-yl) diethylborane — A06 — 10 a.m.
John Cerritelli (St. John's University), Elizabeth Speck (Hillsdale College)

Abstract: Frustrated Lewis pairs (FLPs) are increasingly being studied for their unique chemical properties, ability for bond activation, and formation of metal complexes. One FLP, (picolin-2-yl)diethylborane was structurally characterized and was found to react with carbonyl and nitrile groups. Additionally, (picolin-2-yl)diethylborane exists as a rigid dimer with an eight-member ring in a tub conformation. In this project, we evaluate the reactivity of (picolin-2-yl)diethylborane dimer toward (1) fluoride, (2) methyl cation, and (3) Diels-Alder reactions. Products were characterized with multinuclear NMR spectroscopy, X-ray diffraction, and elemental analyses.

REU University of South Dakota
Advisor(s): James D. Hoefelmeyer

Optimization of High Performance Computing Clusters with Hyper-Threading Technology — C07 — 12 p.m.

Elizabethann Cook, Noam Stanislawski, and Rachael Auch

Abstract: Intel's Hyper-Threading Technology is an implementation of simultaneous multithreading upon Intel proprietary CPU architecture. This technology allows for a single CPU core to handle two distinct processes concurrently, with the end-user and operating system recognizing the single core as two "logical processors." Under certain conditions, this technology can improve processing speed by thirty percent. The goal of this research is to determine the potential performance boosts or degradations exist when utilizing Hyper-Threading in a high performance computing cluster environment. Hyper-Threading technology introduces a multitude of additional possible bottlenecks and runtime slow downs via the added logical cores, and isolating these issues when possible to improve performance can be crucial in large scale applications. The central hypothesis of this work is that heavily parallelized or multi-threaded applications will see increased performance from Hyper-Threading, while processes that must be run in serial will experience little to no computational benefit. The project strategy is to re-examine and retest the earlier findings of T. Leng et al. conducted at Dell in 2002 using our small-scale development high performance computing cluster. Our data collection relies on two types of softwares: cluster computing benchmarks and a performance analysis tool evaluating said benchmarks performance. In this case, we have used four benchmarking programs: High Performance Linpack and the EP (Embarrassingly Parallel), IS (Integer Sort), and FT (Fourier Transform) benchmarks from the NAS Parallel Benchmark suite. All of these applications are monitored by Intel''s VTune Profiler for performance analysis, which determines statistics such as multi level cache misses, cycle per instruction retired, and total number of floating-point instructions. By utilizing these software and our cluster architecture it is determined that Hyper-Threading is a worthwhile technology for cluster computing if optimized parallel programs are being run.

REU South Dakota State University
Advisor(s): Anton Semenchenko, Rachael Auch

Ensuring Network Security: IoT Device Identification Using Network Traffic — B09 — 11 a.m.
Sofia Crespo Maldonado, Helen Chen, Mark Elder, and Kaushik Ragothaman

Abstract: IoT devices have become an essential component of our everyday lives, and the increase in their use, along with their vulnerabilities, make them common targets for continuous attacks. Due to rising concerns in the IoT, device identification is one of the fundamental tasks in cybersecurity. Many services like access control and intrusion detection are built on correctly identifying unique devices. Multiple approaches have been proposed for device identification, such as cryptographic key-based approaches and machine learning-assisted approaches. In IoT, cryptographic key-based approaches may raise key management and scalability issues. On the other hand, machine learning can be used to differentiate between known devices authorized in a network and devices that are either unknown or non-authorized. However, the research on machine learning-assisted approaches is very limited. The goal of this research is to reliably identify IoT devices using features pulled from network traffic. Various machine learning classifiers (Random Forest, Decision Tree, Logistic Regression, Support Vector Machine (SVM)) were applied with a pipeline in order to test which classifier produced the most accurate results. Among all, Random Forest provided the highest accuracy at around 98%, while Decision Tree and Logistic Regression delivered approximate accuracies of 83% and 87% respectively, and SVM produced a high accuracy of around 95%. The devices used include an Amazon Echo, a Google Home, and an Apple iPad, and their traffic was captured on a WiFi Pineapple. We collected a dataset of correctly labeled devices from a TCP dump that contained approximately 20,000 entries. This was tested against unlabeled data in order to analyze the accuracy outcome from each classifier. The research demonstrated that machine learning-based approaches could be used for device identification with high accuracy. Future research will focus on the probability of the machine learning-based approaches being scalable and practicable in large scale enterprise networks.

REU Dakota State University
Advisor(s): Yong Wang

Self-Assembly of Actinyl Peroxide Nanocapsules in Basic Peroxidic Environments — C08 — 12 p.m.
Nicholas Dahlen

Abstract: Many actinyl-peroxide nanoclusters have been experimentally isolated, however the low nuclearity intermediates involved in their growth in basic peroxidic environment are difficult to isolate. We have conducted a density functional theory study of the formation and interconversion of monomeric and dimeric actinyl-peroxide species with UVI, UV, NpVI, and NpVvia a ligand
exchange mechanism. We aim to gain insights as to why only species with oxidation state VI have been successfully isolated as well as the consequences of alkali counterions on the formation of nanoclusters.

REU University of South Dakota
Advisor(s): Pere Miro

Investigate the effect of Crystallographic Orientation on the Mechanical and Corrosion Properties of Copper Single Crystals — C09 — 12 p.m.
Devin Davis, Ananth Kandadai

Abstract: The main objective of this work is to investigate the effect of crystallographic orientation on the mechanical and corrosion properties of copper single crystals. Copper has unique microbial resistance and is the material of choice for 2 Dimensional (2D) materials deposition for a wide range of applications. The lack of grain boundaries in a single crystal will minimize the defects in the 2D coatings and help minimize the microbial corrosion. Single copper crystals were produced using Czochralski process, and the process parameters such as rotational speed, crystal lift rate and melt temperature were optimized. It is believed that the differences in planar densities in various crystallographic planes (Eg: (111), (100), 110)) would have an influence on both mechanical and corrosion properties. So, the main objective is to evaluate these properties as a function of different crystallographic orientations. The mechanical properties of single crystals are evaluated using nano indentation technique and the corrosion properties of the crystals are evaluated using electrochemical methods. The crystallographic orientation of the crystals was analyzed using XRD and EBSD techniques.

REU South Dakota Mines
Advisor(s): Bharat Jasthi

Design and CFD Modeling of 3D Printed Polymer Heat Exchangers — A07 — 10 a.m.
Maia Delwiche

Abstract: In recent years, polymers have been increasingly explored as alternative materials to metals for heat exchangers. Polymers, i.e. plastics, are an attractive alternative to metals for heat exchanger applications because they are lightweight, noncorrosive, inexpensive and easy to manufacture. Additive manufacturing (3D printing) allows parts to be produced as a single solid, without assembly requirements, and with complex internal geometry. The predominant drawback of using polymers in heat exchangers is their low thermal conductivity compared to traditional metals. Solutions such as using thinner walls separating fluids and maximizing the air-to-plastic contact surface areas have shown promise. In this study, a commercial computational fluid dynamics (CFD) software called StarCCM+ was used to predict performance of plastic, liquid-to-gas heat exchanger models. Heat transfer data from a past experiment involving two, polymer heat exchanger prototypes was used to set up and confirm an accurate CFD modeling process. This process was used to predict the performance of a new design with different channel geometry for enhanced heat transfer. The development of effective, liquid-to-gas heat exchangers constructed from polymers could benefit the power production industry by allowing greater siting freedom as power plants could be built in arid regions. By using air as the cooling fluid, the water consumption of power plants would be reduced, creating environmental incentives, and using plastic in place of metal as a material would make this transition economically viable.

REU South Dakota State University
Advisor(s): Stephen Gent, Gregory Michna

An Application of Cooperative Game Theory to Study the Economic Behavior of Illicit Operators — B10 — 11 a.m.
Layla Devlin (Occidental College)

Abstract: This research investigation involves capturing the profit-motivating behavior of an illicit operator, as opposed to a consumer, to offer insight into dismantling illicit operations. More specifically, the rise in fentanyl-related overdose deaths, as well as the considerable profit potential for suppliers of illicit opioids suggests that new approaches are needed to combat the opioid epidemic as well as the increased availability of illicit fentanyl. Researching the opportunity to reduce illicit opioid availability via the supply-side primarily explores the feasibility of integrating aspects of economics, mathematics, and sociology to understand the financial motivation of illicit actors for participation in production, transportation, and distribution of illicit opioids. A branch of mathematics known as Cooperative Game Theory has the potential to provide insight into the behavioral attributes of entities engaging in illicit activities. The proposed study details quantifying the illicit economy through a linear regression-based price function that estimates the revenue potential for illicit operators in a 3-person cooperative game. In addition, Shapley values are calculated to allocate revenue among the players according to the value of their individual contributions. The expected outcome is that the players with the highest allocation of revenue are the players that law enforcement should focus on eliminating. Based on data collected on the price and weight of fentanyl seizures in the United States–sourced from the Custom Border and Protection Services (CPB)–the proposed model showed that retailers consistently maximize the profit in the illicit supply chain for fentanyl.

REU South Dakota Mines
Advisor(s): Saurav Kumar Dubey

Annotating the Vitis riparia genome with Nanopore full length cDNA reads using RNABLOOM — A08 — 10 a.m.
Marissa Driesen, Jacob Ingram, and Conner Thaler

Abstract: Vitis riparia, is an economically relevant plant species. It is a relatively cold and disease resistant breed and is often used as a main source for rootstock in commercial grape production. The goal of this study is to improve the annotation of the recently sequenced Vitis riparia genome. Our group is using full length cDNA Oxoford-Nanopore reads from 11 different tissues and conditions. The process involves assessing quality of the data, trimming it appropriately, running RNABLOOM to assemble all contigs, and annotating these contigs. We will compare the quality of the data between other groups considering N50 score, number of bases, number of contigs, and total length.

REU South Dakota State University
Advisor(s): Jose Gonzalez, Sen Subramanian

Evaluation of soybean genomic variation to identify accessions with potentially enhanced nitrogen fixation — C10 — 12 p.m.

Marissa Driesen

Abstract: Biological Nitrogen fixation is important to plants and all life. Increasing the level of biological nitrogen fixation can decrease the need for chemical nitrogen, such as fertilizers that expensive and environmentally hazardous when used in excess. The primary sites of biological nitrogen fixation in agriculture are root nodules of legume plants such as soybean. These nodules arise from symbiotic interaction between legumes and rhizobia bacteria. Previous research has identified that roots with reduced auxin output and increased cytokinin output have more nodules, and delayed maturity. As soybeans develop, they continue to draw nitrogen from soil, but peak nitrogen fixation occurs near an early developmental stage, R2. The reason delayed maturity is desirable is because it provides a longer window of time for potential nitrogen fixation. Certain genes have already been identified to affect the signaling, biosynthesis, and transport of auxin and cytokinin (e.g., microRNA160 and microRNA 167). In my project, I will be analyzing genome sequences using bioinformatic approaches to identify other variations that change nodule auxin-cytokinin levels or signaling. I will be annotating the genomes from vcf files into protein sequences, and comparing the mutations between different plants. After the mutations have been identified, that information could be used to assess their effects on auxin and cytokinin levels, with the goal of finding which combination of mutations produced the lowest auxin and highest cytokinin levels in the plant, therefore increasing biological nitrogen fixation.

REU South Dakota State University
Advisor(s): Sen Subramanian

Investigating UV Catalytic Conversion of a Polycyclic Aromatic Hydrocarbon to a Biologically Extant Quinone on Planetary Relevant Mineral Phases: Implications for Origins of Life — C11 — 12 p.m.

Samuel Drummond (1), Christina Maloney (1), Siddhant Sharma (2, 3), Dr. Arthur Omran (4, 5), Dr. Jessica Weber (6), Dr. Laura Barge (6), Dr. Anna Oliveri (7), Dr. Patrick Videau (7)
(1) Dakota State University (2) University of Delhi (3) Blue Marble Space Institute of Science (4) University of South Florida (5) University of North Florida (6) California Institute of Technology (7) Southern Oregon University

Abstract: Polycyclic aromatic hydrocarbons (PAHs) are abundant in astrochemical environments and are disbursed into planetary environments via extraterrestrial infall where they may undergo ultraviolet (UV)-catalyzed reactions on mineral surfaces to produce biomolecular precursors (e.g., quinones) that influence origins of life chemistries. To address the reasonableness of this idea, we assessed the catalytic potential of the planetary minerals montmorillonite (MONT), kaolinite (KAO), aluminum oxide (Al2O3), and a Martian soil simulant (MMS) to catalyze conversion of the representative cosmic PAH anthracene (ANTH) to 9,10-anthraquinone (ANTHQ) – a biologically extant quinone that may also have influenced the origins of life on the primordial Earth and on other planetary bodies – in the presence of UV light. ANTH-spiked minerals were irradiated with UV-A, UV-B, and UV-C under four atmospheric conditions relevant to the primordial Earth and present-day Mars. ANTHQ production trends exhibited an approximately dose-response pattern as UV wavelength decreased under Earth ambient atmosphere but were more variable under anoxic atmospheres. Isotopic labeling studies showed that O needed for ANTHQ production is derived from both atmosphere and mineral substrate, suggesting that, even under anoxic conditions (i.e., those prevalent on the primordial Earth and present-day Mars), ample oxygen could be available to drive production of biologically useful quinones. Implications for origins of life on the primordial Earth and in other prebiotic planetary environments will be discussed.

REU Dakota State University
Advisor(s): Michael Gaylor

Testing hydrotropism in soils using maize seedlings — B11 — 11 a.m.

Hunter Eide, Muyu Gu

Abstract: Drought is a constant threat to agricultural producers throughout the world. Plants use hydrotropism as a growth response to acquire water when the root faces a moisture gradient in the soil. While hydrotropism is believed to be an important biological process, the significance of hydrotropism in plant survival and production has not been clearly demonstrated. The objective of this project is to develop a system that allows to observe hydrotropic response and quantify plant performance due to hydrotropism in maize seedlings. To effectively induce hydrotropism, we arranged potting soils of different moisture contents in a petri dish to create a moisture gradient. We found 95% of the maize primary roots successfully demonstrated the hydrotropic bending in our system. The seedlings with their primary roots showing hydrotropism and eventually reaching the water source showed greater plant height, primary root length, the number of lateral roots, length of seminal roots, plant fresh weight, and leaf length compared to the roots that did not show successful hydrotropic response. In conclusion, hydrotropic responses in maize improved overall success of the young seedling in a heterozygous soil moisture environment, and a healthy primary root is crucial for early development of maize seedlings.

REU South Dakota State University
Advisor(s): Yajun Wu

Development of Tissue Engineered Synovial Membrane Constructs — A09 — 10 a.m.
D'Nia Elston

Abstract: Osteoarthritis (OA) is one of the most common forms of arthritis and represents prolonged deterioration of the synovial joints. As a chronic condition, OA breaks down cartilage, the material that cushions the joints, subsequently causing the bones to rub against each other, leading to joint stiffness, pain, swelling, and reduced movement. Tissue engineering applies biological and engineering principles to develop biological substitutes that restore, maintain, or improve tissue function through a three-dimensional (3D) scaffold. The scaffold offers mechanical as well as biological influences to guide the maturation and integration of cells to form tissues. The major challenge in tissue engineering is designing and fabricating a suitable scaffold to fulfill the growing needs of the cells. The electrospinning method is used to generate a web of long nanofibers to produce an ideal scaffold with a main structural feature suitable for the growth of a cell. Freeze drying, also known as lyophilization, is a low temperature dehydration process that allows for the frozen water in the material to sublime. The electrospun fibers and freeze-dried material will mirror the natural extracellular matrix (ECM) of a synovial membrane (i.e., joint capsule) in both form and composition to promote a physiological phenotype of both synovial fibroblasts and macrophages. The results from this project will be integrated into a broader 'joint on a chip' system which will be used for early preclinical drug screening research to identify disease modifying osteoarthritis drugs (DMOADs). By imitating the architecture and composition of natural tissue, our constructs will help cells react as if they are in the human body, which will lead to faster development of the first ever DMOAD to treat OA.

