SD EPSCoR

RESEARCH. EDUCATION. ECONOMIC DEVELOPMENT.

10th Annual

Research Symposium

featuring **Undergraduates in South Dakota**

Tuesday, July 25, at Best Western PLUS Ramkota

Undergraduate and graduate STEM students, faculty and industry experts from institutions across the state gather Tuesday, July 25, at the Best Western PLUS Ramkota in Sioux Falls to participate in the tenth 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.

SIOUX FALLS, SD

JULY 25, 2023

About

SD EPSCOR

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

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

Current goals of South Dakota EPSCoR include:

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

Visit sdepscor.org for more information.

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SD EPSCoR

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Sponsors

SD EPSCoR thanks our generous sponsors of the Sanford Research Center evening mixer and tour on Monday, July 24.

south dakota biotech

Connect. Collaborate. Innovate.

110 S. Phillips Avenue, Suite 304
Sioux Falls, SD 57104

Joni Ekstrum, Executive Director
Phone: 605.274.3714
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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 that includes business, universities, service providers and state-wide economic development entities to expand the bioscience industry.

SIOUX FALLS
SOUTH DAKOTA

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Since 1954, the **Sioux Falls Development Foundation** has been leading the way in creating one of the most vibrant, secure, and growing economies in the nation. Founded by a group of far-sighted business leaders, the SFDF is a non-profit economic development corporation with the mission of improving the economy of the Sioux Falls region.

SANFORD RESEARCH

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Sanford Research is a separate 501(c)3 research enterprise within one of the largest health systems in the nation with a presence in 26 states and nine countries. With a team of more than 250 researchers, Sanford Research supports basic, translational and clinical research in diverse areas.

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Schedule

Monday, July 24

4:00 - 7:00 p.m.	SD Biotech Mixer with tour of Sanford Research Center cosponsored by the Sioux Falls Development Foundation Meet at Sanford Center (2301 N 60th St., Sioux Falls).

Tuesday, July 25

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 Amphitheaters 1 and 2)*

9:30 - 10:30 a.m.	Graduate and Professional School Presentations	Amp 2
10:30 - 11:30 a.m.	Company Presentations (7-minute) 7 companies Startup Sioux Falls, POET, Sanford Health, Houdek, Avera Research Institute, Medgene Labs, and Pipestone	Amp 2
10:30 - 11 a.m.	NRT Grad Student Panel (25-minute)	Amp 1
11 - 11:30 a.m.	GFRP Presentations (25-minute)	Amp 1
	(Afternoon sessions are repeats of the morning sessions)	
1:30 - 2:30 p.m.	Company Presentations (7-minute) 7 companies Startup Sioux Falls, POET, Sanford Health, Houdek, Avera Research Institute, Medgene Labs, and Pipestone	Amp 2
2 - 2:30 p.m.	NRT Grad Student Panel (25-minute)	Amp 1
2:30 - 3 p.m.	GFRP Presentations (25-minute)	Amp 1
2:30 - 3:30 p.m.	Graduate and Professional School Presentations	Amp 2

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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 (**SD Mines**)
- Security Printing and Anti-Counterfeiting Technology: 1852336 (**SD Mines**)
- Security Printing and Anti-Counterfeiting Technology: 1852177 (**SDSU**)
- Promoting Leadership in Advanced-Research-Computing for Interdisciplinary Sectors (PLAINS): 1950448 (**SDSU**)
- Interdisciplinary Research for Undergraduates in the Plant Sciences: Genomes, Phenomes, and Landscapes: 1950503 (**SDSU**)
- Security Printing and Anti-Counterfeiting Technology: 1852306 (**USD**)

Use #**ResearchSymposium** on social posts.

Presenters in Morning

** Individuals indicated with an asterisk are students presenting in Amphitheater 1 as part of the NSF Research Traineeship (NRT) Program.*

Allen, Erik — 1a
Anderson, Jack — 2a
Arellano Pacheco, Oscar — 3a
Ashbridge, Lindseigh — 4a
Baker, Gavin — 5a
Bass, Jordyn — 6a
Becher, Janae — 7a
Berntson, Andrew — 8a
Biertzer, Michael — 9a
Blue, Abbey — 10a
Blythe, Sean — 11a
Boothe, Vincent — 12a
Breidenbach, Ellie — 13a
Brown, Cole — 14a
Bruse, Maggie — 15a
Budd, Cayden — 16a
Bullard, Hailey — 17a
Burke, Rachel — 19a
Burmood, Zachary — 20a
Burton, Jack — 21a
Cazares Cruz, Jaritza — 22a
Clair, Alonna — 23a
Cochran, Jaime — 24a
Colombo, Elissa — 25a
Conde, Hugo — 26a
Conlin, Ruth — 27a
Corpuz, Josefa — 28a
Corsi, Sara — 29a
Culver, Lindsey — 30a
Domergue, Cynthia — 31a
Eisenbraun, Kai — 32a
Elliott, Lin-Lin — 33a
Faubion, Shikayla — 34a
Faust, Kyler — 35a
Fedde, Alysandra — 36a
Ferrie, Mason — 37a
Fischer, Caden — 38a
Flores, Aaron — 39a
Flores, Steven — 40a
Follett, Derek — 41a
Gad, Barien — 42a
Galvin, Claire — 43a
* Giefer, Clarissa — NRT
Guerrero, Jacob — 44a
Haas, Sam — 45a
Hagedorn, Grace — 46a
Hall, Rachel — 47a
* Hanka, Janean — NRT
* Hasse, Jason — NRT
Helms, Mary — 48a
Hooda, Isha — 49a
Howard, Jessica — 50a
Ikeji, Abraham — 51a
Isacco, Sophia — 52a
Jal, Dori — 53a
Kamojjala, Rishi — 54a

Presenters in Afternoon

** Individuals indicated with an asterisk are students presenting in Amphitheater 1 as part of the NSF Research Traineeship (NRT) Program.*

Jerome, Gabriel — 1p
* Kessinger, Sam — NRT
Khalaf Mohammed, Hazem — 2p
Kommareddy, Varun — 3p
* Lancelot, Jonathan — NRT
Lasekan, Mololuwa Faithful — 4p
Lawver, Amelia — 5p
Leininger, Matthew — 6p
Lettow, Matthew — 7p
Lindner, Margaret — 8p
Loth, Rheannon — 9p
Matya, Mary — 10p
May, Baily — 11p
Meehan, Hannah — 12p
Montanez Hernandez, Lilia Ernestina — 13p
Nguyen, Ngan — 14p
Nolder, Jackson — 15p
Overvaag, Samara — 16p
Palomino, Yuriani — 17p
Pardy, Katherine — 18p
Parliament, Jace — 19p
* Patten, Cole — NRT
Radliff, Nicholas — 20p
Ramirez, Anh — 21p
Reese, Kyle — 22p
Rehberg, Naomi — 23p
Rehwinkel, Elizabeth — 24p
Roesler, Titus — 25p
Row, Mary — 26p
Ruiz, Lucia — 27p
Russell, Olivia — 28p
Schiefen, Samantha — 29p
Schilling, Kiara — 30p
Schulz, Sable — 31p
Schumacher, Alyssa — 32p
Sethu Madhavan, Athira — 33p
Shah, Richa — 34p
* Spencer, Levi — NRT
Start, Daniel — 35p
Steffen, Brady — 36p
Stelling, Abigail — 37p
Sullivan, Ryan — 38p
Thomas, Andrea — 40p
Thompson, Margaux — 41p
Tillquist, Abraham — 42p
Torres, Miguel — 43p
Tounjian, Catrina — 44p
Tran, Mary — 45p
Tuuk, Sydnee — 46p
Uhrmacher, Xavier — 47p
Viehweg, Elizabeth — 48p
Wang, Matthew — 49p
Weddell, Eva — 50p
Welton, Georgia — 51p
Wilcox, Reesa — 52p
Williams, Steven — 53p
Zhang, Huixin — 54p

Abstracts

Xenon Ops at the LZ Dark Matter Detector — 1a — Erik Allen, Gavin Cox, Ellie Breidenbach, Lindsey Weeldreyer

Abstract: The LUX-ZEPLIN dark matter detector at the Sanford Underground Research Facility utilizes 10 tonnes of xenon on site. Due to the already expensive gas becoming vastly more expensive in the past few years, care must be taken when moving xenon for the purposes of calibration and maintenance. As an intern at LZ, my main purposes were to observe and participate in the various processes needed to keep the experiment running. This included several xenon transfer operations in which I participated in the full procedure — from planning, to construction of transfer setups, to execution of the transfers. The main procedure shown in my poster is a transfer of xenon containing radioactive isotopes used for calibration.

The overall goal for me, as a prospective physics teacher, was to gain an understanding of the daily activities of experimental physicists such that I can describe the experience to students who may be interested in the field. I believe one of the main obstacles for students in deciding to pursue a STEM degree is a lack of knowledge of what careers like this actually entail. The transfer described above involved calculations to avoid surpassing the pressure limits of our bottle, as well as leak checking using helium gas, and cyropumping with liquid nitrogen. Some of these required us to read through and sign Standard Operating Procedure and Job Hazard Analysis forms, which described the associated procedures, hazards, and hazard mitigation. We were successful in moving xenon without any losses, and the experience gave me an appreciation for how much care and planning goes into moving precious materials.

REU Augustana University
Advisor(s): Doug Tiedt

Validating Cell Number Differences in the airway ciliary microenvironment of Mouse Models with PCD — 2a — Jack Anderson, Casey Mckenzie, Michael Kareta

Abstract: Primary ciliary dyskinesia (PCD) is a genetic disorder that affects 1 in 16,000 children and is characterized by impaired ciliary function, leading to impaired fluid flow throughout the body and causing a wide range of symptoms, including chronic respiratory infection, infertility, and hydrocephalus. PCD mostly affects motile cilia that play a crucial role in fluid flow throughout the body, and we use three mouse models lacking proteins on the central pair apparatus: SPEF2 (*bgh*), CFAP221 (*nm1054*), and CFAP54 ($CFAP54^{gt/gt}$), which all have a PCD phenotype. From previous single cell RNA sequencing, it was found that there were small differences within the number of major cell types within the mouse airway ciliary microenvironment. This study aimed to validate cell numbers in the mouse airway ciliary microenvironment across wild type and the three PCD-associated genotypes (*bgh*, $CFAP54^{gt/gt}$, and *nm1054*). We used RNAscope on tracheal tissue samples to validate if the cell number differences from the single cell RNA sequencing were accurate and to better understand the pathway of differentiation within the three mutant mice. We use High Content Screening Software and RStudio to quantify the ratios of the major cell types. From these data, we will learn more about how cilia dysfunction affects cell numbers in the airway.

