SD EPSCoR

RESEARCH. EDUCATION. ECONOMIC DEVELOPMENT.

9th Annual

Research Symposium

featuring **Undergraduates in South Dakota**

Thursday, July 28, at SDSU's Club 71 in Brookings

Undergraduate STEM students, faculty and industry experts from institutions across the state gather at SDSU's Club 71 on Thursday, July 28, to participate in the ninth 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.

CLUB 71, SDSU

JULY 28, 2022

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.

This material is based upon work supported by the National Science Foundation/EPSCoR Award OIA-1849206 and by the South Dakota Board of Regents. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Sponsors

110 S. Phillips Avenue, Suite 304,
Sioux Falls

Joni Ekstrum, Executive Director
Phone: (605) 274-3714
Email: joni@sdbio.org

South Dakota Biotech is the state affiliate of the Biotechnology Innovation Organization (BIO). This non-profit organization is dedicated to developing biotechnology through expanding research, advocacy, funding, education, infrastructure development and promotion.

Formed in 2006, South Dakota Biotech serves a membership which includes business, universities, service providers and state-wide economic development entities to expand the bioscience industry. The primary goals of the association are to:

- Connect leaders and experts
- Collaborate to shape the future
- Drive innovation to feed, fuel, and heal the world

Research Park at SDSU Administrative Office —
Suite 113, Brookings

Dwaine Chapel, Executive Director
Phone: 605.696.5600
Email: Dwaine@rpsdstate.com

The Research Park at South Dakota State University is located adjacent to SDSU in Brookings, South Dakota. Located on 125 acres, the Research Park will provide more than one million square feet of first-class office, lab, conference and greenhouse space at full build-out.

The Research Park is divided into 32 leasable lots available to businesses for construction of their own facilities or for lease of building space from private developers. Currently there are three buildings on the property — the Brookings Innovation Center, the Lloyd Companies Building, and the Young Brothers Seed Technology Laboratory.

Partnerships

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Schedule

Wednesday, July 27

4:00 - 6:00 p.m.	Tours at SDSU Labs and Brookings companies
6:00 - 7:00 p.m.	SD Biotech Mixer at SDSU Research Park *(2301 Research Park Way, Brookings)*

Thursday, July 28

Poster Session Schedule

8:30 - 9:15 a.m.	Networking Continental Breakfast and Poster Setup
9:15 - 9:30 a.m.	Welcome
9:30 - 11:30 a.m.	Morning Poster Session
11:30 a.m. - 1:30 p.m.	Networking and Working Lunch
1:30 - 3:30 p.m.	Afternoon Poster Session
3:30 p.m.	Adjourn and Take Down Posters

Presentation Schedule *in Coughlin Alumni Lounge (at south end of Club 71)*

9:30 - 10:30 a.m.	Graduate and Professional School Presentations · **NRT Grad Student Panel (10-minute)** The NSF Research Traineeship (NRT) program is available to students at DSU, SDSU, SDSMT and USD. · **University Graduate and Professional Schools (4)**
10:30 - 11:30 a.m.	Company Presentations (10-minute) 5 companies Prairie AquaTech, Medgene Labs, Pioneer BioTech, Avera Health and Cambridge Technologies.
1:30 - 2:30 p.m.	Company Presentations (10-minute) 5 companies Prairie AquaTech, Medgene Labs, Pioneer BioTech, Avera Health and Cambridge Technologies.
2:30 - 3:30 p.m.	Graduate and Professional School Presentations · **NRT Grad Student Panel (10-minute)** The NSF Research Traineeship (NRT) program is available to students at DSU, SDSU, SDSMT and USD. · **University Graduate and Professional Schools (4)**

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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 Technology: 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

** Individuals indicated with an asterisk are students presenting with Prairie BioTech in its company presentation.*

Alcantara, Korina — 1a
Allen, Lindsey — 2a
Baker, Gavin — 5a
Basaran, Riley — 16p
Bernard, Claire — 7a
Biever, Sydney — 8a
Borchert, Dylan — NRT
Braghin, Elias — 10a
Brandt, Andrew — 64p
Brekke, Benjamin — 12a
Brooks, Kameron — 13a
Brown, Taylor — 14a
Burmood, Zachary — 15a
Butler, Katherine — 16a
Castillo, Alex — 17a, 5p
Cates, Jackson — NRT
Chisari, Sebastian — 19a
*Christensen, Ashley
*Christopherson, Kayla
*Cole, Matthew
Conde, Hugo — 23a
Crawford, Carter — 24a
Dalton, Katherine — 25a
Daniels, Brandon — 26a
Derenge, Jonny — 27a
Disbrow, Damian — 28a
Dougan, Nikita — 29a
DuBray, Michael — 30a, 39p
Ebrahem, Thomas — 31a
Eddy Harvey, Michael — 32a
Eide, Hunter — 33a
*Evink, McCormick
Featherman, Tressa — 34a
Ferrie, Mason — 35a
Fofie Jr., Charles — 37p
Follett, Derek — 37a
Forsberg, Adam — 38a
Foy, Ryan — 39a
*Franken, Aubrie
Gad, Barien — 40a
*Garvis, Caleb
Gauker, Charles — 41a
Graf, Cameron — 42a
Grassrope, Ash — 43a
Greathouse III, Harold — 44a
Green, Kiran — 45a
Greyer, Nicole — 46a
Grothe, Jordan — 48a
Gruber, Savannah — 49a
Haas, Sam — 50a
Hanisch, Mikaela — 51a
Hoffman, Haley — NRT
Holm, Jay — 53a
Hooda, Isha — 54a
Janis, Mikayla — 55a
Jatico, Brandon — 56a
Jensen, Ashton — 57a
Jochum, Andrew — 58a
Jundt, Logan — 59a
Kass, Kathryn — 60a
Khalaf Mohammed, Hazem — 61a
Knutson, Ava — 62a
Korst, Julienne — 63a
Kovash, Isaac — 64a
Krason, Trevor — 65a
LaBee, Lacey — 66a
Lacota, Melinda — 67a
LaGarde, Shyra — 68a
Lang, Lydia — 69a
Larsen, Jake — 70a
Larson, Kylie — 71a

Presenters

** Individuals indicated with an asterisk are students presenting with Prairie BioTech in its company presentation.*

Lemke, Sean — 2p
Little Eagle, Michael — 55a, 3p
Locke, Elaine — 4p
Loutsch, Nathan — NRT 17a
MacDonald, Emily — 7p
Mathias, Katherine — 8p
Mayer, Joseph — 9p
McConnell, Evan — 10p
McKeever, Ava — 11p
McMinn, Bryce — 42a
McQueen, Sean — 50p
Merritt, Cody — 14p
Modeo-Price, Luke — 16p
Moechnig, Aiden — 17p
Mofle,Peyton— 18p
Moses, Emmily — 19p
Nielson, Isabel — 21p
O'Connor, Grace — 22p
Oedekoven, Morgan — 23p
Palmer, Jeffery — 24p
Patocka, Delaney — NRT 25p
Pike, Timothy — 26p
Quigley, Wesley — 27p
Quilt, Issah — 43a
Rachynska, Oleksandra — 26a
Raszler, Megan — 30p
Rebstock, Travis — 26a
Rehberg, Naomi — 32p
Richardson, Karac — 33p
Rosa, Kathryn — 34p
Ryan, Madeline — 43a
Sachen, Colin — 63a
Sager, Kasey — 37p
Salesa, Darratu — 38p
Sandoval, Cameron — 39p
Sansom Botstein, Natalie Claire — 40p
Schnetzer, Erin — NRT 14a
Schramm, Aiden — 17p
*Schuh, Ian — 43p
Schulte, Megan — 44p
Schulz, Sable — 45p
Seagren, Wyatt — 46p
Shaw, Logan — NRT
Simpson, Andrew — NRT
Smith, Alexandra — 1a
Smith, Izabelle — 50p
Steinmeyer, Grace — 51p
Swanberg, Joel — 52p
Ta, Hoa — 53p
Taylor, Austin — 54p
Taylor, Kai — 55p
Thaler, Conner — 56p
Thomas, Andrea — 57p
*Trapp, Adam — 10p
Traub, Jordan — 66p
Usavage, Cat — 59p
Voirin, Hannah — 60p
Wall, Casey — NRT
Wells, David — 62p
Whorton, Charlotte — 63p
Willweber, Micah — 64p
*Wolf, Logan — 66p
Wright, Tjaden — 65p
Wynn, Sierra — 67p
Wysong, Jax — 68p
Zarembski, Anya — 69p
Zhou, Evan — 70p
Ziegler, Claudia — 71p
Zimmel, Adam — 17p

Abstracts

A Comparison Review on Medical Device Security Regulations and Standards — 1a —
Korina Alcantara, Alexandra Smith

Abstract: Multitudes of threats and attacks are reported targeting medical devices in healthcare. Due to the importance of the medical devices to patient care and sensitive data, medical device security is crucial for any health organization. This research aims to review medical device security standards while comparing regulations between the United States and European Union. The first goal of the project was to discover medical device security regulations and requirements. Another goal of this project was to demonstrate an outline of the regulations based on stakeholders, cybersecurity frameworks from both the U.S., EU, and sub-organizations. Because of how novel the topic of cybersecurity is, challenges arose with how vague the regulations were from the FDA, finding how secure hospitals truly are, and paywalls when it came to documents from the EU. The results discovered showed many similarities and differences between the two locations when it came to their regulations and standards.

REU Dakota State University
Advisor(s): Yong Wang

Modeling electric field sitribution through human tissue — 2a —
Lindsey Allen, Ashley Jorgensen, Dr. Mark Messerli

Abstract: Applying electric fields (EFs) to non-excitable cells in epithelial tissues and cartilage is known to promote healing, but the mechanisms are largely unknown. One mechanism may involve the fact that EFs induce electro-osmotic flow, electrically driven water flow that causes transport of macromolecules and removal of metabolic wastes from tissues. To better understand how this process works and its limitations, we are developing computational fluid dynamics (CFD) models that accurately represent the electric field distribution within tissue. The volume of tissue is modeled as two concentric cylinders where voltage is applied at each end. This study uses a commercially available multi physics solver, SimCenter STAR- CCM+ to monitor how voltage affects the transport characteristics and thermal profile of tissue while comparing our results with benchtop studies. By optimizing characteristics within the software including meshing, boundary features, and geometry, we will generate a representative model that produces the spindle-like shape of the EF distribution. The long-term goal of this research is to create a process for explaining and predicting the effects of electro-osmotic flow at the cellular level. This research has a wide range of applications, from healing chronic wounds, to delaying cartilage degeneration, and to helping scientists more effectively engineer tissue.

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

Crystal Structure and Magnetic Properties of CoMoFeAl and Related Compounds: Theory and Experiment — 5a — Gavin Baker, Paul Shand, and Pavel Lukashev

Abstract: Materials showing a high degree of transport spin polarization, a Curie temperature above room temperature, and moderate magnetization are desired for spintronic devices. We have carried out joint theoretical and experimental investigations of three Heusler compounds CoMoFeAl, CoMo0.5Fe1.5Al, and Co1.5Mo0.5FeAl. Our first-principles calculations show that all three compounds show either ferro- or ferri magnetic order. In addition, the first two alloys show high spin polarization of almost 80% but the third one is nearly non-spin polarized. Samples were prepared using arc melting and high vacuum annealing. All the samples show cubic crystal structure. The parent compound CoMoFeAl shows ferromagnetic order with moderate saturation magnetization of 11.8 emu/g and a Curie temperature above room temperature at 480K. The other two compounds, namely, Co1.5Mo0.5FeAl and CoMo0.5Fe1.5Al, show ferrimagnetic order with slightly high saturation magnetizations of 62 emu/g and 54 emu/g, respectively, and substantially high Curie temperatures of approximately 1000 K, Fig.1. These experimental results are consistent with our theoretical prediction. Our results indicate that this family of compounds has potential for spintronics devices and for other magnetic applications that desire moderate magnetization and a high Curie temperature.

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

Survey and analysis of candidate genes in cold-adapted Drosophilia melanogaster — 7a — Claire Bernard, Paul Shand, Pavel Lukashev

Abstract: Previously, whole genome sequencing (WGS) of six inbred lines of cold-adapted Drosophila melanogaster was performed and 22 candidate genes were identified using the Drosophila reference genome for comparison. Here we used RT PCR to begin a survey of possible expression differences in these candidates by comparing the cold-adapted lines to a standard laboratory line (Oregon R). This process consisted of dissecting ovaries from each line, extracting RNA, and converting the product into cDNA. Primers were designed for each gene around their SNP of interest (obtained from WGS), and endpoint PCR was performed. Gel electrophoresis was used to identify expression differences. Stathmin (stai) in the OregonR control lines consistently produced two bands, one at 523 bp and a second one at 368 bp. While the cold-adapted lines consistently produced only the larger band. Stathmin is believed to act to destabilize microtubules and has multiple human homologs, some involved in cancer. We raised the flies in reciprocal incubators and confirmed that the difference in expression was not caused by the difference in incubator temperature. The small band found in Oregon R but missing in the six cold-adapted lines was sequenced and identified as stathmin Isoform A. Interestingly, the specific SNP of interest did not differ between the cold-adapted lines and Oregon R, though the expression clearly did. The study of genetic pathways involved in this adaptive response to temperature in D. melanogaster may provide a deeper understanding of the response of complex traits in general, possibly including a clearer understanding of human disease.

REU Augustana University
Advisor(s): Cecilia Miles

Studying the Function of USP27X in Pluripotent Stem Cells — 8a —
Sydney Biever, Emily Konz

Abstract: Up to 2% of the population is affected by intellectual disability. This presents formidable difficulties for those afflicted and those around them. MRX105 is an X-linked intellectual disorder caused by a mutation of the USP27X deubiquitlyase (Kniffin, 2016). Symptoms of MRX105 include poor or absent speech and behavioral issues (Hu et al., 2016). Because USP27X is a deubiquitinating enzyme, we hypothesize that mutations in this gene can disrupt ubiquitin-related signaling pathways that when damaged, result in the intellectual disability MRX105. However, as no current cure or treatment exists, there remains reason to determine the molecular mechanisms contributing to this disorder. To understand the molecular mechanisms underlying MRX105, we aim to determine the role of USP27X in stem cell biology and neural differentiation. For this, we generated USP27X knockout mouse embryonic stem cells and analyzed their cell growth and cell cycle in comparison to wild type cells with the use of colorimetric assays and flow cytometry, respectively. Additionally, pluripotency properties were analyzed via Alkaline Phosphatase staining, and quantitative RT-PCR. So far, we have found similarities in both cell growth and cell cycle analyses between the two lines, which demonstrates congruity in proliferation. Another significant finding shows differences in pluripotency capacity between the wild type and USP27X knockout cell lines. Further research on the developmental functions of USP27X would aid in developing targeted therapeutic interventions for intellectual disability MRX105.

REU University of South Dakota
Advisor(s): Francisco Bustos

Synthesis of Carbon Dots with Red Phosphorescence for Security Ink Purposes — 10a — Elias Braghin

Abstract: Carbon dots, or CD`s, are quasi-spherical structures that typically span 5-10nm. The applications in which CD`s can be used for ranging from bio-imaging to solar cells. This research attempts to synthesize CD`s for security ink purposes. A variety of colors already remain available, however a red, or near-infrared (Near-IR) phosphorescent CD is not readily available for these purposes. This leaves gaps in security where verification needs to be more broad and less easy to encrypt. In order to synthesize CD`s with desirable properties, synthesis began with EDA diluted in water (under agitation), and slowly mixed with phosphoric acid after and heated at 180° for 2 hours. After initial set of chemicals were mixed, other chemicals were added in hopes of an expected outcome. Purification process consisted of centrifugation and filtration, followed by freeze-drying. A second heating treatment was applied at 280° for 2 hours. Same purification processes were followed after. As of now, no CD`s with red phosphorescence have been achieved, but there are still tests underway, with hopes that one will give the desired outcome.

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

Ruthenium complexes and their applications in Dye-Sensitized Solar Cells (DSSCs) — 12a — Benjamin Brekke, Ashley Jorgensen

Abstract: The world is in an energy crisis and needs to start transitioning to renewable energies such as solar energy. A promising new type of solar energy has recently gained a lot of attraction, Dye-Sensitized Solar Cells (DSSCs). We focus on synthesizing a ruthenium complex with a dipyrazolylpyridine ligand integrated with anchoring groups such as carboxylic acid (-COOH). Ruthenium complexes are recognized as one of the best dyes(s) that can absorb light energy efficiently when it binds to Titanium (IV) Dioxide. This combination is used in Dye-Sensitized Solar Cells as a photosensitizer. The novel ruthenium complex is synthesized in multistep reactions and characterized by NMR, ESI-MS, and single-crystal XRD. We are also reporting brief photophysical studies on the new ruthenium complexes.

REU University of South Dakota
Advisor(s): Dr. Katrina Donovan

The analysis of protein trafficking in mammalian motile cilia using live imaging — 13a — Kameron Brooks

Abstract: Primary ciliary dyskinesia (PCD) is a rare pediatric syndrome. that causes recurring respiratory infection and female and male reproductive issues. This disease is caused by genetic mutations that affect cilia, however molecular mechanisms that regulate cilia are not understood yet. There are two types of cilia; motile cilia and non-motile cilia (sensory). Motile cilia can be found in airways, reproductive systems, and the brain and is responsible for generating fluid flow. This project is focused on motile cilia, and the goal is live imaging of protein trafficking in motile cilia, will give us a better understanding of motile ciliary mechanisms. To capture live images of motile ciliary proteins, the frame rate has to be fast and have good resolution. The method for imaging motile cilia involves breeding PCD mouse models, dissecting the mice to retrieve their tracheas, isolate the epithelial cells, plant the cells on a membrane, transduce the cells with a GFP-tagged intraflagellar transport protein, induce ciliogenesis by culturing at an air-liquid interface, and cut the membrane out for live imaging. This method will also be validated using non-motile (sensory) cilia on cultured NIH3T3 cells. The live imaging will be quantitatively analyzed to determine protein velocity and trajectory, and the PCD mutant cilia will be compared to wild type controls. This novel approach will uncover how protein trafficking is regulated in mammalian motile cilia.

REU Sanford Research
Advisor(s): Dr. Lance Lee

Inkjet Printing of Silver Ink Labels for SERS-Based Anti-Counterfeiting — 14a —
Taylor Brown, Erin Schnetzer, Yifeng Huo

Abstract: With the global counterfeiting rate steadily increasing, government stability and health issues are negatively impacted. As a new approach of anti-counterfeiting, security labels based on Surface-Enhanced Raman Scattering (SERS) can combat this. Their commercial rarity and spectroscopic characteristics allow for a higher level of complexity of anti-counterfeiting mechanisms. In this study, a silver ink was first synthesized using a method modified from literature. This ink was then printed to make security labels using a commercial inkjet printer. Although hundreds of probe molecules can be used, this proof-of-concept study focused on three Raman probes: phthalocyanine, 4-mercaptobenzoic acid, and 4-aminothiolphenol. We obtained SERS spectra with distinguishable peaks that are related to the selection of probe molecules. Our results also showed that the SERS signals increase as the probe concentrations increase in the silver inks. Meanwhile, the temperature and time of post-print treatment also impacts the SERS intensity. With further optimizations, our silver ink can be used to easily and conveniently print anti-counterfeiting labels which will ultimately deter the global counterfeit impact.

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

Understanding HCO3- Binding in Metal-Organic Supercontainers for Direct Air Capture — 15a — Zachary Burmood, Levi Spencer

Abstract: Carbon Dioxide (CO 2) is a part of the earth's atmosphere but has started to grow to alarming levels due to society's increasing consumption of fossil fuels. The growing levels of CO 2 are contributing to a rise in global temperatures, causing climate change and threatening people's daily life. Methods have been implemented to slow the rising levels of CO 2 , including post-combustion carbon capture, which removes CO 2 from the flue gas at fossil-fuel-fired power plants before its transportation and storage in geological formations. However, post-combustion capture only mitigates ongoing carbon emissions but does not reduce the amount of CO 2 already present in the atmosphere. An alternative approach, known as direct air capture (DAC), aims to remove CO 2 directly from the ambient air and thus allows negative global CO 2 emissions. Due to the ultra-dilute nature of CO 2 in the ambient air (~410ppm), DAC is challenging and energetically costly. This project focuses on investigating a new DAC mechanism involving metal-organic supercontainers (MOSCs), which are nanostructured cage-like molecules constructed from metal ions and organic linkers and feature endo- and exo- cavities capable of selectively binding to small molecules or ions. The anion bicarbonate (HCO 3 -) is one of these small ions that are capable of binding with MOSCs. Preliminary studies suggest that this HCO 3 - binding behavior allows one particular MOSC to be an effective adsorbent for DAC. This presentation describes our efforts in investigating several different MOSCs and comparing their binding capabilities with HCO 3 - . Understandings gained from this study will allow us to identify key structural and chemical characteristics of the MOSCs that contribute to their HCO 3 - binding and DAC capability. Future studies will leverage these understandings to optimize the design of new MOSCs for DAC applications.