REU South Dakota Mines
Advisor(s): Scott Wood

Organisms in Action: Syntropic Relationships Between Methane-Oxidizing and Sulfate-Reducing Bacteria — B12 — 11 a.m.
Rachel Engel, James Horne, and Sam Haas

Abstract: In nature, a variety of microbial species congregate to form a complex ecosystem. A few microbes prefer anaerobic growth conditions (devoid of oxygen) over an aerobic (oxygenated) environment. Interestingly, a syntropic relationship is often reported among anaerobic sulfate-reducing bacteria and methane-oxidizing archaea in many natural scenarios. One microbe provides the essential nutrients required for the growth of the other strain. However, no report is available on the anaerobic oxidation of methane by a pure bacterial culture, individually or in synergy with other microbes. Thus, the SURE group this summer sought to see if this oxidation could be possible. An exploratory work of growing the two compatible, facilitative and obligatory strains on a mixture of miscible C6 and C1 compounds was designed. For the syntrophic growth of both strains, previously standardized operational and nutritional parameters were used. The purity of the growing cultures was determined using imaging and sequencing techniques. The process of designing an ideal environment for both of these bacteria was not yet reached, as some minor setbacks prevented the team from advancing. Syntrophic growth experiments are underway, and the expected result is that the two bacteria will interface in an ideal environment.

REU South Dakota Mines
Advisor(s): Saurabh Dhiman

Modifying magnetic properties of MnBi with Carbon: An experimental and theoretical study — C12 — 12 p.m.
Matt Flesche, Gavin Baker

Abstract: Research on rare-earth-free permanent magnet materials have attracted much attention due to the limited supply and high price of the rare-earth metals used in current state-of-the-art permanent magnets. MnBi and MnBi-based magnets have been investigated as prospective rare-earth-free magnets because the magnetic anisotropy of MnBi increases with increasing temperature reaching a maximum value at 540 K. However, segregation of Bi during synthesis of MnBi is one of the issues which reduces the saturation magnetization. We have found that MnBi synthesized in carbon environment substantially reduces the amount of Bi segregation improving its saturation magnetization. We have synthesized MnBi and MnBi:C samples (with nominal composition Mn55Bi45) using arc melting and high vacuum annealing. The room temperature x-ray diffraction patterns indicate that both MnBi and MnBi:C crystallize in the hexagonal NiAs crystal structure (Low temperature phase, LTP). The X-ray diffraction pattern also indicates that the amount of Bi segregation in MnBi:C is less than that in MnBi. The high field (3T) magnetization measured at room temperature are 61 emu/g and 66 emu/g for MnBi and MnBi:C, respectively. In order to understand the origin of the increase in magnetization, we have carried out first principles calculations of MnBi alloy as well. In this presentation we will discuss the details of the first principles calculation and experimental data on structural and magnetic properties of MnBi and MnBi:C samples.

NSF EPSCoR Track-1 South Dakota State University
Advisor(s): Parashu Kharel

Electro-Osmotic Flows Through Microscopic Geometries — A10 — 10 a.m.
Turner Frank, Alethia Henderson

Abstract: Interstitial flow between cells and in the extracellular space is a natural phenomenon vital for survival of multicellular organisms. In the absence of blood flow, interstitial flow may promote cell survival until vessels can regrow. The goal of this research is to build a series of computational models to simulate and predict the movement of extracellular fluid through different cellular matrices. Circular and rectangular cross-sections are the focus of the study. Various matrices and physics continuum were tested in each type of geometry. The models used for this study are made in SolidWorks and imported into Star CCM+ to simulate the fluid dynamics. The sizes of the models range from centimeters down to the nanometer scale. Various geometric obstacles were created to simulate a molecular mesh through which the fluid was to flow. The first set of models was created to simulate pressure-driven flow and another set of models was created to simulate the effects of electro-osmotic flow, i.e., electrically driven waterflow through the tubes. A better understanding of how this is done in vivo will result in better wound healing capabilities, tissue engineering, and the opening of many new avenues of research.

REU South Dakota State University
Advisor(s): Stephen Gent, Mark Messerli

EMS Mutagenized Populations for Characterization of Resistance to FHB in Wheat — B13 — 11 a.m.
Nicholas Frede, Yeter Karakoc, Jinfeng Zhang, Jyotirmoy Halder, Harsimardeep Gill, Navreet Brar, Conner Thaler, and Naomi Torres-Irizarry

Abstract: Fusarium head blight (FHB) is a fungal disease that causes significant economic damage to wheat. A small time frame for fungicides application limits their effectiveness against FHB. Therefore, genetic resistance is necessary for minimizing FHB damage; however, only a few FHB resistance/susceptibility genes have been characterized. We are developing EMS mutagenized populations and Targeted Induced Local Lesions In Genomes (TILLING) populations in two spring wheat cultivars, RB07 (moderately resistant to FHB) and Berkut (FHB-susceptible). In 2020, 750 M4 lines from variety RB07 (MR) and 80 M4 lines from variety Berkut (S) were evaluated for FHB in a mist irrigated nursery. Several FHB susceptible mutants in RB07 (MR) background were identified. Two susceptible mutants were crossed with wild type (RB07). The resulting F2 population will undergo bulk RNASeq for mapping FHB resistance in RB07. In 2021 we are evaluating another 141 M4 lines Berkut (S) for FHB in a mist irrigated nursery to identify and FHB resistant mutants. In addition, two TILLING populations are under development, with 790 M1 lines harvested (M2 seed) from RB07 and 213 M1 lines harvested (M2 seed) from Berkut. Individual M2 plants will be grown to isolate DNA and develop TILLING pools for screening genes like Lipoxygenases, cell-wall-degrading enzymes (CWDEs), and other transcription factors that lead to wheat FHB susceptibility.

REU South Dakota State University
Advisor(s): Sunish Sehgal

Analysis of Rivet and Plate Corrosion Interactions for the USS Arizona — C13 — 12 p.m.
Mallory Gehrer, Michael West

Abstract: On December 7, 1941, the battleship USS Arizona was struck by bombs during the attack on Pearl Harbor. This attack triggered a catastrophic failure, and the ship sank to the bottom of the harbor. The USS Arizona has been left there for almost 80 years and it is now a popular memorial site under the care of the National Park Service. Previous models have been made to estimate when the ship will collapse due to corrosion damage, and it has been recommended that more research be done on the rivets used to fasten together the ship. Various samples taken from the superstructure of the USS Arizona were investigated to determine composition, hardness, and the yearly corrosion rate of both steel plates and rivets, as well as the possibility of galvanic corrosion between the two. Special attention was given to the testing environment, with a focus on accurate seawater solutions and heat treatments of steel samples, in order to provide a more accurate model of the corrosion of the USS Arizona.

REU South Dakota Mines
Advisor(s): William Cross

FirmwareScout: Scaled Web-Based Automation forFirmware Analysis — A11 — 10 a.m.
Paolo Gentry

Abstract: This research explores the automation of vulnerability identification within firmware designed for IoT (Internet of Things) devices. Due to the low computational power of embedded devices, primitive and elementary vulnerabilities are frequently present. Such vulnerabilities would commonly be resolved on more traditional devices. In addition to the overall lack of consistency in combination with the peripheral dependent nature of firmware, vulnerability discovery becomes a time consuming process. In many cases, manual analysis allows for only partial emulation at best. This proposed solution seeks to solve this problem by utilizing design science to create an open source framework for scaled vulnerability identification. FirmwareScout will utilize a combination of both static and dynamic analysis for identifying memory corruption vulnerabilities within binaries. Additionally, FirmwareScout will automate the process of file system extraction, identification of outdated and vulnerable services, weak user credentials, and insecure configurations. In order to accomplish automated vulnerability identification, FirmwareScout has utilized manual analysis to determine a repeatable methodology for analysis. This process relies on a master firmware repository which currently contains several hundred samples. In comparison to previous platforms for automated firmware analysis, no solution combines both automated binary analysis whilst identifying system configuration based security flaws. Unlike many other solutions, FirmwareScout will remain open source.

REU Dakota State University
Advisor(s): Yong Wang

U-statistics for Kernel Density Estimation for Classification of Chemometric Data — B14 — 11 a.m.

Janean Hanka

Abstract: In analyzing chemometric data, it is difficult to assign probability measures for likelihood-based decisions. This is due to the complexity of the data. Chemometric data consists of many dimensions of many different types of information (e.g., continuous, discrete, non-numeric). What is typically used to characterize the difference between groups of observations in chemometrics are known as discriminate functions. For example, linear discriminate analysis (LDA) is designed to find a set of projections that provide optimal separation between classes relative to the within class variation. This can be contrasted with principal component analysis (PCA), which is designed to find the linear projections that characterize the direction of maximum variation, while ignoring group classifications. Neither of these methods are ideal for chemometric data: PCA gives biased representation of the separation between groups (i.e., the groups are farther separated than the plots of PCA scores suggest), and we may not meet all necessary assumptions to use LDA. In answer to this difficulty, we suggest a U-statistic discriminate function in terms of pairwise differences. This method can be used for kernel density estimation (KDE) of chemometric data. It provides a way to generate probability measures without needing to know the mean, variance, or covariance, or re-running data. Since we are looking at all of the possible pairs of the data, this method should be accurate and applicable for generating a likelihood ratio (which has potential for use in combating the illicit economy, e.g., the likelihood ratio can help us decide which brand a pill or potential counterfeit is more likely to have originated from). This can be accomplished through the development of the model, creation of a correlation coefficient, and generating a dissimilarity score.

REU South Dakota State University
Advisor(s): Christopher Saunders

DD Neutron Generator shielding — A12 — 10 a.m.

Keegan Harrison, Walker Johnson

Abstract: The Deep Underground Neutrino Experiment (DUNE) is the future leading-edge, international experiment for neutrino science and discoveries of physics beyond the Standard Model. The experiment consists of a high intensity neutrino beam, a near detector at Fermilab in Illinois, and a 40-kton fiducial mass far detector deep-underground in the Sanford Underground Research Facility (SURF) in South Dakota. For the experiment, trillions of neutrons will be fired from Fermilab through an 810-mile baseline to SURF. At SURF the neutrinos will hit a liquid argon detector. The Goals of this study are to help understand proton decay, neutrino oscillations, and to search for different types of Neutrinos. Achieving physics sensitivity in DUNE requires a precision detector calibration that constrains the uncertainties from relevant detector response parameters. Conventional calibration methods are quite limited due to the deep underground location and the large scale of the far detector. A novel way is to inject neutrons into the liquid argon detector using a Deuterium-Deuterium (DD) neutron generator, providing neutron capture signals with a fixed energy deposition of 6.1 MeV in the form of multi-gamma cascades. The DD generator gives off high amounts of radiation and therefore must be shielded. Using programs such as Geant4 we are working on simulations to find the best way to shield the generator. We have simulated many different designs to find the most cost-effective shield. Through our simulations we have found that we can safely build a shielding structure that has borated Polyethylene for neutron radiation and lead lining around it for gamma radiation. This information will help us to build a shield that will keep those working with and or around the DD generator safe from radiation, and by doing so make it possible to operate at the liquid argon far detector in DUNE for calibration purposes.

REU South Dakota Mines
Advisor(s): Jingbo Wang

Metagenomic Analysis of the Microbiome Found in Samples from Homestake Mine for the phaC Gene — A13 — 10 a.m.

Paycen Harroun, Tanvi Govil

Abstract: Polyhydroxyalkanoates (PHAs) are microbial storage polymers accumulated by many different groups of bacteria as an intracellular carbon and energy reserve. The use of methane (CH4) as a feedstock for PHA production can significantly decrease costs and environmental impacts. In this study, an analysis of the phylogenetic and ecological distribution of potential PHA-producing microbes is being carried out in the samples collected from Sanford Underground Research Facility (SURF) in Lead, SD, at depths of 1800, 4100, and 4,850 feet below the surface. While a culture-independent approach is being followed to amplify and clone the PHA synthase (PhaC, Class I-IV) from this genomic repository to understand and link the potential physiology existing in the subterranean environment of SURF to PHA synthesis. Culture-dependent enrichments are being carried out to isolate unique microorganisms capable of oxidizing methane to produce Polyhydroxyalkanoate (PHA) by carrying out enrichments in nitrogen-deficient Mineral Salt Media (MSM) four-day cycle with daily feeding of equal volumes of methane and oxygen gas. Together, this study has the potential to support future bioprospecting efforts towards better targeted and relevant taxa further to enhance the diversity of exploitable PHA production systems. It is envisaged that these outcomes will help to uncover microbes from SURF with properties that could potentially improve PHA production from methane.

REU South Dakota Mines
Advisor(s): Rajesh Sani

Data-Driven Bioprinting for Biomedical Applications — A14 — 10 a.m.

Tim Hartman, Evgeni Radichev, and Gideon Kassa

Abstract: Biomaterials in three-dimensional (3D) structures mimic natural conditions better than those in 2D structures, which makes evolution in the realm of 3D scaffolds inevitable. Normally, knowledge search involving these structures requires manual labor by researchers, which is tedious and limited in scope. As a result, some discoveries are overlooked due to a massive body of existing research. Furthermore, a lack of accessible semi-automatic bio-image analysis processes discourages more data capture, which would otherwise improve the statistical power of experiments. Herein, we propose a data mining and retrieval process that enables a more accurate replication of biological conditions and leads to the discovery of new biomaterials and scaffold models. Researchers may pull from this discovered data to strengthen their experiments with better materials and 3D-printable scaffolds. Our data mining process begins with our open-source tools. The Bioimage Analysis, Statistic, and Image Comparison (BASIN) tool performs segmentation on multiple 2D images, retrieves segmented object features, then reports on relevant descriptive and inferential statistics. ELNPy mines published text for relevant knowledge related to cells/microorganisms, materials, and 3D structures. Biovisualizer provides 3D reconstruction of published results for subsequent modelling. We propose these tools will send quality-assessed 3D models, materials, and reproducible protocols to our Ontology Driven Bioimage Dataset Discovery System (OntoBIDS) database for storage and public access. This approach is set to cut manual search time and labor by a significant amount while remaining easy to use by a community with diverse skill sets. Quality assessments made using our proposed tools and based on community standards is meant to reduce laboratory time and reagent waste. Ongoing work involves improving communication between proposed tools and commercially available software, validation of the process using our own 3D printing technologies, and continually improving the quality and quantity of data in OntoBIDS.

NSF EPSCoR Track-1 University of South Dakota
Advisor(s): Etienne Gnimpieba

Reading and Analyzing Transcriptome of Vitis Riparia Long Reads Recorded by Oxford Nanopore DNA Sequencing — B15 — 11 a.m.

Tatum Okamoto, Dallas Kreisa, Ian Hastings, Sen Subramanian, Mike Robben, and Anne Fennell

Abstract: Vitis Riparia is a common grapevine found throughout North America, from Quebec all the way down to Texas and the American southwest. This plant, abundant as it is, holds the key for temperature resistance via the form of hybrid graft plants. Plants grafted onto the roots of Vitis Riparia show an increase to cold temperature tolerance when planted. The purpose of our study is to assemble a full-length transcriptome from Oxford nanopore long reads from multiple tissue samples to help in annotation of the genome. In this study we tested the transcriptome assembler Trinity to assemble Oxford nanopore long reads. Trinity's three-part system allowed for high fidelity attachment of k-mer's to generate complete and full-length transcript sequences available for annotation. This annotation will assist those in the future who will be working with Vitis Riparia and garner a deeper understanding to the mechanism of resistance.

REU South Dakota State University
Advisor(s): Jose Gonzalez

Using Laser-Induced Breakdown Spectroscopy to Determine the Provenance of Tantalum — B16 — 11 a.m.

Paxson Heath, Sam Kessinger

Abstract: In 2010, congress passed the Dodd-Frank act. Section 1502 of this act requires companies to determine if any tantalum used in their products originated in the Democratic Republic of the Congo (DRC) or adjoining countries. If so, the company must verify that the purchase of said tantalum did not contribute to the funding of any armed groups. The goal of this research is to determine if Laser-Induced Breakdown Spectroscopy (LIBS) is an appropriate tool for detecting major, minor and trace elements that would indicate whether or not a sample of tantalum originated, at least partially, in the DRC or an adjoining country. LIBS is a good candidate for a tool for sourcing tantalum as it is fast, requires little sample preparation, is minimally destructive, and can be miniaturized for use in a hand-held device. This project aims to test the validity of LIBS as a method of verifying the origin of tantalum by conducting tests on tantalum capacitors. Capacitors were obtained from old circuit boards and related electronic components. They were mounted in Bakelite and then ground to expose a capacitor cross-section. LIBS was used to obtain spectra for the capacitors, which are being analyzed for impurities. If impurities are present in the capacitors and are a match for known impurities in coltan (the mineral source of tantalum) from the DRC, it is likely that LIBS is a valid method for determining if a given sample of tantalum originated in the DRC. If this is the case, it will greatly improve the ability of companies to perform accurate, reasonable country of origin inquiries into tantalum. This could significantly decrease the financial burden imposed on companies, especially small businesses, by the Dodd-Frank Act, as well as increase the ability of these companies to avoid inadvertently funding armed groups.