REU: Northwestern University
Advisor(s): Lance Lee

Functionally Characterizing a Novel Tonne-Kalscheuer Syndrome Variant — 3a — Oscar Arellano Pacheco

Abstract: Tonne-Kalscheuer Syndrome (TOKAS) is a neurodevelopmental disorder causing intellectual disability and stunted developmental growth. Characterized by mutations in the *Rlim* gene **—** and subsequently, the E3 ubiquitin ligase protein RNF12, critical processes in human development are crippled. Poor regulation of embryonic stem cell differentiation and imprinted X-chromosome inactivation leads to symptoms such as microcephaly, hypogenitalism, and intellectual disability seen in TOKAS patients. The underlying biochemical mechanisms driving this disorder are poorly understood, leading to a lack of available, effective treatments for those suffering from TOKAS. By functionally characterizing several TOKAS mutations, including the novel *Rlim* N581K mutation, we attempt to identify specific mechanisms of the disease. Utilizing Western blots, Immunofluorescence, Ubiquitylation assays, and qPCR techniques, we determined that the N581K mutation may inhibit the ubiquitination of RNF12's substrate, REX-1, while maintaining healthy RNF12 and ubiquitin protein expression. Additionally, the N581K mutant did not appear to affect the localization of RNF12 proteins. This understanding can be utilized in the future to design individualized therapeutic treatments for patients suffering from a TOKAS variant.

REU Mercer University
Advisor(s): Dr. Francisco Bustos

Determination of quality traits in winter wheat varieties via dry weight matter and genome-wide association studies — 4a — Lindseigh Ashbridge, Pradeep Kumar

Abstract: *Triticum aestivum*, the common wheat plant, remains an essential crop worldwide. Many regions rely on wheat as a sustainable food source, provided its high carbohydrate and protein content. With an increasing global population and unprecedented climate changes, the need for research delving into methods of reducing water reliance, especially in Midwestern states due to severe drought, and increasing crop yield to support large populations remain highly important. Understanding the relation between root and shoot length provides insight into plant health, and thus crop quality, as well as the allocation of nutrients above or below ground. Wheat plants with more complex, dense root systems tend to be preferred in drought conditions due to increased area and may signify a genotype better suited to the environment. 5 seeds from each of the 365 genotypes chosen from previously stored wheat seeds were germinated in Petri dishes for 24 hours and transferred to germination paper to be "cigar rolled". Rolls were then placed into buckets with an appropriate ratio of deionized water with Hoagland solution added after 7 days and data to be collected after a 15-day growth period. Analyzing the genome of each genotype, similarities and differences may provide insight into important traits. For example, a large ratio number between the root and shoot lengths indicates a healthy, well-adapted cultivar that can compete in environments, and larger dry-weight content found in the roots of wheat plants suggests a more complex root system with a greater area for nutrient search. Understanding the genes closely associated with successful crops allows for ease of navigation into breeding procedures and offers the potential of ensuring steady crop yield for future generations.

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

Enhancing Degree of Spin Polarization of CoFeVAl by Stoichiometric Engineering — 5a — Gavin Baker[1], Matthew Wieberdink[1], Paul M. Shand[2], Pavel Lukashev[2], Parashu Kharel[1]
[1] Department of Physics, SDSU [2] Department of Physics, University of Northern Iowa

Abstract: A combined theoretical and experimental investigation of two Heusler alloys CoFeVAl and $CoFeV_{0.5}Mn_{0.5}Al$ has been carried out. Heusler alloys show interesting properties that have been of great interest to material scientists and condensed matter physicists for years. Their half-metallic and spin-gapless semiconducting properties with a high Curie temperature (T_c) above room temperature especially make them desirable for spintronic applications. The parent alloy CoFeVAl is a quaternary Heusler alloy (XX'YZ) which orders ferromagnetically with a very low Curie temperature of about 30 K. Our first principles calculations indicate that this material is nearly half-metallic with spin polarization of 87%. However, after partially doping the vanadium site with manganese, the magnetic and electronic band properties are substantially improved. The Curie temperature increased to 454 K, and the degree of spin polarization became 96%. In addition, the crystalline quality also improved due to Mn doping. The observed results indicate that the Mn doped alloy $CoFeV_{0.5}Mn_{0.5}Al$ may be used in room temperature spintronic devices.

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

Lithographic Production of a Photocurable, Biodegradable Polyester-Based In Vitro Articular Cartilage Model — 6a — Jordyn Bass, Hosein Mirazi

Abstract: There is currently no cure for certain joint diseases like osteoarthritis (OA). One reason a cure doesn't exist yet is that we don't have an accurate model for studying the cells in the joints outside of a body. Currently, animal models are the gold standard for studying joint diseases. However, due to anatomical differences, animal models are inaccurate. Animal models also have ethical concerns and time and cost inefficiencies. Making an artificial joint model would allow us to study and find cures or treatments for diseases like OA. A good cartilage model is key to making a good joint model, but cartilage cells are difficult to work with in the lab since they artificially flatten out and change their behavior using standard culture techniques. Because of this, the Wood lab has developed the 'CellWell' to help these cells maintain their shape and function in vitro. However, finding a suitable biomaterial has been a challenge. The research goal of this project is to make CellWells out of a new proprietary biodegradable polyester-based biomaterial called Photoset® (Poly-Med, Inc.) that allows a higher percentage of cells to stick to its surface than previous CellWell materials. Here, we used soft lithography techniques to make Photoset® CellWells. During this process, we used a silicon wafer to make a master mold out of polydimethylsiloxane (PDMS), which was treated with a non-stick coating and used to make a PDMS stamp. We then used the PDMS stamp and UV crosslinking to make Photoset® CellWells. The result is that we were not able to cure the Photoset® in the UV oven that we had available, but we were able to improve the soft lithography process needed to make them.

REU South Dakota Mines
Advisor(s): Dr. Scott Wood

GCMS study of the lipid composition of fermenting bee bread and common pesticides — 7a — Janae Becher

Abstract: This work proposes that the lipid composition of bee bread will change during the fermentation process. The target lipids include monosaccharides, fatty acids, and fatty acid derivatives, which should be present at high levels and are of particular interest due to their diverse roles in cellular functions. Oxalic acid, a common treatment for mite infestation in beehives, will also be examined. Bee hives around the Sioux Falls area were surveyed during the summer of 2022 and the surrounding plants were also recorded. Samples of pollen and bee bread were collected over three consecutive weeks, which correlates to the predicted fermentation time for bee bread and then frozen until examination. Nine compounds that should be present in significant amounts in the ethanolic extraction layer were chosen to react with BSTFA (N, O-bis(trimethylsilyl) trifluoroacetamide) to serve as standards. Ethanolic extractions of the ground bee bread were treated with BSTFA and analyzed via a GCMS method published by Isidorov. Retention times were compared to the standards to determine if the concentrations vary over the different fermentation periods. In the one location studied so far, the composition of bee bread does change over time, but not in a consistent pattern in composition.

REU Augustana University
Advisor(s): Dr. Olson-Manning and Dr. Duffy-Matzner

The Effect of Divergent Anti-Herbivory Metabolite Strategies of Hybridizing Milkweeds on Monarch Growth, Survival, and Sequestration pesticides — 8a — Andrew Berntson

Abstract: Climate change is increasing plant hybridization as species ranges shift. Understanding how hybridization of plant species affects the herbivores that rely on them will shed light on the impact of climate change on coevolutionary relationships. Milkweeds (*Asclepias*) have evolved anti-herbivory compounds as a form of defense against insect herbivores. Monarch butterflies (*Danaus plexippus*) have coevolved with milkweeds to tolerate and even co-opt these anti-herbivory compounds into a defense against their own predators. However, high levels of these toxins can slow the growth and development of monarch caterpillars. Here we ask how monarch caterpillar growth on showy milkweed (*A. speciosa*), common milkweed (*A. syriaca*), and their hybrids differ.

To build a framework to correlate specific anti-herbivory compounds in the parental species and hybrids to herbivore growth, we measured caterpillar growth every 2-3 days until the 4th instar stage. Milkweed anti-herbivory compounds were extracted from each plant before caterpillars were placed and after the final weight was taken. The anti-herbivory compounds, cardenolide and phenylpropanoids, were identified and quantified with high-performance liquid chromatography. We find that when grown on 4 week old plants, caterpillars gained the least weight on the hybrids, though there was no difference between caterpillar weight gain when grown on the parental species. However, when grown on >8 week old plants, caterpillars gained the least weight on *A. speciosa*, while there was no difference between the hybrids and *A. syriaca*. This suggests that not only is caterpillar growth influenced by a milkweed's ancestry, but also the plant's age.

REU Augustana University
Advisor(s): Dr. Carrie Olson-Manning

Exploration of batten disease pathology in the retina and visual processing centers of Cln6 mice treated with a small molecule inhibitor of SORT1 — 9a — Michael Biertzer, Melissa Pratt

Abstract: Batten Disease is a devastating lysosomal storage disorder that causes progressive neurodegeneration in children often beginning with a decline in vision, onset of seizures, and leads to premature death. This disease is caused by a mutation in one of 13 genes. CLN6-batten disease is caused by a mutation in the CLN6 gene which codes for an endoplasmic reticulum transmembrane protein. CLN6 has been shown to play a role in ER-Golgi transport of lysosomal enzymes, ultimately impacting overall lysosomal function. Symptom onset for CLN6-Batten begins in the first decade of life, with a life expectancy of 12-15 years. There are currently no approved treatments. The small molecule sortilin inhibitor AF38469 is being explored as a potential treatment for multiple forms of Batten Disease, and is hypothesized to be effective by stimulating lysosomal biogenesis ultimately rescuing lysosomal function. Here we explore the potential for AF38649 to prevent photoreceptor loss in the retina of *Cln6*^{nclf} mice, as well as assess for therapeutic benefit of the drug on brain regions associated with visual processing in these mice.