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

Assessing the Performance of 3D Printed Heat Exchangers using CFD — 16a —
Katherine Butler

Abstract: For over a century, heat exchangers have been made almost exclusively of metal. More recently, researchers have explored the possibility of using polymers and additive manufacturing (3D printing) to create non-metallic heat exchangers. The devices are used in many engineering applications including power plants, which are one of the largest consumers of freshwater in the United States. By utilizing air-cooled heat exchangers, the amount of water used can be significantly reduced or completely eliminated. Polymers offer many advantages such as low cost, flexibility in shape, and are non-chemically reactive. The drawback is that polymers are not as thermally conductive as their metallic counterparts. These shortcomings can be overcome by using designs that increase the surface area to volume ratio. The goal of this study is to exploit the ability to manufacture complex geometries that additive manufacturing provides. This study begins by using existing heat exchanger designs, which are modeled in Solidworks, a computer aided design software. Next, the geometric models are imported into Star CCM+ which is a computational fluid dynamics software. Physics continuums are created to represent the operating conditions the heat exchangers would experience. Using velocity and temperature visuals, the results of cooling the liquid inside the device are compared to existing experimental data and analyzed for effectiveness. Current results support the hypothesis that a higher surface area to volume ratio increases heat transfer effectiveness. The computational simulation process is used to create novel designs and predict the performance. This research can be used to discover heat exchanger designs that reduce the amount of water used by heat exchangers in power plants.

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

Exploring Reactions Using Heterogeneous Frustrated Lewis Pairs —17a —
Alex Castillo, Nathan Loutsch

Abstract: The use of frustrated Lewis pairs (FLPs) has gained attention over the last two decades; however, there are scarce examples of heterogeneous FLPs. The unique environment of a heterogenous FLP mixture can provide many benefits over that of a homogeneous liquid mixture, such as additional scalability in reactions, cheaper materials, and safer reaction conditions. Our group tested the reaction of glycerol with a heterogenous Lewis acid of solid phase Al 2 O 3 paired with three separate liquid phase FLP bases: dicyclohexylamine, lutidine, and tetramethylpiperidine. This FLP interaction could allow the attachment of glycerol to the Al sites, potentially offering a storage and recycling method for glycerol. Our group also tested a Diels-Alder reaction between CO 2 and 2, 3-dimethylbutadiene with the combination of Al 2 O 3 and dicyclohexylamine. The potential implications of an interaction of heterogeneous FLPs and CO 2 such as this could be a low cost scalable form of carbon capture.

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

Substituents effect on electronic properties of fluorinated dibenzo [a,c]phenazines — 19a — Sebastian Chisari, Anjaneyulu Putta

Abstract: Organic semiconductors have been versatile in the modern era. Charge transport is one of the critical parameters that determines the performance and efficiency of the organic semiconductor materials. To understand and improve the charge transport process, the relationship between crystal packing and molecular interaction needs to be established. Lamellar crystal packing is one of the most significant transport channels among the several crystal packing modes that exist. Our group demonstrated that perfluoroalkylation is a successful strategy to steer the crystal packing from herringbone to ideal lamellar packing. At present study, we have studied the effect of substituents (H Vs C 4 H 9 Vs C 4 F 9) on electronic properties and intermolecular interaction energy of fluorinated dibenzo [a,c]phenazines using computational chemistry. Results show that compared to substituent H, CF 3 convey that the Lumo energy has decreased while the CH 3 substituent shows an increase. Additionally, the dipole moment changes based on the positions of the substituents. Lastly, compared to substituent H, CF 3 substituents have higher IP and EA values than CH 3 , which have lower EA and IP values.

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

Microbiome diversity in the soil surrounding root zone of winter wheat under different levels of nitrogen fertilization — 23a —
Hugo Conde, Sunish K. Seghal, Harshimardeep S Gill, Dinesh K. Saini, Emmily Moses, Sierra Wynn, Connor Thaler, Michael Eddy Harvey

Abstract: Nitrogen is an essential nutrient for winter wheat and is often considered the most yield-limiting factor. The application of chemical nitrogen fertilizers is one of the most crucial agronomic practices that has contributed to the increase in wheat production. Nevertheless, the majority of the applied nitrogen is lost from runoff causing serious environmental problems. This necessitates continuous efforts to increase the nitrogen use efficiency in wheat. Recently, plant root-associated microbiomes have been reported to play a key role in host nutrition and development. Various studies have shown that plant roots drive the assembly of microbial communities in the rhizosphere from the surrounding soil which might influence important processes in the host plant including the assimilation of available nitrogen. However, it has not been studied how the changes in nitrogen input shape the microbial diversity in the root zone. Here, we studied the bacterial composition of the soil surrounding the roots (bulk) of winter wheat under four levels of inorganic nitrogen fertilization. The soil samples were collected from the winter wheat plots and subjected to different levels of nitrogen in two replicates. The DNA was isolated from the bulk soil and 16 S V4 and V5 gene amplicons were sequenced to identify the bacterial communities in the soil surrounding the root zone. The results of the project will be presented.

REU South Dakota State University
Advisor(s): Sunish K. Seghal

Extreme Low Temperature Thermal Cycling on Cold Spray Deposits — 24a —
Carter Crawford, Michael Carter

Abstract: Cold spray is a solid-state powder deposition process that is commonly used for repair applications, particularly for military components. There is an increasing need to understand how cold spray repairs perform in Earth's cold regions. The purpose of this research project is to evaluate the microstructure and mechanical stability of common aluminum cold spray deposits, often used to repair military weapon systems, when subjected to extreme low temperature thermal cycling. 6061 Al cold spray depositions were performed on Al 6061 and ZE41 Mg alloy substrates using high pressure cold spray. As-deposited specimens were subjected to thermal cycling from 25°C to −60°C for 51 cycles. Cross-sectional optical microscope and scanning electron microscope (SEM) imaging was conducted before and after thermal cycling to assess the influence of thermal cycling on the microstructure of the depositions. In addition, triple lug shear strength testing was performed to determine the adhesion strength of the cold spray depositions before and after thermal cycling. The findings from this work will provide important guidance to the U.S. Army in the implementation of 6061 Al cold spray depositions in Earth's cold regions.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Grant Crawford

Tuning redox profiles of polyoxovanadate-alkoxides by transition metal functionalization — 25a — Katherine Dalton

Abstract: Currently, there is a high demand for single-species redox agents with tunable properties for use in a wide variety of applications, such as the development of non-aqueous redox flow batteries that provide environmentally friendly energy storage. Polyoxovanadate-alkoxides (POV-alkoxides) are a class of compounds with the potential to fulfill this demand, necessitating further study of their tunability. Therefore, the effects of transition metal installation into POV-alkoxide clusters were examined. Redox potentials of POV-alkoxides functionalized with cobalt, iron, hafnium, titanium, and/or zirconium ions were computed with different computational methodologies. From these values, we sought to determine which method offers the best level of theory for the study and looked for correlations between redox potentials and orbital energies. Preliminary results suggest that functionalization with iron or cobalt shifts potentials down with respect to the pristine, all-vanadium POV-alkoxide cluster, while titanium, hafnium, and zirconium shift potentials up. The best agreement with the available experimental results can be attained by using the def2TZVP basis set for all atoms with either the B3LYP-D3 or M06 exchange-correlation functional and solvation in acetonitrile. This study will aid us in understanding the structure-redox relationships of POV-alkoxides and identifying new synthetic targets with improved redox properties.

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

Quantitative Real-Time PCR Identification of Soybean Pathogens in Eastern South Dakota Soil — 26a — Brandon Daniels, Oleksandra Rachynska, Travis R. Rebstock, Conner L. Tordsen

Abstract: South Dakota planted 5,450,000 acres of soybeans in 2021, and 5.8 percent of potential soybean production was lost due to diseases. Revealing prevalent soilborne soybean pathogens throughout the state and utilizing the proper management strategies could increase South Dakota soybean yields. With the relatively recent (2014) first report of soybean sudden death syndrome (SDS) in South Dakota and confirmation of SDS in three more counties in 2017, we utilized quantitative real-time polymerase chain reaction (qPCR) assays to detect pathogens that cause SDS and other soilborne soybean pathogens using DNA extracted from the soil. Soil was sampled from six fields under commercial soybean production in Deuel County and Brookings County. Collected soil was dried at 55°C for two days, and three DNA extractions were done for each field sampled. qPCR assays were performed on a Bio-Rad CFX Opus 96 Real-Time PCR system with SYBR Green master mixes using primers specific to several soybean pathogens such as Fusarium virguliforme, Fusarium brasiliense, Phytophthora sojae, Phytophthora sansomeana, and Phialophora gregata. qPCR reactions were run in triplicate with three technical replicates on each of the three biological replicates per field assessed. qPCR assays failed to detect F. virguliforme, F. brasiliense, P. sojae, and P. sansomena, which indicated that these pathogens were not present in the six fields evaluated. The presence of P. gregata was detected in three out of the six fields evaluated. Our primary objective was to develop distinct qPCR protocols on samples of DNA extracted directly from the soil for a more extensive South Dakota soilborne soybean pathogen survey in Fall 2022 and Summer 2023. qPCR-based diagnostics efficiently and specifically test for pathogens with high sensitivity. Providing South Dakota soybean growers with accurate, timely information about pathogens detected in their soil should allow them to take proper management strategies and increase their yields.

REU Dakota State University
Advisor(s): Dr. Sathoff

IoT Vulnerability Exploitation — 27a — Johnny Derenge

Abstract: Consumer demand for convenience, accessibility, integration, and remote management of electronic devices has led to the rapid growth of the Internet of Things (IoT). The rapid adoption of edge computing and 5G have also increased adoption in the manufacturing, retail, and health care sectors. Cost is a significant factor in consumer choice of IoT devices. Vendors have responded by producing a wide variety of ever more capable devices in a wide range of categories. Unfortunately, security considerations may be secondary. Our research is heavily focused on house-hold smart consumer appliances representative of the multitude of devices currently on the market. The devices examined include an IoT smart electric space heater, a combination smoke detector and Bluetooth speaker, and an IoT security camera. A testing environment was created consisting of all our devices connected to one access point—a Hak5 Wi-Fi Pineapple (Mark VII model). Using a black box methodology, several attack vectors/vulnerabilities were investigated including default configurations, running services, weak passwords, TLS/SSL, and vulnerabilities in the accompanying client-side mobile applications. Upon the conclusion of the research, the vendors will receive a copy of the final report highlighting the security issues affecting their product.

REU Dakota State University
Advisor(s): Robert Richardson

Greenhouse tests of coal-based soil amendments on alfalfa growth — 28a — Damian Disbrow

Abstract: It is expected that the global population to be over 9.7 billion by 2050. The world faces the challenge of producing sufficient crops to meet growing food demand for future generations. Forage crops are the foundation of livestock and dairy industries in North America. Use of leguminous forages like alfalfa (Medicago saliva L.) can minimize nitrogen fertilization because they fix atmosphere N, thus reducing inputs and the risk of environmental contamination. Alfalfa is an important forage and conservation crop in North America, such as the restoration of farmland and disturbed grasslands by improving soil quality. A common issue with these areas of land is a lack of organic carbon. This study we tested a lignite - based fertilizer to see what effects it would have on alfalfa growth and production, and if it would be at all possible and effective to use in the restoration of the grasslands. The experiment consisted of three treatments with six replications. Five seeds from commercial cultivar were sown in each of six pots (13 -cm X 13-cm X 13-cm) for each of three treatments. Three treatments included nutrient-rich soil as positive control, degraded soil as negative control, and degraded soil with the addition of the coal-based soil amendment material. Seed emergence is recorded daily. Plant growth parameters (e.g. shoot height, root length, number of leaves, aboveground and belowground biomass) will be measured at the final harvest. Pre- and post-treatment soil property including bulk density, soil organic carbon, NPK will be measured. The results will be analyzed using appropriate methods based on the dataset. The results from the study will provide the evidence if there is a potential a cleaner use of coal and restoration of degraded grasslands.

REU Millersville University
Advisor(s): Lan Xu

Biodegradable polysaccharide seed coating as a method for delayed seed germination — 29a — Nikita Dougan, Prashant Dahal, Said Badshah, Ali M. Nafchi

Abstract: Finding ways to meet the rising food demand has become a rapidly expanding field of research as the global population continues to gradually increase. In this regard, improving the efficiency of the crops (and land) can have a significant impact on food supply given the limited arable land and the seasonal constraints. Interplanting is the method of planting, in which a fast-growing crop is cultivated along with slower-growing ones, allowing the plants to make use of most of the land and are harvested separately based on their harvest timeframe. This approach can be inferred for the same crops, wherein the germination timing would be controlled by the seed coating strategy, allowing seeds to be sown in a single sowing cycle and harvested over different timeframes. In this study, we attempt to coat the radish (Raphanus Sativus) seeds using the Generally Recognized As Safe (GRAS) polysaccharides through the number of layers and measure the germination delay. Alginate concentration of 2% (w/v) was used to coat the thin layer in seeds via crosslinking through a CaCl 2 solution of 100mMol/L. The coated seeds were then planted, and the signs of germination were checked every 24 hours. The preliminary findings indicate that the number of the coating layer in the seeds are proportional to the germination delay in days per coating. The result displays the potential of seed coatings by altering the plant growth in a way that is environmentally conscious and could be used as a practical strategy in large-scale cropping of agricultural plants.

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

Assay of Ultra-low Background Radiation for Rare Event Searches —30a, 39p — Michael DuBray

Abstract: The Sanford Underground Research Facility(SURF) is home to the LUX-ZEPLIN(LZ) dark matter experiment. Dark matter makes up approximately 85% of the mass of the universe but has not been detected directly. Ionizing radiation causes background in the LZ detector, which can overwhelm a possible dark matter event. Rare event search detectors are placed deep underground,using the granite to shield radiation from cosmic rays on the surface. However, the LZ detector itself contains small amounts of radioactive elements, which are also background sources. To minimize these background sources, the Black Hills State University Underground Campus (BHUC) is tasked with screening materials used in the construction of LZ and other rare event searches. The BHUC is home to several High-Purity Germanium (HPGe) detectors which are used to assay ultra-low background samples. In addition, we are constructing another detector at Black Hills State University to pre-screen materials. The result of these assays will be used to establish background radiation levels in the rare event detectors, against which the collected data can be compared.

REU Oglala Lakota College
Advisor(s): Dr. Brianna Mount

Metal-Organic Supercontainers for Direct Capture of CO2 from Air — 31a — Thomas Ebrahem

Abstract: Antibiotic-resistant pathogens are a major concern in global healthcare since they reduce the efficacy of antibiotic treatments. In the US alone, antibiotic-resistant microbes caused 2.8 million infections and 35,000 deaths in 2019. It is projected that by 2050 global deaths from antibiotic-resistant microbes will be ~100M/year unless new technologies are developed to combat them. A key contributor behind antibiotic resistance is a small portion of the bacterial population (known as persister cells) which survive antibiotic treatment by entering a metabolically repressed state during antibiotic treatment. These surviving populations can reestablish infections after antibiotic treatment, leading to chronic infections, have high mutation rate which eventually increases the chances of gaining antibiotic resistance. Although persister have been identified more than 70 years ago, but their mechanisms are still debated. To better understand the persister mechanism, we isolated total RNA from persister population treated with high doses of an antibiotic at different time-points (3h, 6h and 24h). We have found 32 genes upregulated more than 2 fold in all different time-points in comparison to before antibiotic treated population. In this study, our goal is to only focus on 2 uncharacterized genes (yfgD and ykiA) out of those 32 genes. We will knockout those genes using CRISPR/Cas9 system and evaluate their effect on persister subpopulation. Overall, this study will help us to understand the function of these 2 genes under different antibiotic stress and will allow us to identify some new drug targets for persister subpopulation. So far, we have not had enough time to analyze the effect those two knockouts has on persister cell formation.

REU South Dakota State University
Advisor(s): Dr. Nicholas Butzin, Dr. Medhav Nepal

Rhizosphere microbiome analysis in winter wheat reveals the presence of different types of nitrogen-fixing diazotrophic bacteria — 32a — Michael Eddy Harvey, Dinesh K. Saini. Harsimardeep S Gill, Sierra Wynn, Hugo Conde, Connor Thaler, Emmily Moses

Abstract: Nitrogen (N) is an essential nutrient for plants to flourish. By forming a symbiotic relationship plants like legumes develop root nodules that house N-fixing bacteria which provide N-fixation for the plant in return of carbohydrates. Other important food crops including cereals generally require additional nitrogen fertilizers, like manure, compost, and chemical fertilizers. Although, cereals are also known to have relationships with a variety of microorganisms, including nitrogen-fixing bacteria termed diazotrophs, however, they are understudied and underutilized. Therefore, we isolated DNA from the rhizosphere of wheat grown in poor N soils to understand the diversity in the rhizosphere microbiome and abundance of N-fixing bacteria using more advanced culture-independent methods like next-generation sequencing (NGS). Results revealed the presence of different proportions of important diazotrophs. Further, differential expressions of bacterial nitrogenase genes will be studied in different wheat genotypes. The present study showed the potential of sophisticated culture-independent techniques such as next-generation sequencing (NGS) to investigate the rhizosphere microbiome with the prospect of discovering potential N-fixing bacteria and novel bacteria with plant growth-promoting traits.

REU University of South Dakota
Advisor(s): Sunish K. Sehgal

FAST REEU Fellowship Experience — 33a — Hunter Eide

Abstract: The purpose is to elaborate on the benefits of the South Dakota State University (SDSU) Future Agriculture and Science Taskforce— Research and Extension Experiences for Undergraduates (FAST REEU) two-year fellowship program and to provide insight into the lessons learned through the program. During the first summer, researcher received research experiences at SDSU to develop a strategy for increasing competitiveness for graduate school, careers in FANH industries, or teaching agriculture or science in schools. Over the subsequent second summer, participated in a career-oriented internship at a place of their choice (Kwame Nkrumah University of Science and Technology — Kumasi, Ghana). A deeper analysis of the program itself provides insight into the learning outcomes. Hunter Eide is a second-year fellow who was in Dr. Yajun Wu's lab during the first year and researched the impacts of hydrotropism on maize. He developed the fundamental lab and scientific writing skills to land a research position at KNUST and researched heart health and dementia in older patients in Ghana during his second year. Throughout his time in Ghana, he further developed his passion for science, learned about the culture, and developed normative data for assessing dementia in Ghana. In conclusion, there is significant value in the FAST REEU program at SDSU for students to develop their potential, propel their career success, and cultivate an understanding of the current scientific issues in agriculture and/or science.

REU South Dakota State University
Advisor(s): Dr. Madhav Nepal

Health Streams on The Pine Ridge Reservation — 34a — Tressa Featherman

Abstract: The objective of this research was to learn more about the health of two local streams on the Pine Ridge reservation, including one near the towns of Potato Creek, South Dakota, and Porcupine, South Dakota. Vernier labquest testing probes were used to collect stream health data. The structure of the streams and weather both played a role in the results of this study. As spring storms decreased and temperatures increased, the turbidity and dissolved oxygen of Porcupine creek decreased, whereas the DO of Bull Creek slightly increased and turbidity did not significantly change throughout the study period. This research has provided an understanding of how to take ph levels, temperature readings, turbidity and dissolved oxygen, and the differences in the turbidity and dissolved oxygen in the streams. Continued water flow is very important to the ecosystem around these streams and for the future generations of the Oglala Lakota people. The freshwater supply of many streams plays a significant role as the sole source of water for animals, plants, and people.

REU Oglala Lakota College
Advisor(s): Dana Gehring

Electrochemical Reduction of Perfluoroalkylphenazine Compounds — 35a — Mason Ferrie, Yao Feng

Abstract: There is a need to decompose and repurpose hydrofluorocarbons (HFC) as they are widely known for contributing to global warming. However, decomposing these compounds is very difficult due to their strong C-F bond and C-H bond. One way to decompose HFCs is defluorination through electrochemical reduction. Perfluoroalkylphenazine compounds can be used as intermediates in decomposing hydrofluorocarbons. By using cyclic voltammetry, perfluoroalkylphenazine compounds can be analyzed to discover their electrochemical properties. These compounds gained unique properties when they are altered to have shorter or longer perfluoroalkyl side chains. We first analyzed a perfluoroalkylphenazine compound with perfluoropropyl side chains. This compound's first reduction is diffusion-controlled reversible one-electron reduction, and the second reduction is irreversible due to following chemical reactions. This compound also polymerized like that of a previously studied pentafluoroethyl substituted analog. The trifluoromethyl substituted analog, however, displays diffusion-controlled two reversible one-electron reductions, a completely different electrochemical behavior than that of the pentafluoroethyl and perfluoropropyl substituted phenazines. This proves our previous hypothesis that an electron can be transferred from the ring to the side chain. Future work will include testing the perfluorobutyl substituted phenazine compound to see how it compares to the other compounds. Our results show that potential useful fluoropolymers can be generated through electrochemical polymerization of hydrofluorocarbon derivatives.