REU South Dakota Mines
Advisor(s): Prasoon Diwakar, Jon Kellar

Development of CFD simulations for pressure-driven and electro-osmotic flows in circular cross section vessels — C14 — 12 p.m.
Alethia Henderson, Ashley Jorgensen

Abstract: Medical professionals have been utilizing the apparent healing effects of electrical stimulation on tissues for decades. However, the mechanisms used by cells that enable this healing to occur are not presently well understood. This project seeks to develop a method to computationally simulate interstitial flows that are either driven by pressure gradients or electrical gradients in order to better understand the effects of electro-osmotic flow (EOF) in regard to mammalian tissue preservation and regeneration. By computationally modeling these interstitial flows, we are able to modify simulations to include different tissue characteristics and equip other researchers with valid estimated values for these situations while also eliminating the cost and time required for undertaking these experiments in the lab. In addition to the work surrounding cell and tissue proliferation, our research will also serve to find scale-related limitations in the commercially available software used for the models, including Star-CCM+ and SolidWorks. Our results indicate that creating models and simulations is possible at the nanometer scale but that the utilized software are not efficient or accessible at this size. The acquired data, however, appears as though these simulations will have the intended capabilities and that future research will be able to validate data obtained by different means. Computational fluid dynamics modeling of interstitial flows has the potential to make a great impact on the medical field and patient treatment as well as the ability to increase knowledge of cellular mechanics and the possibilities this knowledge holds for future research endeavors.

REU South Dakota State University
Advisor(s): Stephen Gent, Mark Messerli

Loading of Porous Walled Hollow Glass Microspheres with Quantum Dots — C15 — 12 p.m.
Adam Ickler, Kirstie Gildemeister

Abstract: Porous-walled hollow glass microspheres (PWHGMs) provide a unique method of encapsulating functional materials, such as fluorescent particles. Their chemically inert nature and ability to hold functional cargo allows PWHGMs to greatly simplify the creation of security inks, as well as providing evidence of physical tampering due to their relative fragility. The purpose of this project is to develop techniques for loading PWHGMs with carbon and graphene quantum dots creating fluorescent microspheres for use in security inks. PWHGMs were loaded using a wet vacuum loading technique, and a technique for verifying the load was developed using VSC, SEM and UV-Vis Spectroscopy.

REU South Dakota Mines
Advisor(s): Grant Crawford

Effect of Phosphorus and Potassium Fertilizer Application on Endophytic Fusarium in Soybean — B17 — 11 a.m.

Jacob Ingram, NabinDangal, Nathan Braun, and Brian Kontz

Abstract: Species of Fusarium include endophytic fungi that can inhabit plant tissues without causing obvious disease symptoms. However, studies on endophytes species of Fusarium in soybean (Glycine max L.) are limited, although these fungi have been reported causing Fusarium root rot. In the present study, we characterized endophytic species of Fusarium that are associated with soybean roots and determined how phosphorus and potassium fertilizer application affects the fungal composition. A field trial was established using a commercial variety in a randomized complete block design with four replications at Brookings, SD, in 2021. Five treatments were included in the field trial, which comprised of two levels of phosphorus (46.6 and 67.0 kg/ha P_2O_5) and potassium (33.6 and 67.3 kg/ha K2O) fertilizer applications as well as a non-treated control. Six plants were randomly uprooted from each plot at second trifoliate (V2) growth stage. Roots were separated from the plants, washed, cut into small pieces, surface-sterilized and incubated on potato dextrose agar (PDA). Following 7 days of incubation at 22±2°C, cultures were scored for the presence of Fusarium by examining morphological characteristics on PDA and sequencing of partial translation elongation factor-1 alpha genes. A total of 77 isolates belonging to the Fusarium genus were recovered and the isolation frequency of Fusarium was calculated for each treatment. At six trifoliate (V6) growth stages, values of Normalized Difference Vegetation Index (NDVI) were obtained for each plot from a handheld sensor (GreenSeeker, Trimble, CA) to evaluate crop health. The Analysis of variance results showed no significant effect of phosphorus and potassium fertilizer applications on the percentage isolation of Fusarium and NDVI values under field conditions (α=0.05). Further studies are required on root–endophyte associations, as well as on the role of endophytic Fusarium in the development and control of root diseases in soybean.

REU South Dakota State University
Advisor(s): Febina Mathew

Water Reduction in the Mining Industry: Sustainable Mineral Processing — A15 — 10 a.m.

Jennifer Johnson, Bernardo Sansao, William Cross, and Albert Romkes

Abstract: In 2015, the mining industry used an estimated 4 billion gallons of water per day, in the United States. Many areas of the United States heavily in the mining industry include New Mexico, Arizona, Nevada, and Utah which do not have the water to sustain humans and mining operations. Mineral processing is the treatment of removing valuable minerals from ore. A common mineral concentration method is froth flotation. Froth flotation involves use of a ground mineral slurry in water, and air bubbles are injected into the system. Hydrophobic minerals attach to the rising air bubbles while hydrophilic minerals remain in the slurry. Mineral hydrophobicity can be achieved using chemicals called collectors (surfactants). The goal of this research is to eliminate the need of froth flotation, and therefore, reduce the amount of water the industry consumes. This research involves use of a dry blending approach, mixing mineral particles with neat surfactants to modify the hydrophobic/hydrophilic balance of the mineral particles. The goal is to create the desired surface property, either hydrophobic or hydrophilic tendencies without the use of water, and to separate particles based upon adhesive forces. The surface chemistry of ground fluorite, CaF_2 (mineral), and oleic acid, $C_{18}H_{34}O_2$ (surfactant) was investigated. A planetary centrifugal mixer was used to blend the sample. Fourier-transform infrared spectroscopy (FTIR) was utilized to determine the presence of chemisorption and unactive oleic acid on the fluorite surface. The results show that mineral particle surfaces can be modified via adsorption of surfactants without the presence of water.

REU South Dakota Mines
Advisor(s): Jon Kellar

SURF E&O Summer 2021 Internship — B18 — 11 a.m.

Elliot Keller, SURF E&O Team

Abstract: This past summer, I was given the unique opportunity to inform, apply, and refine my conceptions, regarding my future-career aspirations, within a world-class scientific research environment. As an undergraduate, preservice teaching student, hoping to teach high school math or biology, I am truly grateful for the privilege of working with the Education & Outreach team, at the Sanford Underground Research Facility, facilitated through Black Hills State University, and SD-EPSCoR. Personally, upon applying and being accepted for this internship, my goals involved building a deeper appreciation for the processes, practices, and people working within the fields of STEM, education, and those other fields which have far-reaching, direct and indirect, effects on communities of various cultural and demographic groups. One of the many highlights of this internship, which have met and surpassed my initial goals and expectations, involved gaining new insights into the values of effective, systemic, well-ordered collaboration, and its applications to, and necessity within, various professional learning, and working, environments. From professional development workshops, curricular design modules, presentations, and demonstrations; to complex scientific experiments, and vast engineering solutions; this internship has broadened, cultivated, and elucidated my perspectives on the connections between, and the significance of, the scientific, educational, and at-large communities; the benefits, implications, and consequences therein, which I hope to convey to my future students, I believe, will help me to inform their growth, development, and future world-views.

NSF EPSCoR Track-1 Black Hills State University
Advisor(s): Peggy Norris

Inhibition of Biofilm Formation by Mammalian Placenta Extracts — A16 — 10 a.m.
Kelly Kleekamp, Josh Schumacher, Matthew Osmanski, and Jenny Gubbels

Abstract: The placenta is an organ that is composed of both maternal and fetal tissues. One role of the placenta is to produce antibacterial factors and signaling molecules that are part of innate immunity. It has been demonstrated that whole-placenta extracts inhibit bacterial biofilm formation, but there is little information about the mechanism by which the placenta inhibits biofilm growth, or whether the factors involved are derived from maternal or fetal placenta tissues. To study the antimicrobial properties of placenta, Staphylococcus aureus and Escherichia coli biofilms were cultured with and without homogenized maternal and fetal mammalian placenta extracts. We found that treatment of cultures with placenta extracts reduced biofilm formation by both S. aureus and E. coli; however, planktonic growth of only E. coli was inhibited. We also found that pretreatment of surfaces with placenta prevents adherence of S. aureus. Future work will determine whether antibacterial factors are associated with the maternal or the fetal portion of the placenta, the identity of the factors, and the mechanism by which the placenta inhibits biofilm formation.

NSF EPSCoR Track-1 Augustana University
Advisor(s): Paul Egland

Microstructure and Corrosion Resistance of Cold Sprayed Coatings — B19 — 11 a.m.
Joe Kleindienst, Bharat Jasthi

Abstract: High temperature salt environments are highly corrosive. This is a main problem in the viability of molten salt reactors. However, coatings can be used to protect substrate materials from molten salt corrosion. The aim of this research project is to investigate if cold sprayed coatings could feasibly be used in molten salt environment. Cold spray coatings of nickel and 17-4 PH stainless steel will be examined for corrosion resistance capabilities. The microstructure and physical properties of the coatings will be analyzed. Hot salt corrosion tests will take place in a eutectic composition of 53.43% NaCl, 14.95% $MgCl_2$, 31.61% $CaCl_2$ tested at 600 °C. In addition, the effects of carrier gas used in the spraying process on coating quality and heat treatment of the 17- 4 PH stainless steel coating will also be studied.

REU South Dakota Mines
Advisor(s): Michael West

Analysis of Lakota Artifacts — C17 — 12 p.m.
Ava Knutson

Abstract: This project has focused on the authentication of a Lakota hide scraper from the Heritage Center at Red Cloud Indian School. To authenticate the hide scraper a series of analytical experiments, such as infrared spectroscopy, X-ray fluorescence spectroscopy, optical microscopy and multi-spectral analysis were run to authenticate the materials of construction. The analytical analysis was performed in parallel with interviews with content matter experts (e.g., Lakota elders and paleontologists). The information was used to validate or invalidate the primary information given when the artifact was received. The authentication of this artifact will aid in helping combat stereotypes and false history by giving an accurate glimpse into the past of the Lakota people.

REU SPACT South Dakota Mines
Advisor(s): Jon Kellar and Grant Crawford

Soil Microbial Community Structure Influenced by Plant Functional Group and Grazing Intensity in a South Dakota Pasture — B20 — 11 a.m.
Dallas Kreisa, Cody Zilverberg, Jose L. Gonzalez Hernandez, Sen Subramanian, Trevor Van Den Top, and Dwayne Beck

Abstract: Rangelands in the northern plains region of the U.S. were once composed of a diverse mixture of C3 grasses, C4 grasses, and forbs. In the past century, many have become dominated by invasive C3 grasses, which limits productivity and the season of greatest forage quality. Reintroducing native warm season grass species, increasing diversity, and using targeted grazing might improve water and nutrient use efficiency and soil health. In central South Dakota, an experimental site was established in a randomized complete block design to understand the impacts of seeding C4 grasses and forbs in C3-dominated pastures under two different grazing densities. Soils were taken at 0-10 cm from the base of C3 grasses (crested wheatgrass, Agropyron cristatum; smooth brome, Bromus inermis), C4 grasses (big blue stem, Andropogon gerardii), and forbs (fringed sage, Artemisia frigida; prickly lettuce, Lactuca serriola; western ragweed, Ambrosia psilostachya) in replicated plots under high and low grazing intensities as well as grazing-enclosures. Soil microbial community structure was analyzed by extracting microbial DNA, sequencing, and matching with the best corresponding microbial species or genius.

REU South Dakota State University
Advisor(s): Sutie Xu

Ethical Hacking and Incident Reconstruction for IoT — B21 — 11 a.m.

Alexis Kulm, Easton Hay

Abstract: Drones, also known as Unmanned Aerial Vehicles (UAVs), have become common household items due to a fast-paced society and a rapidly changing technological world. There has been a rapid increase in drone crime involving smuggling drugs and other items across borders, and into prisons in recent years. Such crimes are relatively new to law enforcement. This creates a need for drone forensics and vulnerability testing. In this research we conduct a digital forensic case on a drone using a DJI Mini 2. The data extracted from the drone includes, but is not limited to, data from the drone's micro-SD card, the iPad Air 2 that is used to fly the drone, and the drone itself. Since the drone model used is relatively new, there is little information about what data or vulnerabilities it may contain. The use case aims to extract as much data as possible using forensic tools including Cellebrite, XRY, and Axiom and conducts forensics on the extracted data. It also targets to test any vulnerabilities that exist in the drone. The use case leads to findings such as GPS coordinates from the last known location the drone was flown, PII information, and Exif data. The GPS coordinates are important because law enforcement could use the last known location to find evidence, or the criminals themselves. We are also able to identify pieces of data that can confirm who may have been flying the drone, the drone's specific flight path, and specific errors that may lead to indication of criminal activity. This research demonstrates that conducting digital forensics on drones may provide important evidence for law enforcement to combat crimes.

REU Dakota State University
Advisor(s): Ashley Podhradsky

Heavy Metal Soil Intake in Cattle Grazing in the Badlands, Pine Ridge, and Eagle Butte Locations — C18 — 12 p.m.
Erica Lafferty

Abstract: Heavy metals are natural occurring elements found in soils; however, most heavy metal contamination occurs through anthropogenic activities. All soil types have varying types of heavy metals. Heavy metals are considered to be an environmental, animal, and human health hazard. The effects of heavy metals transfers through the food chain from soil, plants, animals and then humans. On the Cheyenne River and Pine Ridge Reservations in western South Dakota there are many cattle range units where cattle are able to graze in open fields where they intake soil along with grass when grazing. Heavy metals absorbed from soil in the intake process in cattle have the potential to transfer down the food chain when cattle meat or cow milk is consumed by humans. What are the heavy metal levels in the soils at these two sites and how do they compare to the acceptable concentrated relative standard deviation (RSD) levels and the concentrated standard deviation levels from the USGS website?

REU Oglala Lakota College
Advisor(s): Dana Gehring

Bud production genes in Vitis riparia — A17 — 10 a.m.
Julia Lankisch, Kyle Pfaffenberger, Nick Frede, and Anne Fennell

Abstract: Vitis riparia, colloquially known as frost grape, is native to North America and is economically beneficial due to its high tolerance of fluctuating microclimate and soil conditions. Assembling and annotating the genome of V. riparia would provide insight into its mechanisms and evolutionary history. V. riparia RNA was sequenced with both Nanopore and Illumina technology, and Pychopper and Trimmomatic programs, respectively, were used to trim the reads. The transcriptome was assembled using hybrid data in RNA SPAdes. The assembly combined the Illumina and Nanopore reads into a complete transcriptome and was compared to the NCBI gene database and a previously assembled V. riparia genome. We aim to determine gene function based on known sequences in other species and compare them to those of Equisetum arvense and Viola pedatifida to understand the evolutionary history of genes that regulate the production of dormant buds in all three species.

REU South Dakota State University
Advisor(s): Jose Gonzalez

Pascopyrum smithii and Bromus inermis competition in harsh nutrient conditions — B22 — 11 a.m.
Julia Lankisch

Abstract: Replacing invasive smooth bromegrass (Bromus inermis) with native western wheatgrass (Pascopyrum smithii) in degraded tallgrass prairies proves difficult, as lingering brome often outcompetes wheatgrass for resources and prevents the establishment of native grass stands. However, in harsh environments, P. smithii has been found to produce a higher relative yield than B. inermis, so a nitrogen concentration threshold could be established at which a restoration project is likely to succeed. This experiment was multifactorial, with four levels of nutrient solutions (0%, 0.1%, 0.5%, and 1% N) to simulate harsh soil conditions and five levels of competition (WW, SB, WW-WW, WW-SB, and SB-SB) to simulate intra- and interspecific competition. Seedlings of similar size in the 2-leaf growth stage were planted in pots of pure sand based on their respective competition levels and watered with nutrient solutions once per week, supplemented by deionized water every other day for six weeks in a greenhouse. The plants will be weighed, relative yield calculated, and leaf area measured using ImageJ. The results will be analyzed using an ANOVA test of variance to determine whether soil nitrogen concentration significantly affects competition between P. smithii and B. inermis.