REU Nebraska Wesleyan University
Advisor(s): Jill Weimer

Ruthenium(II) polypyridyl Complex containing phosphoric acid group as anchoring group: Synthesis, characterization & application — 10a — Abbey Blue

Abstract: Ruthenium complexes containing phosphoric acid as anchoring group are well known as dyes for water splitting reactions when combined with TiO 2 . A three-pot synthesis using 2,6-diacetylpyridine, *n*-octyloxybenzaldehyde, phenylhydrazine and lead (IV) tetraacetate yielded a Pyridine dipyrazolinel tridentate ligand (**L3**). The ligand **L3** is well characterized by ^{1}H NMR. Reaction of ligand with $RuCl_3.3H_2O$ yielded [$RuCl_3$. **L3] (2)**, which was characterized by single-HR mass spec. The ruthenium (III) complex **(2)** is further reacted with tetraethyl[2,2'-bipyridine]-4,4'-diylbis(phosphonate) to make [RuCl(**L3**).tetraethyl[2,2'-bipyridine]-4,4'-diylbis(phosphonate)]Cl **(3)**. The black dye [RuCl(**L3**). tetraethyl[2,2'-bipyridine]-4,4'-diylbis(phosphonate.NCS]ClO 4 **(4)** is synthesized by reacting compound 3 with an excess of potassium thiocyanate followed by a metathesis reaction with LiClO 4 (aq). This new black dye was characterized by ESI MS, UV and emission spectroscopy and it needs to be hydrolyzed prior to test for water splitting reactions after thorough analytical characterization. Long alkyl chains adorn this new pyrazolyl ligand to limit solubility and promote stability of the ruthenium dye complexes in dye-sensitized solar cell applications.

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

Exploring calcium carbonate micro- and nanoparticles as the active component of environmentally friendly non-toxic sunscreens — 11a — Sean Blythe, Mahadi Hasan, Sajith Wijewardhane

Abstract: Nanoparticles play an increasingly important role in today's skincare industry. Many sunscreens sold today use titanium and zinc oxides nanoparticles, which while mostly safe for human use, are damaging to the environment. Most of the organic components of sunscreen are damaging for the environment, particularly for corals. Thus there is a demand for environmentally friendly sunscreens. Our research goals are to develop alternative particles that are safe for both (people and the environment) human use and safe for the environment, and develop practical in-vitro methods for measuring SPF. To date we have successfully synthesized calcium carbonate nanoparticles and measured their SPF in-vitro utilizing ethanol and PDMS polymers. These particles were found to have SPF comparable to sunscreens already on the market and can also be surface functionalized to potentially boost their SPF or ability to hold environmentally friendly compounds or pharmacons.

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

Diversity of Bradyrhizobium in Symbiotic Nodules with Soy Crops in Eastern South Dakota — 12a — Vincent Boothe, Sukhvir Kaur

Abstract: *Bradyrhizobium* are a genera of nitrogen-fixing bacteria that enter into symbiotic relationships with legume root systems, particularly soy, where they reside in nodules. *Bradyrhizobium* are omnipresent in 99.58 of soils across six different continents and their class, Alphaproteobacteria, makes up roughly 35% of the soil on those same six continents (Delgado-Baquerizo et al.). Given their ubiquitousness, and nitrogen-fixing capabilities, it is important to understand what species reside in varying locations, especially in major crops such as soy. Soybean plants were obtained from 8 locations across eastern South Dakota. The roots were washed and surface sterilized for nodule processing, where they were crushed and diluted. From there the extract from the nodules was streaked and grown on BJSM and Yeast Mannitol agar. Colonies appearing two days after inoculation were subcultured onto R2A until they reached clonality. Upon which they were gram stained, and viewed under a microscope. To determine phylogenetic association the V1-V3 region of the 16S rRNA gene was amplified using PCR and sequenced. Future work will involve multi-locus sequence typing by sequencing the 16S gene to produce a phylogenetic tree. To date, 76 isolates have been obtained, with the phenotypic characteristics of a *Bradyrhizobium*. This will answer the question of this project, how many species of *Bradyrhizobium* nodulate in soy plants? The phylogenetic tree can then be used as a basis of comparison to identify *Bradyrhizobium* in the rhizosphere and soil, as well as display the diversity of the genera for use in further studies.

REU South Dakota State University
Advisor(s): Volker Brozel

LUX-ZEPLIN and the Search for Dark Matter — 13a — Ellie Breidenbach

Abstract: Dark matter makes up about 27 percent of the universe but has never been detected. Weakly Interacting Massive Particles (WIMPs) are a favored candidate particle for dark matter. The LUX-ZEPLIN (LZ) detector is searching for WIMPs at the Sanford Underground Research Facility (SURF) in Lead, SD. While this experiment has yet to detect WIMPs, it is the world's most sensitive dark matter experiment. To achieve this level of sensitivity, the detector consists of 10 tonnes of liquid Xenon. The outer detector is comprised of a scintillator, housed in acrylic tanks, and deionized water, all while being 4,850 feet underground to help shield the inside of the detector from background particles that could mimic WIMP signals. As particles pass through, they can interact with the xenon and create two flashes of light detected by photo-multiplier tubes (PMTs). LUX-ZEPLIN is currently collecting science data. Before this data could be collected, the detector must go through many calibrations to ensure accuracy. Many different sources are injected into the detector to ensure LZ can achieve its maximum sensitivity. Using these sources allows LZ to be calibrated by radioactive decay. This poster will describe how LZ operates and how calibrations play a big role in collecting WIMP data.

REU South Dakota Mines
Advisor(s): Doug Tiedt

Structural and magnetic properties of Fe 73.5 Nb 3 Cu 1 Si 13.5+x B 9-x alloys — 14a — Cole Brown, Gavin Baker, Parashu Kharel

Abstract: When creating electromagnetic induction devices such as transformers and inductors, it is important to have core materials that are as close to being lossless as possible. The FINEMET family of alloys demonstrates the properties necessary to create low-loss devices. Improving upon the properties of these materials is important for creating more efficient electric devices. To study the effects of the composition of the alloy on its properties, we synthesized the series of alloys $Fe_{73.5}Nb_3Cu_1Si_{13.5+x}B_{9-x}$ (x = 0, 0.5, 1, 1.5, 2, 2.5, 3). Bulk samples were prepared using an arc melter on a copper cooled hearth in an argon atmosphere and by annealing at 600°C for 24 hours. The crystal structures were investigated using an X-Ray Diffractometer, and it was found that the samples crystallized into a body-centered cubic structure with samples x = 0 and x = 0.5 showing slight phase impurities. The magnetic properties measured using a VersaLab magnetometer show that with increasing x, the saturation magnetization decreases, while the permeability shows a more complex change. These results can help to further inform the creation of soft magnetic alloys specialized to different applications.

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

Simulating Turbulent Transonic Flows Using Star-CCM+ — 15a — Maggie Bruse, Dr. Jung-Han Kimn

Abstract: Turbulent transonic flows found in the field of aeronautics pose challenges as they are unpredictable and irregular which makes them hard to model and solve. Computational fluid dynamics (CFD) is a method of designing fluid dynamics simulations using numerical approaches and computational resources. Experimental studies of turbulent flows are expensive and time-consuming, so being able to understand how flows will react using computational fluid dynamics will be a significant advancement. The objective of this project is to use this technology and simulate compressible turbulent flows with an ideal gas to research how these flows react and how the corresponding shock waves form. This study uses Star-CCM+, a commercially available CFD solver, to create the different geometries, generate the meshes, and perform the simulations. Working with ideal gas and turbulent flow, the simulations will be done utilizing Reynold's Averaged Navier-Stokes (RANS) equations. First, preliminary information is gathered to better understand shock waves using the original hump design; a range of Mach numbers is tested, and it is used to learn how the flow/shock wave changes as the Mach number changes. Then, the primary focus is on using different geometries and how the flows react in different situations. Using the information that the simulations provide will better understand how turbulent flows behave in different situations, by focusing on the physics aspects of the problem. These understandings will provide more insight into best design practices to take into consideration in aeronautics and is the first step in better understanding why planes or jets are built the way they are, and how to best build them to utilize different purposes.

REU University of South Dakota
Advisor(s): Dr. Jeffrey Doom

Characterizing protein-DNA interactions between transcription factor PatB and nif gene promoters using bio-layer interferometry technology — 16a — Cayden Budd, Liping Gu, Ruanbao Zhou, Taufiq Nawaz, Matt Lettow, and Isha Hooda

Abstract: Under nitrogen-limiting conditions, the filamentous cyanobacterium *Anabaena* sp. PCC7120 will differentiate roughly 10% of its cells into nitrogen-fixing heterocysts in sequential intervals along its filaments. While this process is complicated, a few of the proteins involved are known. One is PatB, an important master transcription factor that regulates the expression of genes involved in heterocyst differentiation and functions. Although PatB has been shown to bind to multiple nif promoter sequences through electrophoretic mobility shift assays (EMSA), the mechanisms that control its activity are still largely unknown. To understand the protein-DNA binding further, Bio-layer Interferometry (BLI) was used to investigate the *in vitro* binding kinetics of PatB to the nif promoter sequences in real-time. Synthetic DNA probes representing the promoter sequences of nif genes were prepared through PCR and a recombinant PatB protein was overexpressed and purified from genetically engineered *E. coli*. The PatB protein was then immobilized on the biosensor surfaces, while synthetic DNA probes served as an analyte. The binding interactions were monitored by measuring changes in the interference pattern of the refracted light caused by protein-DNA binding. The BLI analysis provided insights into the distinct binding kinetics of PatB to the nif gene promoters (nifB, nifH, nifV and nifP), respectively, characterized by varying association rates (ka), dissociation rates (kd), and equilibrium dissociation constants (KD). The study focused on understanding the molecular interactions governing heterocyst differentiation regulation in cyanobacteria. In the future, we hope to use the BLI technology to understand the mechanisms that govern PatB's association with the nif promoters. This data will hopefully further our understanding of how cyanobacteria respond to environmental conditions to control their heterocyst formation and nitrogen fixation.

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

Exploring Timing of Tumor Innervation and the Role that Ganglia Play in the Process — 17a — Hailey Bullard, Austin Walz and Jeff Barr

Abstract: Head and Neck Squamous Cell Carcinomas (HNSCC) are peripheral tumors that get innervated, yet a comprehensive molecular understanding of the mechanisms driving this process and the timing by which these tumors get infiltrated with nerves remains incomplete. HNSCC tumor-infiltrating nerves originate from the trigeminal ganglion and can be traced into the central nervous system. The two main focuses of this study are: 1) to define the timing of tumor innervation and 2) to determine what role the closely related glial cells play in the tumor innervation process. These two focus points will allow a better understanding of the mechanisms by which nerves are recruited to these malignancies. To define the timing of tumor innervation, C57Bl/6 mice will be orthotopically implanted with a syngeneic HNSCC cell line. Tumors will be harvested on days 4, 10 and 20 post-tumor implantation. Two days prior to tissue harvest, intra-tumoral injection with a nerve tracer, Wheat Germ Agglutinin (WGA), will be performed. This neural tracer is taken up by nerve terminals and retrogradely transported. Importantly, the WGA tracer crosses synapses so that it will not only map the origin of tumor-infiltrating nerves but also what circuit(s) they converge on. In addition to tumor, the ipsilateral trigeminal ganglion and the brain will also be harvested at each time point. Tissues will be sectioned and WGA tracer labeling quantified. To assess the presence of glia during the process of tumor innervation, these tissues (tumor, trigeminal ganglion, brain) will be immunofluorescently stained with glial cell markers (GFAP, EAAT1, CD40, and IAB1). Localization and quantification of glia at the three time points will be assessed by confocal microscopy. The findings from this study will determine the time course of tumor innervation as well as the presence and localization of glial cells during this process.