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

Utilizing 3D Printing to Produce Supplementary Parts for Use in Microfluidic Experiments — 37a — Derek Follett

Abstract: Microfluidics is the study of the movement of fluids through micro-channels. This emerging technology can use micrometric volume through micro-channels that complement studying fluid dynamics, creating micro-environments for real time observation of bacterial growth, biofilm formation, antimicrobial resistance and so on. The advancement of microfluidics in synthetic biology allows us to study bacteria at the single cell level by entrapping and imaging them with an advanced confocal microscope. However, a few obstacles have been seen when attempting microscopic imaging through microfluidic devices and working with anaerobic bacteria. During time-lapse imaging, frequent stage movement causes the microscope to slowly lose focus, which results in blurred images and failed experiments. Also, a standard microscope setup is not feasible to study the anaerobic bacteria within microfluidics as an oxygen-free chamber is required. To overcome these challenges, I used a Creality Ender 3s1 fused deposition modeling 3D printer, Autodesk Fusion 360 CAD software, and Creality Slicer 4.8 to build a microfluidic device holder and an anaerobic chamber for a Nikon TI-2 Eclipse confocal microscope. So far, I've been able to get a more stable microfluidic device holder printed and have been making small adjustments to make sure it remains level. As for the anaerobic chamber, I am currently adjusting it to make sure that the two pieces of the chamber fit properly and are as airtight as possible. When finished, these designs will aid in both multi-day microfluidic experiments and enable testing of anaerobic bacteria in microfluidic systems.

REU South Dakota State University
Advisor(s): Dr. Nicholas Butzin

Making Soybean Hulls Economically Useful — 38a — Adam Forsberg, Mohammad Raihan, Jaimie Gibbons, Bishnu Karki

Abstract: Soybean hull and whey are two byproducts of industrial production that are currently underutilized. Traditionally, soybean hulls are partially utilized in animal diet to support the animal production and attempts have been made to produce bioproducts as enzymes and metabolites via microbial fermentation. However, the production of such bioproducts along with multiple required processing steps compared to the final product yield is still costly. Similarly, there is an urgent need for an efficient technology to recover and reuse the nutrients from whey streams. Therefore, the major goal of this research is to develop the microbial fermentation process for soybean hulls supplemented with whey streams to produce fermented bioproducts meeting that of market demand as an animal feed with less downstream processing. The research uses whey to hydrolyze the soybean hull to then feed to microbes. The soybean hulls were fermented with generally regarded as safe (GRAS) yeast-like fungi Aureobasidium pullulans under submerged fermentation conditions. Fermentation was conducted for 5 days by using a 10% solid loading rate and 30 °C incubation temperature in a shaker (150 RPM). Samples were withdrawn every 24 h for 5 days and analyzed for mass balance, crude protein content, crude fiber content, phytic acid, total phenolic content, and ash. The findings of the results show the potential of using microbes to convert soybean hulls into a more digestible animal feed ingredient. The results are very positive, the liquid byproduct produced is more plentiful and healthier with the soybean hull and whey. With our research, we can find usefulness for soybean hull and whey. Making less waste caused by the discard of the two byproducts and the implications of making more marketable healthy animal feed.

REU South Dakota State University
Advisor(s): Dr. Bishnu Karki

Correspondence Between the Segal-Atiyah-Witten Axioms of the TQFT Symmetric Modular Functor and the Eilenberg-Steenrod Axioms of the Homology Functor — 39a
— Ryan Foy

Abstract: In 1988 Michael Atiyah published his “Topological Quantum Field Theory” paper in which he formulated TQFT into an axiomatic system. This formulation uses category theory as it describes TQFT as a functor between the cobordism category and the category of R-modules. In this project, our goal is to establish a correspondence between the axioms of the TQFT symmetric modular functor (constructed by Graeme Segal in the context of conformal field theory in 1989) with another well known axiomatic system related to homology theory developed in 1952 by Samuel Eilenberg and Norman Steenrod in “Foundations of Algebraic Topology” called the homology functor. The research objective was accomplished by means of detailed analysis of each category and functor in TQFT and homology theory. In particular, the Eilenberg-Steenrod homology functor H relates the category of pairs of topological spaces and morphisms Hq relates the category Top^(2) of pairs of topological spaces and morphisms that are continuous functions to the category of R-modules and morpshisms that are homomorphisms satisfying the axioms of homology theory. The Segal-Atiyah-Witten axioms, satisfied by symmetrical modular functor Hq relates the category qCob of q-dimensional compact oriented topological manifolds and morphisms that are classes of cobordisms ((q+1) dimensional oriented topological manifolds with boundaries), to the category of R-modules or vector spaces (could be finite dimensional) over a field K and morphisms that are isomorphisms. We found that there are remarkable similarities between the axioms satisfied by the homology functor H and the axioms satisfied by the TQFT symmetric modular functor . We also demonstrate the motivation of the TQFT symmetric modular functor from a Feynman path integral formulation of QFT by using the Chern-Simons functional, which is a topological construction, and note the computation of the numerical Witten invariant for 3-manifolds which can be interpreted as a consequence of the TQFT axioms satisfied by Tq.

REU Black Hills State University
Advisor(s): Dr. Parthasarathi Nag

Examining SOX2 Proteomic Partners in the Regulation of Small Cell Lung Cancer — 40a — Barien Gad (Illinois Institute of Technology)

Abstract: Small cell lung cancer (SCLC) is an aggressive rare disease with little to no development in treatment in the past forty years. When examining SCLC, there are four major subtypes that determine disease aggressiveness, chemoresistance, and progression. These four subtypes are majorly differentiated based on the expression of key transcription factors — ASCL1, NEUROD1, YAP1, or POU2F3. Clinically, the progression of Ascl1 to NeuroD1 has been observed, and is of great significance as the NeuroD1 is the most aggressive of the subtypes and tends to develop chemoresistance during treatment. It has previously been established that ¬¬SRY (Sex Determining RegionY) HMG-box-protein 2 (Sox2) as a transcription factor that serves a role in maintaining stem cells in embryonic development. Sox2 is a potentially strong oncogene due to its capacity to change the cellular state. Furthermore, we showed that Sox2 will promote oncogenesis when tumor suppressor Rb is knocked out. Undeniably, the role of SOX2 has not been well studied. In better understanding the proteomic function of SOX2, it is important to examine other proteomic partners. Using BioID, ARID1A and DACH1 were identified as proteins of particular interest that bind to SOX2. ARID1A is involved in the SWI/SNF complex which is important for chromatin remodeling and shows consistent expression across all four subtypes. DACH1 plays an important role in embryonic cell fate and interestingly shows a unique expression in the NEUROD1 subtype. To better understand the role ARID1A and DACH1 play in SCLC and chemoresistance, the two transcription factors were knocked down using siRNA in two different SCLC lines. Cell viability in the knockdown samples was then examined using Alamar Blue Assay. By these investigations we aim to further understand the SOX2 network and contribute to SCLC therapies.

REU Sanford Research
Advisor(s): Michael Kareta

Can A36 Steel be a Simulant Material for Corrosive Testing Instead of the USS Arizona?
— 41a — Charles Gauker

Abstract: During the bombing of Pearl Harbor, the USS Arizona was hit by several enemy attacks, and ultimately it and 1177 members of its crew sunk to the bottom of the harbor. Since then, the top deck of the USS Arizona was salvaged, and the remaining section of the battleship became a memorial and tomb for the sailors lost in the battle. While in the harbor, 500,000 gallons of fuel oil remained in the hull and began leaking into the ocean. Previous studies have tried to determine how long before the hull degrades and releases all the remaining oil, but the samples of the USS Arizona are becoming scarcer as time passes. The steel from the USS Arizona is chemically comparable to some modern steel under the categorization of A36, which gets its name from the 36 ksi tensile yield strength which the steel is known for. This project will compare modern hot-rolled A36 steel plates and A36 rivets with samples taken from a previous research project involving the USS Arizona to determine if A36 steel can replicate the corrosive and physical properties of steel from the USS Arizona. The tests performed on the A36, and USS Arizona samples were galvanic cell corrosion testing, X-Ray Fluorescence, metallographic comparison, and Vickers microhardness. Early data from XRF show that the A36 steel plate and USS Arizona plate share most alloying elements. In contrast, the A36 rivet contained large amounts of Aluminum, Silicon, and Strontium, which were not prevalent in the other samples. As such, A36 steel is too vague of a category for a focused research effort, and instead, the samples will have to be checked for carbon content for proper labeling in this project.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Michael West, Dr. William Cross

Quantitative analysis of phenotypic variability of shoot internode length for use in selecting improved canopy architecture — 42a — Cameron Graf, Bryce McMinn, Anne Fennel

Abstract: Internode length is a key factor in determining vineyard spacing, canopy structure, and overall yield. Grape vine growth between cultivars varies, thus the training methods used must adhere to the internode length. The more vigorous the plant, the more space it must have to prevent shading to promote good fruit ripening. While different training systems are used to accommodate differences in cultivar growth characteristics, there has been limited genetic analysis of shoot architecture as a selectable trait. The goal of this research is to identify genetic control of internode length using a F2 population and linkage map to determine the genetics regulating vine size. Data was compared to the F1 parents tracking heritable traits, and phenotypes were quantified to determine genetic control. We performed a phenotypic characterization of the internode length of the grape vine shoots in an F2 population derived from a single F1 progeny of a cross between the native Vitis riparia 'Manitoba 37' and wine grape V. sp. 'Seyval Blanc.' Methods used included taking three samples of replicate shoots per plant of the 292 F2 population plants, recording the number of nodes and length, and statistically analyzing the internode characteristics. Average internode length of the F2 and F1 populations were 10.5 and 9.8, respectively. Progeny internode length showed a normal distribution with variation in internode length across the F2 population. Quantitative trait loci (QTL) analysis was then conducted to determine chromosome location and candidate genes regulating internode length. Markers identified will be used to select vines with improved growth habit and size.

REU Middle Tennessee State University
Advisor(s): Anne Fennel

Growing Produce With Different Methods — 43a — Ash Grassrope, Maddy Ryan, Isaah Quilt

Abstract: We are participants in a youth-led nonprofit program that works to provide fresh produce for our community. We are experimenting with many different methods to grow food indoors and around our garden. We are trying to understand what are the most efficient and effective ways to grow healthy food. We planted produce both outside and inside of a greenhouse, in raised beds with an irrigation system. We also used hydroponic methods in a greenhouse, which used styrofoam float trays for lettuce, and dutch buckets for tomatoes. Lastly, we used a hydroponic growing tower indoors, growing lettuce and strawberries. We used intuitive methods to get a sense of the pros and cons of the different methods. Through this research, we were able to figure out that growing indoors or in a greenhouse is potentially valuable because it providesless risk from weather events for these plants. However, we also realized that growing outside in raised beds provides more opportunities to expand the amount of food grown. Other people in our community can take up this method more easily, as it does not require electricity. We also learned that hydroponics works quite well, allowing plants like lettuce, tomatoes, and strawberries to grow in environments safer from extreme weather. This research project is important because it provides valuable knowledge to our community about how we might best grow food in Lower Brule. This is useful for our food sovereignty work, and our goal of providing greater access to healthy produce. We look forward to researching and expanding these methods in the future.

REU KulWicasa Wopasi
Advisor(s): Devon Riter

Characterization of Spatial Composition Gradients in Ag-Cu-Ni, Ag-Cu-Ti Thin-Film Alloys Synthesized By Plasma Laser Deposition (PLD) — 44a — Thomas Greathouse III, Ananth Kandadai

Abstract: Corrosion is a ubiquitous phenomenon ranging from the bacteria mediated corrosion of industrial infrastructure to inside the body where bio-medical implants are subject to corrosive environment. A corrosion resistant coating is a solution to both problems alike. The goal of this research is to create and characterize the physio-chemical properties of ternary alloys created by the novel combinatorial process for potential application in corrosion resistant coatings. In this project, two ternary alloy thin films with spatially varying stoichiometry, AgX-CuY-TiZ and AgX-CuY-NiZ, were created by pulsed-laser deposition (PLD). The samples were sectioned into 49 sites, each containing a local average composition as measured with EDS. Where only layer synthesis time was varied to ensure uniform layer thickness, a significant difference in maximum atomic % Ag were seen between the two specimens, possibly attributed to the deposition sequence. Nanoindentation tests conducted correlate an increase in %Ag with lower modulus E, and hardness H. Increasing the % Ag decreases hardness and elasticity. X-ray diffraction (XRD) was utilized for crystal structures present on selected sites. Though an amorphous alloy film was predicted due to rapid thermal quench rate (~1011 K/sec), peaks from crystallites of Face-centered-cubic (FCC) symmetry and other unidentified symmetries were prevalent. Substrate heating (5 hours, 200° C) facilitated crystallization during the course of synthesis. Electrical resistivity measurements on Ag-Cu-Ti sample reflect the trend in resistivity of each metal in bulk form, e.g. additional Ag decreases resistivity. The range of physical properties characterized within the alloys synthesized allows one to select for composition to achieve a specific purpose as a thin-film coating.

REU UC Berkeley
Advisor(s): Dr. Bharat Jasthi

Characterization, Processing, and Performance of Belle Fourche Shale for Ceramics — 45a — Kiran Green, Samuel Kessinger

Abstract: Belle Fourche Shale was processed and characterized for use as a ceramic. The shale was wet sieved to produce products that were greater than and less than 150 microns. X-ray diffraction (XRD) revealed that the raw material (prior to sieving) contained around 35% quartz and a variety of clays, nontronite, montmorillonite and kaolinite). However, the sub 150 micron material was enriched in clay content compared to the unprocessed materials, whereas the oversize material was enriched in quartz compared to the starting material. Particle size analysis was performed on the sub 150 micron particles, and showed that the mean particle size was around 10 microns. Scanning electron microscopic analysis further confirmed the small plate size, which appeared to be primarily clay particles. Next, the fine particles were rolled into a green body, dried and fired (998 o C). The fired piece was again analyzed by XRD and contained 6% hematite (possibly responsible for the bright orange color of the fired piece), 55% quartz, 19% microcline, and various other crystal structures. Three-point bend testing and micro-computed tomography were also conducted on the fired to determine strength and porosity.

REU University of Mary
Advisor(s): Dr. Jon Kellar

Analyzing Heat Generated from Electro-Osmotic Flow Utilizing Computational Fluid Dynamics— 48a — Jordan Grothe, Ashley Jorgensen

Abstract: In the absence of extensive vascularization, the transfer of essential fluid and nutrients through human tissue is limited to diffusion and weak interstitial flow. Electroosmosis, or the flow of fluid driven by an electrical field, has become a promising solution. Clinicians and scientists have recently began applying an electric field to human tissue to promote stronger interstitial flow; however, optimization of this process has proven to be a significant challenge due to the ohmic heating that occurs. Cells function and proliferate within a small range of temperatures, and exposing cells to voltages exceeding the threshold will cause them to degrade and die prematurely. This research seeks to better understand and quantify the range of voltage where the heat generated leads to cell degradation and death. When voltage is applied, heat is generated, yielding an increase in the temperature of the nearby cells. At lower voltages, this heat easily dissipates at the surface without causing a significant increase in temperature; however, at higher voltages, the overall tissue increases in temperature, and cell death begins to occur. Utilizing a computational fluid dynamics software, Sim Center Star-CCM+, a representative model of tissue mimicking a clinical application of electricity was created and used to test different voltages while monitoring the temperature and time; then, this data was compared to prior-established values depicting when cells undergo irreversible damage. Analysis revealed that, for a 10 mm diameter cathode/anode, an electric field of 3729 mV/mm was the threshold for cell degradation after 5 seconds; for 30 seconds, the electric field threshold was 1340 mV/mm. Research has already shown that electrical stimulation can drastically increase the rate at which a wound heals; understanding the thresholds for when damage occurs will allow clinicians and scientists to optimize this process while avoiding cell damage.

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

RNAseq Analysis of ENOD2 and ENOD40 Nodule Zone in Soybeans — 49a — Savannah Gruber, Sunita Pathak

Abstract: Soybean roots produce root nodules in association with nitrogen-fixing rhizobia bacteria. These group of bacteria can convert inert dinitrogen into usable ammonia through a process called biological nitrogen fixation. A mature nodule has a central zone that is encircled by peripheral tissue that is made up of endodermis-separated nodule parenchyma and nodule cortex. Rhizobia bacteria, which fix nitrogen, are present in the infected cells of the central tissue. The early nodulin gene ENOD40 is expressed in every cell of the nodule primordium, while the ENOD2 gene is expressed in the inner cortical cells at the proximal and lateral site of the nodule primordium. By analyzing the mRNA profiles, my goal is to identify the genes that are differentially expressed in parenchyma tissue (ENOD2) and central zone tissue (ENOD40) early during nodule development. Previous work in the lab had obtained transcriptomes of these zones using isolation of nuclei tagged in specific cell types (INTACT). To determine the differentially expressed genes, RNASeq analysis was performed as follows: Cutadapt was employed for successful quality trimming; Hisat2 was used to index the reference genome assembly and map the trimmed reads; Using HTSeq, mapped read counts were obtained and a matrix table of read counts for all the samples were created; DESeq2 was used to identify genes differentially expressed between the two nodule zones. At 5 dpi, 4 genes were upregulated in central zone versus peripheral zone while 18 genes were upregulated in peripheral versus central zone. At 7 dpi, 25 genes were upregulated in central zone versus peripheral zone while 22 genes were upregulated in peripheral versus central zone. The results yielded several candidate genes including transcription factors and hormone metabolism genes for functional analysis.

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

Using BASIN-ML for Cellular Analysis and Data Interpretation — 50a — Sam Haas, Timothy Hartman, and Evgeni Radichev

Abstract: Both cellular comparison and scientific interpretation are becoming increasingly important within the scientific community. However, in the midst of current analytical software development, there are still some challenges that researchers face. While current cellular image analysis software is already quite powerful, both sufficient reproducibility and individual system modification have room for improvement. BASIN-ML can be utilized by researchers that have minimal programming knowledge to easily run mass cellular image analyses. This will enhance the user's accessibility to a simple, and reproducible method for macroanalysis on cells. The overarching goals of BASIN-ML start with having a simple way for researchers to run analyses on large amounts of cells. The open-source software uses preset machine learning to further improve the reliability of the cellular analysis. But, the user has the ability to import their own machine learning, to get more specialized, or personalized results. BASIN-ML's usability can be expanded by implementing different kinds of image modalities (SEM, confocal, light microscopy, etc.) BASIN-ML primarily aims to assist researchers by readily offering reliable, and reproducible data analyses on sizeable quantities of cellular images. The necessary information can then be extracted with an automatically generated report. With the user-friendly customization of the desired machine learnings, users can have a solid foundation for practically limitless procedures. After imaging, and running a variety of different cell types through BASIN-ML, it appears that the software meets its expectations. It performs strong cell segmentation, and provides accurate information on the data extracted in the report. While outside machine learning software is able to be imported, the limits to that feature are still unknown. There is still more testing to be done, but the primary goals have been reached.

REU University of South Dakota
Advisor(s): Etienne Gnimpieba

Feeding Preference and Feeding Behaviors in Northern Prairie Skinks — 51a — Mikaela Hanisch

Abstract: The Northern Prairie Skink (Plestiodon septentrionalis) is a ground dwelling lizard within the great plains ranging from Kansas to Manitoba and known to mainly feed on arthropods. There is little known about their arthropod feeding preferences and feeding behaviors. This research was conducted at the Oak Lake Field Station (OLFS) in Brookings County, South Dakota. Skinks captured at OLFS were kept in captivity and provided a variety of ground level arthropods found at OLFS. Feeding trials were conducted on four male skinks total, three adults and one juvenile, using a ten-inch by ten-inch section of their twenty-gallon enclosures to limit the amount of space between the skink and the live arthropod. A GoPro camera was used to record the trials, then the video recordings were reviewed later, and their feeding behaviors were assessed and documented at that time. The feeding behaviors that were assessed for the time lapsed from dropping the arthropod into the feeding section until fully swallowed, time lapsed of the trial when the arthropod was not consumed, interested in the arthropod, and attempted to consume. A total of 25 different species of arthropods were offered to the four skinks collectively in the 188 feeding trials. From this research, it appears that the Northern Prairie Skinks' diet primarily consists of the class Orthoptera with 52 successful feedings, Arachnids (35), followed by Isopoda (8). There was a strong interest in the order Coleoptera with 22 failed attempts for consumption. There was also interest in the class Diplopoda and larvae from order Lepidoptera, with 17 attempts to figure out an angle to grab, with one successful consumption. In conclusion, this research gave a clearer picture of what the Northern Prairie Skinks' food preferences and their behaviors during consumption by showing signs of interest or attempting to consume. With this we can infer that they may consume other species within the Coleoptera order than the 8 species they were presented with. The length of the Diplopoda and Lepidoptera may have prevented the skink from consuming, however, they may consume smaller species than the 4 species presented.