REU South Dakota State University
Advisor(s): Lan Xu

Cellulose Extract from Corn Stover: It's Potential to Reduce Plastic Pollution — A18 — 10 a.m.
Jake Larsen, Hoque Mominul

Abstract: Ever since the mass commercialization of plastic products, pollution in the world has been getting steadily worse. From microplastics being found in our rainwater to a giant floating trash heap in the ocean; inexpensive, lightweight, and easily producible plastics have flooded daily life in more ways than one. There are numerous projects pursued actively throughout the world to reduce the use of plastics such as recycling programs, green containers, and the development of products that facilitate plastics degradation. Among the available options, agriculture biomass presents a sustainable and economical way to design and develop biodegradable plastics, mainly by extracting cellulose and designing suitable products, e.g., packaging films. Cellulose is a low-density biomaterial with a strong and stiff structure, and meets the quality attributes of cellophane products. This project aims to test and streamline the cellulose extraction process and create usable, biodegradable cellulose films. The cellulose is extracted using chemical treatments involving acetic acid, hydrogen peroxide, and sodium hydroxide. The viability of cellulose films is established via water permeability, water absorption, color, and biodegradability properties. Overall, this project demonstrates that cellulose from corn stover has potential for use as a bioplastic, but it still requires a fair amount of work to optimize the process as a feasible solution. If, in the future, this occurs then farmers will have a potential source of additional revenue, plastic consumption could be reduced also lowering fossil fuel usage.

REU South Dakota State University
Advisor(s): Srinivas Janaswamy

Effect of Urbanization on water quality and benthic macroinvertebrate along Rapid Creek — A19 — 10 a.m.
Blaine Leftwich

Abstract: Rapid Creek is an integral part of tourism, recreation, and wildlife population in the Black Hills area and Rapid City. It has also had a bacterial impairment designation and exceedances of fecal coliform bacteria criteria since 1998, with no source yet identified. Therefore, it is also essential to monitor the water quality and identify possible pollution sources. Benthic macroinvertebrates are often good indicators of stream health and may be used to predict water quality. This study aims to assess the effect of urbanization on water quality, and identify any correlation of pollution locations using macroinvertebrates and other physicochemical characteristics along Rapid Creek. Several sites along the creek were sampled for macroinvertebrates, heavy metals, temperature, and dissolved oxygen. Locations used were above, in, and below Pactola Reservoir, as well as in Rapid City. We are expecting the variety of macroinvertebrates to decrease as Rapid Creek gets closer to Rapid City, and levels of heavy metals and other pollutants due to runoff from urban sites are expected to increase. Correlating our data with our locations, we may narrow down the areas where pollution is entering.

REU Oglala Lakota College
Advisor(s): Bree Oatman, Dana Gehring

Lanthanide Doped Nanoparticles for Photo Applications — B23 — 11 a.m.
Joe Lincoln, Nurul Muttakin

Abstract: An emission process driven by lower energy incident photons is known as upconversion. Lanthanide doped nanocrystals are a well-studied upconversion material. For example, Er/Yb co-doped NaYF4 nanocrystals absorb light at 980 nm (near infrared, NIR) and emits at 800 nm. The upconversion effect has been exploited in bioimaging, security printing, and fingerprint detection applications. A limitation of the current upconversion nanocrystal technology is the requirement of a powerful NIR source, provided by a laser. This presents cost and regulatory issues in deploying technology that use upconversion nanocrystals. If the excitation could be provided by LED source, it would be a major advantage. We propose the preparation of TiO2 nanocrystals co-doped with transition metal and lanthanide ions that simultaneously achieve visible light absorption and upconversion. In the first step we synthesized sodium europium fluoride (NaEuF4) seed nanocrystals to be used as both a source of a lanthanide and fluoride. TEM data shows the NaEuF4 seeds to be uniform with a diameter of 4.8 nm. Rod-shaped anatase TiO2 nanocrystals were prepared separately, and we are developing a synthesis of doped TiO2 based on solid state reaction in solution between the TiO2 and NaEuF4 nanocrystals. This will be followed by transition metal doping to achieve the final functional nanomaterial.

REU University of South Dakota
Advisor(s): James Hoefelmeyer

Regolith Soil for Food Production on Mars — A20 — 10 a.m.

Madisen Lindholm, Venkataramana Gadhamshetty

Abstract: Plants are an important part of everyday life. They provide us with nutrients needed to survive. With access to great crop production designs on Earth, we need to start developing crop production designs for space, more specifically, Mars's. In the future, humans may inhabit Mars. We will need sustainable food sources on Mars, with plants being the main supply. It will be difficult to transport food produce to space, so designing and researching crop production designs for space will be beneficial for the future Mars missions. The main research goal is to understand the role of effective inoculum for amelioration of regolith properties and use it as soil material for food production. For the experiment, five different test conditions were established i.e., native soil only, native soil + regolith at 25/75, 50/50, 75/25 ratio and regolith only. Arugula was used as a test plant, which is commonly used in salads and quick to grow. Regolith soil was Mars Simulant Soil that was simulated by the NASA Exolith Lab, which is rich in silica ~50-60%. From the on-going tests, the native soil to regolith ratio of 75/25 mixtures was found to be the optimal mixing ratio for growing the plants. The plant growth can be attributed to the pH, buffering capacity and available macro-micronutrients concentrations. However, we need to study the role of effective inoculum addition under this mixing ratio and its impact on microbiome structure followed by plant growth stimulations and leaching of minerals from regolith. This would further help determine how to manipulate the conditions to grow food on Mars and use regolith as soil material.

REU South Dakota Mines
Advisor(s): Parthiba Karthikeyan Obulisamy

Iron/DOX-doped Mesoporous Silica Nanoparticles for Chemotherapy and Chemodynamic Therapy of Cancer — C19 — 12 p.m.

Nathan Loutsch, Le Tang

Abstract: Cancer is one of the leading causes of death. New and advanced therapeutic strategies are needed to combat this disease. Nanotechnology has been widely used for cancer diagnosis and therapy because of its advantages. Especially because multi-model therapeutic strategies can be easily integrated by using nanomaterials. For instance, chemotherapy and chemodynamic therapy can be combined by doping the related drugs into a single nanoparticle. In this project, we plan to synthesize a mesoporous silica nanoparticle (MSN) for cancer therapy through both chemotherapy and chemodynamic therapy. In this probe, iron ions will be doped into the MSN for a Fenton reaction. Because of the abnormally high concentration of H2O2 in the cancer microenvironment, the probe will generate toxic hydroxyl radicals to kill cancer cells. Meanwhile, a chemotherapeutic drug, doxorubicin (DOX) will be also doped into the MSN for chemotherapy. With this design, the chemotherapy and chemodynamic therapy will be integrated into a single nanoprobe based on MSN. In the last few weeks, we have synthesized the MSNs doped with iron ions and tested the feasibility of the Fenton reaction in the presence of H2O2. The results showed that the iron-doped MSNs generated enough hydroxyl radicals for chemodynamic therapy. In the next few weeks, we will thoroughly characterize the iron/DOX-doped MSN and test its therapeutic effect on cancer cells. With the success of this project, we are hoping to provide a novel powerful nanomaterial for cancer therapy through both chemotherapy and chemodynamic therapy, which might have promising potential for the clinical translation.

REU University of South Dakota
Advisor(s): Steven Wu

Vibrational Analysis of Bone Cells on Titanium Dioxide Nanotubes and Fibronectin-Coated Glass — B24 — 11 a.m.

Amanda Lueth, Zachary Nix

Titanium-based implants are widely used in orthopedics today and are preferred because of their biocompatibility. Creating nanostructures, such as titanium dioxide nanotubes (TiO2 NTs) on the surface of these implants has been shown to positively influence cell adhesion, spreading, and differentiation on the surface, which in turn increases the chances of success of the implants. This project focused on measuring single cell vibrational movement on the surface of TiO2 NTs. Mouse pre-osteoblast cells were plated on the surface of both fibronectin-coated glass, as well as on TiO2 NTs, and vibrational movement was monitored using atomic force microscopy. The vibrational power spectral density (PSD) analysis was used to compare cell dynamics on the surface of TiO2 NTs and fibronectin-coated glass and correlated with changes in cell morphology and stiffness. This study may provide insight into the variation in cellular outcomes between substrates by elucidating differences in the energetic state of intracellular cytoskeletal dynamics, which may be indicative of variations in mechanotransduction processes within the cells between substrates. Ultimately, this may help to better understand why it is that bone cells respond favorably to TiO2 NTs.

REU South Dakota Mines
Advisor(s): Grant Crawford, Scott Wood

Investigating Thermal Catalytic Conversion of a Polycyclic Aromatic Hydrocarbon to a Biologically Extant Quinone on a Carbonaceous Asteroid Simulant: Implications for Origins of Life — C20 — 12 p.m.

Christina Maloney, Samuel Drummond, Sarah González Henao, Vytis Karanauskasb, Lillian Dewitt, Christina Mulua, Siddhant Sharma, Arthur Omran, Jessica Weber, Laura Barge, and Patrick Videau

Abstract: Polycyclic aromatic hydrocarbons (PAHs) are abundant in astrochemical environments and are disbursed into planetary environments via extraterrestrial infall where they may undergo thermal catalytic reactions on mineral surfaces to produce biomolecular precursors (e.g., quinones) that influence origins of life chemistries. To address the reasonableness of this idea, we assessed the catalytic potential of a carbonaceous asteroid simulant (AST) to catalyze conversion of the representative cosmic PAH anthracene (ANTH) to 9,10-anthraquinone (ANTHQ) – a biologically extant quinone that may have been important at the origins of life. The AST catalyzed conversion of ANTH to ANTHQ over temperatures encompassing a wide range of astrobiologically interesting environments (25-500 oC). Apparent rates of ANTHQ production exhibited sigmoidal behavior with temperature. To account for this trend, apparent rates of ANTH and ANTHQ loss from the AST were also assessed and found to be sigmoidal, with loss of ANTHQ occurring at greater rates than ANTH above 100 oC. We further observed appreciable production of the ANTH dimer 9,9'-bianthracene (BIANTH). Detection of BIANTH is important as PAH dimers undergo pi stacking to produce more complex repeating structures that could have functioned as primitive information coding molecules at the origins of life. Implications for origins of life on the primordial Earth and in other prebiotic planetary environments will be discussed.

REU Dakota State University
Advisor(s): Michael Gaylor

Techniques and Material Analysis of 3D Bio-printing — C21 — 12 p.m.
Evan McConnell, Laura Brunmaier, Emily Hyde, Katrina Donovan, and Travis Walker

Abstract: The history of 3D Bioprinting is not as long as one may suspect. It is still, in comparison to other medical practices, a newer technique that introduces life-saving medical options to people. There are currently three main types of Bioprinting which include inkjet, laser-assisted, and extrusion. The main focus of this research is analyzing the extrusion-based Bioprinting. Currently, 3D Bioprinting is an effective yet expensive process in which living tissues, hearts, bones, etc. are produced. The main expense is attributed to the model of printer and the materials used. Although the process is effective now, minimizing the expenses is crucial. This calls for research into more cost-effective techniques and materials that will not trade effectiveness for costliness. This research will further investigate the extrusion techniques used in 3D Bioprinting similar to that of the FRESH extrusion method. More specifically, it will dive deeper into collagen and sodium alginate bio-inks. Research methods include but aren't limited to rheological analysis on printing mediums such as Xanthan Gum, Gelatin, and Life Support, Scanning Electron Microscopy (SEM) on collagen prints, and 3D Bio-printing using a lab-made printer. The ultimate goal is to be able to determine the most effective printing medium for printing collagen and create an extrusion-based technique that could be easily replicated and ultimately be used in applications such as Tissue Engineered Vascular Grafts.

REU South Dakota Mines
Advisor(s): Katrina Donovan

Genome Wide Association Study for Root Traits in Oat — B26 — 11 a.m.
Isabel McIntyre (Mount Holyoke College), Krishna Ghimire, and Brent Turnipseed

Abstract: The health and productivity of plants is greatly influenced by the roots of the plant. Roots are critical for water and nutrient uptake, as well as anchoring the plant. The root system architecture (RSA), or critical traits of roots such as length and number, has an important impact on this. This study aims to locate single nucleotide polymorphisms (SNPs) that are associated with desirable root traits by conducting a genome wide association study on 300 oat varieties and breeding lines. We grew germinated seeds on a blotter paper between two plastic sheets, then imaged the root systems. These images were analyzed using RootNav and a variety of traits were measured, including total root length, lateral root number, and the average length of lateral roots. For these three traits, we conducted statistical analysis using R Studio and performed a genome wide association study using TASSEL V.5.0. The identification of SNPs significantly associated with root traits will provide a better understanding of the genetic control of RSA in oats and may be helpful for identifying which genes are responsible for those traits. In addition, these SNPs could be used in breeding to produce plants with the desired RSA. This may increase the efficiency of the plants by allowing for greater nutrient and water uptake and may also increase grain and forage yield.

REU South Dakota State University
Advisor(s): Melanie Caffe-Treml

Analysis of leaf and root microbiomes of sorghum under chilling stress — C22 — 12 p.m. ~ALSO presented at B25 (11 a.m.) and A27 (10 a.m.)

Isabel McIntyre (Mount Holyoke College), Sonya Erlandson, Monica Alba, Shankar Bhat, Marissa Driesen, Nick Frede, Ian Hastings, Jacob Ingram, Dallas Kreisa, Julia Lankisch, Tatum Okamoto, Brandon Palomino, David Peery, Kyle Pfaffenberger, Kate Philips, Austin Taylor, Conner Thaler, Naomi Torres, Rebecca Yox, Jose González, and Krishna Jagadish

Abstract: Sorghum is used in a variety of ways, such as for food, paper, and feed, making it one of the most common crops. It is economically important because of its versatility. However, sorghum is sensitive to changes in temperature, making it more difficult to grow in colder climates such as the Midwest, where agriculture is a significant part of the economy. Therefore, strategies to enhance early-stage chilling tolerance would enable cultivation of sorghum in marginal lands of the Midwest region. There is evidence to suggest that sorghum's microbiome may be important for its ability to tolerate cooler temperatures. Microbes influence plants in a variety of ways, including their development and tolerance to different environmental stress factors. Therefore, we aim to characterize sorghum's microbiome to determine the effect that it has on sorghum's chilling tolerance. Using the galaxy program mothur, we performed 16s rRNA sequencing on data collected from sorghum leaves and roots. We expect that the results of this study will allow us to determine what species of microbes are present in sorghum. Additionally, we expect this to provide insight into how sorghum's microbiome may influence its chilling stress tolerance. The results of this study may be used to develop sorghum varieties that are more strongly suited to colder climates, thus expanding its growing season, and creating a hardier plant.

REU South Dakota State University
Advisor(s): Sen Subramanian

3-D printer workshop — A21 — 10 a.m.

Cyle Miller

Abstract: Students assembled the Prusa 3-D printer and I believe gained a strong understanding of the machinal make up of this type of printer. Furthermore, the insight gained into the electronic mechanical interface was superb. Due to the advanced experience of my group, we decided that it would be interesting to let these students decide the best use of our time and equipment. They did not disappoint. As a group they decided to attempt to draw and print an object of constant diameter. They drew and 3-D printed an object broadly known as a Meisner's Tetrahedron. Desiring a deeper challenge, we explored the cam side of Fusion 360 and the students wrote the G Code to cut this object in aluminum using a cnc milling machine. Due to the complexity of this object the students designed and 3-D printed a fixture to hold this object to finish machining the 4 side.

NSF EPSCoR Track-1 South Dakota Mines
Advisor(s): Katrina Donovan

Theoretical Investigation of Spin Crossover in a Mn(III) Complex — A22 — 10 a.m.

Hoang Thien Ngan Nguyen

Abstract: Spin Crossover (SCO) of metal complexes is an interesting phenomenon in which the molecules having 3d4-3d7 electronic configurations can undergo switching of ground spin states (from low-spin to high-spin or vice-versa) by means of external stimuli such as temperature, pressure, or irradiation of light. Owing to the inherent bistability in different spin ground states, the molecules have potential applications in the molecular electronics as the building units of molecular switches, data storage devices, and in molecular catalysis. Fe(II) and Fe(III) complexes are common examples of SCO complexes; however, this property is rarely observed for manganese complexes. We are investigating the thermal SCO mechanism of a Mn(III) complex, experimentally characterized by Morgan et al. (Angew. Chem. Int. Ed. 2006, 45, 7192), using a combined density functional theory (DFT)-wave function theory (WFT) approach. The DFT functionals provide good molecular geometries, but often fail in predicting the ground spin states and spin-splitting energies with sufficient accuracy, due to an improper treatment of electron correlation arising from the underlying multi-configurational electronic structure. On the other hand, the WFT methods such as multireference second-order perturbation theory (CASPT2) describe the electronic structure accurately. From the computed molecular geometries and electronic energies, we determine the structural changes associated with SCO. Our results show the effect of the metal-ligand bond vibrational modes on the orbital interactions in the respective molecular geometries, which in turn govern the fate of the SCO mechanism.

REU University of South Dakota
Advisor(s): Bess Vlaisavljevich

Rapid Quantification of Specific Bacterial and Fungal Components In Soil Using qPCR — C23 — 12 p.m.