REU Sanford Research
Advisor(s): Dr. Vermeer

Investigating sex as a factor in CEPO efficacy in an mouse model of autism — 18a
— Riggins Bundy, Elizabeth Viehweg, Vedant Thakkar, Monica Sathyanesan, Samuel Sathyanesan, Alexander Kloth

Abstract: According to the Centers for Disease Control and Prevention, about 1 in 44 children in the United States today are affected by autism spectrum disorder (ASD). This neurodevelopmental disorder is characterized by difficulty with social interactions, repetitive behaviors and activities, high anxiety, and intense reactions to sensory inputs, among other symptoms, and symptoms vary widely among patients. The etiology of ASD remains unknown but is hypothesized to be a combination of genetic and environmental factors, contributing to the lack of systematic and effective treatment for the core features of ASD. Erythropoietin (EPO) may be a potential pharmacological agent for treating ASD due to its neurotrophic and neurogenic properties that provide support and protection to the brain, however erythropoietic side effects make EPO as a neurological treatment unfavorable. Our previous studies observed that a Carbamoylated version of EPO with its erythropoietic function silenced known as CEPO rescued aspects of the antisocial and anxious behavior present in male BALB/c mice, an idiopathic model that displays some ASD-related social deficits. However, the presence sex-specific differences in behavior and response to drugs between males and females that show up with other models is unknown in CEPO administration in ASD models. Therefore, in this study, we investigated the effects of CEPO on ASD-like behavior in female BALB/c models. C57BL/6J mice were used as controls. Both strains of mice received 11 intraperitoneal injections of vehicle or CEPO (40 µg/kg) over 21 days. Subsequently, we assess behavior in the three-chamber social approach task, the open field, the elevated plus maze, and the forced swim task to measure sociability and anxiety. Our results will demonstrate whether there are sex-specific variations in behavior and treatment response in the BALB/c mice and will strengthen the evidence supporting CEPO as a potential therapeutic for ASD patients.

REU Augustana University
Advisor(s): Alexander Kloth

Effect of Oat Allelopathy Among Sterile Response Corn — 19a — Rachel Burke, Avery Knoll

Abstract: Oats (*Avena sativa* L.) are known to be allelopathic — beneficial or harmful to surrounding plants via chemical exudates — by altering surrounding plant growth, nutrient uptake, among others. This experiment is a follow-up to a previous experiment that aimed to determine if certain oat varieties support a rhizosphere microbiome that promotes corn growth using DNA extraction, generic bead PCR purification, DNA quantification, and 16S/ITS rRNA sequencing using QIIME 2. Our current experiment aims to determine if the corn response to oat conditioning observed in the previous experiment is influenced by oat allelopathy by growing corn (*Zea mays* L.) after oats in a sterile environment, eliminating the effect of microorganisms. Five different varieties of oats, along with corn and spring wheat (*Triticum aestivum* L.), were sterilized using ethanol and Cl 2; then, the seeds were aseptically planted in sterilized growing jars with Hoagland/Arnon nutrient solution and Rockwool, a physical substrate used for hydroponics. Half of the treatments were inoculated with 5 mL of microbial wash, and 5 mL of sterilized microbial wash were added to the remaining half. After approximately four weeks of growing in a growth chamber, the treatment plants and Rockwool will be aseptically removed, and the response corn seeds will be sterilized and aseptically planted using new Rockwool. After approximately three weeks, the response corn will be aseptically removed. From each jar, a sample of the remaining nutrient solution will be saved for chemical analysis and a sample will be plated on tryptic soy agar (TSA) to determine the sterility or microbial concentration of the jars. Shoot and root biomass will be taken after both harvests. Comparing the results of the corn response from the inoculated jars to the sterile jars will explain the effect of oat allelopathy vs. microorganisms on corn planted following oat.

REU South Dakota State University
Advisor(s): Dr. Patrick Ewing and Dr. Melanie Caffe

Sub-Micron Phosphor Materials by Ball Milling Process — 20a — Zachary Burmood, Levi Spencer

Abstract: Counterfeiting products have become a widespread issue affecting consumers, businesses, and governments worldwide. The United States alone loses over a billion dollars each year due to counterfeit products, which is expected to grow as time progresses. Traditional anti-counterfeiting methods can be vulnerable to replication by counterfeiters. Thus, using new materials with novel properties is necessary to combat counterfeiting. Our research group is exploring the synthesis and application of a series of germanate phosphor materials with unique fluorescent and phosphorescent properties for anti-counterfeiting. A ball milling process was used to reduce the phosphorus particle size to increase the processibility in label fabrication. Several milling parameters were explored, including rotation speed, ratio of sample to grinding media, and grinding environment. Preliminary results have shown that particle size can be reduced below one mm. The milling process resulted in more stable particles in solution compared to a conventional method of motor and pestle. Furthermore, the luminescence properties of post-milling phosphors were compared to the un-milled sample. Continuous optimization of the milling process will be done to achieve the desired particle size for application in anti-counterfeiting.

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

Expansion of the drug delivery properties of casein-coated mesoporous nanoparticles to the enzyme-triggered release of N-acylhomoserinelactones — 21a — Jack Burton

Abstract: Nanoparticles show promising use in targeted drug delivery and cancer treatment. The Sereda lab has been exploring their use in the targeted therapy of colorectal cancer by the enzyme-triggered release of veratridine from mesoporous silica nanoparticles. We confirmed the successful fabrication of the veratridine-mesoporous nanoparticle assembly that efficiently works in a mouse cancer model. Currently we and are exploring N-acetylhomoserine lactones as another anti-cancer and anti-biofilm drug load. We have successfully synthesized homoserine lactone and its caproyl derivative by a known procedure and properly characterized them for the first time.

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

Biological Screening of Estrone-Triazole Analogs for Antiproliferation Activity in Melanoma — 22a — Jaritza Cazares Cruz, Trevor Ostlund, Fathi Halaweish, Kakan Sutradhar

Abstract: Melanoma is the third most common skin cancer and most prevalent cancer in the US. Current treatments include targeted therapy and immunotherapy. However, most patients do not respond to it, or the cancer eventually returns. For this reason, new drugs are needed to fight melanoma. Screening synthesized compounds designed for cancer treatment is a possible approach. This research examines a library of estrone-triazole analogs to identify potential drug candidates for melanoma treatment. Screening protocols using MTT, cycle analysis, cell migration, and Western blot analysis, will be used to explore the antiproliferation mechanisms of selected compounds. This study could discover potential drug candidates for melanoma treatment. During the study, 20 compounds were examined using the A375 melanoma cell line. Three estrone-triazole compounds Fz60, Fz300, and Fz25 showed IC50 of 8.12, 16.59, and 20.07, respectively. These were identified as successful candidates based on the results of MTT assays. Cell cycle analysis and in-cell Western assays will be conducted to further evaluate their effectiveness, to provide insights into their impact on cell cycle progression and protein expression, respectively. These additional assays will help to understand the specific mechanisms underlying the antiproliferative effects of these compounds. It is important to note that the investigation is not limited to these three compounds. The ongoing research involves screening and testing a broader range of compounds from the estrone analog library. This extensive screening approach aims to identify additional potential drug candidates with enhanced efficacy against melanoma. By identifying and characterizing promising drug candidates, we can contribute to the development of effective therapies for melanoma treatment. Ultimately, this research may lead to the discovery of novel and targeted treatments that improve outcomes for patients with melanoma.

REU South Dakota State University
Advisor(s): Dr. Fathi Halaweish

Material Characterization and Animal-Component Free Cell Media Adaptation Method for Development of a Tissue Engineered Vascular Graft — 23a — Alonna Clair

Abstract: Every year, over 800,000 people in the US suffer from a heart attack, and it is estimated that about 200,000 of those cases are recurring heart attacks. One treatment of heart attacks is cardiovascular autologous bypass grafting, which is the current gold standard. However, blood vessel mechanics and cellular composition will vary depending on the branch of the vascular system the bypass vessel is harvested from. This statistic demonstrates that there is a vital need for developing a tissue engineered vascular graft (TEVG) that has the potential to replace conventional autologous vessels to prevent recurring complications. Development of clinically translatable TEVG offer surgeons an off-the-shelf vessel for use in bypass surgery with predictable mechanical properties capable of withstanding the forces experienced in the arterial system. The research aim of this project is to better define our knowledge of both the cellular and material components necessary to develop a TEVG. Through rheological characterization of preprocessed polymers, we can choose a specific processing method that will emphasize the material's innate properties, thus, maximizing the material's mechanical output. Cells remodel their three-dimensional environments to adapt to external stimuli. Traditional media is composed of undefined constituents, such as fetal bovine serum (FBS), which is a primary contributor to the undefined nature of cell culture media. We are developing an animal-component free (AF), defined, media for human umbilical vein endothelial cells (HUVECs). By using AF media, developing a TEVG construct with defined and replicable results significantly decreases the risk of unpredictable and undesirable effects during clinical translation. Here we show shear rheology characterization of polymers, various processing methods, and an AF media adaptation method.

REU South Dakota Mines
Advisor(s): Dr. Travis W. Walker and Laura A. E. Brunmaier

Ultra-Low Background Counting at Black Hills Underground Campus (BHUC) — 24a —
Jaime Cochran, Steven Flores

Abstract: At the Davis Campus of the Sanford Underground Research Facility (SURF), rare event searches are shielded by 4850’ of rock from cosmic ray backgrounds. Additionally, meticulous material selection and shielding design of the LUX-ZEPLIN (LZ) dark matter detector make it an incredibly sensitive detector that requires taking into account the small amounts of radiation surrounding the detector. The Black Hills Underground Campus (BHUC) houses six high-purity germanium low-background counters that assay samples for their U, Th, and K content. The data from the low background counted samples taken from LZ characterize its background signals, allowing clearer identification of rare dark matter interactions within the detector. This poster will present results from a recent assay. An additional goal of this summer research is to integrate Python and LabVIEW coding to streamline remote communication and real-time monitoring of an automated liquid nitrogen system. By leveraging LabVIEW’s equipment-reading capabilities with Python's communication flexibility and libraries, the system will be able to read changing liquid nitrogen conditions and relay them to relevant individuals. This program is mainly targeted towards an above-ground detector called SOLO, which will screen samples for radioactivity before they are potentially assayed using the more sensitive underground detectors. The Python-LabVIEW program chain will monitor and communicate cryogen levels of SOLO so that the detector remains cool and stable, and electronic noise is reduced for optimal performance.