REU South Dakota State University
Advisor(s): Dr. Bruce Eichhorst

Grassland Passerine Habitat Preference: Recently Burned vs. Unburned Grassland in Eastern South Dakota — 53a — Jay Holm

Abstract: Grasslands are among the most imperiled ecosystems in the world due to fire suppression, poor grazing practices, agricultural/urban development, habitat fragmentation, and woody encroachment. It is important to understand how recovery efforts such as prescribed burns affect grassland birds, as little research has been done on these effects in the immediate years following burns. In this study, our objective was to determine if grassland passerines such as bobolink (Dolichonyx oryzivorus), grasshopper sparrow (Ammodramus savannarum), western meadowlark (Sturnella neglecta), dickcissel (Spiza americana), brown-headed cowbird (Molothrus ater), and sedge wren (Cistothorus platensis) display any preference between recently burned and unburned grassland. Point counts and nest searches were performed at the Oak Lake Field Station in eastern South Dakota to gauge bird habitat preference. Two repetitions of twenty point counts on 50m-radius plots were conducted during the breeding season of most grassland passerines. Ten of the plots had recently been burned, while the other ten had not. Nest searches were conducted throughout the field station from June 7 th through July 7 th of 2022. We also performed vegetative analysis at all plots and nests. We found that all species listed above except sedge wren displayed a slight increase in abundance at unburned plots, with the strongest increase shown by bobolink (21 at burned plots vs 47 at unburned) and grasshopper sparrow (17 at burned plots vs 64 at unburned). Average litter depth at unburned plots was over triple that of burned plots (2.74 inches at unburned plots versus 0.87 at burned). Although only three sparrow nests were found, all three were within unburned grasslands with an average litter depth of 6 inches at nest sites. Our findings suggest that litter depth is an important variable in grassland passerine habitat selection, and recently burned grassland with minimal litter may be less favorable.

REU South Dakota State University
Advisor(s): Dr. Bruce Eichhorst

Effect of Excell All Natural on Characterization of Bacteria in Rumen Fluid of Beef Cattle — 54a — Isha Hooda, Emily Fowler, Anlly Fresno Rueda

Abstract: In ruminants, millions of bacterial species reside in the first chamber of the stomach in beef cattle as each host consumes a different diet resulting in a different microbiome. As ruminal microbiomes tend to vary amongst different cattle, there are some types of bacteria that tend to be more abundant than others. The puzzle lies within the different types of bacteria that exist in the stomach depending on the diet of the cattle leading to a variety of species in the stomach. This project aimed to look at the specific types of bacteria when rumen fluid was mixed with a commercial product Excell All Natural (Pacer Technology Inc.). Starting with a total of 3000 kmers, contigs were assembled from this dataset using customized Perl scripts. A total of 88 contigs were assembled and the combined length was 3,243,256. Genome sequences were run through RAST to characterize the different types of bacteria enriched from the commercial product and running metagenomic analysis to determine the metabolic function of the bacteria. The output from RAST provided information that would help create pathways to better understand the function of the bacteria. In the future, the goal is to continue to find more genome sequences to figure out the function of bacteria and which ones are the most abundant.

REU Augustana University
Advisor(s): Dr. St. Pierre Benoit

Assessing Genetic Differences among Morus rubra, M. alba and Hybrids — 55a — Mikayla Janis, Michael Little Eagle, Bibek Adhikari, Dillan Nelson

Abstract: North American Red Mulberry hybridizes with an introduced invasive Asian white mulberry that co-occur throughout the range of Red Mulberry. Hybridization between the two species is believed to have threatened the integrity of the endangered Red Mulberry in North America. This has also caused taxonomic confusions among some taxonomists and public alike. Mulberries are used by Native Americans for medicine and as fruits, in Asia they are commercially grown for silkworm industry. The main objectives of this research were to 1) conduct literature review to gather prior knowledge about Red Mulberry, White Mulberry, and hybridization between the two species, 2) determine the placement of hybrids in a previously published phylogeny of the genus Morus, and 3) develop molecular markers for identifying pure Morus species and their hybrids. To accomplish these objectives, we reviewed previously published research articles and datamined M. rubra ITS and trnL-F sequences available in NCBI GenBank and phylogenetic analysis were conducted using Maximum Likelihood method. We also collected Morus samples from three different sites in Kansas and Nebraska. We extracted DNA from the fresh leaf, the ITS and trnL-F regions were amplified through Polymerase Chain Reaction and sequenced using Sanger Sequencing. We have also sent DNA samples from each of the species and hybrids for the whole genome sequencing. We have just received some sequence data, the analysis of which, is currently in progress. We expect the placement of hybrids in between Morus alba and Morus rubra in the phylogenetic tree. In our presentation, we will discuss sequence variation among the samples of M. alba, M. rubra and hybrids.

REU South Dakota State University
Advisor(s): Madhav Nepal

Testing Guanidine's toxicity and its Potential as a Nitrogen-Fertilizer Using Non-N2-fixing Cyanobacteria — 56a — Brandon Jatico, Kathryn Kass, Maxwell Jakubiak

Abstract: Guanidine (CH5N3), a nitrogen rich compound containing 71.1% nitrogen, has various uses such as a propellant, a precursor to pharmaceuticals, antimicrobials, and a slow-release N-fertilizers. The diazotrophic cyanobacterium Anabaena sp. PCC 7120 was engineered to produce and secrete guanidine using N2, CO2, mineralized water, and sunlight. As a N-fertilizer, guanidine however degrades slowly and is a toxic compound causing genomic instability, chlorosis and protein denaturation in bacteria. Guanidine's utilization and detoxification relies on guanidinase, an enzyme that degrades guanidine coded by gene Sll1077 in Synechocystis 6803, providing tolerance to guanidine (Yu et al. 2021). The level of tolerance however is unknown. To understand cyanobacterial tolerance to guanidine, cultures with 0 mM, 1mM, 2mM and 3mM of guanidine concentrations grew in nitrogen present Bg11 and deprived Bg11 for 10 days. Cell density of the cultures were measured and chlorophyll content was measured to determine cell viability. Both cell density and cell viability displayed a progressive decline in the guanidine-containing Bg11 cultures, as guanidine concentrations increased. Bg11 cultures showed no significant change in cell viability or cell density, compared to day 0, over the growing period at all concentrations except for 3mM. Bg11 3mM depicted an average cell density value of 0.222, and chlorophyll content value, 1.64 ug/mL. Bg11 cultures reveal tolerance to guanidine is around 3mM as cell density dropped below the day 0 value. Decline in cell density and viability of Bg11 cultures with guanidine suggests expression of Sll1077 is possibly inhibited by the abundance of nitrogen. With all Bg11 cultures showing no significant change in growth or viability, except at the highest tested concentration, 3mM, could imply a minimum threshold before guanidinase begins to be expressed in nitrogen absent conditions.

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

Use of an LC-MS/MS Method and Chemometric Analysis to Authenticate Aspirin — 57a — Ashton Jensen

Abstract: The illicit trade of pharmaceuticals is a growing and developing industry. Current methods to combat this industry are falling short of their intended goal; unique packaging and serialization are easily replicated by counterfeiters, supply chain management is ineffective in nations with limited governmental regulatory industries, and methods of product authentication are underdeveloped. Product authentication via advanced chemical analysis allows for definitive authentication of authentic or counterfeit pharmaceuticals. In order to further develop pharmaceutical product authentication methods, a previously developed liquid chromatography-tandem mass spectrometry (LC-MS/MS) and linear discriminant analysis (LDA) method was expanded via the discovery and addition of multiple other chemical compounds. Because the initial method was limited to three compounds, expanding the number of unique compounds was hypothesized to increase the authenticating power of the method. Five unique compounds were discovered for addition to the method. In positive mode mass spectrometry, unique ions, likely corresponding to unique compounds, at 109.2 m/z, 229.2 m/z, and 359.4 m/z were found. In negative mode, two more unique ions, 153.0 m/z and 261.0 m/z, were found. These precursor ions were further fragmented and analyzed to determine the fragmentation patterns of these compounds. The resulting transitions were then used to expand the initial LC-MS/MS method. The addition of these compounds to the method should increase unique identifiers from three to eight compounds, thereby increasing the authenticating power of the LC-MS/MS, LDA method. The next steps in this project include implementing these ions into the method, testing the consistency of the newly identified ions, and testing the effectiveness of the method using LDA.

REU South Dakota State University
Advisor(s): Dr. Brian Logue

Synthesis of Perfluoropropyl Substituted Sulfur Containing Phenazines for Potential Electronic Applications — 58a — Andrew Jochum, Shankar Gairhe

Abstract: Organic semiconductors are important for next generation electronics. Inorganic semiconductors are widely used in modern electronics; however, they undergo with various shortcomings like expensive fabrication cost, high temperature processing, and difficult purification techniques. On the other hand, organic materials are suitable for designing flexible semiconductors at low cost which can be processed via both solution and sublimation techniques. The major focus of this research is to synthesize perfluoropropylated phenazine compounds with sulfur heteroatoms and study the charge transfer properties and molecular state packing. Introducing sulfur on a fused aromatic ring system not only greatly affects electronic and charge transfer properties, but also initiates either thermal or electrochemical polymerization for developing redox active polymers from sulfur containing aromatic systems. A synthetic pathway for obtaining the desired compound has been attempted. In addition, NMRs have been taken at multiple steps along the procedure to ensure that the desired compound will be obtained in the end.

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

Integrin Frequency Analysis — 59a — Logan Jundt

Abstract: As the most common joint disorder, Osteoarthritis (OA) is proving to be a large issue for countries with an aging population. In OA, the cartilage degrades which causes bone on bone contact which results in constant pain for those affected. OA is challenging to treat with drugs given the avascular nature of cartilage. Currently, treatments for OA are centered around symptom relief since there is no drug approved that will slow/stop OA disease progression. The cells that make up the cartilage are called chondrocytes. These chondrocytes must regulate themselves to build and break down the cartilage when necessary through cell signaling. When this signaling isn't done properly, the chondrocytes may break down too much cartilage and result in OA. To better understand the signaling within the chondrocytes, an Atomic Force Microscope (AFM) was used to measure the movement of the cells. However, there was not enough certainty that thermal, instrument, and building noise was not a significant factor within the data. The focus of this project was to take the noise out of the displacement data to ensure noise was not significant within the data collection. The instrument noise and building noise was found from the negative control, Bare Silica. Random thermal noise curves were generated by finding the theoretical RMS value and randomly generating a curve with a minimum and maximum of ±RMS3 . A Fast Fourier Transform (FFT) was applied to each individual curve and each noise FFT was subtracted from the chondrocyte displacement curve in Python code. An inverse FFT was then taken of the resulting curve and the noiseless, time domain, displacement curve was left. The noiseless displacement curves have the same shape as the original curves which suggests that noise was not significant within the data.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Scott Wood

Testing Guanidine's toxicity and its Potential as a Nitrogen-Fertilizer Using Non-N2-fixing Cyanobacteria — 60a — Kathryn Kass (Stephen F. Austin State University), Max Jakubiak

Abstract: Guanidine (CH 5 N3), a nitrogen rich compound containing 71.1% nitrogen, and has various uses including as a component of slow-release fertilizers, a propellant, or as a precursor to pharmaceuticals and antimicrobial polymers (Wang et al. 2019). The diazotrophic cyanobacterium Anabaena sp. PCC 7120 was engineered to express an ethylene-formation enzyme (EFE) under nitrogen fixation conditions. This strain was able to produce and secrete both ethylene (C 2 H 4) and guanidine using N 2 , CO 2 , mineralized water, and sunlight (Wang et al. 2019). Guanidine however degrades slowly and is a toxic compound causing genomic instability, chlorosis and protein denaturation in bacteria. A promising potential solution is cyanobacteria Synechocystis 6803 which contains guanidinase, an enzyme that degrades guanidine coded by gene Sll1077, providing tolerance to guanidine. The level of tolerance however is unknown. To better understand cyanobacterial tolerance to guanidine, cultures with 0 mM, 1mM, 2mM and 3mM guanidine concentrations grew in nitrogen present Bg11 and deprived for 10 days. Cell density of the cultures were measured via spectrometry at and chlorophyll content extracted and recorded at to determine culture viability. Guanidine present Bg11 cultures displayed a progressive decline in both cell density and chlorophyll, especially compared to the Bg11 0 mM culture, as guanidine concentrations increased. The Bg11 3mM culture notably had an average cell density of 0.109, smaller than the day 0 value, 0.163. cultures showed no significant change in chlorophyll content or cell density, compared to day 0, over the growing period at all concentrations except for 3mM. 3mM depicted an average cell density value of 0.222, and chlorophyll content value, 1.64 ug/mL. Bg11 cultures reveal tolerance to guanidine is around 3mM as cell density dropped below the day 0 value. Decline in cell density and viability of Bg11 cultures with guanidine suggests expression of Sll1077 is possibly inhibited by the abundance of nitrogen. With all cultures showing no significant change in growth or viability, except at the highest tested concentration, 3mM, could imply a minimum threshold before guanidinase begins to be expressed in nitrogen absent conditions.

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

Rhizobial Root Nodule Count —61a — Hazem Khalaf Mohammed, Athira Sethumadhavan, Lilia Montanez Hernandez

Abstract: Nitrogen is a crucial component for regulating growth and development of plants. The roots of leguminous plants (such as Soybean, Bean, Peas for example) develop symbiotic associations with a group of soil bacteria called Rhizobia that can reduce inert N2 into assimilable NH3 to obtain nitrogen nutrition. This mutualistic association results in the formation of a new root organ called nodules where rhizobia fix nitrogen for use by the plant in return for carbon. One of the problems encountered in this kind of association is the competition between rhizobial strains for nodule occupancy. Multiple rhizobial strains in soil with different nitrogen fixation capacities compete and infect legume plants and this leads to a reduction in the overall symbiotic efficiency. The goal of the present work is to understand how Soybean roots respond to different strains of Bradyrhizobium upon simultaneous inoculation in a split root system. We hypothesized that the soybean plant would favor colonization by a strain with higher nitrogen fixation capacity. The Bradyrhizobium strains selected for this study include- USDA 110 which has a high nitrogen fixation capacity, USDA 140 which has an intermediate fixation capacity, and USDA 126 which has a low nitrogen fixation capacity. Results from the current split root assays at early time-points (7- and 14-days post inoculation) showed that root halves inoculated with USDA 110 and USDA 140 respectively (USDA 110/ USDA 140, day 0) did not differ significantly in primordia or nodule counts suggesting that the plant did not distinguish these strains at these timepoints. However, root halves inoculated with a poor nitrogen fixing strain, USDA 126, produced very few primordia and nodules compared to the USDA 140 inoculated side. These results are in accordance with our previous study wherein USDA 126 inoculation produced fewer nodules compared to USDA 110 inoculated root sides. This study provides evidence for potential selection mechanisms operating in host plants in response to colonization by Bradyrhizobium strains with varying nitrogen fixation capacities.

REU South Dakota State University
Advisor(s): Athira Sethumadhavan

Authenticating Native American Ledger Art —62a — Ava Knutson

Abstract: The American Indian Arts and Crafts Act of 1990 is a federal law that prohibits the sale or marketing of Native American art from a non-Native American. Since this law was enacted there have only been a handful of prosecutions across the country, even though fraudulent Native American art continues to be sold in large quantities. The primary focus of this research project was to determine the authenticity of seven pieces of potentially fraudulent ledger art that were purchased online. Ledger drawings emerged between the 1860s to the 1920s, largely by Plains Indian artisans. The pieces were analyzed through video comparator multi-spectral analysis, Fourier transform infrared spectroscopy, laser profilometry. These analyses were compared to a similar suite of analyses on authentic pieces of ledger art.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Grant Crawford, Dr. Jon Kellar

Distribution and infestation of Eastern Redcedar by seed-feeders — 63a — Julienne Korst, Colin Sachen

Abstract: Woody encroachment of Eastern Redcedar (Juniperus virginiana L.) (ERC) in the Northern Great Plains is a challenge ranchers and land managers are up against. The closed tree canopies shade out native grasses, transform grassland into woody land, reduce forage production and habitat for wildlife, and alter soil property and moisture regimes. Once mature, a female ERC tree can produce roughly 1.5 million seeds per year. Thus, it is reasonable to expect that discovery of ERC seed-feeders will result in potential biological control strategies. This project aims to determine if temperature and precipitation gradients affect distribution and infestation rate of ERC seed-feeders. Seven sites invaded by ERC along the temperature and precipitation gradients were selected in eastern South Dakota during summer 2022. ERC berry-like cones were collected from the ground under a collection of five trees from each site. Four replications with 100 berry-like cones per replication were randomly selected for each site. Seeds in each berry were dissected and examined for infection status. The infestation rate from each site is calculated and compared among the sites to determine the abundance and distribution of seed-feeders and the relationship associated with temperature and precipitation gradients. Seed-feeders can possibly help slow and control the rapid spread of ERC trees across the landscape. Our results will provide a basic understanding of where seed-feeders of Eastern Redcedar trees are most prevalent across Eastern South Dakota. It is critical knowledge to develop potential biological control strategies.

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

Exploring the role of uncharacterized gene yjbE in bacterial persistence — 64a —Isaac Kovash, Tahmina Hossain, Ruqayyah Amaratunga

Abstract: Antibiotic resistance has become a major global health concern, as it decreases antibiotic efficacy and continues to emerge each year. Global mortality is expected to exceed 100 million per year by 2050 unless significant steps are taken to curb this disturbing trend. A major driving force behind antibiotic resistance is a small subset of the bacterial population (known as persisters) that enter a metabolically repressed, state in response to antibiotic and allowing them to survive long-term antibiotic treatments for long periods of time. After antibiotic treatment period is over persisters can reestablish and reoccur the infection. However, the central mechanism behind persister formation remains debated and unclear. Our previous transcriptomic analysis of persister population of Escherichia coli Dh5αZ1 showed that several genes are upregulated during persister state, and we hypothesize that these genes allow cells to go into persister state in response to antibiotic. In this study, we focused on understanding the role of an uncharacterized gene, yjbE, which is upregulated in persister state gene. We used to two different mutation approaches, (1) yjbE gene is knocked out using CRISPR-Cas9 homologous recombination system and (2) yjbE gene is cloned under Plac/ara promoter, to observe its effect on the persister population. Our result showed that ΔybjE mutants have ~14 fold decreased persister percentage in comparison to control strain under Ampicillin treatment at 3h and overexpression of yjbE gene leads to cessation of growth. This result confirms that the yjbE gene play an important role in the formation of persister cells and further studies need to be done to determine how the yjbE gene helps in persister formation and identify ways to counteract its function.

REU South Dakota State University
Advisor(s): Dr. Nicholas Butzin

Generative Data Obfuscation in Low-Dimensional Settings Utilizing Generative Adversarial Networks — 65a — Trevor Krason, Dr. Kyle Caudle, Dr. Larry Pyeatt, Dr. Michael Frey

Abstract: The release of data that contains sensitive information is an issue for both corporations and governmental agencies alike. The removal of this sensitive information is a must to ensure privacy and security. The processing of data in this manner, known as data obfuscation, can be completed through a variety of methods, but no existent technique is without limitations or inherent flaws. This research aims to obfuscate data with a generative adversarial network (GAN), a system of neural networks designed to replicate samples from a population. If multiple samples of data from a population containing sensitive information, known as the marked population, are obfuscated to form target samples, a GAN can learn to reproduce samples from the target population. This obfuscated data maintains complete security where other methods such as aliasing and redaction fail, and it allows for data analysis unlike encryption. Difficulties arise for training a GAN when the number of target samples is limited. This research focuses on efficiency and stability of training GANs on low-dimensional data sets utilizing genetic algorithms, transfer learning, convolutional layering, and reinforcement learning algorithms such as proximal policy optimization.