Tatum Okamoto (Hawaii Community College), Ian Hastings, Kristina Reinel, Jose Gonzalez

Abstract: Microbial components of soil contribute to plant growth and development; these relationships can be cooperative or detrimental to the plants overall health. Major benefits include nitrogen fixation and nutrient release by bacteria and acquisition of nutrients and plant protection by mycorrhizal fungi. Therefore, they facilitate sustainable agricultural production practices by reducing the need for synthetic inputs. For instance, in states like South Dakota, plant development is particularly important considering the focus on agricultural production for economic growth and sustainability and in other states like Hawaii such concepts are also important especially in maintaining biodiversity among the island's ecosystems and developing food security across communities. To quantify specific bacterial and fungal components of the soil, total DNA extractions from soil samples will be analyzed for total bacteria, total fungi, arbuscular mycorrhizae, ammonia oxidizers, and nitrogen fixers by utilizing quantitative polymerase chain reaction (qPCR). This would yield measurable results that indicate gene presence in comparison with other samples. Quantitative investigation of the presence of specific bacterial and fungal genes among select soil samples using qPCR will provide suitable indicators of soil biological health. The information combined with other soil health indicators would help develop customized strategies and practices for optimal and sustainable crop production.

REU South Dakota State University
Advisor(s): Sen Subramanian

Examining the Chemical Environments of Underground Microbial Life — B27 — 11 a.m.

Emily Ormé, Micheal Zehfus

Abstract: The Sanford Underground Research Facility (SURF), located in Lead, SD, has welcomed researchers across the world to uncover the curiosities of the natural sciences. For several years, microbial life has been discovered at SURF, provoking scientists to examine these microbes's survivability in harsh climates. The conditions range from extremely cold to hot and humid environments. A plausible reason as to why these organisms survive in these conditions, could be due to their evolved chemical pathways in the environment they possess. Undergraduate students and their mentors have previously investigated their chemical environments through water and biofilm sampling. Water testing and biofilm extraction help continuing research fellows trace and track the chemical environment of these microbes. New research efforts involving rock and solid samples containing these bacterial environments, are now included in the overall chemical analyses. With the continued work of water sampling, biofilm extraction, rock, and solid samples, a better understanding of how microorganisms thrive under harsh conditions underground is further investigated. Through the use of Inductively coupled plasma mass spectrometry, (ICP-MS) and Atomic absorption, samples are analyzed for their chemical compositions, at an elemental level. With the help of the SURF team and their guides, sites such as the 300, 800, and 4850 levels, allow for variation of samples. These sites provide more rock, solid, water, and biofilm samples to the chemistry undergraduate students and their mentors for study. These groups can further quantify the chemical environment of the microbes, given the variability in conditions. Several underground analyses such as pH, pressure, temperature, dissolved oxygen, and conductivity readings will still be performed. Chemical analyses performed in the laboratory include total alkalinity, sulfate and nitrate compositions, chloride potentiometric titrations, and the introduced techniques on solid samples. These analyses provide an overall understanding of the chemistry behind SURF's microbial life.

REU Augustana University
Advisor(s): Katrina Jensen

Developing N2-fixing cyanobacteria as a bioNitrogen fertilizer — B28 — 11 a.m.

Brandon Palomino-Alonso, Maxwell Jakubiak

Abstract: Nitrogen fertilizer is one of the most limiting and expensive inputs in agricultural production. Current fossil fuel-dependent ammonia production is both energy-intensive and environmentally damaging. An economically-practical and environmentally-friendly solution for production of ammonia is urgently needed. Fortunately, N2-fixing cyanobacteria provide such a unique opportunity to use the unlimited sunlight and the most-abundant atmospheric N2 gas to produce bioNitrogen fertilizer. This project is to test six cyanobacterial strains for BioNitrogen fertilization. The groups 1-2 are Anabaena sp., the other four groups (groups 3-6) were isolated from South Dakota natural ecosystems. The overall goal is to develop a bioNitrogen fertilizer using N2-fixing cyanobacteria. We applied different types of cyanobacteria to each group of wheat seedlings in greenhouse. The positive control contains chemical nitrogen fertilizer, while the negative control has no nitrogen fertilizer. Groups 1-6 are treated with the different cyanobacterial strains. Wheat plants in positive control group had an average height of 246mm, while in negative-control group had an average height of 102.4mm. The wheat plants in group 1 through group 6 had an average height (mm) of 232.2, 194.2, 162.2, 204.8, 144, 110.2, respectively. Except for group 6, all tested N2-fixing cyanobacterial strains appeared providing substantial amount of bio-Nitrogen fertilizer to support growth of wheat seedlings. The N2-fixing cyanobacteria in group 1 and group 4 supported the wheat seedling grown to 83.3-94.4% of wheat height (246mm) in the positive-control group. The dry biomass data are being collected as well. The findings from this project will help develop N2-fixing cyanobacteria as a producer of N fertilizer in crop soil. The long-term goal of this project is to enable these isolated N2-fixing “bugs” in crop fields as in situ “solar-powered living N-fertilizer factories” to reduce current cost for N-fertilizer and also improve self-sustainable soil health in agricultural lands.

REU South Dakota State University
Advisor(s): Ruanbao Zhou

A Study of Efficient Parallel Implementation using PETSc — B29 — 11 a.m.
Neal Patron, Rylee Sundermann, Hyun Lim, and Nathan McClanahan

Abstract: The objective of this project is to study the efficient implementation of parallel data structures and a parallel solver. Through this study we hope to better understand how to implement efficient parallel simulations. With parallel data structures, our goal is to construct matrices for a biological model simulation that is based on a system of equations describing biofilm. For the parallel solver, our aim is to implement a preconditioner, which is a numerical technique that can improve the efficiency of an iterative solver. The preconditioner can then be applied to a solver in a physics model simulation based on the Dirac equation. Our implementations are written in C/C++ using parallel data structures and routines provided by the Portable, Extensible Toolkit for Scientific Computation (PETSc) libraries. MATLAB prototype codes and preexisting PETSc codes are used as a basis for implementing parallel matrices and preconditioners, with new code being written for the final implementations. We are reviewing the results from our preliminary preconditioner implementation to determine if improved efficiency is being achieved. Successful results from this project could be helpful in finding an approach to faster simulations for similar problems.

REU South Dakota State University
Advisor(s): Jung-Han Kimn

Annotation of the genome of prairie cordgrass using RNA-seq data and protein homology — A23 — 10 a.m.
Joseph Peery

Abstract: Prairie cordgrass (Spartina pectinata Link.) is an ecologically important perennial grass native to North America with potential for development as a cellulosic biomass crop. Recently, we sequenced and assembled the prairie cordgrass genome for the first time. Because the prairie cordgrass genome is the first in the Chloridoideae subfamily of grasses to be sequenced, assembled, and annotated, this work also provides biological insights for the other species in the Chloridoideae subfamily. Here we will present our annotation of the novel genome. To annotate the genome, we used RNA-seq data from different experiments with prairie cordgrass and protein homology information from the model system sorghum (Sorghum bicolor), a close relative of prairie cordgrass. We predicted about 50,000 genes using these datasets. We also predicted the function of some of these genes using NCBI's blast tool.

REU South Dakota State University
Advisor(s): Jose Gonzalez

Novel Geometries for Jet Impingement Heat Transfer — C24 — 12 p.m.
Solomon Peitz, Gregory Michna

Abstract: The heat generation on microelectronic devices continues to increase as new technology allows these components to decrease in size, and unconventional methods are now being used to manage heat transfer on these devices. Jet arrays used for the enhancement of liquid cooling have proven to be the front-runner for this cooling technology. The goal of this technology is to increase the surface average heat transfer coefficient on the microelectronic devices, while maintaining an acceptable heat transfer distribution. The main issue with using jet arrays is that spent fluid from inner jets negatively affects the heat transfer coefficient near the outside impinging jets due to the crossflow of the fluid. Previous research has shown that non-uniform arrays can decrease the effect of the spent fluid crossflow so that the overall heat transfer coefficient on the surface increases. To analyze the performance of jet arrays, various arrays were modeled and analyzed in a commercial CFD software, StarCCM+. Results from these models are compared to a previous experimental data to ensure proper setup of physics continua and boundary conditions. The simulations analyze how crossflow affects the heat transfer coefficient in different regions on the target surface . Models that are the most promising are selected to be experimentally verified in a future study. Models analyzed have an array of circular jets that are both normal and oblique to the target surface, as well as 5 mm above the surface. This study aims to determine geometries that will further increase the heat transfer and improve heat transfer distribution on a target surface with a large heat flux.

REU South Dakota State University
Advisor(s): Stephen Gent

Hydrogel beads as carriers of bioactive compounds — A24 — 10 a.m.
Kyle Pfaffenberger, Prashant Dahal

Abstract: Bioactive Compounds (BCs) are effective to combat and prevent detrimental health problems such as diabetes, obesity, and cancer. Their incorporation in foods is challenging, however, due to low aqueous solubility, temperature instability, and susceptibility to enzymes encountered in the digestive tract, to name a few. Toward this end, carrier systems that could effectively protect BCs and deliver are in high demand and food grade polysaccharides such as carrageenan, starch and xanthan are couple of successful examples. Herein, curcumin and κ-Carrageenan (KC) have been chosen as the model BC and carrier system, respectively. Curcumin is a natural polyphenol derived from turmeric, specifically the Curcuma longa species. It is a preventative agent for many human diseases due to its antioxidative, anti-inflammatory, and anticancerous effects. Like many BCs, curcumin has low systemic bioactivity once ingested in humans due to its low tolerance to unfavorable conditions. KC is a naturally occurring polysaccharide derived from red seaweed. It is edible, biodegradable, and non-toxic. Herein, KC hydrogel beads have been used to encapsulate and deliver curcumin. The intended results of the research are to measure the encapsulation efficiency of curcumin in KC beads and establish release kinetics during the simulated gastro-intestine conditions.

REU South Dakota State University
Advisor(s): Srinivas Janaswamy

Protein modeling and transcript level analysis of ABA receptor-like genes in alfalfa — A25 — 10 a.m.
Kate Philips, Surbhi Gupta

Abstract: Abscisic acid (ABA) is a phytohormone that closes stomata under water deficit conditions thereby reducing water loss in plants. Previous studies in our lab demonstrated that Riverside (RS), a natural collection of alfalfa from the National Grassland in South Dakota, shows higher sensitivity to ABA in stomatal closure when exposed to water deficit conditions compared to Alfagraze (AF), a commercial variety. Some of the possible explanations for a higher ABA sensitivity can be that ABA receptors in RS are expressed at higher level and/or are structurally different compared to AF. To investigate these possibilities, we first examined the transcript level of PYL genes, a major gene family of ABA receptors in plants, and their structural features of the ABA binding domain through protein modeling in alfalfa. While all 15 PYL homologs identified in alfalfa were expressed in the leaf, they varied greatly in transcript level in well-watered plants. We are currently examining their transcript levels in water-stressed leaf tissues in RS in comparison with AF. Meanwhile, we are investigating the structures of the ABA binding domain of 15 PYL proteins following a homology-based approach. The modeling will reveal if any of the 15 PYL proteins exhibit differences in structure compared to other known PYL proteins in other species. Our future studies will then address whether these changes in structure differ in RS and AF and whether the difference may lead to a higher affinity of the proteins to ABA. Data of the transcript level changes under water deficit and structures of the ABA binding domain of PYL genes will be presented.

REU South Dakota State University
Advisor(s): Yajun Wu

Assembly of Vitis riparia transcriptome — C25 — 12 p.m.
Kate Philips, Austin Taylor, Naomi Torres Irizarry, Anne Fennel, and Mike Robben

Abstract: Vitis riparia, also known as River-bank Grape or Frost Grape, is a wild native species of North America with a high potential of development due to its tolerance to local weather and soil conditions. Vitis riparia has good resistance to wet conditions as it usually grows in wetlands. However, it is occasionally found in non-wetland sand so it can have fair resistance to dry and hot conditions. The transcriptome of Vitis riparia has not been previously reported. The assembly of its transcriptome can aid in evolutionary mapping and taxonomic distinctions. Here, Illumina sequencing was used to generate short reads of RNA that were trimmed and assembled using the Trinity software. Results to be presented with poster.

REU South Dakota State University
Advisor(s): Jose Gonzalez, Sen Subramanian

Ruthenium complexes containing dipyrazolylpyridine derivatives as a black dye for water splitting reactions: Synthesis and Characterization — B30 — 11 a.m.
Grant Pierce, Andrew Sykes, and Anwar Hussain

Abstract: Ruthenium complexes containing an anchoring group are well known as dyes for water splitting reactions when combined with TiO2. A three-pot synthesis using 2,6-diacetylpyridine, n-octyloxybenzaldehyde, phenylhydrazine and lead (IV) tetraacetate yielded a pyridine based pyrazolyl tridentate ligand (1). The ligand 1 is well characterized by 1H and 13C and COSY NMR. Reaction of ligand 1 with RuCl3.3H2O yielded RuCl3.1 (2), which was structurally characterized by single-crystal X-ray crystallography. The ruthenium (III) complex (2) is further reacted with 4,4-dicarboxy-2,2'-bipyridine to make [RuCl(1).Hdcbpy] (3). The black dye [Ru(1)Hdcbpy.NCS] is synthesized by reacting compound 3 with an excess of potassium thiocyanate. This new black dye will be tested for water splitting reactions after thorough analytical characterization. Long alkyl chains adorn this new pyrazolyl ligand to limit solubility and promote stability of the ruthenium dye complexes in dye-sensitized solar cell applications.

REU University of South Dakota
Advisor(s): Kadarkaraisamy Mariappan

The role of physiologically relevant oxygen of the ovarian tumor microenvironment on T cytotoxic lymphocyte biological functions — A26 — 10 a.m.
Allison Pittman, Kristan Calar

Abstract: Ovarian cancer (OC) is typically diagnosed in later, more progressive stages, resulting in a higher death rate among women with the disease. OC was one of the first human cancers in which the presence of CD8 cytotoxic T cells (CD8s) was correlated with patient survival. However, many factors such as immunosuppressive cells and hypoxia, can affect the presence and functionality of the CD8s in the tumor microenvironment (TME). Inadequate tissue oxygen, or hypoxia is a hallmark of all tumors and can have many effects on cellular and biological functions of the tumor and in the TME. This project further defines the affects that hypoxia has on CD8s biological functions within the TME. A monoculture of the CD8s and a coculture, including the SKOV3 OC cell line, were cultured in two different models, a 2D model and a novel physiologically relevant 3D model, recapitulating physiological and pathophysiological oxygen levels of the ovary. The models were then analyzed using fluorescence readings and flow cytometry assays for rate of apoptosis, cellular metabolism, cytotoxic capabilities, and the stages of the cell cycle the CD8s are in. CD8s showed a significantly higher cytotoxic profile in hypoxia compared to normoxia levels. In addition, CD8 metabolism, apoptosis and cell cycle functions were impacted in hypoxia compared to normoxia. Hypoxia influences the functionality of the CD8s in the TME; therefore, it is important to understand these impacts for developing more effective drug treatments, diagnostic methods and reduce cancer cell proliferation.

REU Sanford Research
Advisor(s): Pilar de la Puente

Using CNNs for Image Retrieval after Image Reconstruction — A28 — 10 a.m.

Nicholas Rasmussen

Abstract: Since the inception of law enforcement agencies worldwide, many criminals have gotten away with crimes. However, with the refinement of many different forensic tools, law enforcement agencies have been better able to track criminals worldwide after the perpetration of their crime. Many different types of prints can appear in a crime scene, including visible prints, plastic prints, and latent prints. Along with the different prints, there are different methods for collecting these prints for analysis later in labs. These methods can include collecting the entire print from the crime scene to create a print's cast model. However, many different methods do not require a physical print collection, such as adhesive lifters. Once these prints are safely in the labs, various processes refine the images. At this point, Artificial Intelligence (AI) guided tools get used to help law enforcement narrow down suspect lists with various image analysis techniques. These tools can pinpoint various features in the shoe prints and cross-reference big data sets from government agencies to help pinpoint potential suspects. Our project aims to develop Deep Neural Networks (DNN) to extract distinct features automatically so ranking is possible per similarity matching after reconstruction gets carried out on the shoe print. This process could potentially lead to examining forensics to help agencies pinpoint potential suspects in investigations. Our long term goal is to generalize the models so extensions can analyze tire prints in the scene. References provided in poster.

REU University of South Dakota
Advisor(s): KC Santosh

FAST REEU Experiences for a Performing Arts Major — B31 — 11 a.m.