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

Building the Genome of an Unknown Rumen Bacterial Species from Beef Cattle that Can Digest Starch — 25a — Elissa Colombo, Vinay Bandarupalli, Emily Fowler

Abstract: Cows are able to digest the feed that they eat thanks to bacteria in their rumen, many of which are currently unknown. In beef production, cattle are fed grain or corn to accelerate their growth, but this can cause health problems due to the accumulation of lactate in the rumen from digesting high amounts of starch. During this REEU, I continued a project started by a previous Ph.D. student at SDSU who identified an unknown rumen bacterial species that can digest starch. I used custom scripts that run with Perl to build and merge contigs that are from the genome of this bacterial species. I used three sequence datasets, each from a sample of a culture enriched with this unknown bacteria: S1D14, S3D7, and S3D14. Once several of the contigs were built and merged into longer segments, I analyzed the merged contigs through Rapid Annotation using Subsystem Technology (RAST) to identify different components of the genome and their functions. The contigs found in S1D14 had 1,124,050 total nucleotide bases with a range of 351–52,832 nucleotide bases per contig. The contigs found in S3D7 had 1,384,887 total nucleotide bases with a range of 472 – 27,426 nucleotide bases per contig. The contigs found in S3D14 had 389,235 total nucleotide bases with a range of 478 – 40,967 nucleotide bases per contig. They had 115, 120, and 61 total contigs respectively built at the time that this abstract was submitted, and the number of coding sequences found in the contigs was 1754, 1766, and 888 respectively. The project is still ongoing. By building and analyzing the genome of an unknown rumen bacterial species that can digest starch, the animal science community will understand more about gut health in beef cattle and how to help prevent them from going into varying degrees of acidosis.

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

Integrative Genome Analysis of Fusarium graminearum and Associated Toxin Genes — 26a — Hugo Conde, Tasneem Fathima, Sahukat Ali, Rachel Hall, Jose Gonzalez, Gazala Ameen

Abstract: Bioinformatics has become a crucial tool to modern genomics research. Particularly in plant-pathogen studies, deciphering the structural changes in pathogen genome, virulome corresponding to its survival fitness and phenotypes related to host adaptations, accompanied by more affordable high-throughput sequencing, it massively gained traction. The recent boom in availability of multiple open-access tools intended for downstream analysis made this task substantially easier to carry out; yet, it is important to consider the appropriate pipeline relevant to each unique biological question. Thus, our project goal is to integrate bioinformatics learning along with research questions related to genome evolution of *Fusarium graminearum* (*Fg*), a clade of ascomycete fungi, causal organisms of *fusarium* head blight (FHB) disease in cereal grains. *Fusarium* secretes various mycotoxins that are harmful to humans, animals, and the environment, making infected grain unsuitable for food and feed. FHB is a persistent disease of cereal crops in world food baskets including South Dakota, and a serious threat to the quality and quantity of grain production in wheat, barley, triticale, and oats. We sequenced 23 *Fg* isolates collected from barley, wheat, and oat fields in South Dakota from 2012 to 2022 using the Illumina Nextseq500 platform. For genome analysis, we used both denovo assembly as well as reference based reads mapping to both genome and the mycotoxin producing gene cluster (which includes the *Tri5* and *Tri3* genes). In our approach we used 5 different assembly tools (for short and paired-end reads) and found SPAdes works best for our data. We hypothesize that identifying acquired mutations and rearrangements in important coding and regulatory regions of its genome will enable us to predict their effect on *Fg*'s adaptation, hence, on the local host species. Our ongoing work will analyze the shift in pathogen virulence and determine dominant chemotypes using appropriate genome analysis tools.

REU South Dakota State University
Advisor(s): Shyam Solanki

Impact of Biochar-Based Controlled Release Nitrogen Fertilizer on Soil Microbial Community — 27a — Ruth Conlin, Nidhi Priya

Abstract: The use of fertilizer is important for meeting the growing global food demand, but many chemical fertilizers cause declining fertilizer efficiency and environmental problems from excess release of nutrients such as nitrogen. Biochar based controlled-release nitrogen fertilizers are a new technology that could address these problems because the nitrogen is gradually released and the biochar is degradable in the soil. This research project was designed to study the impact of the biochar-based controlled-release nitrogen fertilizer on the soil microbial community, because this has not been extensively researched, and the soil microbial community is important for crop yield and soil health. DNA was extracted from soil samples from maize plots with different fertilizer applications and timepoints. The bacterial and fungal DNA was amplified, sequenced, and analyzed.

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

Growth Response of Duckweed (Lemna minor) to Copper and Cadmium Pollutants — 28a — Josefa Corpuz

Abstract: Duckweed (*Lemna minor*) is an aquatic vascular plant that has demonstrated potential as a phytoremediator. Because it is capable of absorbing contaminants such as copper, lead, and zinc into its tissue, it can treat heavy metal-contaminated wastewater that results from mining, tanning, and other industrial activities. Such phytoremediation treatment might improve water quality and protect wildlife from potentially dangerous metals. Previous studies have shown that duckweed can tolerate certain levels of the industrial pollutants cadmium and copper. However, it is not yet known how much this ability depends on the plants' surrounding microbial environment. We hypothesize that microorganisms may influence duckweed's ability to accumulate these pollutants in its body, and that inoculating duckweed with beneficial microbes could increase its phytoremediation ability. A growth chamber study was conducted to evaluate the potential role of microorganisms in duckweed metal accumulation. The experiment consisted of two heavy metals, three concentration levels, plus control with six replications for each treatment. Ten duckweed plants with two healthy fronds were selected and placed in 100-ml glass containers, totaling 480 plants. Plants were observed and the number of fronds were counted every two days for 18-20 days. Any visible budding, discoloration, or disintegration was recorded. Our results show that the heavy metals affected the plants' survival and population growth. Interestingly, plants exposed to a moderate concentration (1 mg/L) of copper grew more fronds than all other treatments, including controls, which suggests that duckweed growth may benefits under CuSO4 (1mg/L) concentration. Plant growth results will be analyzed using appropriate methods based on the dataset. Microbiota presence in the solution will be profiled and quantified, and metal accumulation in the plants' tissues will be assessed. The findings of this experiment may provide evidence of the feasibility of microbe-assisted phytoremediation as an eco-friendly technique for mine site reclamation.

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

Computational Benchmark for the Structure and Behaviors of Polyoxovanadate-Alkoxide Species — 29a — Sara Corsi, Susan Genevieve Duggan (Ph.D. Student)

Abstract: Polyoxovanadate-alkoxides are a class of multinuclear transition metal compounds based on earth-abundant elements with highly tunable catalytic and magnetic properties. These species are a perfect candidate for the high demand for new 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 or biomedical purposes such as anticancer, antibacterial, and antiviral applications. Previously, the Miro Group studied the nucleation and redox potentials of these species using state-of-the-art computational methods. Here, we examine the conformational stability, energies, and redox potentials of monomeric and dimeric polyoxovanadate-alkoxide species, as well as an ongoing computational benchmark that compares the accuracy of various modern state-of-the-art methodologies such as density functional theory and domain-based local pair natural orbital coupled cluster.

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

Assessing the Effects of Nanochannel Geometry on Electroosmotic Flow — 30a — Lindsey Culver, Dr. Mark Messerli and Dr. Stephen Gent

Abstract: Electrical stimulation (ES) has been identified as a therapy process that aids in healing ailments such as chronic epidermal wounds or delays articular cartilage degeneration. Although this process has been recognized as beneficial, the mechanisms as to why electrotherapy assists in healing are still unknown and a standardized treatment process is yet to be implemented. One proposed mechanism for why ES works is once an external electrical stimulus is applied, the electric fields generated induce electro-osmotic flow in the channels of the extracellular matrix. This study aims to employ Computational Fluid Dynamics (CFD) to gain a better understanding of how geometry affects the flow profiles, specifically velocity, in the channels. This study varied the channel heights at 10nm, 100nm, and 1000nm. Along with this variation, a comparison among channels with and without calcium was made. An external electric potential that induces an electric field of 1000 V/m was used in each case as cells begin to degrade quickly at electrical fields higher than this value. For this study, these external potentials included .06 mV, .6 mV, and 6 mV. A key feature of EOF is the Electric Double Layer (EDL), a buildup of ions along the surface wall prompted by the surface charge density of cells. The EDL helps drive the flow of substances helping generate a square flow profile in channels. This square profile is to be expected when analyzing channels in the range of 100nm tall whereas a parabolic flow profile is associated with narrower channels. By using the CFD solver, COMSOL Multiphysics, velocity profiles were captured for each case and compared. This allows for a better insight into understanding how geometry affects the flow in nanochannels in hopes of optimizing treatment plans for patients who undergo electrotherapy.

REU South Dakota State University
Advisor(s): Ashley Jorgensen-Blocker

Adhesive Forces of Minerals and Substrates — 31a — Cynthia Domergue, Dr. Peterson

Abstract: Traditional processing for the separation and concentration of minerals requires a large volume of water to process ores to produce metals and other mineral resources. Furthermore, most copper mines in the US are located in the southwest, particularly Arizona and New Mexico, which both have arid climates. Therefore, sustainable practices need to be developed in order to maintain the production of metals. The research in this project focused on characterizing the adhesive forces of silica and mica discs, minerals that are commonly found in mineral deposits. Each disc was modified to control surface wettability to be either hydrophilic or hydrophobic. The samples were prepared using the following chemical treatments: plasma cleaned (hydrophilic), trichloro(octadecyl) silane (TCOD, hydrophobic), and N1-(3-trimethoxysilylpropyl) diethylenetriamine (TMPA, hydrophilic). An atomic force microscope (AFM) was used to determine the average adhesive force of the samples used in this project. A comparative analysis using the AFM adhesion results of the hydrophilic or hydrophobic samples can provide an understanding of the adhesive behavior of mica and silica of varying wettability. In addition, to improve the particle-substrate adhesion measurements, a mineral particle tip will be manufactured from mineral samples using the focused ion-beam facility in the Engineering and Mining Experiment Station (EMES). Once the particle probes are manufactured, these mineral particle probes will be attached to a cantilever and used in the AFM to record adhesive forces. Ultimately, this research will be a preliminary step to developing a sustainable (dry-based) system for mineral beneficiation based upon adhesive forces, thus decreasing significantly the consumption of water by the mineral industry.