REU South Dakota School of Mines & Technology
Dr. Randy Hoover

Metal-Metal Bonding in Tungsten Complexes — 66a — Lacey LaBee, Rina Bhowmick

Abstract: Complexes with tungsten metal-metal bonds have unique electronic structures making them relevant for applications in optoelectronic and magnetic devices. Understanding the nature of these tungsten metal-metal complexes is essential for catalyst design. To model their electronic structure, quantum chemical methods such as density functional theory (DFT) and second order multireference methods (CASPT2) were used to study three experimentally characterized ditungsten complexes: (W2(TFA)4, W2(TFA4)2PPh3, [W2(DippF)2]-2). DFT is less computationally expensive than CASPT2, so it is preferred when the results are similar; however, it cannot describe multiconfigurational electronic structures. Molecular geometries were optimized using seven different DFT functionals, specifically BP86, PBE, PBE0, B3LYP, TPSSh, M06, and M06-L. When selected DFT geometric parameters were compared to experiment, W2(TFA)4, and W2(TFA4)2PPh3 were in good agreement for all functionals; however, [W2(DippF)2]-2 was not well described by DFT. For this reason, a CASPT2 study was undertaken to best understand the electronic structure and, in turn, the experimental results. A scan along the W-W bond distance to determine the CASPT2 minima will be performed.

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

Understanding the Impact of Mural Creation on the Reservation — 67a — Melinda Lacota

Abstract: Many people know murals as important symbols used by communities and neighborhoods to express collective identities or endorse shared values. However, research is relatively sparse on the impact of murals in reservation communities. In 2022, a local youth-led educational nonprofit decided to create a mural in their community. They wanted to create something that built community pride and helped bring joy to local residents. The goals of this research were to try to assess the impacts of the mural that was created. Understanding these impacts is important to evaluate the relative costs and benefits of this project, and make more informed decisions about the potential for future mural projects in rural reservation communities. I used interviews of local residents and youth to gauge the impact of the created mural. The results of this study highlight the positive impacts of a community mural in a reservation community and discusses how these compare to the costs. The implications of this are important for community groups interested in creating positive community impact projects and potentially helps them more deeply consider the full costs and benefits of creating a community mural.

REU Sinte Gleska University
Advisor(s): Devon Riter

A Quantitative Investigation of the Effectiveness of 3D-Printed Plastic Natural Convective Heatsinks Using Computational Fluid Dynamics — 68a — Shyra LaGarde (Valdosta State University), Jack Koester, Scott Deprez

Abstract: Electronic devices employ heat sinks, which provide cooling of key components, thus improving the reliability and life of these devices. The heat sinks often rely on natural convection, which simplifies the design by not relying on a fan. This maintains a lower air velocity which helps reduce noise. This thermal management solution is cost-effective in comparison to forced convection because there are no additional components, such as a fan to promote heat dissipation. Natural convection heat sinks made of aluminum are typically used for these devices because of the material's high thermal conductivity, which can effectively transfer heat without assistance. Traditional manufacturing methods limit the possible geometries to optimize heat transfer. The objective of this research is to design optimized geometries made of plastic rather than aluminum, so we can take advantage of advances in 3D printing technology because they are lightweight, low cost, and resist corrosion. We use computational fluid dynamics software to create simulations that will predict the heat transfer performances of the heat sink geometries. The generated models compares the overall heat transfer and velocity of the traveling air. Multiple characteristics of the simulations can be refined, including ambient temperatures for a representative electric device and heat flux on the heatsink surface. By developing computational models of geometries with plastic materials we can create shapes that are not possible with conventional manufacturing methods through 3D printing techniques.

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

Mesoporous silica nanoparticles for targeted anticancer drug delivery — 69a — Lydia Lang, Nisitha Wijewantha

Abstract: New cancer diagnoses affect over 10 million people worldwide each year, 150,000 of which are colorectal cancer cases in the United States alone. Current treatment options for cancer, such as radiation and chemotherapy, are destructive to both healthy and malignant cells. Along with this, these current options are ineffective at treating late-stage colorectal cancer due to drug resistance. By using mesoporous silica nanoparticles (MSNs), we aim to increase anticancer drug efficiency and decrease healthy cell death during treatment. Veratridine is a natural product found in the lily family and shows anticancer properties by encouraging the expression of the protein UBXN2A. Eugenol is another natural product found in clove oil and shows promising anticancer properties as well by inducing cell death and inhibition of metastasis. The MSNs are loaded with either veratridine or eugenol and capped with casein protein until they are delivered to the cancer site, where they are degraded by an enzyme overproduced by cancerous cells, and the drug is released. Using a series of syntheses and analyses through TEM, SEM, XRD, BCA, and observation of cell morphology, the results show that MSNs can be accurately reproduced and efficiently suppress colorectal cancer cells with 80.6% drug loading and 85.45% drug release after 48 hours. Characterization of the MSNs confirm the spherical shape and the hexagonal mesoporous structure, suitable for optimal drug loading and delivery. These results confirm the potential for efficient and safer delivery of cancer treatment through MSNs.

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

Summarizing and Evaluating the Experience of the FAST REEU Program — 70a — Jake Larsen

Abstract: The FAST REEU program is a prestigious summer scholarship program available to freshman students upon completing their first year of college. I will be summarizing and evaluating my experience of the two summers I have spent in the program. The first summer I was paired with Dr. Srinivas Janaswamy and his graduate students, where I assisted in research on Dr. Janaswamy's cellulose biofilm project. I created functional, biodegradable films from processed corn stover and tested their functional qualities. This first part of the program is to teach students about independent research, lab etiquette, designing experiments, and how to present to their fellows. During this first summer, the program also provides other resources like career development workshops, resource tutorials, and self-betterment talks. My second year has been an internship experience under Dr. Jason Clark on his soil fertility project. During this internship I assisted with fieldwork, processing collected samples, and supportive work. The second year is for students to choose fields that are of interest to them, so they can gain some experience with their potential future. Specifically for Dr. Clark's internship, he focused on learning how to layout research plots and treatment areas, learning how to properly collect plant and soil samples in a standardized fashion. Also, a sense of attention to detail was prevalent in Dr. Clark's instruction, especially towards sample collection and processing. Nearing the completion of my second summer I can confidently say that this program has accomplished both what it sets out to do and what I desired from it.
REU South Dakota State University
Advisor(s): Dr. Srinivas Janaswamy, Dr. Jason Clark

Synthesis of Synthetic Cannabinoid Metabolite THJ-019 Pentanoic Acid — 71a — Kylie Larson

Abstract: Synthetic cannabinoids pose a risk to their users, as they have been associated with multiple deaths. These synthetic cannabinoids are a major component in the illicit drug economy and are commonly combined with other drugs such as opioids, alcohol, and other dangerous products. THJ-018 is the major metabolite of THJ-2201, a new synthetic cannabinoid. There are currently no synthetic pathways in making this metabolite. This metabolite is useful in toxicology reporting and drug screening. A synthetic plan for the metabolite was made using the expertise of Dr. Rachel A. Willand-Charnley and Scifinder functionalities. So far, the first synthetic step has been tentatively completed. Synthetic materials and methods include, but are not limited to, NMR analysis, flash column chromatography, and a Grignard reagent. Future work must be done to complete the synthesis of this compound.

REU South Dakota State University
Advisor(s): Dr. Rachel A Willand-Charnley

Investigating Carbamoylated Erythropoietin as a Pharmacological Treatment for Autism Spectrum Disorder — 2p — Sean Lemke, Kevin Schumacher, Amaya Street, Liza Schoenbeck, Vedant Thakkar

Abstract: Autism spectrum disorder (ASD) is a neurodevelopmental disorder that affects over 2% of the population worldwide, which is characterized by repetitive behaviors, restricted areas of interest, deficits in social communication, and high anxiety. Currently, there are no know effective treatments for the core features of ASD. Previous literature has established erythropoietin (EPO) as a promising antidepressant, working as a neurogenic and neurotrophic agent. However, EPO is also associated with an increase in red blood cell production, leading to high blood pressure, fever, and edema amongst other negative conditions. Carbamoylated erythropoietin (CEPO), a newly synthesized compound from the Sathyanesan group at the University of South Dakota, appears to retain the neuroprotective factors of EPO without the hematologic properties. Using an idiopathic ASD mouse model (BALB/c), we investigated whether CEPO can recover deficits in social behavior and anxiety which are associated with ASD. BALB/c mice score markedly higher in scales of anxiety and lower in sociability. C57 mice were used as controls. After an injection period of CEPO (40 µg/kg in PBS) or vehicle over 21 days, we analyzed the behavior in the three-chamber social approach, the open field, the elevated plus maze, and the Porsolt's forced swim tests. Preliminary evidence suggests a rescue of heightened anxiety and lower sociability, suggesting that CEPO may be an effective pharmacological option for treating ASD. Upon completion of behavior testing, brain tissue samples will be harvested to examine both the gross physical structure and levels of gene expression in brain structures related to behaviors of anxiety and sociability.

REU Augustana University
Advisor(s): Dr. Alexander Kloth

Decoding the Population Genetics of Artemisia ludoviciana Using Nuclear ITS and Chloroplast trnL-F DNA Sequences — 3p — Michael Little Eagle, Bibek Adhikari, Dillon Nelson, Mikayla Janis

Abstract: Artemisia ludoviciana (Nutt., Asteraceae family) is a plant species native to North America, distributed throughout from Canada to Mexico. The plant is important for its ecological services, medicinal and ornamental uses, as well as cultural importance to the indigenous communities of North America. Although there are multiple published works on the medicinal uses and phytochemistry of the species, very little is known about its genetics and genomics. The main objectives of this study were to analyze genetic resources already available in the GenBank, determine the phylogenetic placement within the genus Artemisia, and work toward developing whole genome sequences for its nuclear and chloroplast DNA. To achieve these objectives, we datamined sequences using the NCBI BLAST Search and constructed a phylogenetic tree of the North American Artemisia species. We also collected fresh leaf samples from Iowa, Kansas, and South Dakota for DNA extraction. Nuclear ITS and chloroplast trnL-F gene regions were amplified using Polymerase Chain Reaction and sequenced using Sanger Sequencing. Phylogenetic analysis of the ITS region and trnL-F sequences available on the GenBank shows that A. ludoviciana and other North American Artemisia species form a monophyletic group consistent with the previous studies. We expect our addition of the ITS region and trnL-F sequences in the present study will perhaps show the samples collected from Iowa, Kansas and South Dakota will form a monophyletic group. We have submitted samples to Iowa State DNA facility for the whole genome sequencing, and an update on the genome building will be discussed at the presentation.

REU South Dakota State University
Advisor(s): Madhav Nepal

Materials and Manufacturing for the Future: Lakota Tech High School — 4p — Elaine Locke, Catherine Chapman, Madison Long

Abstract: 3D Printing allows individuals and manufacturers to quickly produce products which are composed of complex shapes. The goal of our project is to configure a model replicating an organic bison with realistic details using computer aided design (CAD) software and resin material. The model's details consist of both flat and intricate surfaces within the design itself. The South Dakota School of Mines and Technology lab will be utilized along with advisors in computer and experimental engineering and mechanics. This project will be beta-launched into our school's future artistic endeavors in 3D modeling and electronics.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Katrina Donovan, Ms. Caitlyn Bordeaux

Exploring the uses of heterogeneous frustrated Lewis pairs — 5p — Nathan Loutsch, Alex Castillo

Abstract: Frustrated Lewis Pairs (FLPs) utilize sterically hindered Lewis acids (LAs) and Lewis bases (LBs) to polarize and even heterolytically cleave bonds or activate small molecules like carbon dioxide. In a heterogeneous FLP, the LA, LB, or both would be in the solid phase. This provides increased separability and recyclability. We have investigated the uptake of glycerol on alumina sites in glycerol/water waste mixtures and the polarization of a carbon dioxide CO bond for a Diels-Alder reaction. FT-IR was used to analyze the contents of the glycerol water mixture, and GC-MS and 1H NMR were used to analyze the Diels-Alder products.

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

Genome-wide association mapping for -glucan in Oat (Avena sativa) — 7p — Emily MacDonald, Sumandeep Bazzer

Abstract: Oat beta-glucan (β-glucan), a soluble dietary fiber, has nutritional value due to its positive health benefits to humans. Understanding the genetic basis of β-glucan is important for oat breeding, and genome-wide association studies (GWAS) are a useful approach to identify genomic regions associated with complex traits. Thus, our objective was to identify single nucleotide polymorphic (SNP) markers associated with β-glucan. This study was conducted using ~230 breeding lines grown at five locations in South Dakota for two years, 2020 and 2021. There were significant ($P \leq 0.00$) positive correlation ($0.48 \leq r \leq 0.85$) between different locations for β-glucan. β-glucan has high heritability, ranging from 0.78 to 0.88 across locations. After quality assessment, ~7000 polymorphic SNP with minor allele frequency ≥5 % were used for association analysis. GWAS analysis was conducted using FarmCPU and Blink algorithms. Within location analysis for 2020, we found 26 significant associations for β-glucan distributed over 11 chromosomes and explained phenotypic variations (R2) ranged from 0.1 to 5.8 %. Out of these 26 associations, three associations identified on chromosomes 2A, 4D, and 6A were consistent in at least three locations. Similarly for 2021, a total of 8 associations for β-glucan distributed over four chromosomes were identified, and three associations on chromosomes 1D, 5C, and 7C were consistent in at least two locations. Gene annotation in the candidate regions revealed several putative proteins of specific interest. Favorable alleles from significant SNPs identified and validated in this study may be an importance resource for improving β-glucan content inoats. This study provides valuable insights into the genetic basis of β-glucan in Oat.

REU University of Rhode Island
Advisor(s): Melanie Caffe-Treml

Loading Porous Wall Hollow Glass Microspheres with Nanoparticles and Creating a Silica Coating — 8p — Katherine Mathias

Abstract: Creating systems to detect counterfeit products grows in importance as the illicit economy continues to expand. Porous wall hollow glass microspheres (PWHGMs) could serve as counterfeit detection systems if doped with functional materials. Additionally, a coating on the exterior of the spheres is necessary to contain the functional material. In this research, graphene quantum dots (QDs) and gold nanoclusters (NCs) are loaded into PWHGMs. Both graphene QDs and gold NCs are fluorescent meaning when the spheres are broken, the nanoparticles are released and can be detected. The coating is composed of silica nanoparticles which are synthesized using the Stöber process. The PWHGMs are combined with the aqueous nanoparticles under vacuum to promote diffusion into the spheres and increase loading yield. To synthesize the coating, tetraethylorthosilicate, methanol, and a base catalyst are combined and added to the loaded microspheres. VSC images exhibit that the graphene QDs were successfully loaded into the PWHGMs. SEM images suggest that silica coatings were synthesized on the PWHGMs with low evidence of silica particle agglomeration. This research found that graphene QDs can be successfully loaded into PWHGMs and the Stöber process is viable to synthesize silica coatings on the PWHGMs. Further research is needed to evaluate whether gold NCs were successfully loaded into the PWHGMs.

REU Augustana University
Advisor(s): Dr. Grant Crawford

Materials and Manufacturing Education for the Next Generation : Sturgis Brown High School — 9p — Joseph Mayer

Abstract: The goal of this research is for the students' exposure and integration of the technologies of 3D printing for future career use and/or entrepreneurship. The participants come from a diverse background of culture, ethics, motivations, and personalities, which will prove to have a wide application for future use. Participants were exposed to all sorts of aspects of engineering from chemical, geological, mechanical, etc. This provided an amazing breeding ground for critical and creative thinking for scientific solutions for a wide spectrum of life and science. The participants in this camp were challenged to build and troubleshoot their own 3D printers, learn and understand the software to run these machines and to come up with 3D printed solutions to solve engineering problem and everyday tasks and challenges, as well as how to use this technology to possibly find a niche and make a business or sale a product out of it. Our finding for this research comes from the participants' reflection of their experience through a final project presentation where they will cover their personal experience of camp, 3D tech, their possible future implications of this technology, and diving further into the importance of art within science or science within art.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Katrina Donovan

Sodium Alginate and Silk Processing and Mechanics — 10p — Evan McConnell, Dr. Travis Walker, Laura Brunmaier, Adam Trapp

Abstract: There is a strong need for biocompatible materials in the medical industry. Currently, Silk Fibroin is a widely used biomaterial that demonstrates high biocompatibility, mechanical strength, and the ability to be easily modified. Alginates are commonly used in the pharmaceutical and food industries. Silk Fibroin is extracted from Bombyx mori cocoons in a degumming process. Both biomaterials could prove to be suitable for tissue engineering. This research provides a deeper understanding of properties of both sodium alginate and silk fibroin. Mechanical and biological characterization was executed on microtubes constructed through two different processes: co-extrusion and dip coating. The efficacy of these techniques was studied using several forms of mechanical and biological characterization. These include SEM, burst strength, compliance, and tensile testing. The data obtained provides valuable insight into the viability of a tissue-engineered vascular graft using silk fibroin as a biomaterial. A rheological analysis was also performed on silk hydrogels. The rheological analysis produced valuable data on the structural and strength properties of silk fibroin and sodium alginate. Based on these results, both biomaterials have the potential to be used in various medical applications including but not limited to vascular tissue engineering.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Katrina Donovan

Culturing Bacteria from Sediment Macroaggregates from the 4850 level of the Sanford Underground Research Facility — 11p — Ava McKeever

Abstract: Profiling microbes using the 16S rRNA gene were used to survey the composition of the microbiomes of the 4850 level of Sanford Underground Research facility. Using both liquid and solid media we took micro aggregates from sediment collected from SURF and put them on 96 well microwell plates. We then took cultures from these microwell plates and streaked them onto solid agar media to see colony morphotypes and see potential consortia of microbes. We then profiled the microbes using Illumina Next Generation Sequencing to create a library of microbial genomic data. Many species of bacteria living in the deep underground substrate of SURF are unknown. There is also potential for antibiotic-producing bacteria to be growing in SURF.

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

Extracting Manganese Using Bioleaching — 50p — Sean McQueen, Dr. Scott Beeler

Abstract: Manganese is the fourth most used metal in the world. It is a critical element in the production of steel and is also a component in many battery types, medical devices, and pigments. Currently, the United States imports 100% of the manganese used domestically, with the main imports coming from South Africa, Ukraine, Gabon, and Australia. With the global economic climate causing worldwide supply line issues, the United States will need to produce its own source of manganese to prevent an infrastructure collapse. Bioleaching is an emerging technology used to extract metal from ore using bacteria or fungus. This method is being studied as a more environmentally friendly technique as compared to common processing means of hydrometallurgy or pyrometallurgy. The research in this project focusses on testing the efficacy of extracting manganese using natural occurring organisms. Twelve experiments were prepared using four variables: pH adjustments, light exposure, agitation, and sterilization. Each experiment was compared to another in the group to identify that variable's efficacy with respect to manganese extraction. X-ray fluorescence (XRF) was used to determine the initial composition of the samples used in the project. Samples from each were then tested using an inductively coupled plasma mass spectrometer (ICP-MS) to identify how much of the starting material was extracted using each set of variables. A comparative analysis was also conducted using two concentrations of sulfuric acid and acetic acid at room temperature and at an elevated temperature to determine a baseline extraction amount.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Brett Carlson

Variation of the Seasonal Cycle of Methane sulfonic Acid Concentration in Greenland Snow — 14p — Cody Merritt, Jihong Cole-Dai, Bishnu Kunwar

Abstract: Methanesulfonic acid (MSA) is an atmospheric oxidation product of dimethyl sulfide (DMS) emitted by marine plants. MSA in polar precipitation (snow) is preserved on polar ice sheets and can be measured in polar snow. MSA records from ice cores can be useful to examine the impact of climate change on marine biogenic emissions. MSA concentration in Greenland snow follows a regular annual cycle (seasonality) – its concentration reaches an annual maximum in summer and a minimum in winter – resulting from the seasonal emission of DMS. The DMS emission may be influenced by climate. The objective of the research is to determine if the MSA seasonality linked to DMA emission cycle may have changed in the last several hundred years, as the climate of the Arctic has changed significantly. Ice core samples from Greenland were analyzed using ion chromatography and mass spectrometry for MSA and several other trace chemicals in snow at sub-annual resolution. Using calcium seasonal cycles, which are known to peak at the same time every year, we can determine what time of year MSA reaches its highest and lowest concentrations. The preliminary data for samples dated between 1600 and 1700 CE indicate that MSA concentration in Greenland snow shows a distinct seasonality and the maximum concentration occurred during the springtime for the Northern Hemisphere, around March or April. This shows a shift in the time of year that MSA reaches a maximum between now and a few hundred years ago.