Wiyaka Pomarleau

Abstract: The FAST REEU program provides opportunities for students to learn skills and techniques useful for their real-world application in their future careers. In my presentation, I will first cover some important skills and experiences that I acquired from the FAST REEU program. Particularly, I will be focusing on the molecular biology lab techniques, soft skills, and our ethnobotanical research project. The lab techniques I learned in four different labs include lab safety, DNA extraction, gel electrophoresis, and translating lab research findings/protocols into lessons for K-12 students through lesson plan development (Nepal' lab), particle counting in image files, managing disease control procedures, and creating "bacteria art" (Butzin's Lab); the process of extracting quality cellulose from corn stover (Janaswamy's Lab); and bioengineering of cyanobacteria (Zhou's Lab). Secondly, I will discuss the soft skills training workshops: the most impactful being strength utilization, stress management, open mindedness towards new opportunities, and appreciation for cultural diversity. Lastly, I will focus on my research project on ethnobotany of Oceti Sakowin Oyate, the Indigenous communities in South Dakota, and a detailed comparison between their medicinal plants and those of Sherpa, the indigenous tribe of the Nepali Himalayas. Using the chloroplast RubisCo (rbcL) gene sequences, we reconstructed phylogeny of over 300 plant species used by the indigenous communities in South Dakota. I will demonstrate how we applied Indigenous ethnobotany databases to research medicinal plants and the comparisons drawn from the Sherpa-based ethnobotany catalogue published by Dr. Nepal. Similarities in medicinal uses between related plants in the respected areas would suggest medicinal compounds of the plant may deserve further investigation within modern medicines. Analysis of the ethnobotanical comparison is underway, updated information and project outcomes will be shared in my presentation.

REU Institute of American Indian Arts
Advisor(s): Dillon Nelson, Mani Nepal

Development of a Self-Contained Wearable EEG — C26 — 12 p.m.

Kristen Quigley

Abstract: Two factors limiting both research and application of EEG recording technology are cost and laboratory constraints. Over the past decade the price of non-medical EEG recording equipment has significantly declined. One of the first at-home 6-channel EEG recording systems was being sold for $400 in 2004 by OpenEEG, the system came disassembled and required a soldiering iron to piece together. Many companies have since created fully functional systems for $200. This project seeks to extend the use of EEG recording to non-lab environments. The objective of this project is to create a portable and waterproof case for a commercially available EEG, which would allow for recordings to be done in any environment. Through many prototypes and adjustments, we have successfully modified a Pelican 1010 Micro Case to house an OpenBCI Ganglion (4-channel) or Cyton (8-channel) EEG board and rechargeable battery. This presentation aims to describe the iterative development of the waterproof system. Our device has been subject to a strict testing protocol under variety of conditions and it has consistently been able to produce a viable EEG signal. In addition, the OpenBCI system uses both Bluetooth and SD recording signals, making our device completely self-contained and portable. The implications of this project could include having participants or patients record their brain activity during physical activity, or other day-to-day activities. This would allow researchers to collect data which is representative of a given individual's brain function during any activity, allowing for further research to be done in areas that were not previously accessible. For our team in particular, this device will allow further our ongoing study on the effects of neurofeedback training on athletic performance, where we aim to work with college swimmers.

REU University of South Dakota
Advisor(s): Doug Peterson

Pathogenicity of Pythium Isolates Causing Pythium Seed and Root Rot in Alfalfa (Medicago sativa) — A29 — 10 a.m.

Travis Rebstock, Jenni Giles, and Conner Tordsen

Abstract: Alfalfa is a significant crop in South Dakota that provides numerous benefits for growers. It is used as a protein-rich feed for livestock, a cover crop that protects against soil erosion, and a natural fertilizer. South Dakota plants the most acres of alfalfa in the United States but is sixth in terms of production. Alfalfa seedlings are susceptible to many diseases, which leads to poor field establishment and contributes to this alfalfa yield gap. Pythium diseases of alfalfa cause reduced root systems, stunting, seed rotting, and damping-off, which is the destruction of seedlings near the soil line resulting in the seedlings falling over on the ground. Pythium sp. isolates from eastern South Dakota were baited from soil samples using the “rolled towel” technique, which uses soil from field samples in germination paper with seeds of a susceptible alfalfa cultivar (Saranac). The seedlings germinate and are placed on water agar (WA) plates to obtain subcultures of hyphal tips. DNA is extracted from the pure culture is PCR amplified using ITS primers before being sequenced to confirm Pythium sp. identity. Pythium isolates were subcultured onto WA and grown until mycelium covered the plates. Alfalfa seeds (Saranac and Mustang Seed lines 625 and 425) were placed on the surface of plates to assess pathogenicity. The germinated seeds were then assessed on a 1-5 scale; 1 being a healthy seedling with primary root free of necrosis and 5 being a dead seed, ungerminated seed rotted. This research will provide local alfalfa growers with increased awareness of Pythium diseases and encourages the usage of fungicides along with cultivars that offer resistance to Pythium.

REU Dakota State University
Advisor(s): Andrew Sathoff

Multi-Electron Reduction of Sanger's Reagent Derivatives for Battery Cathodic Materials — B32 — 11 a.m.
Brady Samuelson, Brock Goeden

Abstract: The industrial demand for higher capacity, light-weight battery materials has skyrocketed in recent years due to heavy investments in portable electronics, electric vehicles, and renewable energy sources. However, rechargeable battery technology has seen little improvement since the invention of the Lithium-Ion battery in the 1980s. The low energy density of the traditionally utilized LiCoO2 cathodic material (specific capacity: 272 mAh g-1), has limited its potential to meet these increasing demands. To solve this problem, our research group is investigating new types of lightweight, organic, polymeric materials with conductive heterocyclic backbones as a possible replacement for the cathodic materials in Lithium-Ion batteries. These polymers could be utilized as a rechargeable battery material by relying upon the redox couple between the nitroso and phenylhydroxylamine functional groups. These rechargeable materials would have a calculated theoretical capacity of 459.60 mAh g-1 or 433.52 mAh g-1. Future work would focus on the optimization of polymerization conditions of the monomers and to begin preliminary lithium battery discharge testing. This project explores the field of light-weight organic cathodic materials and has the potential to greatly increase the energy density for Lithium-Ion batteries. This would ultimately serve to remove the technology bottleneck that is holding research in other areas back and would be to the benefit of anyone who relies upon battery technology in their daily life.

REU University of South Dakota
Advisor(s): Haoran Sun

Using Deep Learning to detect corrosion faster and more accurate — A30 — 10 a.m.
Mrityunjay Sani (Washington State University), Venkata Gadhamshetty

Abstract: Metal after contact with water and oxygen will weaken over time. It is because of corrosion (or rust) that break down the molecules inside. Hence, metal will be easier to bend and even break. Which cause hazards especially in the industrial scene. Also, corrosion it harder to detect because it can be under the paint and it can be very small and when large, the problem gets complex. Hence an implementation of an Artificial Intelligence (AI) to detect corrosion using various techniques is beneficial. Mask R-CNN is the fastest data detection that detects objects in imagery. Mask R-CNN is an upgrade from Faster R-CNN with the difference that Mask R-CNN Uses Pixel segmentation to detect objects in the images. Like Fast R-CNN, Mask works is just an extension where another branch is added for a strong prediction for masks in the object (e.g., Region of interest). In this instant, we are using the AI to detect corrosion to make metal invulnerable. Our methods include using a Multispectral Camera and Optical imagery. There, we go to a few locations, to sample data using imagery and then feed it to the Mask R-CNN to detect corrosion quicker. From there, we can use that AI to recapture corrosion and use this tool in developing strategies to mitigate corrosion.

NSF EPSCoR Track-1 South Dakota Mines
Advisor(s): Shankarachary Ragi

Airborne Surveillance of Metal Infrastructure for Corrosion Detection via Deep Learning — C27 — 12 p.m.
Mrityunjay Sani (Washington State University), Venkata Gadhamshetty

Abstract: Metal after contact with water and oxygen leads to corrosion and subsequently weakens the metal over time, which costs billions of dollars annually in the U.S.. Manual inspection and cataloging of corroded regions in large and complex infrastructures is laborious, time-consuming, and costly. To address this challenge, we implement an artificial intelligence (AI)-driven aerial corrosion detection and surveillance approach, which runs with or without human-in-the-loop. Specifically, we implement a deep learning approach called Mask Region-Convolutional Neural Network (Mask R-CNN), which enable automatic instance segmentation of the corroded regions from the optical and multispectral imagery generated via an unmanned aerial vehicle (UAV). Mask R-CNN is built upon another widely used approach called Faster R-CNN with the difference that Mask R-CNN Uses pixel segmentation to detect objects in the images. Our sensing modalities include optical/visible mode, and multispectral mode - the corresponding sensors are integrated with the UAV. We measure the performance of our corrosion detection approach including metrics such as detection and segmentation accuracies, model training time, and training and validation losses.

NSF EPSCoR Track-1 South Dakota Mines
Advisor(s): Shankarachary Ragi

Olefin Metathesis with Vanadium Catalyst — C28 — 12 p.m.
Emma Saucerman, Samuel Fosu, and Wesley Farrell

Abstract: Olefin metathesis is broadly used as a synthetic strategy in polymer design and drug discovery. Homogenous catalysts with molybdenum and ruthenium centers are commonly used; however, complexes with vanadium have attracted attention recently as it is cheaper and more abundant. One challenge with this family of catalysts is their tendency to break down. Using density functional theory, the relative energies and reaction barriers are determined for productive metathesis and decomposition pathways. Specifically, the complex can undergo ß-hydride elimination leading to catalyst degradation. Our aim is to understand the two competing pathways and ultimately suggest ligand modifications to favor productive metathesis over ß-hydride elimination. The catalyst of interest will be tested with one or two phosphine ligands coordinated and unsubstituted and chloride substituted aryloxide ligands. Our results compare the reaction mechanisms for the vanadium catalyst with one and two coordinated phosphine ligands to determine at which step the phosphine decoordinates. Additionally, the catalyst with the Cl-substituted aryloxide group more readily undergoes productive metathesis compared to the decomposition pathway. Future work will explore the effect of using an H-substituted aryloxide or replacing this ligand with a single Cl atom.

REU University of South Dakota
Advisor(s): Bess Vlaisavljevich

Parallel Transmission Switching on Power Grids — B33 — 11 a.m.
Carter Schafer

Abstract: The electrical power grid continuously supplies electricity to its customers and enables a high quality of life. The electric grid is a unique and complex system wherein the commodity produced must be instantaneously consumed; an excess of either the supply or the demand can lead to a blackout. Unplanned power line contingencies such as fallen trees or failing components commonly affect electrical power grids. Research shows that intentionally taking offline more transmission lines, known as transmission switching (TS), can provide relief in such situations. The goal of this project is to develop an algorithm that determines the optimal line to disconnect following an unplanned contingency. The algorithm will then be optimized using parallel programming to make it computationally tractable. This project utilizes an Exascale Grid Optimization toolkit (EXAGO) solver built in the C language and the Portable, Extensible Toolkit for Scientific Computing (PETSc) library. The test cases for this study range from 9 to around 2,000 buses. The integration of PETSc allows for the effective parallelization across multiple cores. The results of this study can assist with contingency planning efforts, even on statewide or federal scales, as well as serve further research in this area in the future.

REU South Dakota State University
Advisor(s): Jung-Han Kimn

Parallel Distribution of Traffic Flow Network — C29 — 12 p.m.
Jordan Schnell, Rylee Sundermann

Abstract: The objective of this project is to develop a program that generates a traffic network and efficiently distributes it over multiple processors. The network is constructed via data files that contain information regarding streets and junctions, as well as their associated component data. This information is then grouped in appropriate structures that are subsequently utilized to erect the network. Employing the C language, the aforementioned program implements the DMNetwork, a data management object designed to handle parallel distribution of network architecture and the underlying physics, and the Message Passing Interface (MPI) functions of the Portable, Extensible Toolkit for Scientific Computing (PETSc) libraries to evenly distribute a traffic network over a designated number of processors. Moving forward, distribution efforts will be shifted to improve allocation of the network workload, such as apportioning the workload predicated on the network process weight at runtime. Parallelization increases the efficiency and functionality of network analyzation when processing large-scale networks. Additionally, efforts will be shifted to implementing the mathematical equations necessary to simulate traffic flow within the established network. The analyzation of traffic networks prior to system design allows for heighted safety precautions, limited traffic congestion, and retail placement optimization. For these reasons, it is vital that networks may be efficiently analyzed prior to the creation of a road system or other large-scale project.

REU South Dakota State University
Advisor(s): Jung-Han Kimn

Modification of PVDF Crystalline Structures in Electrospun Nanofibers — A31 — 10 a.m.
Erin Schnetzer, Zishen Yang

Abstract: Polyvinylidene fluoride (PVDF) is an excellent candidate for biomedical sensors, actuators, and energy harvesting applications. It has desirable piezo/pyroelectric properties and good mechanical, thermal, and chemical stabilities. PVDF has unique crystalline structures, including α, β, γ, and δ phases. The most common and thermodynamically stable crystallinity is the α phase, while the β phase gives PVDF its piezoelectric, pyroelectric, and ferroelectric properties. Studying the transitions between the α and β phases can give us a better understanding of the fundamentals for these PVDF crystalline structures. In this study, PVDF nanofibers were produced using the electrospinning method. The fiber mats were characterized using FTIR and optical imaging after heat treatments at different temperatures and over different amounts of time. It was found that both longer treatment times and higher treatment temperatures lead to a larger decrease in the β structure of the nanofibers. Our work on the phase transition of PVDF nanofiber can provide valuable information in designing stable PVDF materials for various applications.

REU University of South Dakota
Advisor(s): Chaoyang Jiang

Defining the role of cholesterol binding on DVL2 protein-protein interactions — C30 — 12 p.m.
Maycie Schultz, Sonali Sengupta

Abstract: Genetic disorders of cholesterol metabolism are rare diseases which broadly impact tissue development and function, primarily within pediatric subjects. Our lab previously determined that loss of cholesterol inhibits DVL2 (Disheveled Segment Polarity Protein 2) activity, a critical protein which regulates signal transduction pathways and cell function mediated by Wnt/beta catenin activity. DVL2 is known to bind numerous proteins via one of its protein domains: DIX, PDZ and DEP. Thus, defining the broad impact of cholesterol on DVL2 binding to proteins of interest is important to understand DVL2 function and disorders of cholesterol metabolism. To screen for cholesterol's impact on DVL2 protein interactions, BioID (proximity -dependent biotin identification) was employed. This method uses expression of DVL2 fused to a promiscuous biotin ligase that selectively biotinylates endogenous proximal proteins. Using a retroviral delivery system, DVL2-BioID was expressed in HEK293T cells and putative protein partners were identified under cholesterol replete and cholesterol depleted conditions. The first aim of this study is to validate putative interactions between DVL2 and candidate proteins using co-immunoprecipitation (Co-IP). Selected candidate proteins fused to a HA-tag were transiently expressed in HEK293T cells and protein complexes were pulled down with anti-HA antibody followed by immunoblotting with anti-DVL2 antibody. The second aim of this study is to determine how the validated protein interactions may be important to cell health and function. Mapping the in vivo protein binding behavior of DVL2 under changing cholesterol conditions will help us to dissect the role of lipid metabolism in the regulation of this critical molecule.

NSF EPSCoR Track-1 Augustana University
Advisor(s): Kevin Francis

Knockdown of Motile Cilia Genes in Mouse Tracheal Epithelial Cells — C31 — 12 p.m.
Morgan Seffrood, Casey McKenzie, and Lance Lee

Abstract: Motile cilia are essential organelles responsible for facilitating movement and clearance of fluids, particles, and important signals. Defects in the structure and function of motile cilia result in the rare pediatric disease primary ciliary dyskinesia (PCD). Due to the highly complex nature of motile cilia, we are interested in studying the role of ciliary genes involved with proper structure and function by knocking them down in cultured mouse tracheal epithelial cells and investigating the effect on cilia formation and function. Based on previous studies, we are validating our approach using shRNA constructs to knock down two known motile cilia genes: FOXJ1 and CFAP221. Because the FOXJ1 gene is required for proper cilia formation, we investigated the effects based on cilia formation via immunofluorescence analysis. It is found that there are cells with the FOXJ1 knockdown present that have less cilia formed compared to control cells. Furthermore, the CFAP221 gene is required for proper ciliary motility, so we investigated the effects based on ciliary motility by analyzing ciliary beat frequency (CBF) and directional flow. Our data shows that there are cells with CFAP221 knockdown present that have decreased CBF compared to the control. A lot is unknown about how motile cilia function, so investigating the role of novel genes will help us better understand the structure and function of mammalian motile cilia and thus help develop drug therapeutics for diseases like PCD.