REU St. Mary's University
Advisor(s): Dr. William Cross

Culturing of Endophytic Bacteria of Indigenous Food Plants (Pediomelum spp.) — 32a
— Kai Eisenbraun, Camille Griffith

Abstract: Legumes play a crucial role in sustainable agriculture due to their ability to form symbiotic associations with nitrogen-fixing bacteria, such as Rhizobia, which contribute to enhanced N availability in the soil. Culturally, prairie legumes provide food and medicine to indigenous peoples. There is a need to characterize these bacteria in legumes for their potential benefits involving approaches to promote climate friendly agriculture. This study aims to culture N-fixing bacteria from native prairie legumes (nodules/tissues).
Field sampling locations selected were Sheep Mountain Table in the Badlands South Unit, and the Piya Wiconi campus of OLC, representing relatively undisturbed and moderately disturbed mixed-grass prairie, respectively. The species selected for harvesting are: *Pediomelum argophyllum*, *Psoralidium tenuiflorum*. Long spade shovels were used to dig around samples with an approximate 6” circumference around plants, keeping roots intact. No root nodules were observed on any of the sampled species; instead they possessed deep tubers or taproots. Root and stem tissue samples were surface-sterilized with bleach and ethanol, applied to YMB (Congo Red) plates and incubated at 28°C with growth monitored daily. Method blanks were maintained to assess sterility. The method followed for tissue surface sterilization did not prove effective and significant growth was observed in the sterility check plates, though no growth was observed from plates exposed to the working environment or streaked with instruments. More refinement of the surface sterilization method is needed. Moving forward with this research, experiments run on the bacteria will involve identifying dry stress tolerance on isolated N fixing bacteria. The objective is to identify the dry stress tolerance with sodium, simulating a dry environment. Research with mycorrhizal fungi is of interest due to the symbiotic relationship involving nutrient exchange between the fungus and the plant.

REU Oglala Lakota College
Advisor(s): Nick Klein

Augustana University ExploSTEM Camp Reaches Middle School Students — 33a — Lin-Lin Elliott

Abstract: The ExploSTEM Camp aims to promote diversity in science. The camp consisted of student designed experiments, undergraduate mentors, and activities led by professors and teachers. The 2023 camp cohort consisted of eleven students from five countries and four ethnic groups. During the week-long camp students worked in pairs with their undergraduate mentors to ask questions, design experiments, analyze results, and present their findings at a poster symposium. Student research topics included comparing bacterial biofilms and their morphology in various environments, the physiological response of *Daphnia magna* to sucrose and caffeine, and the effectiveness of different types and SPF sunscreen. All eleven campers attended a session to experiment with biofilms. In that session groups selected different environments around Augustana University that could have different bacteria and made comparisons. When students were surveyed about camp, 100% of them would recommend it to a friend. Students' average confidence in their science ability increased by 11%. Students' belief that science is an important part of their lives increased by 7%. In addition, 89% of undergraduates felt that their scientific identity was enhanced by participating in the camp and 100% reported that working with students improved their leadership skills.

REU Augustana University
Advisor(s): Dr. Sally Mallowa

Dog abundance in Kyle, SD on the Pine Ridge Reservation — 34a — Shikayla Faubion

Abstract: There is an overabundance of rez dogs in Kyle, SD on the Pine Ridge Reservation. There are reservation dogs that do not have homes and run in packs in Kyle, SD. This causes sickness in dogs and overpopulation because of breeding (*Bogel et. al. 1990*). Knowing the abundance of dogs will assist veterinarians in developing more effective and ethical strategies for dog overpopulation control such as targeted spay and neutering. Knowing this from living here my whole life I wanted to try trap cameras to get an abundance of dogs here in my community. My hypothesis is that I would predict that there is a higher abundance of dogs in cluster housing where people and stores would also have an effect on the abundance of dogs also. I set up trap cameras at 16 sites in Kyle for a duration of 3 to 4 days. The distance for each trail camera set up is 200 meters apart. I did in housing and outside of housing to try to get an estimate of dogs and how many people were in my data to collect. After I collected all my data with my materials, I then put my data in Excel to prepare for R coding. The R coding will tell me what the difference is with the abundance of dogs in and outside of housing. I want to use Reservation dog abundance as a future use of mine for when I graduate college to become a veterinarian and help my community here back home.

REU Oglala Lakota College
Advisor(s): Cami Griffith

Upconversion nanoparticle — polymer dot nanohybrid materials for bioimaging applications — 35a — Kyler Faust, Abraham Chibuikem Ikeji, Steven Wu

Abstract: Upconversion nanoparticles (UCNPs) are promising candidates for bioimaging due to their unique luminescence properties, good photostability, narrow emission spectra and no autofluorescence. Often UCNPs are coated with oleic acid as capping agent and are dispersible in non-aqueous solvents such as cyclohexane. Surface functionalization of UCNPs with water dispersible ligands by removing the oleic acid result in decrease of luminescence. Here we report a simple method that overcomes this challenge by preparing a UCNP-Polymer dot (Pdot) nanohybrid materials that are dispersible in water without removing oleic acid from the UCNPs. Our strategy for functionalizing the UCNP is based on entrapping the conjugated polymers around the UCNP through hydrophobic interactions during the UCNP-Pdot formation. Poly (styrene-co-maleic acid), an amphiphilic copolymer is co-condensed with UCNP to provide the carboxylic groups for water dispersibility and bioconjugation. UCNP-Pdot nanohybrid materials synthesized have good water dispersibility. Scanning electron microscope (SEM) and dynamic light scattering studies indicates that UCNP-Pdot nanohybrids are around 230 nm in size with spherical shape. These nanohybrid materials showed 800 nm NIR luminescence when excited with 980 nm NIR laser and showed blue fluorescence when excited with UV. UCNP-Pdot nanohybrids can be potential candidates for bioimaging applications.

REU University of South Dakota
Advisor(s): Anjaneyulu Putta

Effects of the Calcineurin Mediated Immunosuppressant Cyclosporine A on Binge Alcohol Drinking and Neuroinflammation in a Conditional Excitatory Neuron Specific Calcineurin Knockout — 36a — Alysandra Fedde[1], Katherine Pardy[1], Patrick Ronan[1], Emily Dorn[1], Jenny Agar[1], Brock Goeden[1], Liam Porter[1], Ryan Burdine[1], Thomas P. Beresford[2];
[1]Sioux Falls VA/USD Sch. of Med., Sioux Falls, SD;
[2]RMRVAMC-SOM U Colorado, Denver, CO"

Abstract: We have found that the calcineurin mediated immunosuppressants cyclosporine and tacrolimus inhibit binge alcohol drinking in mice. Further, we have shown that this effect is mediated directly in brain, as intracerebroventricular administration also significantly decreases drinking. As these immunosuppressants have severe systemic toxic effects, our goal is to determine proximal mechanisms by which these immunosuppressants are working in order to develop effective treatments for alcohol use disorder (AUD) with fewer side effects. To this end, we are employing genomic, molecular, transcriptomic, metabolomic, anatomic, and behavioral approaches to explore the relationship between binge alcohol drinking and calcineurin mediated immunosuppressants in signaling and neuroinflammatory suppression. Calcineurin is a somewhat ubiquitous phosphatase, involved in a wide range of signaling pathways — both in neurons and glia. One major question is whether immunosuppressants are acting through neuronal signaling pathways, regulating reward and stress/anxiety pathways, or in glia, mediating neuroinflammatory effects. To address this, we have developed multiple transgenic models using a floxed calcineurin line (C57BL/6-Ppp3r1tm1Stl/J) crossed with various Cre driver lines to knockout CN in various neuronal or glial populations. Here we report results for a conditional neuronal CN knockout; a "panneuronal" CN knockout line (CamKIIα-Cre). Extensive experiments have determined that binge-like drinking, both acute and chronic, is not affected by the CN knockout. Furthermore, cyclosporine still had a robust inhibitory effect on alcohol drinking in this population. These findings along with data from other neuronal CN knockout and molecular data showing inhibitory effects of CsA on neuroinflammation are converging to suggest that CsA effects on drinking are likely mediated by glial mechanisms.

REU Mount Marty University
Advisor(s): Patrick Ronan

Electrochemical Reduction of Fluorinated Benzophenazine Compounds — 37a —

Mason Ferrie, Shankar Gairhe and Yao Feng

Abstract: Hydrofluorocarbons (HFCs) will soon be phased out as refrigerants as they are known for their contribution to global warming. Phasing out large quantities of HFCs creates a significant need to search for effective methods to decompose and repurpose these small molecules. However, decomposing and repurposing HFCs is very difficult due to the strong carbon-fluorine bonds and the corresponding carbon- hydrogen and carbon-carbon bonds within the same molecule. One technique that can be used to investigate the decomposition of HFCs is defluorination through electrochemical reduction. We have been analyzing benzophenazines with four different perfluoroalkyl side chains (trifluoromethyl, pentafluoroethyl, perfluoropropyl, and perfluorobutyl) using cyclic voltammetry, a method that displays each compound's unique electrochemical properties. These benzophenazines with perfluoroalkyl side chains exhibit one diffusion-controlled reversible one-electron reduction waves as well as irreversible reduction waves caused by reductive defluorination. With repetitive scans passing the second irreversible reduction wave, we observed that an appreciable amount of redox active material was deposited onto the electrode surface evidenced by increased current in cyclic voltammograms. We further observe that such electrode surface deposition seems to depend on the perfluoroalkyl side chains. We speculate that this deposition can be linked to the formation of a new polymer after reductive defluorination of the perfluoroalkyl side chains on the benzophenazines. Then Scanning Electron Microscopy (SEM) was used to study the surface deposition morphology on the working electrode. These results show that perfluoroalkylated benzophenazines could be used as intermediates for repurposing hydrofluorocarbons into possible useful polymer materials in the future.

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

Local Deep Galerkin Method (LDGM) applied to 2D - Cahn-Hilliard Equation (2D-CH) — 38a — Caden Fischer, Yangxiao Bai, Shi Wen Wong, Dr. Nathan McClanahan, and Dr. Jung-Han Kimn

Abstract: Artificial Neural Networks (ANNs) have been at the forefront of development because of advancements in computing resources. With this computational power, many applications of ANNs have been discovered, including medical diagnosis, image recognition, speech recognition, machine translation, among others. However, these applications work well because of the vast data available for these problems. Physics-informed Neural Networks (PINNs) allow the power of ANNs to be applied to physics problems which typically have a much lower amount of data. Some PINNs try to find an approximate solution to Partial Differential Equations (PDEs). The solutions to PDEs are typically approximated by classical numerical methods, which can be computationally expensive. The PINN used in this study is meshless, meaning the solution is not confined to a grid of distinct points. Thus, this type of PINN promises less expensive solutions for high-dimensional problems, which is extremely expensive for classical methods with a mesh. This study examines the continuous-time inference algorithm, the Local Deep Galerkin Method (LDGM), and its application to the 2-Dimensional Cahn-Hilliard Equation (2D-CH). The 2D-CH models phase separation. One application of this is to modeling biofilm. We present a network architecture that can capture the dynamics of the 2D-CH equation. The model is trained on a loss function that minimizes the residual of the equations. After the training, the model is compared to a Finite Element Method code simulating the same equations. The results of this study show that LDGM produces accurate results for the 2D-CH equation and can greatly speed up simulation computation compared to a classical numerical method.