REU South Dakota State University
Advisor(s): Dr. Jihong Cole-Dai

Adapting Electric Vehicles over 5G Networks with Nudge Theory — 16p — Luke Modeo-Price, Riley Basaran

Abstract: Electric Vehicles (EVs) are equipped with advanced networking capabilities, such as 5G New Radio (NR), which allows for transmitting and receiving large amounts of data, even if the vehicle's processing components are not capable of handling compute-intensive algorithms (e.g., image processing, machine learning). It is expected that future vehicular communications include the coexistence of 4G LTE and 5G transmission nodes, which can then be used to relay data gathered by EVs and other networking capable vehicles for use in real-time or near real-time algorithmic computation on edge computing servers. Inverse Reinforcement Learning (IRL) is used to derive "Nudge" parameters, specifically distraction, anxiety, and fatigue, based on data received by EVs. This data is gathered per-vehicle and transmitted via 5G NR (or 4G LTE in cases of transitioning infrastructure) to nearby NR nodes, relayed to edge or cloud computing, where it is then aggregated and processed using IRL. The results are then sent back down the network path and multicast to vehicles capable of utilizing them. Using vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications, other vehicles can be informed about unsafe driving behaviors before they occur, recent traffic incidents that have occurred, as well as roadway obstacles that may require route adjustments. Drivers that receive this information are "nudged" into choosing certain routing or control options that optimize both safety and efficiency. This entire process is simulated using Simu5G built in OMNET++, with VeinSUMO integration for simulating vehicle behavior and traffic movements.

REU Dakota State University
Advisor(s): Dr. Bhaskar Rimel

Importance of Amateur Radio and Other Related Technologies — 17p — Aiden Moechnig, Aiden Schramm, Adam Zimmel

Abstract: On May 12th, 2022, a Derecho tore through South Dakota with near seventy to a hundred mph winds. The property damage was immense, but fortunately a small group of amateur radio operators used their self-built infrastructure to prepare, react, and rebound from the traumatic weather activity. With tens of thousands of dollars in linked radio repeater setups, a small but dedicated group of radio operators were able to recover from the storm. All of them using a radio system built upon the purpose of emergency communication. Several organizations and individuals assisted in different roles in hopes of rebuilding affected communities. However, there is much work to be done as far as improving and maintaining these critical emergency systems. This is an in-depth analysis of possible caveats involved in the design. Topics include Automatic Packet Reporting System (APRS). Including the state's largest linked repeater setup, also known as SD-Link. Together these systems work together to better help others be prepared during a time of need.

REU Dakota State University
Advisor(s): Yong Wang

Synthesis and Characterization of Dipyrazolylpyridine Ruthenium Complexes for Water Splitting Reactions — 18p — Peyton Mofle, Anwar Hussain

Abstract: Ruthenium complexes are categorized as one of the best dyes(s) that can absorb light energy efficiently when it binds on Titanium (IV) Dioxide and this combination used for water splitting process. Our present study is to make a ruthenium complex that contain dipyrazolylpyridine ligand which will be used as a better catalyst for water splitting. A series of ruthenium(II) complexes has been synthesized and obtained as an air-stable dark maroon solids. These ruthenium complexes are characterized by NMR, Single Crystal X-Ray diffraction and ESI MS studies. We are reporting a brief photophysical studies on the new ruthenium complex as well.

REU South Dakota Mines
Advisor(s): Dr. Kadarkaraisamy Mariappan, Dr. Sykes

Tracing the origin of broad-spectrum powdery mildew resistance gene Pm57 in wheat wild relatives — 19p — Emmily Moses (Ohio Northern University), Harsimar Gill, Sierra Wynn, Connor Thaler, Michael Eddy Harvey, Hugo Conde, Shyam Solanki

Abstract: Powdery mildew disease causes severe damage to wheat supplies across the world. The effects of the disease, caused by the fungus, Blumeria graminis f. sp. Tritici (Bgt), are extremely detrimental to the plants cause a significant yield loss and degradation of grain quality. This disease is a major concern in farming communities and for worldwide food supply. The Pm gene has been found to be the most effective way to control the effects of the disease. The Pm gene supplies resistance to Bgt, however recently multiple deleterious traits and new Bgt isolates have caused resistance to decrease and become ineffective. Previous research has located a new Bgt- resistant Pm gene. Pm57 in Aegilops searsii has been previously mapped to the long arm of chromosome 2S s #1 with a 77Mb genomic region. Pm57 is an initiate effecter and codes for triggered immunity with local cell death. This study is concerned with the use of multiple different species of wild wheat (Ae. searsii, Ae. bicornis, Ae. shasonensis, Ae. speltoides and Ae. longisimma) to amlify the Pm57 in order to locate similarities in the resistant between the various lines of wheat.

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

Utilizing Commercial Pottery Glaze Composition to Create Glazes from Raw Materials
— 21p — Isabel Nielson, Olivia Grinager

Abstract: The art of pottery has been around for thousands of years. Ancient pottery glazes are still being researched to find composition or technique used to create the distinct designs, but there is little research being done on how to replicate those designs in a more accessible way. This research will explore the chemical composition of commercial glazes through several imaging types to give a basis for formulating a clear glaze from raw materials from the surrounding area. The base of the glaze will be water, whiting (calcium carbonate), pacer (feldspar and other minerals) and a polymer. Whiting is what is called a flux as it is the part of the glaze that lowers the melting point of silica. The polymer is a very important part when using raw materials in water because the mixture would appear as sand settling at the bottom of water without the polymer. Adding this polymer helps to suspend the materials in the water as well as make the glaze more viscous; having a higher viscosity allows an even coating of the glaze over the clay. These components will produce a clear glaze, which leaves plenty of room for modification through adding pigments to change color, adding dolomite to make the glaze matte, or changing the ratio of components to reduce the firing temperature.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Katrina Donovan

Materials and Manufacturing Education for the Next Generation: Spearfish School District — 22p — Grace O'Connor

Abstract: Minority and underserved populations of students who are in title one schools are often shorted opportunities to develop advanced technology and problem-solving skills. The goal of the research is to meet and serve this community and provide a variety of students with new experiences and skills preparing them for advanced mathematics and scienced instruction. These early exposures to 3D printers and computer aided drafting (CAD) software will allow elementary and middle school students to further develop learning in a variety of subjects and post-secondary opportunities. To begin the research middle school students and high school students were grouped and provided a Prusa 3D printer kit to build. Using a variety of methods students and coaches carefully assembled the printer. The advantages to assembling the printer verses purchasing an operational unit include coaches and students fully understanding the intricate pieces and mechanisms of the 3D printer. Personal investment and time with the equipment also allows for better problem solving and student involvement later during the drafting and printing portions of the course. Additionally, each day students and coaches began to integrate and develop CAD skills in the CAD software. To complete the grant and project development students and coaches developed objects in the CAD Software and transferred it to the 3D printer where it was translated and printed on the printer. Student engagement was high and students produced a variety of products to demonstrate their understanding of the printer and software. They also completed challenges that allowed for problem solving skill development as well as the ability to evaluate a problem and reverse engineer solution in the CAD software print solutions for developed solutions. As a result of the program development and skills students will use once the learning process is completed students will have a variety of skills to move into advanced mathematics, science and technology courses providing skills that allow them to be prepared for post-secondary learning or the job market with enriched skills.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Katrina Donovan

Determining Effects of Standard of Care Treatment on Exosome-Mediated Neurite Outgrowth — 23p — Morgan Oedekoven, Austin Walz, Sarah Farber

Abstract: Patients with densely innervated tumors suffer a worse prognosis than patients with sparsely innervated disease. The Vermeer laboratory discovered that tumors release small extracellular vesicles (sEVs, also exosomes) which serve as signals to recruit loco-regionals neurons to the tumor bed. sEVs contain a rich cargo consisting of DNA, RNA, proteins, lipids and miRNAs. This cargo is not a random parceling of cytosolic materials but rather it is governed by specific molecular signatures and cellular machinery. Cancer cells usurp this machinery and alter the sEV cargo such that, when released into the extracellular space, cancer-derived sEVs promote tumor innervation. While the lab described this mechanism of tumor innervation in 2018, it remained unclear how cancer therapies may impact these signals. My project is to define the effect of standard of care treatment on sEV-mediated tumor innervation. Given the lab's expertise in head and neck squamous cell carcinoma (HSNCC), I focused my studies on this cancer type. Standard of care treatment for HNSCC consists of cisplatin and radiation. Therefore, I treated HNSCC cell lines with cisplatin (0.5 ug/ml), radiation (4 Gy) or the combination. The cells were maintained in sEV-depleted media which was harvested 48 hours after treatment. I purified the sEVs from this media by differential ultracentrifugation, validated them by nanosight particle tracking analysis and quantified them by BCA protein assay. To assess their neurite outgrowth activity, 3 ug of total sEVs were used to stimulate dorsal root ganglia (DRG) that were isolated from wildtype mice. Forty-eight hours later, the DRG were processed for immunofluorescent localization of β-III tubulin, a neuronal marker. Controls included treatment with nerve growth factor (positive control) or vehicle alone (negative control). This is how they become innervated. Our current standard of treatment is chemotherapy (usually cisplatin), radiation, or a combination of the two. We know that patients with nerves tend to do worse, and we know what causes the innervation, but how does our standard of care treatment effect the exosomes and their nerve recruitment? This is the question guiding the research. We treated mEERL cells, a type of cell that mimics HPV + head and neck squamous cell carcinoma, with cisplatin, radiation, and a combination of the two. We then purified the exosomes from those cells, treated dorsal root ganglia--DRG (a bundle of sensory neurons) with the exosomes, and then stained and imaged the DRG. They were compared to a positive control (neuron growth factor) and a negative control (PBS-vehicle).

REU Sanford Research
Advisor(s): Dr. Paola Vermeer

The role of triethylamine in the ligand-centered reactivity on Pd triaminoborane-bridged diphosphine complexes — 24p — Jeffery Palmer, Jorge Barroso, Clara Kirkvold

Abstract: Pd complexes with triaminoborane-bridged diphosphine ligands show promise in catalysis for their reactivity with small molecules. It is not the Pd center driving the reaction, but the rather unique ligand-centered reactivity within these complexes, at the bridgehead B-N bond. This holds promise for the design of the next generation of dual-site catalysts. However, we must first understand the reactivity of this system in order to guide future work by means of density functional theory (DFT). Previous DFT mechanistic studies on reactions with HCl have shown that the bridgehead nitrogen must be protonated before the boron can act as a reactive site. Moreover, these reactions exclusively yield the trans products, consistent with experiment. When analogous reactions are performed involving water or alcohols as the substrates, the reaction is sluggish but reaction rates can be improved through the addition of triethyamine. Specifically, in the presence of triethylamine, reactions that normally take days proceed in mere minutes. This study seeks to determine the role of triethylamine in improving the reactivity.

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

Development of bismuth-doped phosphors for anti-counterfeiting applications — 25p — Delaney Patocka (Peru State College), Zishen Yang

Abstract: In recent years, anti-counterfeiting techniques have been quickly developed to combat the ongoing producing and trafficking of counterfeit goods. However, in many cases, counterfeiters reverse-engineer these techniques and are able to replicate products. Thus, it is essential to develop new types of anti-counterfeiting techniques to hinder counterfeit production. In this work, a solid-state synthesis is used to fabricate bismuth-doped germanate materials with a unique property called Photo-Stimulated Luminescence (PSL). This bismuth-doped phosphor was examined by X-ray Diffractometry for determining their crystal structures. The optical properties of the germanate were further studied. Preliminary results suggested the germanate materials had excellent fluorescence, phosphorescence, and PSL properties, which makes it very suitable for a new type of anti-counterfeit labels. We are currently working on the adjustment of synthetic parameters for the optimization of optical properties. Ultimately, this PSL material has great potential in making customer-friendly anti-counterfeit labels.

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

Analysis of Non-Uniform Strain Fields Using Digital Image Correlation — 26p — Timothy Pike

Abstract: Polymers are often utilized in the automotive, aerospace, and sports industries, because these materials promote the reduction of weight. However, polymers can be difficult to join except for the use of adhesives and mechanical fasteners, which can cause weaknesses and be timely. One method of alleviating these detriments is Ultrasonic Spot Welding (USSW), which is rapid, requires very little preparation, and relies on the strength of the polymer itself making a good candidate for bonding. However, little is known about how these joints respond to loading. In this study, the non-unform strain fields of USSW lap joints were analyzed using digital image correlation, a non-contact measurement method, to calculate displacement, measure strain, and determine how, where, and why ultrasonic spot welded lap joints fail when under axial load.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Cassandra Birrenkott

Application of Maximum Flow Minimum Cut to Identify Disruption Points in a Cyber Network — 27p — Wesley Quigley

Abstract: The advancement of technology has created a new platform for cyber criminals to commit illegal activities. These illegal activities include drug smuggling, illegal firearm purchases, human trafficking, and other illicit activities. The spike in cybercrimes, in the last decade, has presented the need to mitigate the occurrence of these events. As cyber criminals commit these illegal activities, they use different methods to remain anonymous. One of these methods, referred to as layering, adds complexity to the cyber network and is a similar representation of the Maximum Flow Minimum Cut theorem. This theorem, also known as Max Flow Min Cut, assists in providing a mathematical model of a cyber network, the cyber network is described as a series of arcs (connections) and nodes (representing routers). The use of the Max Flow Min Cut theorem represents the maximum flow of data, represented by Mb/s (Megabytes per second), through a cyber network and provides a minimum cut, which is a collection of arcs that if disrupted would efficiently stop the data flow through the cyber network. Applying this theorem to the network would represent different approaches to targeting a cyber network, which could potentially minimize illegal cyber activity. This research is directed toward examining an abstract representation of a cyber network then applying this theorem to identify critical points for disruption. After the application of this theorem, more research needs to be completed to develop other possible applications of this theorem to the cyber network. This application would be best used by examining a social network of cyber criminals rather than examining the connections between hardware. This conclusion/recommendation was achieved by looking at the variety of equipment (cords, routers, computers, connection types) that can affect how much and what direction data is flowing through the cyber network.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Saurav Kumar Dubey

Characterization of lipid droplet accumulation due to cholesterol biosynthesis inhibition — 30p — Megan Raszler, Jazmine Yaeger, Ph.D. Bethany Freel, B.S. Sonali Sengupta, Ph.D.

Abstract: While genetic mutations inhibiting cholesterol biosynthesis result in severe neurodevelopmental defects, the mechanism by which these deficits emerge remains poorly understood. Smith-Lemli-Opitz Syndrome (SLOS), the most common cholesterol biosynthesis disorder, affects 1 in 50,000 individuals. SLOS is caused by mutations in DHCR7, leading to an accumulation of 7-dehydrocholesterol or 7-dehydrodesmosterol depending on the cholesterol biosynthesis pathway utilized. As cholesterol and its metabolites cannot be catabolized by cells, excess sterols must be excreted or stored in organelles produced by the endoplasmic reticulum called lipid droplets (LDs). While our preliminary work demonstrated accumulation of LDs in SLOS neurons, it is unknown whether accumulation of LDs is 1) adaptive or pathological, 2) cell-type specific, or 3) localized to specific organelles. To characterize LD accumulation due to defects in cholesterol biosynthesis, various SLOS and control cell types were used, including mouse primary astrocytes, neural stem cells (NSCs) derived from human induced pluripotent stem cells (iPSCs), iPSC-derived and differentiated neurons, human fibroblasts, and immortalized human kidney cells (HEK293Ts). Cells were treated with inhibitors of cholesterol synthesis (Atorvastatin, AY9944, and U18666A) and assessed using immunocytochemistry (BODIPY 505/515 for LDs, TOM20 for mitochondria, KDEL for ER, and Hoechst for nuclei). BODIPY concentrations were first tested on DHCR7-deficient mouse primary astrocytes where LD levels were elevated relative to wild-type astrocytes. Few LDs were observed in NSCs, which may be due to a high proliferation rate. Like NSCs, LDs were present only in low levels in control human fibroblasts and inhibitors of cholesterol synthesis failed to change LD number or size. Current experiments are assessing LD changes in neurons and HEK293Ts and correlating biochemical severity measured by GC-MS with LD accumulation. An increased understanding of LD accumulation will lead to a better understanding of the pathophysiology of cholesterol biosynthesis disorders and help define LD associated neuropathology.

Sanford Research Center
Advisor(s): Kevin Francis, Ph.D.

Managing South Dakota Alfalfa Diseases with Commercial Biological Control Agents — 31p — Travis Rebstock, Conner Tordsen, Brandon Daniels, and Oleksandra Rachynska

Abstract: Alfalfa is the fourth most valuable crop in the United States and is widely grown as feed for livestock due to its high protein content. In 2021, South Dakota harvested 1,320,000 acres of alfalfa and has some of the most acres growing in the United States. Alfalfa seedlings are highly susceptible to disease, which reduces field establishment and yield. Oomycete pathogens, Aphanomyces euteiches and Pythium sp., have devastating effects on newly seeded alfalfa fields causing seed rot and reduced root development. Current management strategies are fungicidal seed coatings and planting disease resistant alfalfa varieties. To create more of an integrated management strategy, we investigated numerous commercial, organic biological control (biocontrol) treatments, which had previously shown to be effective against oomycetes but have not been tested against alfalfa pathogens. South Dakota and USDA isolates of both A. euteiches and Pythium sp. were evaluated against biocontrols with active ingredients such as: Streptomyces actinobacterium K61 (Mycostop), Bacillus amyloliquefaciens D747 (Southern Ag), Streptomyces lydicus WYEC 108 (Actinovate), and Bacillus subtilis QST 713 (Serenade). Biocontrol activity against A. euteiches and Pythium sp. was evaluated in growth chamber assays using seed of a susceptible alfalfa variety, Saranac. Treatment effectiveness against A. euteiches was assessed by rating seedling roots after 29 days using a standardized rating scale. Seedlings inoculated with Pythium sp. were evaluated after 5 days to calculate percent germination. Biocontrols with the active ingredient, B. amyloliquefaciens D747 have antagonistic effects against Pythium sp. increasing percent germination by up to 71%. S. actinobacterium K61 had high activity against several isolates of A. euteiches. Various biological control agents demonstrated activity against alfalfa pathogens, which provides growers with an additional management strategy to protect their fields. In Fall 2022, we plan on testing A. euteiches and Pythium sp. isolates against biocontrol treatments that use fungal antagonists.

REU Dakota State University
Advisor(s): Dr. Andrew Sathoff

Formulation of Security Printing Inks for Identification Cards — 32p — Naomi Rehberg (University of South Dakota), Dr. William Cross, James Randle

Abstract: The counterfeit market of identification cards is growing rapidly. The non-replicable features that prove an authentic card are becoming easier for these illicit companies to replicate, especially with extended feature lifetimes. With these improving fake identification cards, crimes such as identity theft, fraud, and terrorism are enabled. Creation of new security inks is thus a necessity to prevent counterfeiting of identity cards. Upconverting nanoparticles (UCNPs) have been shown to be a viable option for printing onto identification cards, as they are difficult to replicate by counterfeiters. UCNPs present unique light properties that may change the future of security printing. Inks containing UCNPs have been printed by inkjet methods previously, however, this research focused on the use of UCNPs with offset printing methods. Authentic manufacturers use the process of offset printing to print identification cards, hence this research focus. In this study, emulsions of offset printing inks, upconverting nanoparticles, and a clear offset base were studied under a 980 nm laser. The security inks created and imaged were compared on contrast, clarity, brightness, and detail. The luminescent inks that were printed by an offset printer present a viable possibility for a new security printing method. This process may be explored further in the future as it is highly applicable to the authentic market.

REU South Dakota School of Mines & Technology
Advisor(s): Dr. Jon Kellar

Identification of N2-fixing cyanobacteria from natural ecosystems to support wheat growth — 33p — Karac Richardson, Liping Gu, Lan Xu, Yajun Wu

Abstract: Nitrogen fertilizers are one of the most expensive and limiting elements in modern agricultural production. The current means of producing nitrogen fertilizer utilizes fossil fuels and is energy-intensive and environmentally damaging as a result. However, N 2 -fixing cyanobacteria can offer an environmentally friendly alternative to producing usable nitrogen, as they only require readily available sunlight and atmospheric nitrogen gas (N 2). This study seeks to isolate N 2 -fixing cyanobacteria from the local ecosystem and testing their potential as biofertilizer. To do this we collected 16 soil samples from South Dakota and Nebraska, placed them onto plates with nitrogen-depleted media to screen for N 2 -fixing cyanobacteria. Cyanobacterial samples were isolated to produce biofertilizer, which we tested to determine its ability to sustain wheat growth. The wheat samples were then harvested and baked to obtain the dry biomass. We observed that all 11 cyanobacteria strains isolated were able to support wheat growth without being supplied with nitrogen fertilizer, with some strains performing better than others. The findings from this project will help develop N 2 -fixing cyanobacteria as in situ “solar-powered living N-fertilizer factories” in crop fields to produce BioNitrogen fertilizer to reduce application of chemical N-fertilizer and its pollution to the environment.