REU Sanford Research, Sanford School of Medicine of the University of South Dakota
Advisor(s): Lance Lee

Stimulating Biofilm Growth Using OpenFOAM — A32 — 10 a.m.
Jesiah Showers, Rylee Sundermann, Jeffery Doom, and Nathan McClanahan

Abstract: Biofilms are the growth and accumulation of microorganisms in a moist or wet environment. Biofilms are commonly found within sink drains, on plants, in pond water, and on industrial equipment. The growth of biofilms can cause drain clogs, and microorganisms within biofilm are the cause of many chronic infections. An example of an infection is the result of biofilm growth on medical devices inside the human body. The objective of this project is to develop and verify computational code that simulates biofilm growth on a variety of surfaces. Since biofilm is primarily composed of water, it is assumed to be an incompressible fluid. This allows for the biofilm to be calculated using the Modified Cahn-Halliard equations and the Navier-Stokes equations. These equations are written in C to run in OpenFOAM. Star CCM+ is used to create different shapes and to represent the fluid flow. This involves testing and debugging previous developed code as well as verifying the biofilm growth component. The growth component is verified by comparing results found in OpenFOAM to previous publications. This code is designed to be used to test how biofilm growth is affected by different surfaces and flow conditions. By understanding how biofilm growth is affected, we can determine the possible best surfaces that allow for limiting biofilm growth.

REU South Dakota State University
Advisor(s): Jung-Han Kimn

Synthesis and Optical Properties of Highly Selective Pyridoxal-based Chemosensors to Detect Zn(II) — A33 — 10 a.m.
Elizabeth Skelly (Northwest Missouri State University), Anwar Hussain

Abstract: Zn(II) is the second most abundant metal ion in the body and is essential for brain function, gene transcription, immune function, and reproduction and zinc deficiencies may cause Alzheimer's, epilepsy, and stroke. Here we have synthesized a highly selective chemosensor to detect Zn(II) by reacting pyridoxal hydrochloride with 5-aminoisophthalic acid in a cost-efficient, single-step reaction to yield the Schiff base ligand (1) which has been characterized by 1H NMR. The optical properties of ligand 1 were investigated in aqueous solution and found to exhibit large bathochromic shifts after addition of Cu(I), Cu(II), Co(II), Cd(II), and Zn(II); whereas only Zn(II) ion shows excellent fluorescent turn-on response. The competition studies reveal that the response for zinc ion is unaffected by all alkali and alkaline earth metals; and only suppressed by Cu(I), Cu(II), Fe(III), Al(III) ions. Ligand 1 will be used to synthesize the zinc complex to obtain comprehensive knowledge of the coordination geometry of the metal center. We believe the excellent turn-on response and selectivity to detect Zn(II) ions will find practical application in biological sciences.

REU University of South Dakota
Advisor(s): Andrew Sykes

Nucleation of Cyclic Polyoxovanadate-Alkoxide Species — B34 — 11 a.m.
Alexandra Smith

Abstract: The synthesis of novel tunable electroactive species remains a key challenge for many chemical applications such as redox catalysis or energy storage. Polyoxovanadate (POV) alkoxide clusters have emerged as a new class of compounds with highly promising electrochemical applications, however, our knowledge of the formation pathways of POV alkoxides is rather limited. We studied the formation of cyclic polyoxovanadate-alkoxides using computational methodologies based on quantum mechanics. The results lead to a complicated process of joining conformers and ion pairing through various vanadium species. Extensive analysis could lead to minimized energy formation of the polyoxovanadate-alkoxide compounds that could reveal insights in redox catalysis or vanadium redox flow batteries.

REU University of South Dakota
Advisor(s): Pere Miró

IoT Smart-Lock — B35 — 11 a.m.
Max Soto

Abstract: A smart-lock is defined as a locking and unlocking device which is controlled via a wireless protocol. Internet of things Smart Locks are gaining increased market share. Smart Locks are expected to grow 11.98% in the next 6 years. Although smart-locks possess limited processing power capabilities, they frequently utilize WiFi, Bluetooth BR/EDR/Smart (LE), and RFID technologies. The attack surface of these devices have also increased as a result. The increased attack surface exposes multiple potential vulnerabilities that a malicious actor may be able to exploit. The current research examines smart-locks from iGlooHome, eGeeTouch, August, and Kwikset. Two of the locks are the more common mount-on-door design while the other two are traditional padlock style. These locks were tested for vulnerabilities ranging from physical lockpicking to wifi, bluetooth, nfc, and biometric authentication. Strategies such as replay-attacks, denial-of-service, and man-in-the-middle attacks were attempted. Associated mobile apps were also examined for vulnerabilities using source-code review as well as static and dynamic testing. As more smart-locks are deployed year-over-year, privacy and security remain a significant concern for the consumer. Smart-locks should provide access control without sacrificing security in favor of convenience.

REU Dakota State University
Advisor(s): Robert Richardson

Studies in the reactivity of 2-(picolyl)borane dimers with ions and o-cresol — B36 — 11 a.m.
Elizabeth Speck, John Cerritelli

Abstract: Since Stephan's discovery of the power of Frustrated Lewis Pairs (FLPs) to heterolytically cleave H-H bonds spontaneously, many different FLPs have been studied. Picolylborane dimers synthesized by Hoefelmeyer's group in 2012 presented unique reactivity toward carbonyls and nitriles, and we sought to further explore the chemistry of these dimers. The 2-(picolyl)boranes appear to react through a nucleophilic methylene carbon to give apparent cycloadditions upon 1,2-insertion into the B-C bond rather than reacting between the Lewis Acid-Base sites as generally expected of FLPs. The dimer structure of these molecules also lends to its nucleophilic reactivity. We attempted to isolate the monomer and study its active sites through Fluoride ion binding and methylation. We also planned to study how the monomer or dimer would interact with ortho-cresol to see whether it would undergo a cycloaddition toward a tub-shaped dimer or form a spiro dimer. Understanding the chemistry of these molecules may lead to improvements in synthesis or bond activation processes.

REU Hillsdale College
Advisor(s): James Hoefelmeyer

Extracellular Communication of Microbes from Extreme Environments - Rhodobacter and Methylobacterium Ajmalii — B37 — 11 a.m.

Jacob Zaug, Cody Allen, Nitin Singh, Venkateswaran Kasthuri, and Venkataramana Gadhamshetty

Abstract: Methanotrophs present an interesting topic of research with their ability to metabolize methane as a carbon source. Understanding the mechanism of how the methanotroph interacts with other microbes in its environment can help us perceive the most efficient way of utilizing the methanotrophic bacteria for industrial bioprocessing and bioprospecting. Though studies have been performed on the effects of different carbon sources and media on the methanotroph, little research has been conducted on exoelectrogenic properties and metabolic interactions of these types of microbes. Here, we study the interaction of Rhodobacter sp., a methanotroph, with the Methylobacterium ajamalii, a methylotroph to explain the bacterial synergy. These two unique microbes are isolated from the extreme environments, and the study reports their interactions for the first time. The hypothesis is to explain their direct (e.g., nanowires) and indirect communications (e.g., extracellular metabolites) under simulated test conditions. Cyclic Voltammetry tests indicate the presence of unique metabolites and exoelectrogenic properties from the microbes. These excreted metabolites stimulate the growth of counterparts and produce unique electrochemical mediators. Specifically, we measured 80% higher growth from Rhodobacter sp., when grown with the M. ajamalii's metabolites in minimal medium, indicating a positive interaction between the two microbes. This can all be extrapolated to a better understanding of microbial communication in the complex environment or in industrial
bioreactors, which, in this case, could lead to developing a model of microbe-microbe and exploit such models for industrial applications for producing valuable products from methane.

NSF EPSCoR Track-1 South Dakota Mines
Advisor(s): Parthiba Karthikeyan Obulisamy

Dry Particle Coating of Titanium Alloy Powder — B38 — 11 a.m.
Cory Stone

Abstract: Titanium is a highly useful metal, particularly for the aerospace and biomedical industries. Unfortunately, Titanium (Ti) is expensive and difficult to manufacture. In order to extend the lifetime of parts, it is desirable to produce parts with a hard, wear-resistant coating. This can be accomplished using Cold Gas Dynamic Spraying, or cold spraying. Cold spraying is a material deposition technique that accelerates micron-scale particles to supersonic speeds so that they are plastically deformed upon impact and are adhered to a substrate material. However, untreated Ti powder forms oxides and hydroxide groups on the particle's surface, which produces undesirable properties in the end product. In order to remove these properties, this research explores a surface-treated Ti powder, namely TiC-coated Ti powder, for its chemical inertness and brittleness. Its chemical inertness would allow it to remain chemically pure during storage as well as acceleration and flight during cold spraying, while its brittleness would minimize the amount of coating that remains in the end product. This research applies principles of mechanochemistry to achieve this particle coating. Vials of micron-scale Ti powder and Charcoal nanopowder (C) are mixed using a centrifugal mixer, as the size differential between the two types of particles allows mechanical stress to be introduced to the reagents without the use of external media. Mixed samples are analyzed using Fourier Transform Infrared Spectroscopy (FTIR), Raman Spectroscopy, X-Ray Diffraction (XRD), and a mechanical setup for surface adhesion testing (impact testing) to help determine a possible chemical reaction.

REU South Dakota Mines
Advisor(s): Jon Kellar

Nudging Information in a Cloud-based Smart Vehicular System — C32 — 12 p.m.
James Suh, Katja Mathesius

Abstract: Traditional vehicular systems present a variety of inefficiencies in modern society, such as serious traffic congestion in cities around the world. To address these issues, the advances made with the new wave of semi-autonomous vehicles can be harnessed. In particular, a pervasive computing and networking paradigm is necessary for vehicles to convey information that human drivers could not easily perceive on their own. A cloud based network made up of a combination of edge and remote clouds could meet the demands of the proposed network. Using such a system, drivers' behaviors, road conditions and surroundings could be communicated between vehicles, providing the information necessary to better optimize transportation. In this research, we seek to test how the psychological concept of Nudge Theory could be applied to smart vehicular transportation. First, we look at how nudging drivers' psychology can affect the overall system. Second, we develop a mathematical model to investigate the relationship among nudging parameters. Third, we create a simulation environment to implement the nudging algorithm in a cloud-based smart vehicular system. The expected outcomes will be an optimized nudge algorithm and a cloud-based smart vehicular system. Such a system is useful for transportation departments to simulate drivers' behaviors and resolve shortcomings in traffic management.

REU Dakota State University
Advisor(s): Bhaskar Rimal

Defluorination of Perfluorodecalin via Electrochemical Reduction — C33 — 12 p.m.

Bali Summers, Yao Feng

Abstract: Fluorocarbons (FCs) and hydrofluorocarbons (HFCs) are potent greenhouse gases that persist in our atmosphere. Estimated to have a 3,770 times larger global warming potential than carbon dioxide, there is a high level of need to develop efficient methods of decomposing these compounds. One method of decomposition currently being studied is electrochemical reduction. Using cyclic voltammetry the reduction process by which fluorocarbons are irreversibly defluorinated can be studied. However, these electron transfer reactions have poor kinetics and occur at very negative voltages due to the large strength of the carbon-fluorine bond, making the process ineffective for large scale applications. Perfluorodecalin is currently studied as a model compound for perfluoroalkane defluorination, as shown by Combellas et al. Preliminary results from reducing perfluorodecalin collected in this study have confirmed the sluggish rate of electron transfer and the large over-potential of the reduction, which is observed near -2 V. By utilizing an electron transfer catalyst, the reaction barrier for the electrochemical reduction can be lowered. Molecules with both an aromatic functional group and a perfluoroalkyl chain may perform well in the role of an electron transfer catalyst in this context. Theoretically, these functional groups together would provide an easier pathway for electrons to flow from a working electrode to a fluorocarbon compound in an electrochemical cell. The reduction of molecules with this structure have been considered both in the study by Combellas et al. and by our lab in the past with widely varying reduction potentials due to the large diversity in structures possible. Designing a versatile and intelligent structure for an electron transfer catalyst for this type of defluorination will be important to progress the viability of reductive decomposition of FC and HFC pollutants into the future.

REU Colorado State University
Advisor(s): Haoran Sun

Predicting the metabolic potential of an uncharacterized bacterial species from the rumen of beef cattle — C34 — 12 p.m.

Austin Taylor (Jackson State University), Cheyenne Hron

Abstract: In ruminants, feed is digested by the microorganisms that reside in the rumen, the first compartment of the four-chambered stomach in these animals. However, the ruminal microbiome remains mostly a mystery, since only 5% of ruminal bacteria have so far been isolated and cultured. The host's diet has a major impact on the ruminal bacteria composition. Since plant fiber represents the highest proportion of a ruminant's diet, most efforts have gone into identifying fibrolytic bacteria. In comparison, our understanding of digestion for other components of ruminant diets such asl lipids is much more limited. To gain further insight, this project aimed to determine the metabolic potential of an uncharacterized ruminal bacterial species that was found in higher abundance in the rumen of steers that were fed a high lipid-inclusion diet. This novel bacterial species was found to be most closely related to Ruminococcus albus. From a starting dataset of 13,278,041 MiSeq(2X300) sequence reads, the ones that showed the highest similarity to currently available R. albus genomes were identified using the publicly available USEARCH tool. Starting from this pool of sequences, contigs were then assembled from the full dataset using custom written Perl scripts. So far, 38 contigs have been built and assembled, with lengths ranging between 1126 and 182,166 nt. From these contigs, 4,312 coding sequences (cds) were predicted. Blast was then used to identify contigs that encoded protein sequences that were closely matched to R. albus. While cds for lipases have yet to be identified, a candidate gene encoding acetate kinase was identified, indicating that the novel strain of R. albus may produce acetate as an end-product. As this work is still ongoing, more insights will be obtained as progress continues.

REU South Dakota State University
Advisor(s): Benoit St-Pierre

Summer at SURF — C35 — 12 p.m.
Kennedy Teeslink

Abstract: This Summer I had the opportunity to work alongside the Sanford Underground Research Facility Education and Outreach Department through a grant funded by EPSCoR. Through this I was able to gain new strategies for teaching, new perspective, insights, and relationships. During the duration of my internship I have learned countless things that I plan to incorporate into my future classroom but the one that sticks out to me the most is three dimensional learning. I believe that three-dimensional learning is a powerful tool that can be used in a classroom to not only get students engaged in lessons but also ignite a passion for learning. Although this is strategy can be used across all subject areas I believe that it is key to developing student's science identity. Throughout this program, I had the Opportunity to participate in three different professional developments – Cores, EPSCoR 1, and Train the Trainer. During these I made connections with educators across the state while simultaneously growing as a future educator through the content covered and conversations with educators. During this internship, I studied the curriculum units that are developed and ones that are currently being developed. I was also able to contribute to these units by formatting worksheets, notetaking guides, and games that help enhance the curriculum units that are being created.

NSF EPSCoR Track-1 Black Hills State University
Advisor(s): Peggy Norris

GWAS for Genetic Characterization of Root Traits in Wheat — A34 — 10 a.m.
Conner Thaler, Harisimardeep Gill, Nicholas Frede, and Naomi Torres-Irizarry

Abstract: Understanding the root system architecture (RSA) is crucial for improvement in resource-use efficiency in wheat. However, little attention has been paid to understand the genetic basis of RSA traits. In recent years, understanding RSA traits has become an important topic for plant breeders based on a growing need to adapt plants to changing and more demanding environmental conditions worldwide. Genome-wide association studies (GWAS) have the potential to identify the genetic loci governing RSA traits. Here, we are using a diverse panel of 380 wheat landraces and cultivars obtained from the US National Small Grains Collection in Aberdeen, ID, to study the variability in the RSA traits and dissect the genetics underlying this variability. The 380 accessions were selected from the geographical diverse panel of 890 accessions, which were sequenced using a wheat exome capture assay in a previous study. The genotypic data for these accessions was extracted and filtered to identify ~2,20,000 high-quality SNPs spanning the 21 wheat chromosomes. Principal component analysis using the SNPs suggests four distinct clusters in the diversity panel. A paper roll-supported hydroponic system is being used to measure various RSA traits at the seedling stage. Image-based software WinRHIZO is being employed to analyze the roots in two independent experiments. A high-resolution GWAS employing exome-based SNPs will be used to identify marker-trait associations (MTAs) for different RSA traits recorded in the study. Furthermore, the candidate genes will be identified for each of the MTAs.

REU South Dakota State University
Advisor(s): Sunish Sehgal

Authenticating Aspirin Brands Using LC-MS/MS — A35 — 10 a.m.