REU South Dakota State University
Advisor(s): Dr. Kaiqun Fu

The Search For Dark Matter: Rate of Rise — 39a — Aaron Flores, Gavin Cox, Tomasz Biesiadzinski

Abstract: There are various tasks performed routinely to ensure satisfactory performance for the Lux Zeplin (LZ) dark matter detector approximately a mile underground at Sanford Underground Research Facility (SURF) in Lead, South Dakota. The onsite team performs detector calibration using radioactive sources, remote systems monitoring, sampling of xenon gas, and maintenance of vacuum spaces, to name some tasks. This poster focuses primarily on automation of timestamps for Rate of Rise (ROR) tests performed on the LZ detector vacuum spaces. Keeping a satisfactory vacuum requires constant pumping to prevent pressure from building. Roughly once a week the onsite team valves off the pump from the space and plots the Rate of Rise in pressure to simulate a situation where there is a loss of power to the Davis Campus on the 4850 level of SURF. Being able to test if an extremely low-pressure vacuum space can be maintained for a satisfactory period is one of the safeguards used by the experiment to safeguard over 100 million dollars' worth of xenon. A current drawback of an ROR is the process is not automated. The onsite team must take time to search the LZ database by manually inputting the time the test was performed for the desired status sensors. In this project, I was able to successfully automate a process where a function written in Python returns timestamps for the desired sensors. Intended to run on a daily basis, the function returns the times an ROR test was performed for sensors the onsite team wanted automated. With this, the team can have daily reports of this critical test sent to them without them having to manually search for the data.

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

Ultralow Background Counting for the LZ Collaboration — 40a — Steven Flores, Jaime Cochran

Abstract: The LUX-ZEPLIN (LZ) experiment focuses on detecting dark matter through interactions with liquid Zenon. The photons produced are detected by the photo multiplier tubes (PMT). The work done at the Black Hills Underground Campus (BHUC) on the 4850L of the Sanford Underground Research Facility is essential to the success of the LZ experiment, because the materials that make up LZ must be assayed for radioactive nuclides. The BHUC utilizes high-purity germanium (HPGe) crystals to detect the small traces of radioactivity in a certain sample.

One of the HPGe detectors known as Morgan counted a sample for the LZ experiment and radioactive nuclides were identified in the sample. In addition to the HPGe detectors at the BHUC, the SOLO detector is located above ground on the main BHSU campus. It will be used to assay samples before they are counted underground at the BHUC. This poster will describe work currently being done to build a program via LABVIEW in which liquid nitrogen can be monitored and controlled for the SOLO detector.

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

Leveraging 3D Printing to Produce High-Quality, Durable, and Cost-effective Devices for Microfluidic Experiments — 41a — Derek Follett, Taufiqur Rahman

Abstract: Microfluidics is an emerging technology that can process tiny fluids using micrometer-scale channels. Microfluidics offers a new paradigm of research in conjunction with cutting-edge 3D printing, microfabrication, and advanced imaging systems. Observation of live cells' behavior, live-imaging, cell tracking, and cell counting leverage the benefits of this system over conventional technology. We use ultra-precision and high resolution Two-Photon Polymerization (2PP) 3D printing technology to fabricate micro-structures and construct polydimethylsiloxane (PDMS)-based microfluidic chips. Our goal is to use microfluidic devices for counting small bacterial cells, single cell tracking, study anaerobic bacteria, and the dynamics of enrichment of antibiotic-resistant bacteria. However, several challenges have arisen during microscopy experiments with microfluidics. These include frequent stage movements leading to focus loss, hindering image clarity and experimental outcomes. Additionally, standard microscope setups do not meet the requirements for studying anaerobic bacteria within microfluidics, requiring an oxygen-free chamber. Moreover, the production of numerous micro-structures using 2PP can be time-consuming and expensive. To address these challenges, we developed a microfluidic device holder and an anaerobic chamber using a fused deposition modeling (FDM) 3D printing system. This enabled us to overcome focus loss issues and create an appropriate environment for anaerobic bacteria research. To overcome the production challenges, PDMS is employed to create multiple replicas using a single 2PP-fabricated structure, enabling the construction of multiple PDMS-based microfluidic chips. Furthermore, we leveraged 3D printing capabilities to produce low-cost custom holders for slides and petri dishes that fit our microscopy system. These holders, along with the microfluidic device holder offer flexibility, are cost effective, durable, and ease of modification, contributing to the optimization of laboratory experiments.

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

Identifying and Targeting Neoantigens in Small Cell Lung Cancer — 42a — Barien Gad, Robert Szczepaniak Sloane

Abstract: Small Cell Lung Cancer (SCLC) is a deadly and quickly progressing disease, caused by the inactivation of tumor suppressors p53 and RB1. A distinctive feature of SCLC is its high burden of missense mutations usually caused by smoking. These mutations are predicted to result in a high rate of neoantigen formation, offering an opportunity for immune surveillance in this disease. This project investigates the MHC1 Antigen Presentation and self/non-self discrimination of missense mutation-derived neoantigens and assesses their potential as targets for cancer immunotherapy. A combination of computational and experimental tools was applied to analyze five SCLC lines for all missense mutations. In silico tools facilitated the quantitative prediction of peptide-MHC binding, enhancing understanding of neoantigen formation from missense mutations. Subsequent molecular docking of selected mutations - those with the highest probability of MHC surface expression - helped visualize the 3D structure of peptide-MHC complexes, considering both wildtype and mutant peptides. Further computational analysis investigated the effects of these specific mutations on TCR-peptide-MHC interaction and docking variations, providing insights into changes in binding affinity, kinetics, and stability induced by these mutations. In summary, this research employs computational and experimental methods to characterize missense mutation-derived neoantigens and identify candidates for targeted immunotherapy for SCLC. The findings contribute to the broader understanding of SCLC's interaction with the immune system and offer potential avenues for future investigation.

REU Illinois Institute of Technology
Advisor(s): Micheal Kareta

Learning the Bacterial Leaf Streak Genome — 43a — Claire Galvin, Ahmed Alhusays, Ellen Fitzpatrick, Meenu Sengar, Jose Hernandez-Gonzalez, Shyam Solanki

Abstract: Bacterial leaf streak (BLS) is an emerging disease that affects the yield and quality of wheat and barley plants in the upper midwest region of the US. BLS is caused by a bacterial pathogen *Xanthomonas translucens*. Currently, there are no chemicals registered to control the disease and not a single variety of wheat or barley provide complete resistance to BLS. Moreover, there is less information about the bacterial pathogen and its pathovars. Our goal is to dissect the BLS-wheat pathosystem for better understanding of the pathosystem and develop strategies for disease management in the wheat growing regions of the world. Our research objective is to sequence the whole genome using four strains of *Xanthomonas translucens* isolated from wheat leaves found around the state of South Dakota. We are using nanopore sequencing and flye to get the whole genome assemblies of the four strains. While also annotating the genome and using homology to identify virulence factors of the *Xanthomonas translucens* pathogen. The outcome of the research will lead to functional validation of the virulence factors for BLS. We will also be able to provide robust diagnostic markers for BLS detection that can be used by researchers worldwide.

REU South Dakota State University
Advisor(s): Gazala Ameen

One Step Exonuclease III-Assisted Target Recycling Strategy for Highly Sensitive Detection of DNA — 44a — Jacob Guerrero

Abstract: In recent years, numerous studies have focused on developing new methods to amplify specific DNA sequences. Currently, the most used technique for DNA sequence amplification is polymerase chain reaction (PCR). While PCR is highly sensitive, it has drawbacks such as being time-consuming, prone to false positives, and requiring specialized thermo-equipment. However, the Wu group has recently developed a DNA platform for targeted sequence amplification. Our project aims to create a simple and efficient method for highly sensitive DNA detection by utilizing exonuclease III (Exo III) to assist in amplification. The DNA platform consists of three components: a magnetic separation portion, a recognition portion, and a signal reporter portion. The magnetic separation portion involves using streptavidin-coated magnetic beads, while the recognition portion utilizes probe DNA bound to biotin. The signal reporter portion comprises of Pdots, which were synthesized using DSPE, PEG, and DBSO polymers, with PFCE serving as the fluorine sensor. The overall outcome of our research demonstrated that the DNA platform successfully bound to the target DNA with a specific sequence using Exo III to assist in the amplification. Upon binding, both the target DNA and Pdots were released, resulting in a detectable signal. Importantly, Exo III facilitated the release of the target DNA and Pdots without requiring harsh conditions and within a short timeframe. This work holds potential for future applications in laboratory and medical settings, paving the way for advancements in the field.

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

Using SIMPL for Automatic Image Capture and Analysis — 45a — Sam Haas, Bichar Shrestha Gurung, Timothy Hartman, Manish Rayamajhi, Etienne Gnimpieba

Abstract: Microscope-based image capture and analysis remains imperative in research and clinical settings. Current methods for quality analysis of micrographs are powerful and have immense value. However, many processes lack user functionality and reproducibility. These are some shortcomings where our Smart Imaging of Micrographs Process and Labeling (SIMPL) system aims to improve. SIMPL is an open-source and automatic image capture software that promotes reproducibility and automatic reporting for high throughput applications.

Using a Raspberry Pi to support Jupyter Notebook and R programming, SIMPL is designed to perform automatic image capture to strengthen image quality and take micrographs of full samples. This is done by using a z-stack approach to capture images at each unit position and calculating Laplacian variance to measure the focus quality of the image. The resulting quality scores and corresponding z-positions are processed to locate the best focal point of the microscope. X- and y-axis stage movements allow SIMPL to complete a full-sample image capture on the correct focal plane. The captured images are automatically stored in a local folder. Images' objects are segmented and analyzed using the Bioimage Analysis, Statistic, and Comparison (BASIN) software written in R. BASIN provides the user with an easy-to-read analysis report on the data that was extracted for simple interpretation. SIMPL can automatically find the best height to maximize image quality, move the stage, and capture images at various positions. Having ran analyses on various cell types, it is shown that the software can give reproducible and automatic sample screening in research applications. The reproducibility of the process can be beneficial in research settings while allowing a framework to provide easy automation.