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

Differentiation of Cell Types in the Airway Ciliary Microenvironment of PCD Mouse Models — 34p — Kathryn Rosa, Casey McKenzie, Michael Kareta, Lance Lee

Abstract: Motile cilia function as the agent of movement for mucous or fluids in the brain's ventricles, oviduct, and airways. Dysfunction of motile cilia causes a syndrome named primary ciliary dyskinesia (PCD). The most common phenotype of PCD is chronic respiratory infections. To understand the airway response to cilia dysfunction, the lab took a single-cell RNAseq approach to identify cell-specific differences in PCD mouse models with mutations in cilia genes CFAP221, CFAP54, or SPEF2. The RNAseq data uncovered trends in cell type quantities which this project aims to validate. Tracheas from the PCD models were used for RNAscope and immunohistochemistry to determine differences in airway cell types. Cell-specific markers were used to identify each cell type in the airway. Counting and comparing cell type quantities from each mouse model gives a clearer picture of how each cell type is affected by the genetic mutations. This project will improve our understanding of the ciliary microenvironment of the airway, which has the potential to enable development of better treatments for respiratory conditions in PCD patients.

REU Sanford Research
Advisor(s): Dr. Lance Lee

Internet of Medical Things: Investigating a Zebra Phone — 37p — Kasey Sager, Charles Fofie Jr.

Abstract: The Internet of Things (IoT) encompasses many connected devices that have brought considerable improvements, entertainment, and convenience to our everyday lives. From asking Alexa to tell you the weather, looking at your heart rate on your fitness tracker, reviewing your home security cameras, or creating your grocery list on your fridge, IoT's have improved the efficiency of everyday lives. One emerging aspect of IoT is the Internet of Medical Devices (IoMT). Telehealth is one of the fastest-growing categories in the health care world worldwide. As more people age in place, the adoption of IoMT devices that can give a doctor a constant detail about her patients. Telehealth has been drastically improved by the integration of IoMT devices that can report on oxygen levels, blood pressure, heart rate, blood sugar and more from the comfort of a patient's home. IoMT devices are not limited to home-care devices, rather hospital rooms rely on the sensors and devices to keep tabs on a patient during their stay in the hospital. In this research, we are analyzing a common IoMT communication device, a Zebra Phone. The Zebra Phone has a proprietary operating system that is not seen on other consumer phones. The research team is working to understand what vulnerabilities are introduced by the device, how they can be exploited, how they can be better protected, and how they can be investigated if compromised.

REU Dakota State University
Advisor(s): Ashley Podhradsky

Effect of Spent Coffee Grounds on the Functional Properties of Cellulose Films — 38p —
Darratu Salesa, Sajal Bhattarai

Abstract: Despite multifunctional utilities, plastics pose a significant threat to the environment owing to its their very slow biodegradability (i.e., up to 700 years) and associated detrimental impacts on humans, wildlife, soil, and water. Towards this end, the most abundant, renewable and biodegradable material cellulose stands out as a viable alternative to design and develop plastic alternatives. Cellulose yields high tensile strength and transparent films, however, elongation is quite low and is far from the desirable values found for synthetic polymers. Furthermore, in order to expand cellulose films potential to packed food applications, improving barriers properties against the transport of gases such as oxygen and carbon dioxide, blocking UV and Vis radiation, improving antioxidant and antimicrobial properties are desirable. This research examines the use of biowaste Spent Coffee Grounds (SCG) to modulate the functional properties of cellulose films,. SCG is the residue of the ground coffee obtained after coffee beverage preparation. Herein, SCG extract-cellulose (avicel) composite films have been prepared and water vapor permeability, tensile strength and elongation at break, UV transmittance, water absorption, antioxidant activity and biodegradability are determined. The results suggest that SCG extract addition, enhances the UV blocking and antioxidant property of the cellulose films. Furthermore, films display higher tensile strength and are biodegradable. The outcome not only promises the development of plastic replacing materials but also generates value addition for the underutilized and discorded biowaste Spent Coffee Grounds.

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

HPGe Gamma Spectroscopy for the LZ Dark Matter Search — 39p — Cameron Sandoval, Michael DuBray, Jacey Garcia

Abstract: There is a world-wide search for dark matter, which makes up over 80% of the universe. A front-runner candidate for a dark matter particle is the WIMP (Weakly Interacting Massive Particle) due to its rare interaction with baryonic matter. One experiment designed to detect a WIMP is LUX-ZEPLIN (LZ) located at the Sanford Underground Research Facility (SURF) in Lead, SD. WIMPs interact only via nuclear recoil events, so measures within LZ are taken to eliminate outside sources of radiation that might replicate such events within their detector. We aid in LZ's search for dark matter by maintaining four High-Purity Germanium (HPGe) detectors on the 4850 ft level of SURF, which assay potential LZ building materials for radioactive isotope concentrations. Data acquisition of a sample requires two weeks of low-background counting, then spectral analysis is performed. A sixth detector, SOLO, is being assembled on the above-ground campus at BHSU to begin low-background counting in the summer of 2022. To ensure that low-background counting can be done efficiently with SOLO, it is important to automate SOLO's liquid-nitrogen-filling system using a programming software such as LabVIEW. The goal of this project is to control a weight scale, liquid level controller, and solenoid valves using LabVIEW, therefore making the system more autonomous. HPGe assays will allow scientists to increase the sensitivity of their dark matter detectors and potentially discover a dark matter particle for the very first time.

REU Walla Walla University
Advisor(s): Brianna Mount

Use of RNA-seq data to validate RT-qPCR reference genes for studying the sunflower - D. helianthi pathosystem — 40p — Natalie Claire Sansom Botstein, Brian Kontz, Ruchika Kashyap, Karthika Mohan, Bijula Mankara Sureshbabu

Abstract: Phomopsis stem canker is predominantly caused by the fungus, Diaporthe helianthi in the United States. The disease is currently managed by use of fungicide and agronomic based practices. Although these methods have been effective, research continues to develop varieties with disease resistance for farmers. To better understand the host response to D. helianthi, a pathogenicity study was conducted on three sunflower genotypes [PI 561918 and PI 509062 (expression of partial resistance to D. helianthi) and PI 552934 (susceptible to D. helianthi)]. Samples were taken at 0 and 72 hours after inoculation with three D. helianthi isolates (27 treatments/time point with three biological replicates generated in three independent experiments) and subjected to transcriptome (RNA-seq) analysis to identify putative candidate genes and possible gene function. It was observed that each genotype offered a unique combination of upregulated and downregulated genes in response to D. helianthi infection. Out of the 125 upregulated genes, and 176 downregulated genes across the three genotypes, genes such as basic leucine zipper (bZIP), WRKY transcription factors, SNARE family proteins, pectinesterase inhibitors, and the proteins related to GDSL esterase/lipase family were previously reported to be involved in disease resistance in other pathosystems. In the present study, we selected a set of 11 putative candidate resistance genes from the RNA-seq data to validate by reverse transcription-quantitative PCR (RT-qPCR). The expression levels of these genes were confirmed by RT-qPCR and average cycle amplification values (Cq) values were between 20 and 30, which are within the recommended values for RT-qPCR reference genes. The results from our study can be used to inform the choice of candidate genes to study the interaction between D. helianthi and sunflower as well as identify resistance genes that will be helpful for breeding and development of sunflower varieties with resistance to D. helianthi.

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

Role of Glucosinolates on Cyst Nematode Infected Soybeans — 43p — Ian Schuh, Matthew Cole, Caleb Garvis

Abstract: We are currently researching cyst nematode infections on Soybeans and different methods of prevention/treatment. We have been tasked with this research by the Soybean Council, to help prevent the loss of soybean crops to cyst nematode infections. For this experiment we used a proprietary dirt blend along of 1-part sand and 1-part black dirt, we loaded this blend into conetainers and planted the soybeans in the center of the conetainers. After 1 weeks we infected the soybeans with a cyst nematode culture, we then treated the soybeans and waited 4 weeks then pulled the soybeans out and counted the # of cysts on their roots. We watered the soybeans daily and measured their growth weekly while they were growing, once we pull them out, we pull the cysts off the roots and count the # of cysts as well as save the plants roots to take a root mass. This experiment is currently ongoing.

REU South Dakota State University
Advisor(s): Dr. Jimmy Gu

Pravadoline Metabolites Identification for Reference Standards of Illicit Drug Consumption — 44p — Megan Schulte, Dr. Willand Charnley

Abstract: Synthetic cannabinoids (SCs) are a class of drugs made to mimic the psychoactive effects of the active ingredient in cannabis, Δ 9 -tetrahydrocannibinol (THC). SCs were initially developed as pharmacotherapeutics to probe the endocannabinoid system; however, now they are highly abused. These drugs are often more potent than THC as THC is a partial agonist of the CB1 receptor, and many synthetic cannabinoids are full agonists of the receptor. This discrepancy has led to severe adverse health effects for consumers and abusers. Currently, there is limited testing available for the medical staff to utilize in determining the problem at hand. Often, it is very difficult to accurately identify the problem of the patient without them telling what they took. Furthermore, the packaging does not label active ingredients so even then, narrowing down which SC poses a further challenge. To understand metabolites of Pravadoline, a drug in the aminoalkylindoles class of synthetic cannabinoids, we incubated HEPG2 liver cells with pravadoline and utilized mass spectrometry to identify metabolites. These metabolic standards can be used to develop a test for Pravadoline consumption. This new knowledge will advantage the medical community, address the public health crisis, and help fight the illicit economy as more attention is drawn to the harms of synthetic cannabinoids.

REU South Dakota State University
Advisor(s): Dr. Willand Charnley

Hydrogen atom transfer and oxygen activation in polyoxovanadate-alkoxide clusters — B02 — 45p — Sable Schulz

Abstract: Mixed-valent hexanuclear polyoxovanadate-alkoxide clusters have emerged as stable hexavanadate alternatives with surface bridging alkoxide ligands. These species have a vast variety of applications in redox catalysis since they can function as redox reservoirs in multi-electron processes due to the V V /V IV redox couple. Their redox properties can be further expanded and tuned through the incorporation of multiple first row transition metal centers. Recently, a [(V III V V 5-n V IV n O 5)(O)(OCH 3) 12] (4-n)+ cluster with a “vacant” metal cation embedded withinthe vanadium oxide cluster was identified, in which the vacancy can be filled by either water or oxygen molecules. Herein we present a computational study on the aqueous and non-aqueous hydrogen atom transfer and molecular oxygen activation catalyzed by polyoxovanadate-alkoxides with differing redox states. The bond dissociation Gibbs free energy (BDFE) was used to evaluate the O-H bond weakening and the possibility of thermal H 2 formation. Finally, spin density distribution was used to identify the oxidation states of the various mixed valent species and all further results will be presented.

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

Comparing Genetic Determinants for Virulence and Determinacies Within Different Strains of Listeria Previously Isolated from Dairy Processing Facilities — 46p — Wyatt Seagren

Abstract: The genus Listeria consists of both pathogenic and non-pathogenic strains. Studies have shown the pathogenic strain, L. monocytogenes (Lm), and non-pathogenic, L. innocua (Li) and L. welshimeri (Lw), can survive within the dairy processing plants for prolonged durations. Lm is known to cause listeriosis, a deadly infection in humans, particularly in pregnant women, immunocompromised individuals, neonates, and the elderly above 65 years. In July 2022, the Centers for Disease Control (CDC) reported an outbreak of L. monocytogenes from Big Olaf Creamery, which hospitalized 22 individuals and killed one. While phenotypic features can be utilized to distinguish each strain, genomic sequencing can be used to determine certain genetic determinants that can lead to a bacterial species being pathogenic or virulent. For this study, several previously isolated Listeria species of dairy industry origin were sequenced using the long-read sequencing tool Nanopore MinION® Sequencing technology. The de-novo assembly construction was done in Flye, and thereafter, further polishing of the assembled sequence was done using Nanopolish and Racon. Finally, the annotations for identifying the genes responsible for virulence were done using the RAST server. The Nanopore sequencing data allowed the study of strains of Listeria with different virulence, biofilm formation properties and resistance to cleaning agents.

REU South Dakota State University
Advisor(s): Dr. Jose Gonzalez and Dr. Sen Subramanian

Geochemical Characterization of Manganese Nodules from the Pierre Shale Location in South Dakota — 50p — Izabelle Smith, Scott Beeler, Brett Carlson, Sean McQueen

Abstract: The United States relies solely on foreign manganese. This metal is primarily used as an additive to steel to increase strength and workability. The dependency on foreign manganese could be alleviated through the extraction of this element and others from manganese nodules. The manganese nodules located in the Oacoma, South Dakota area are readily available on the surface, as well as in-situ. The accessibility of the material prompts investigation into characterization and gaining an overview ofmanganese nodule traits. Observations from x-ray diffraction, inductively coupled mass spectrometry (ICPMS), scanning electron microscopy, and thin section analysis were performed. A comparative study was performed on seven nodule sections. It was found that the samples presented greater concentration of manganese based upon the individual nodule rather than a specific region within a sample. Similar geochemical properties were displayed between the seven samples despite varied physical properties. ICPMS data showed 50-80% abundance of manganese from specific regions across all sampled nodules. A comprehensive view of Pierre Shale Formation manganese nodules adds to the conversation regarding the active processes manganese nodules underwent during their formation as well as general geochemical characteristics.

REU South Dakota School of Mines & Technology
Advisor(s): Sarah Keenan

Analysis of Genetic Variation on Different Platelet Responses in the Native American Population — 51p — Grace Steinmeyer, Sophia Connelly (Augustana University), Krista Goerger (University of Sioux Falls), Jordyn Reider (University of Sioux Falls)

Abstract: Thrombosis results from obstructive vascular blood clots, a process that is often driven by platelets interacting with damaged blood vessels. Due to the role of platelets in clotting, individuals whose platelets react more robustly to vascular damage are at higher risk of thrombosis. Native Americans have higher rates of cardiovascular disease, and heart disease is the leading cause of death in Native Americans. Further, previous research suggests other ethnic groups with higher rates of cardiovascular disease are enriched in genetic alleles that correlate with higher platelet reactivity. Therefore, we set out to measure Native American platelet activation and correlate platelet response to genetic variation. We hypothesized that platelets from Native Americans would show elevated responsiveness compared to White platelets, and that Native Americans would have genetic alleles that positively correlate to their responsiveness. Whole blood was drawn from Native American (n=31) and White (n=10) volunteers and stimulated with four platelet agonists to mimic vascular damage. Two indicators of platelet activation were measured simultaneously to quantitate the degree of platelet activation and analyzed using flow cytometry gated on platelets. DNA was isolated from Native American blood samples, and qPCR was used to identify SNPs found in key platelet receptor genes. With all four agonists, Native American platelets have a higher degree of activation compared with Whites for the P-Selectin exposure platelet activation indicator. The most notable increase is seen with a specific agonist that activates a key collagen receptor. Early qPCR results suggest that increased platelet activation can be found in subjects with specific ADP receptor gene polymorphisms.

Conclusion: Native American populations contain individuals who are more responsive to platelet agonists.

REU Augustana University
Advisor(s): Dr. Mark Larson

Identifying Candidate Genes Associated with QTL in Hydrotropism in the Primary Roots of Maize — 52p — Joel Swanberg, Muyu Gu

Corn/maize (Zea mays) plays an incredibly large role in the world's economy and is used as food and raw material by billions of people. Maize roots, like many other plants exhibit hydrotropism which is the ability to turn toward sources of water. To understand the genetic components that regulate hydrotropism in maize roots, our lab identified several Quantitative Trait Loci (QTL) that are associated with hydrotropism. QTL includes Total Time for Hydrotropic Bending, Time Required for Initiating Bending, Final Angle, and Root Elongation Rate. The objective of this study was to examine the genome regions that are associated with QTL and identify candidate genes that may be related to the process of hydrotropism in the primary roots of maize. Several regions have been analyzed and many genes have been identified as ones that may play a role in hydrotropism. The QTL for the Time Required for Initiating Bending is located on Chromosome 2 and covers a region of about 350 Kilo Base Pairs. In this region, 10 genes have been already identified and more will be reported later. Additional bioinformatics analysis is being performed to learn more about proteins and pathways information. This research is a fundamental step in discovering potential molecular players for root hydrotropism.

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

A Study of Implementation of Physics-Informed Neural Networks (PINNs) — 53p — Hoa Ta

Abstract: Along with the advances in computing resources such as graphics processing units (GPU), machine learning is experiencing exponential growth in discoveries and applications in many fields. With the help of computing technology, we now can apply machine learning to many aspects of life, such as informatics, computing vision, and voice recognition. Meanwhile, scientists and engineers also start taking advantage of machine learning techniques to tackle some existing scientific problems that are difficult to approach traditionally, for example, using machine learning to approximate some particular partial differential equations. Partial Differential Equations are used to model many phenomena and problems related to biology, physics, and engineering. However, many PDEs are hard to find analytic solutions to, and ime-consuming when it comes to high dimensional problems, especially when we do not usually have the amount of data to analyze them. Physics-Informed Neural Networks (PINNs) were introduced as deep neural networks that can help solve partial differential equations in numerical methods in an efficient way by combining the law of physics and deep neural networks. In this work, we first study the PINN models' sensitivity over predictive performance concerning the diffusion coefficient of the Bateman-Burgers equations. At the same time, we study the robustness of PINNs by exploring the behaviors of the parameters and comparing them with other baseline methods to verify different scenarios that can improve PINN models' efficiency. Secondly, we study the robustness of the PINN models under multiple initial conditions of given PDEs and explore the feasibility of applying dropouts between the layers of the neural networks. Finally, we demonstrate extensive experimental results to justify the practical applications of the PINNs to biofilm model prediction, fluid mechanics, and some other problems related to partial differential equations.

REU South Dakota State University
Advisor(s): Dr. Kaiqun Fu, Dr. Jung-Han Komn, Dr. Nathan McClanahan, Shi Wen Wong

Predicting the metabolic potential of an uncharacterized bacterial species from the rumen of beef cattle — 54p — Austin Taylor (Jack 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 reads that showed the highest similarity to currently available R. albus genomes were identified using the publicly available USEARCH tool to build 38 contigs during the summer of 2021. A kmer approach was used in 2022 to build additional contigs. So far, 130 contigs have been built and assembled, with lengths ranging between 349,921 and 1,765,849 nt with a total of 6,363,574 nt count. From these contigs, RAST was then used to identify contigs that encoded protein sequences. The process so far has showed the potential of glycolysis and VFA production. More insights will be obtained as progress continues.

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

Internet of Medical Things Security Assessment: Case Studies — 55p —Kai Taylor, Adam Zimmel

Abstract:The ever-expanding world of technology brings more devices on the Internet. Medical devices are no exception. Internet of Medical Things (IoMT) is an emerging area. Medical device security is essential due to the critical functions medical devices provide to patient care and the large amount of sensitive data medical devices may collect. However, cybersecurity is a challenging issue in medical device industry. This research aims to explore medical device vulnerabilities by conducting security assessment and identify practical approaches to mitigate security risks when adopting medical devices in healthcare. Three medical devices, i.e., Smartlinx Axon 810 Capsule, Alaris 8015 PC Infusion Pump, and Samsung Hospitality TV, are selected for this research. Smartlinx Axon 810 Capsule collects data from medical devices and forward the data to a Capsule Server to be sent to the EMR (electronic medical records). Alaris 8015 PC Infusion Pump controls the rate of dosages of various drugs which are given to patients across the hospital. Samsung Hospitality TV displays medical information regarding patients. These three devices are used alongside a number of other devices in a larger network that play a crucial role in hospitals across the country. The research methods used for the security assessment in this project include, but are not limited to, network traffic analysis, vulnerability scanning, and brute force attacks. Security tools used include NMAP, Wireshark, Metasploit, and Burp Suite. The security assessment leads to findings such as hidden SSH shell and open ports. By doing vulnerability testing and mitigation, this research will not only help create better security, but could potentially save lives.

REU Dakota State University
Advisor(s): Dr. Yong Wang

Rhizosphere Diversity Among Old and New Wheat Cultivars — 56p — Conner Thaler, Hasimardep Gill, Swas Kaushal, Emmily Moses, Hugo Conde, Michael Eddy Harvey, Sierra Wynn

Abstract: Sixty years of wheat breeding has led to the development of short stature (dwarf), high-yielding cultivars that are better adapted to current agronomic practices and resistant to biotic and biotic stresses. However, we do not understand what role the microbial diversity in the wheat rhizosphere plays in the better adaptation of these cultivars. Further, it is likely that with the availability of synthetic fertilizers in the last six decades some beneficial associations might have been lost with modern-day breeding. Therefore, the goal of this study is to understand if the rhizosphere microbial diversity varies among old and new wheat varieties. We collected plants and soil samples in three replications from two 60-year-old (tall) and three 2022 wheat cultivars (semi-dwarf) from three different locations (Winner, Pierre, and Brookings) in South Dakota. The DNA was isolated from the rhizosphere and the bulk soil and 16 S V4 and V5 gene amplicons were sequenced. The microbial diversity and abundance were determined for old and modern breed wheat varieties to understand if specific interactions could result in better adaptions to current management practices and if some diversity was lost as a result of semi-dwarf genotypes. The results of the project will be presented.