Wai Than, Jenean Hanka, Cami Fuglsby, Christopher Saunders, and Megan Guetzloff

Abstract: There has been a high illicit market for counterfeit pharmaceutical drugs that have been sold throughout the world. Although counterfeit pharmaceuticals are easily accessed and highly profited, they have negative effects to consumers including death. One main approach to identifying counterfeit drugs is through source authentication via chemical analysis since our lab can afford and accessed to different analytical instruments are not easily accessed to the public and our chemical analysis can't be copy easily by counterfeiters. The main purpose of this research is to develop a method for authenticating aspirin and analyzing it with an analytical instrument called the LC-MS/MS (Liquid Chromatography Mass Spectrometry with Tandem Mass Spectrometry) with the aid of statistical framework done by Jenean Hanka (REU student), Dr.Chris Saunders, and Cami Fulgesby (NRT and Graduate Student). My goals would be to first, establish a sample preparation method and LC-MS/MS method for analysis of aspirin brands. Hopefully, by meeting these first two goals, we could move on to authenticating individual pills of the same aspirin brand. These two goals are a major factor to setting up a counterfeiting method specifically for aspirin and be possibly tested out in other pharmaceutical drugs. The methods that we will be using is a sample preparation method of aspirin in aqueous solution (DI water) which won't be using special extraction techniques and learning to use LCMS/MS which we will analyze our samples on. It will be finding the right concentrations of our samples and stationary and mobile phases to give us better results in the LC-MS/MS. So far for our results, we have found different excipients in aspirin, but still trying to adjust our method in order to collect good data. So, with this research, we will create a method using LC-MS/MS to authenticate aspirin brand with the help of robust statistical analysis. This method of authenticating aspirin would be specifically just for the LC-MS/MS.

REU Concordia College, Moorhead
Advisor(s): Brian Logue

Development of SERS Based Anti-Counterfeiting Labels Using Plasmonic PVDF Nanofibers — A36 — 10 a.m.

Yuan Tian (Black Hills State University), Zishen Yang

Abstract: The production and trafficking of counterfeit goods have been a danger to the global economy and public health. With anti-counterfeiting activities on the rise, various anticounterfeiting techniques and materials have been used. However, many of these techniques have been acquired by counterfeiters to produce replicas which seem closer to the real products. It's essential to develop new anti-counterfeiting techniques to make it difficult or impossible to be targeted by counterfeiters. In this study, PVDF (polyvinylidene fluoride) nanofibers was fabricated using electrospinning. Then these fibers were modified through oxygen plasma etching to introduce negatively charged functional groups on the fibers surface. The modified nanofiber mats were coated with positively charged gold nanoparticles. Moreover, nanofiber mats decorated with negatively charged nanoparticles were fabricated as well. These nanofibers were examined with optical microscopy, UV-vis Spectrometry, Zeta-sizer, and confocal Raman microscopy. The results indicate that both the positive and the negative gold nanoparticles can be adsorbed onto the surface of the PVDF fibers. Our research provides insights for construct unique SERS spectra in developing anti-counterfeiting labels and barcodes.

REU University of South Dakota
Advisor(s): Changyang Jiang

Fungicide Sensitivity Testing of Alfalfa (Medicago sativa) Root Rotting Pathogens Isolated from South Dakota Soils — A37 — 10 a.m.

Conner Tordsen, Travis Rebstock, and Jenni Giles

Abstract: Alfalfa is a high-quality forage that produces the most protein per acre of any crop and digests in half the time of a low-quality forage. This makes alfalfa a useful feed for the large amount of cattle living in South Dakota. Alfalfa seedling diseases inhibit stand establishment and decrease overall yield greatly reducing South Dakota's alfalfa production. Seed coats including a commonly used fungicide, Apron XL (mefenoxam), are currently the main protections provided to alfalfa seeds against infection. The constant usage of Apron XL has created a selective pressure for pathogens to evolve fungicide resistance. South Dakota currently ranks third in the US for newly seeded acres providing a need to investigate fungicidal seed treatments. Isolates of alfalfa pathogens found in South Dakota soils under commercial alfalfa production have been grown in pure cultures and have had their ITS regions of DNA sequenced to confirm their identities. Alfalfa pathogens, including Pythium sylvaticum and Fusarium solani, were subcultured onto corn meal agar (CMA) containing fungicides at varying concentrations (0.01µg/ml, 0.1µg/ml, and 1.0µg/ml). The fungicides evaluated include Apron XL, Quadris (azoxystobin), and CruiserMaxx (thiamethoxam, fludioxonil and mefenoxam). Following a growth period of 72 hours, the diameter of the mycelial growth was measured twice and used to determine the concentration of fungicide needed to reduce fungal growth by 50% (EC50). Numerous isolates displayed high EC50 values and fungicide resistance. These fungicide sensitivity tests provide growers with better information to select effective fungicidal seed coats.

REU Dakota State University
Advisor(s): Andrew Sathoff

High molecular weight genomic DNA extraction from Triticum Monococcum leaves with Oxford Nanopore sequencing — C37 — 12 p.m.

Naomi Torres Irizarry, Conner Thaler, Nicholas Frede, and Joseph Peery

Abstract: Einkorn wheat is the most primitive form of wheat on Earth. This type of wheat has two different species: Triticum boeoticum, the wild form, and Triticum monococcum, the domesticated form. Triticum monococcum was the first type to be cultivated due to its simple diploid genetic structure and conformation that contains only 2n=14 chromosomes compared with the hexaploid genetics of bread wheat (T. aestivum) that contains 6n=42 chromosomes. We plan to extract and isolate high molecular weight genomic DNA from the Triticum monococcum leaves to generate long reads on the Oxford Nanopore Technologies (ONT) sequencing platforms that depend on the isolation of high molecular weight DNA free of impurities. The DNA will be extracted and isolated using the Carlsson lysis buffer followed by purification using the QIAGEN Genomic-tip 500/G. After the extraction and isolation, we expect to make a buffer exchange using the TE Buffer to obtain the pellet DNA which is the translucent sedimentation portion that accumulates during centrifugation at the bottom of the centrifuge tube. Once we obtain the pellet DNA, we are going to remove short DNA fragments using the Circulomics Short Read Eliminator Kit. After we enhance the recovery of long DNA fragments using the Circulomics Short Read Eliminator kit, first we are going to prepare a library using the Ligation Sequencing Kit (SQK-LSK109), and then we are going to perform a sequencing using the MinION with a flow cell from the Oxford Nanopore Technologies.

REU South Dakota State University
Advisor(s): Sunish Sehgal, Jose Gonzalez

A Pan-Genomic Analysis of Rhodobactor Sphearoids — C38 — 12 p.m.
Connor Ullrich, Zacharie Barker

Abstract: There are many methanotrophs. A methanotroph is a prokaryote that consumes a carbon source to survive. The carbon source is any single carbon compound. A big source of this is methane. Some methanotrophs can also use multi-carbon compounds as a food source, like sodium acetate. Here, we will explore type-II methanotrophs. When type 2 methanotrophs consume a single-carbon source, they go through what is called the serine cycle. The serine cycle is the way that the methanotroph will oxidize the carbon source. Rhodobacter sphaeroids (RSP) is a methanotroph that can consume both single carbon and multi-carbon food sources. With Rhodobacter sphaeroides, the food sources that we use are methane and methanol for the single carbon source and then sodium acetate as a multi-carbon food source which puts it in a less stressful environment. Along with that, I am creating a partial pan-genome. A pan-genome is a set of genomes from all of the strains of bacteria in a clade. The pan-genome that I am creating will cover RSP and other bacteria that are close to it in a phylogenetic tree. I also have some samples that I took from the Sanford Underground Research Facility (SURF) at the 0300 level. I will cultivate the samples and isolate them. After that I will be able to do genomics on the isolated samples and do further studies with them. They may also be added into my pan-genome.

REU South Dakota Mines
Advisor(s): Rajesh Sani

Using Bis-Maleimide-Functionalized Graphene Microparticles for Drug Release — C39 — 12 p.m.
Kalista Vanden Berge, Mdtusar Uddin

Abstract: Graphene is two-dimensional, sp2-hybridized carbon that has many functional uses from building materials to electronics to biotechnology. Its honeycomb pattern makes it the strongest, thinnest, and stiffest material in the world. Functionalization of particles normally expands their practical use. It is currently unknown if functionalized graphene microparticles can be used for drug release, so the goal of our research is to determine if bis-maleimide-functionalized graphene microparticles can be used in drug release. To determine if certain drugs can be loaded and released from these particles, we used previously synthesized graphene particles to load acetaminophen and L-cysteine and look at its release to the PBS medium. This research has shown that drugs can be loaded into and released from these graphene microparticles, and current research is being conducted with more complex drugs to determine if the size or complexity of the molecule interferes with the loading and releasing of the drug.

REU University of South Dakota
Advisor(s): Grigoriy Sereda

Heavy Metals in Soils to Plant Uptake in Legumes: Morpha Canescens, Psoralea Argphylla, Psoralea Tenuiflora, Psoralea Esculenta, Oxytropis Campestris, Astragalus Adsurgens & Helianthus in Black Hills, SD & Orella Bridge, NE — B39 — 11 a.m.

Patrisse Vasek, Sen Subramanian, and Bree Oatman

Abstract: The potential for environmental contamination from in-situ leach uranium mining operations in western South Dakota and northwestern Nebraska is of serious concern to the Oglala Sioux Tribe (OST) and others in the study area. Risk assessment and remediation plans are vital tools that should be publicly available to residents on the Pine Ridge Reservation and adjacent counties, many of whom rely on locally-grown food and medicinal plants. Environmental exposure to heavy metals is associated with known risks to human health and ultimately genetic function.

Phylogenetic diversity of native vegetation and soils across the Black Hills to Eastern SD contain a unique vitality and solutions. Phytoremediation has been utilized across the continent as a less abrasive method of remediating soils that have been depleted of nitrogen, become contaminated, under reductive stresses, or have transformed into superfund sites. The increased potential for Black Hill's soils to contain less artificial fertilizer or chemical exposures, convey a baseline of fertile communities for nitrogen fixing bacterium and rhizobium. Sampled legumes and their source soils at 6 sites from across the Black Hills: Little Elk Creek Trail (Dalton), Deer Creek Trail (Silver City), French Creek Trail (Custer), Eagles Rising Ranch (Hill City), Skyline Wilderness, and a local residence in Rapid City, SD. Ranging from some of the least impacted wilderness areas in the Black Hills to grazing sites to more urban impacted areas. ICP-MS analysis of As, Se, Cu, Ba, Pb, and Zn revealed total heavy metal concentrations within soils of the Black Hills, displayed an erosional trend following reduction in elevation and were significantly lower in As and Se than Orella Bridge, NE. Plant uptake indicated balanced and imbalanced levels of metals, potential candidates for diet implications, hyperaccumulationa indicator and phytoremediation.

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REU Oglala Lakota College
Advisor(s): Dana Gehring

Comparison of Manganese Extraction Methods: Acid Leaching vs Bioleaching — A38 — 10 a.m.

Katherine Wild

Abstract: Several manufacturing processes in the United States require manganese, yet there are no active mines in the U.S. working to produce the element. While there are manganese deposits in the U.S., the ore grade is low enough where the usual processing methods are not economically viable. Instead, manganese is obtained through international trading to use in the production of goods, such as steel. To find a more affordable approach to processing manganese from the low-grade ore deposits, this project will compare two different methods of manganese extraction. The first of these methods is the traditional method of acid leaching. Leaching describes the process used for pulling out valued materials into a solution, and the waste is left as a solid. Acid leaching is used in processing several different types of metals, including manganese, and will be the standard method for this comparison. The other method used in this project will be bioleaching, a newly researched method for the extraction of manganese. Bioleaching relies on microorganisms to leach manganese from the ore, instead of acid. While many metals are now being extracted with this method, there has been relatively little research exploring manganese bioleaching. This process may prove to be more economical and sustainable than acid leaching for the low-grade ore deposits in the U.S. The efficiency of acid leaching and bioleaching methods from a low-grade manganese ore will be compared. Additionally, for each of the leaching methods different variables will be tested to optimize leaching efficiency. Manganese extraction efficiency rates will be compared by inductively coupled plasma mass spectrometry. The collected data will give insight into future manganese leaching processes.

REU South Dakota Mines
Advisor(s): Scott Beeler, Brett Carlson

Comparative Developmental Morphology Among Genetic Variations of Switchgrass — A39 — 10 a.m.
Tyler Williams, Arvid Boe, Cody Kneip, Abdulallah Alomair, and Kaitlin Scheuer

Abstract: Native to North America, the C4 plant, switchgrass (Panicum virgatum) is known for its environmental and economic importance due to its high biomass yields and its resiliency in many habitats. Because of its utmost importance, the better understanding of switchgrass development morphology and its relationship between aboveground and belowground counterparts among genetic variations of cultivars will enhance switchgrass systematic management. The objectives of this study were to quantify the developmental morphology of switchgrass (e.g. proaxis, rhizomes, buds, and aboveground internodes) along growth stages between genetic distinct cultivars 'Cave-In-Rock' (CIR) and 'Decotah' (DAC) and examine relationship between proaxis development and aboveground tillers development. For each cultivar fifteen samples were randomly selected each site at each of three sampling date July 3rd, July 31st and September 5th in 2003 located at the Dakota Lakes Research Farm, near Pierre, SD. We found that CIR is consistently larger than DAC in proaxis length and mass, rhizome length, number of crown buds, number of proaxis nodes, and aboveground stem mass. In contrast, DAC more invested on rhizomes, particularly in early growing season. This might contribute to the origin of cultivars and local adaption. CIR is a southern latitude (37°N) cultivar and DAC is a northern latitude (46°N) cultivar. It appears both cultivars reached the peak of the development of proaxis, rhizomes, and crown buds on July 31st and maintained through the September 5th. There was a strong positive relationship between proaxis size and aboveground stem size (r=0.93).

REU South Dakota State University
Advisor(s): Lan Xu

An Overview of the LUX-ZEPLIN (LZ) Dark Matter Experiment — B40 — 11 a.m.
Jax Wysong

Abstract: The LUX-ZEPLIN (LZ) is an ongoing project being completed at the Sanford Underground Research Facility (SURF) in Lead, SD. It is hosted approximately 1 mile underground in the Davis Campus. This experiment attempts to directly detect Weakly Interacting Massive Particles (WIMPs) in order to find evidence of dark matter. The heart of the LZ detector is a liquid xenon time projection chamber (TPC) containing 7 tonnes of active liquid xenon. The TPC sits inside of a 25' diameter, 20' tall water tank to shield the TPC from external gamma radiation. In the TPC, WIMPs will collide with the xenon nuclei and produce scintillation light which will be detected by photomultiplier tubes. To assist with the rejection of background radiation, the TPC is surrounded by a liquid scintillator loaded with gadolinium which will tag neutrons that interact in the TPC, and would otherwise mimic a WIMP signal. With the water tank, this system is collectively known as the outer detector. In this slide show, we will give an overview of the LZ project as well as present some work that we did to help commissioning of the outer detector, xenon handling, and the calibration systems.

REU South Dakota State University
Advisor(s): David Woodward

Native forb rhizosphere microbiomes differ when native forbs are grown together — A40 — 10 a.m.

Rebecca Yox, Jose Gonzalez, Sen Subramanian, and Trevor Van Den Top

Abstract: Tallgrass prairie once dominated eastern South Dakota. Due to modern farming, the diversity of the Midwest prairie has been replaced with a strict monoculture of crop plants leaving only two percent of natural prairie remaining. Studying the effects of diversity in an ecosystem may start from a seemingly small-scale perspective but the results can lead to significant advances in restoring South Dakota prairies back to their original state. Aboveground plant biodiversity and below ground biodiversity directly influence each other, which allows for plant-soil feedbacks to impact their susceptibility to invasiveness. In addition, the soil microbes found in the rhizosphere vary according to the unique plant species. Because soil microbiomes heavily influence the success of a species, studying changes due to age or circumstance give insight into the fragility and stability of not only a species, but a community. This study aims to understand how two different native plant species grown together affect their shared soil microbial community. Here we examine the soil microbiome of six co occurring native forbs (Agastache foeniculum, Dalea purpurea, Echinacea angustifolia, Erysimum asperum, Geum triflorum, Penstemon albidus). These species were chosen specifically due to their importance in tallgrass prairies found in South Dakota as well as their value as pollinators. We compared each of the species unique soil microbiomes to the microbiome of said species growing with the primary species Agastache foeniculum. To compare microbiomes, DNA from soil samples was extracted and used in a 16S/ITS PCR. These amplicons were sequenced on the Illumina MiSeq at SDSU genomics facility. CLC Genomics Workbench was used to analyze these data to assess biodiversity within our soil samples. The results are displayed on the poster.

REU South Dakota State University
Advisor(s): Lora Perkins, Maribeth Latvis

Thank you!

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