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

Synthesis and Characterization of New Metal-Organic Super Containers for Potential Anion Binding —57p — Andrea Thomas, Kriti Chitrakar

Abstract: Anion recognition plays an important role in various chemical and biological processes. While Nature has provided numerous examples of anion binding such as enzyme–substrate complexes, designing synthetic hosts for anion recognition remains a challenging task. Our group have been investigating a new class of synthetic host molecules known as metal−organic supercontainers (MOSCs), which can be constructed from metal ions and carboxylate linkers of various shapes. MOSCs are promising anion receptors due to their highly tunable and multi-pore structure suitable for anion binding. We previously demonstrated that prototypal neutral MOSCs showed favorable cation binding behavior. In this presentation, we describe the synthesis and characterization of a family of anionic MOSCs constructed from the assembly of trivalent metal ions and organic linkers. The new MOSCs were characterized by a range of techniques, including nuclear magnetic resonance (NMR), electron spray ionization mass spectrometry (ESI-MS), and thermal gravimetric analysis (TGA). Despite being anionic in nature, preliminary studies indicate that these MOSCs show selective binding with anions such as fluoride.

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

Modified Upconversion Nanoparticles for use in Deep-Tissue Bioimaging — 59p — Cat Mary Usavage, Shuyi He

Abstract: Upconversion nanoparticles are a form of nanoparticles doped with Lanthanide series ions to reverse their absorbance and emission of light. They can be excited with low energy high wavelength light, like near infrared (NIR) and infrared (IR) spectrums and emit higher energy low wavelength light. This property allows them to be inside of biological specimen and activated with light that is noninvasive when transmitting through tissue. The light that the upconversion nanoparticles emit is not able be read, unless further modified with polymers. It is the coating of these polymers that can change the emission wavelength of the upconversion nanoparticles and give the particles various properties. The Lanthanide doped nanoparticles also are generally able to congregate at tumors in biological systems. This and their ability to become excited with lower energy wavelengths give them an edge on the field of tracking and fighting cancer. Herein, we focused on the modification of blue light emitting upconversion nanoparticles with the red-light emitting polymer, MEHPPV, as well as the optimization of this pairing. Pdots@UCNPs were synthesized via nanoprecipitation and characterized using hyper spectrometry and transmission electron microscopy. Results will be shown evaluating the ability of the upconversion nanoparticles to transfer energy to the red emitting polymer.

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

Integrative Genome Analysis of Fusarium graminearum Associated with the Small Grains in South Dakota — 60p — Hannah Voirin, Tasneem Fathima, Jaswinder Kaur, Evan Zhou, Sunish K. Sehgal, Christopher Graham, Jose Gonzalez, Shaukat Ali, Gazala Ameen, Shyam Solanki

Abstract: Fusarium graminearum, (Fg) clade of ascomycete fungus causing the Fusarium head blight (FHB) disease in cereal crops produces a variety of mycotoxins capable of inducing harmful effects on humans and livestock. FHB is a persistent disease in cereal crops and a serious threat to both the quality and quantity of grain production of wheat, barley, and oats. Dynamic changes in the pathogen population in a given geographical region corresponding to its survival, fitness, and host adaptations greatly influence the pathogen's virulence capabilities on the prevalent crop varieties. Thus, it is important to continuously monitor pathogen population dynamics to predict future disease outbreaks. Evaluating the FHB pathogen's genome rearrangement and changes in mycotoxin producing gene clusters is an approach we are utilizing in the current study to analyze the shift in pathogen virulence and determine dominant chemotypes. To do so, we are evaluating more than fifty Fg isolates collected from barley, wheat, and oat fields of South Dakota from 2012 to 2022. Furthermore, ~20 isolates are selected to carry out whole genome sequencing on the short-read Illumina NextSeq500 platform. Five of the 20 isolates will also be sequenced on Oxford Nanopore long-read sequencing platform for integrative analysis and pangenome assembly. The fungal DNA isolation was previously optimized to achieve high-molecular-weight DNA for long and short read sequencing. The downstream sequencing and analysis are underway. We hypothesize that identifying acquired mutations and rearrangements in the important coding and regulatory regions of the pathogen genome will enable us to predict its effect on the pathogen adaptation on the host species. Our ongoing work will shed light on the aspects of complex warfare on 'Fusarium-cereal crops' and help current efforts of resistance breeding of cereal crops in the state and worldwide.

REU St. Mary's University
Advisor(s): Jose Gonzalez

Supplemental Neutron Shielding for the LUX ZEPELIN (LZ) Experiment — 62p — David Wells

Abstract: LUX-ZEPELIN (LZ) is a dark matter detector located at Sanford Underground Research Facility in Lead, SD that aims to observe Weakly Interacting Massive Particles (WIMPs), a dark matter candidate particle. Data from LZ's first science run indicates that there is a large number of neutrons entering the time projection chamber from the top, which increased the detector's background. Such a background decreases the detector's sensitivity to WIMPs. The purpose of this study is to install additional shielding of water and borated polyethylene and assess its effectiveness at decreasing the backgrounds in LZ. Researchers used a simulation approach based on Geant4, a particle physics simulation software, to assess the effectiveness of shielding. Simulation results indicate that the new shielding may limit the number of neutrons entering the LZ time projection chamber. This implies that a lower background will be observed in future science runs once the installation of the shielding is complete. These results also indicate that future shielding around other entry points to the detector may also decrease the background.

REU Yale University
Advisor(s): Dr. David Woodward

Investigating potential use of organic fertilizer from coal for improving soil fertility and native forage production — 63p — Charlotte Whorton, Damian Disbrow, Abdulallah Alomair

Abstract: Millions of acres of land around the world have been degraded severely due to lost soil organic matter. Soil quality depletion poses a problem for sustainable agriculture to meet continued population growth. To address this issue, recent studies have shown organic fertilizer from brown coal to increase crop production and soil nutrients. Despite this novel use of coal-based fertilizer, few studies exist that have evaluated its use for rangeland species. A greenhouse study was conducted to evaluate impacts of this material on soil properties, seed emergence, and plant growth of Pascopyrum smithii L. (western wheatgrass). This dominant, native, perennial, forage grass is found naturally in the mixed-grass prairie of the Northern Great Plains. The experiment consists of three treatments with six replications. Twenty-five western wheatgrass seeds were sown in six pots (13 cm X 13 cm X 13 cm) for each of three treatments. The treatments included nutrient-rich soil as a positive control, degraded soil as a negative control, and degraded soil with the addition of the coal-based fertilizer. Seed emergence is recorded daily. Plant growth parameters (e.g. shoot height, root length, number of leaves, aboveground and belowground biomass) will be measured at the final harvest. Bulk density, soil organic carbon, and NPK will be measured then as well. The results will be analyzed using appropriate methods based on the dataset. Success of this material in this experiment would not only provide further evidence of its utility but may also suggest it can be used as an effective soil amendment for improving soil health and an alternative use for the coal industry.

REU Occidental College
Advisor(s): Dr. Lan Xu

GPU Acceleration for Deep Learning — 64p — Micah Willweber, Andrew Brandt

Abstract: Researchers in many fields increasingly apply methods of deep learning to their work. Deep learning is an artificial intelligence technique that uses a mathematical model known as a neural network to computationally identify features in data. These neural networks can be successfully used to classify data but first require computationally heavy training to learn the features of a dataset. Network training can take several seconds to several weeks to complete, depending on the size and complexity of the task and dataset. Instead of completing training solely on a computer's central processing unit (CPU), parallelizing the training algorithm so that it utilizes a graphics processing unit (GPU) often speeds up training. Our project examines distinct factors (e.g., class of network, number of iterations) that affect the wide variation in performance improvement realized by using the GPU to accelerate network training. We explored various ways of optimizing neural network training, especially by training with the GPU, using two simple image classification examples. Working with MATLAB software and its Deep Learning and Parallel Computing Toolboxes, we completed the training process hundreds of times with different neural networks, performing all training on an Intel Xeon E5-2697 CPU and an NVIDIA Quadro RTX 6000 GPU. We checked the accuracy of each trained network on test data and recorded the time it took each network to perform the training and testing sequence. GPU-accelerated training was significantly faster than training that only utilized the CPU. Depending on the network and training options, we observed that training with a GPU reduced training time by a factor of 3 to 25. We provide some general suggestions to speed up neural network training that may interest researchers working on diverse deep learning applications.

REU Concordia University
Advisor(s): Dr. Anton Semenchenko

Development of a Novel Biopolymer from Oilseed Oils — 66p — Logan Wolf, Matthew Cole, Jordan Traub

Abstract: Using agricultural byproducts to create biopolymers is an efficient way to reduce waste and the use of petroleum-based plastics. Methods of creation and materials used are currently being researched and experimented on. In this study, Soybean Oil will be used for epoxidation and then Acrylated to increase points of polymerization adding to strength and bond coupling. End uses of this biopolymer would potentially have agricultural applications. The project is divided into two aspects. One being synthesis of biopolymer and the other being mechanical properties tested. Epoxidized soybean oil is the main material while also allowing for different edits to ingredients. A natural oilseed would be preferred for material synthesis of the polymer. Petroleum based plastics have become dangerous to the environment and there is recent a shift to greener alternatives. Biopolymer plastic alternatives have been considered. Polymers have been shown to have many uses in different areas of the economy. Biopolymer still need more research to prove their efficiency in various applications. Many polymers can be biodegradable and can even be beneficial to its environment. A large market for biodegradable polymers is the agricultural field. Polymers that work with nature and degrade can help keep the surrounding environment healthy. Polymers that can be made from natural byproducts can be used to reduce cost. If a polymer can be edible that improves it by reducing risk and possibly adding nutritional value. The goal for this study is to find information on the synthesis and mechanics of an edible, biodegradable polymer. The information gathered will help provide a path forward for further research.

REU South Dakota State University
Advisor(s): Dr. Jimmy Gu

Nearest-Neighbor Gaussian Process for Downscaling Micro-Climate Solar Data using GPUs — 65p — Tjaden Wright

Abstract: An accurate prediction of solar irradiance is key to efficiently using energy for buildings heating/cooling systems coupled with rooftop solar. In areas with high variability of solar, such as islands like Puerto Rico, it is difficult to plan electricity use in the face of outages (such as after hurricane natural disasters). The goal of this project is to design computationally accelerated methods to downscale nationally available climate data (specifically solar irradiance) to forecast micro-climate data for building-local areas in western Puerto Rico. Downscaling is a method to relate global climate models (low resolution, complex/computationally expensive models) to local-scale data [1]; In this case, spatiotemporal data from multiple nearby weather stations and the global weather forecast are used to design highly accurate building-local models in Puerto Rico for hurricane prone regions. Specifically, the project utilizes low-power sensors, small local computing resources, and an empirical downscaling method. It derives quantitative relationships between the global and local data using a computationally efficient (and parallelizable) nearest neighbor Gaussian process (NNGP) [2 – 4]. Then graphics processing unit (GPU) acceleration is used to increase the speed of the NNGP. The results of this project come from different models made from local and global climate data. Each model pertains to different seasons in Puerto Rico. With each model, a prediction of solar irradiance can be found by using known location, times, dates, etc. This allows for the micro-climate data to have a higher accuracy due to more data points. Being able to predict micro-climate data can help in other areas. For instance, knowing the micro-climate of an area can be beneficial to agriculture as this improves the performance of individual plants and other organisms.

REU South Dakota State University
Advisor(s): Timothy Hansen, Hossein Moradi, Kaiqun Fu, Fabio Andrade, Jung-Han Kimn, Pooja Aslami, Andres Lopez, Matias Patino, and Cesar Vega

Diversity in the rhizosphere-associated microbiome in winter wheat under different levels of nitrogen fertilization — 67p — Sierra Wynn, Harsimardeep S Gill, Michael Eddy Harvey, Connor Thaler, Hugo Conde, Emmily Moses, Dinesh K. Saini

Abstract: Nitrogen plays an important role in wheat growth, grain yield, and crop quality. Application of chemical fertilizers is the major source of nitrogen input and an absolute requirement for increased wheat production. Nevertheless, the majority of applied nitrogen is lost in the form of nitrate leaching or as the gaseous products of denitrification, causing serious environmental problems. Thus, it is necessary to study various aspects that improve the assimilation of available nitrogen in wheat. Recently, plant root associated microbiomes have been reported to play an important role in host nutrition and development. Plant roots assemble microbial communities in the rhizosphere from the surrounding soil which might influence important processes in the host plant, including the assimilation of available nitrogen. However, it has not been studied how the changes in nitrogen input shape the microbial diversity in the rhizosphere. Further, it remains unclear if the microbial communities in the rhizosphere of low nitrogen soils are abundant in nitrogen-fixing diazotrophic bacteria. Here, we studied the microbiome diversity of the rhizosphere of winter wheat under four levels of inorganic nitrogen fertilization. The soil and plant samples were collected from the winter wheat plots and subjected to different levels of nitrogen in two replicates. The DNA was isolated from the rhizosphere and 16 S V4 and V5 gene amplicons were sequenced to identify the bacterial communities in the rhizosphere. The results of the project will be presented.

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

Studying Dynamically Stable Ghost-Ridden Systems in Physics Field Theory — 68p — Jax Wysong, Dr. Hyum Lim

Abstract: In physics field theory, the term ghost refers to a system with a degree of freedom that contains a negative kinetic energy term. These systems have been deemed dynamically unstable; this means that they will evolve without bounds which is not physically meaningful. However, recent studies have shown that this is not always the case: some ghost-ridden systems are, in fact, dynamically stable. This research seeks to further the understanding of how different systems can survive while living with ghosts. Ghost-ridden systems occur in multiple areas of physics including cosmology and high energy physics, so it is important to gain insight into their nature. This research was conducted by implementing numerical methods along with PETSc (Portable, Extensible Toolkit for Scientific Computation) of Argonne National Laboratory for the creation of parallel simulations that can show whether a system with a ghost is dynamically stable or not. The method executed here is the fully implicit space time finite element method. So far, data has been produced for cases with dimensions of 1 + 1 (one spatial and one temporal) and 2 +1 (two spatial and one temporal). This is leading up to the 3 + 1 case which is of real interest due to its ability to represent physically realizable states of nature. Both the 1 + 1 and 2 + 1 cases show dynamically unstable behavior, however, it is still unknown if the same condition will occur in the 3 + 1 case.

REU South Dakota State University
Advisor(s): Dr. Jung-Han Kimn, Dr. Hyun Lim

Modeling multiple chemical soil characteristics using remote sensing data — 69p —
Anya Zarembski (Drake University), Dr. Jung-Han Kimn

Abstract: Modeling soil characteristics are vital to the agricultural industry to have healthy and productive soil. However, testing soils in a laboratory is a timely and expensive process. Recently, there have been many models proposed to employ remote sensing data to model various soil characteristics. However, most of this research only models one of the soil attributes at a time. This research proposes modeling multiple soil characteristics using multivariate linear regression. Furthermore, this research employs envelope methodology to reduce the dimension of the response and produce a more efficient estimation for the parameters in the model. All models use a Bayesian approach and inference is performed using MCMC. These models are compared to Bayesian standard models and individual linear regression models fitted for each response variable. It is highly likely that many of the response variables may be correlated, in which case, using envelope models would be highly beneficial. This allows for dimension reduction, increasing efficiency by removing the immaterial information in the response variables. The models are compared through a variety of criteria, such as the posterior mean and variance of the regression coefficients. The methodology used here will allow for more accurate modeling of soil characteristics using only remote sensing data. This process is significantly more efficient than laboratory testing, and increases the understanding of macronutrients in soil, leading to less wasted fertilizer, healthier soil, and maximum crop yields.

REU South Dakota State University
Advisor(s): Dr. Hossein Moradi

Towards Constructing a Pangenome of Diverse Pyrenophora tritici-repentis Isolates and Evaluating Their Host Specificity — 70p — Evan Zhou, Jaswinder Kaur, Tasneem Fathima, Hannah Voirin, Gazala Ameen, Jose Gonzales, Shaukat Ali, and Shyam Solanki

Abstract: Pyrenophora tritici-repentis (Ptr) is a fungal necrotrophic plant pathogen that causes tan spot, a destructive foliar disease of wheat. The effector repertoire of Ptr enabling them to produce the distinctive necrosis or chlorosis phenotype on hosts is a significant component of pathogen race classification and host susceptibility. These host selective toxins (HSTs) in Ptr, specifically the toxins produced by the necrosis inducing effector gene (ToxA) and the chlorosis inducing effector genes (ToxB and ToxC), are the major virulence factors in the effector sensitive wheat genotypes. However, the contribution of other genomic regions important for host determination on wheat, rye, barley, and triticale crop cannot be negated. The lateral virulence gene transfer and other genetic mechanisms have been previously reported contributing to host jump in related fungal species, though in Ptr it is not fully understood. In the present study, our goal is to determine the diversity in Ptr HSTs and race structure, phenotypic and genotypic components of the Ptr host range, and to evaluate if a potential host jump is occurring in Ptr isolates collected from wheat, rye, and triticale fields of South Dakota. Furthermore, we are constructing a pangenome of geographically diverse Ptr isolates. DNA is isolated from ~25 diverse isolates of Ptr collected from wheat, rye, and triticale. We optimized the DNA isolation method since fungi possess a rigid, laminated, and relatively complex chitin-rich cell wall resistant to common lysis reagents used for bacterial or animal tissues. The sequencing library is currently in progress to run on the Illumina NextSeq500 platform. Data will be analyzed using high-performance computing on SDSU's Research Cyberinfrastructure. In this project, we aim to assemble a high-quality pangenome of Ptr as a resource for researchers and identify the genomic determinants defining pathogen virulence on diverse hosts.

REU St. Olaf College
Advisor(s): Jose Gonzales

Creating Educational Supports For Youth Gardening Activities — 71p — Claudia Ziegler

Abstract: In Lower Brule, there is a lack of fresh produce available to residents. Consequently, a local nonprofit has been working to empower youth to take a leading role in starting a food sovereignty program. The main goal of my research was to create multiple educational supports for youth working to grow fresh vegetables as part of a community food sovereignty program. Youth leadership and agency in learning environments is important. When youth are able to make decisions about what they do and how they do it, they may be more motivated to take action and learn from those actions. However, youth also may not have the experiences and knowledge needed to make efficient use of time and resources in areas they are not familiar with, including the process of growing food for a food sovereignty program. I've seen that youth struggle to plant, monitor, and harvest vegetable production on their own. They may not want to conduct research and learn about best methods before beginning their gardening efforts. There needs to be more supports for youth, so they do not make mistakes and have false starts in their food sovereignty efforts. The research methods I used were autoethnography, in which a researcher tells the story of their own experience encountering and dealing with a challenge. The results of this study highlight the need for adult built supports for youth to monitor and understand the challenges they face, and then create resources to help youth understand and deal with those challenges. The implications of this work are important for adults who are trying to simultaneously support youth are able to understand complex topics and take efficient actions voice and agency in learning environments, while also making sure youth are able to understand complex topics and take efficient actions to produce positive results for themselves and their community.

REU South Dakota State University
Advisor(s): Devin Riter

South Dakota

2D BEST

2-Dimensional Materials for Biofilm Engineering, Science and Technology

South Dakota is starting year four of a $20 million five-year NSF EPSCoR Track-1 grant titled "Beyond the 2020 Vision: Building Research, Education and Innovation Partnerships for South Dakota."

The project involves eight public and private universities, three tribal colleges, and the SD Governor's Office of Economic Development (GOED) working to support research related to "biofilms," STEM education and technology-based economic development.

Seed Grants have been awarded to researchers at these NSF EPSCoR Track-1 partner institutions supporting NSF EPSCoR Track-1 goals and objectives.

The South Dakota 2-Dimensional Materials for Biofilm Engineering, Science and Technology (2D BEST) Center's mission is to build competitive, collaborative research and education capacity focused on nanoscale, conformal, two-dimensional coatings that both promote and inhibit biofilm growth on materials with agricultural, biomedical and industrial applications.

Three Thrust Areas Focus on:

- Stress-Resistant Biofilms: Rationally designed 2D coatings to protect metal surfaces from biocorrosion and ...
- Microbial Resistance: Modification of soybean roots with designer attachment proteins to enhance colonization by desirable bacteria will be pursued.
- Modeling and Computational Core: The third research thrust of the 2D BEST project aims to provide researchers in South Dakota with the resources to mine available data for useful biofilm-material relationships.

Thank you!

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We hope to see you again next year!

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