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

Characterization of Y48A6B.7 (xse-1) in Purine Degradation & Xanthine Stone Formation in C. elegans — 46a — Grace Hagedorn, Sushila Bhattacharya, Jennifer Snoozy

Abstract: Purines are necessary for DNA and RNA synthesis and kept at specific concentrations by balancing synthesis and degradation. The importance of purine homeostasis is highlighted by two rare human diseases, Xanthinuria and HPRT deficiency. Xanthinuria is caused by inactivation of xanthine dehydrogenase (*xdh-1*) and leads to accumulation of xanthine stones and renal failure. HPRT deficiency leads to hyperuricemia and gout due to loss of purine salvage. Thus, understanding purine homeostasis is an important goal of human health. To better understand purine homeostasis, we employ genetic strategies in the nematode *Caenorhabditis elegans*. Purine metabolism is highly conserved in *C. elegans*, and we have developed models of purine metabolic disorders. As in humans, *xdh-1* deletion causes xanthine stones in *C. elegans*. Surprisingly, only 1-2% of *xdh-1* null mutants develop stones. Given this low penetrance, we hypothesize that additional pathways act to maintain purine homeostasis during *xdh-1* deficiency. To identify these pathways, we performed a genetic screen for Xanthine Stone Enhancers *(xse*). We identified an uncharacterized deaminase which we named *xse-1*. 86% of *xse-1*; *xdh-1* animals develop xanthine stones demonstrating that *xse-1* is necessary to prevent xanthine stone formation. To characterize the role *xse-1* plays in purine metabolism, we determined the genetic interaction between *xse-1* and established purine metabolic enzymes; purine nucleoside phosphorylase (*pnp-1*) and hypoxanthine phosphoribosyltransferase (*hprt-1*). We demonstrate that *pnp-1* is required for the formation of xanthine stones caused by loss of *xse-1*. Inversely, *hprt-1* deletion increases the number of xanthine stones in the *xse-1*; *xdh-1* null, likely because it prevents the salvage of guanine and hypoxanthine, forcing conversion to xanthine. These genetic data suggest that *xse-1* may function as a guanosine deaminase and establish a role for *xse-1* in animal purine metabolism. These fundamental insights may lead to new understanding of purine metabolism rewiring and homeostasis in these disease models.

REU Sanford Research
Advisor(s): Kurt Warnhoff

Deciphering the genome diversity of wheat pathogen Pyrenophora tritici-repentis — 47a — Rachel Hall, Jaswinder K, Shaukat Ali, Hugo M.M. Conde, Jose Gonzalez, Gazala Ameen, Shyam Solanki

Abstract: *Pyrenophora tritici-repentis* (*Ptr*) is a fungal necrotrophic plant pathogen that causes tan spot, a destructive foliar disease of wheat. Genomics of the *Ptr* pathogen has shown it to have a complex genome with many repetitive sequences and several small-secreted proteins (SSPs) potentially acting as pathogen effectors. The effector repertoire of *Ptr* enabling them to produce distinctive necrosis or chlorosis phenotype on hosts is a major component of pathogen race classification and host susceptibility determination. The pathogen genome encoded host selective toxins (HSTs) in *Ptr*, specifically the necrosis inducing effector gene (*ToxA*) and the chlorosis inducing effector genes (*ToxB* and *ToxC*) are the major virulence factors in the wheat host, yet the contribution of other genomic regions is important for host adaptation. Thus, the goal of our research is to monitor the pathogen population and its genome adaptations which can provide insights into *Ptr*'s race structure and help us to avoid potential disease epidemics. However repetitive genome of pathogen presents a challenge during sequence assembly. To negate this issue and study a diverse panel of 25 *Ptr* isolates collected for various locations worldwide, we isolated the high molecular weight DNA and the short read sequencing in Illumina Nextseq500 platform and complimented the sequence analysis of three isolates using Oxford Nanopore sequencing using LSK110 chemistry. Additionally, we have carried out the short sequence assembly using five different opensource platforms, SOAPdenovo2, Shovill with MEGAHIT, Shovill with SPAdes, SPAdes, and Platanus, on SDSU's cluster computing to evaluate their efficiency of handling such complex genomes. We also phylogenetically classified these isolates based on Tox gene diversity and our results indicate that a diverse population of the *Ptr* exists in South Dakota and warrant that the wheat germplasm should be screened for effective resistance breeding.

REU South Dakota State University
Advisor(s): Shyam Solanki

Using Live Imaging to Analyze Protein Trafficking in Mammalian Primary Cilia — 48a — Mary Helms, Casey McKenzie, Lance Lee

Abstract: Primary Cilia Dyskinesia (PCD) is a rare pediatric syndrome affecting around 1:16000 live births and associated with phenotypes including hydrocephaly, chronic respiratory infections, laterality defects, and subfertility. It is caused by a dysfunction in motile cilia, which generate fluid flow in areas such as the brain, airways, and reproductive tracts. However, there is not currently an effective way to view protein trafficking and dynamics in motile cilia in real time, leaving the mechanism of motile cilia function and PCD pathogenesis poorly understood. Primary cilia are a separate type of cilia in which protein dynamics are easier to image. This project validates novel techniques developed for visualizing motile cilia protein dynamics in primary cilia. NIH3T3 cells undergo viral transduction and lipid mediated transfection to express the ciliary protein IFT52 with a GFP tag. After the cells produce primary cilia via serum starvation, live fluorescent imaging is used to view the protein trafficking of IFT52-GFP in real time, and confocal immunofluorescence is used to view the colocalization of IFT52-GFP with a cilia microtubule marker. Through using these methods on primary cilia, we can effectively apply these processes to view protein trafficking and dynamics in motile cilia and better understand the mechanisms underlying PCD.

REU Wayne State College
Advisor(s): Dr. Lance Lee

Identification of Fast-growing Nitrogen-fixing Cyanobacteria from Natural Ecosystems — 49a — Isha Hooda, Taufiq Nawaz, Cayden Budd, Matt Lettow, Liping Gu, Ruanbao Zhou

Abstract: Cyanobacteria, a group of photosynthetic microorganisms, possess numerous applications in various fields such as biomass production, biofuels, fragrances, pigments, and therapeutics. Historically, their use has predominantly focused on carbon fixation, overlooking the potential advantages of their nitrogen-fixing capabilities. Nitrogen gas, the most abundant component of Earth's atmosphere, needs to be converted into ammonia, a more accessible form, to support essential biological processes. Nitrogen-fixing cyanobacteria have been playing critical roles in maintenance of soil fertility and soil health that harmonize the soil biological, chemical, and physical properties to sustain annual biomass production in natural ecosystems without the need of chemical N-fertilizer. This project is to isolate fast-growing nitrogen-fixing cyanobacteria from native ecosystems (topsoils, air, and fresh bison feces) of Nebraska and South Dakota. We have isolated at least five fast-growing nitrogen-fixing cyanobacterial strains. Next, we will isolate genomic DNA for genome sequencing to identify powerful nitrogenase genes from fast-growing cyanobacteria strains, develop these fast-growing nitrogen-fixing cyanobacteria as a Living Cyanofactory to produce Bio-Nitrogen fertilizer. Eventually we will return these “bugs” to crop fields where the “bugs” may be extinct due to heavily applied chemical N-fertilizer and frequent tillage, Lastly, we will genetically engineer these fast-growing cyanobacterial strains to produce nitrogen/carbon-rich bioproducts using dinitrogen gas (N 2), carbon dioxide, water and sunlight.

REU Augustana University
Advisor(s): Dr. Ruanbao Zhou

Exploring Neurodevelopmental delay in Beta-Propeller Protein Associated Neurodegeneration — 50a — Jessica M. Howard, Brandon L. Meyerink, Krishna S. Karia, Louis-Jan Pilaz

Abstract: Beta-Propeller Protein Associated Neurodegeneration (BPAN) is a biphasic disorder with neurodevelopmental and neurodegenerative components. There is currently no cure for this disorder and treatment options are extremely limited. There has already been investigation on the neurodegenerative component in mouse models of BPAN that has resulted in publication, mainly connected to the loss of motor function and neurons in areas of the brain associated with late-stage disease. However, little to no exploration has occurred to investigate the early developmental delays in BPAN models. These developmental phenotypes need to be investigated in mouse models to determine if they are the bases of later maldevelopments. The present study used a novel mouse model of BPAN mimicking a genetic mutation found in BPAN patients. We looked at behavioral metrics during the first month of these mouse models to assess how early developmental phenotypes start expressing. We used the Ultrasonic Vocalization test on perinatal mice to determine any significant delay in development of communication behavior and circuitry. Our study also includes preliminary data for the Light Dark test and Force Plate tests in the mouse to determine the onset of anxiety and hyperactivity symptoms also experienced by patients with BPAN. Finally, we determined motor delays in our model using the Rotarod and Pole Climb tests. Together this data will help create a more complete picture of how neurodevelopmental delays may be related to neurodegenerative symptoms and open the investigation between the two pathologies of BPAN.

REU Concordia College Moorhead
Advisor(s): Louis-Jan Pilaz

Near infrared upconversion nanoparticle — polymer dot materials for biofilm applications — 51a — Abraham Ikeji, Steven Wu, Anjaneyulu Putta

Abstract: Bacterial infections and biofilms from chronic wounds or medical devices become tough to treat as they develop resistance against antibiotics. Discovery, development, and commercialization of antibiotics is a time intense and expensive process. Therefore, development of novel approaches alternative to antibiotics is a crucial need in treating bacterial infections and biofilms. Nanomaterials are emerging class of materials alternative to antibiotics, however traditional nanomaterials such as ZnO, Fe_3O_4 are limited to treat superficial bacterial infections as they use UV/Visible light as the excitation source. At present study, we developed novel upconversion nanoparticle (UCNP) – polymer dot (Pdot) nanohybrid materials that are excited by near infrared (NIR) light and penetrate tissues deeply and eliminates autofluorescence in the biological window. These nanohybrid materials were prepared via nanoprecipitation method by dispersing NIR upconversion nanoparticles, PCPDTBT polymer along with amphiphilic copolymer PSMA in THF. The carboxylic groups on the outer surface of the UNCP-polymer dots aids in water dispersibility and conjugation with biomolecules. The size and morphology of synthesized nanohybrid materials were characterized using scanning electron microscope (SEM) which showed hexagonal UCNPs are encapsulated by polymer dots via hydrophobic interactions (170-200 nm). The zeta potential (-21.5mV) indicated the surface charge and their colloidal stability. The UCNP-Pdot nanohybrid materials showed good prospect for heat generation when excited with 980nm NIR laser with intensity of 2.00 W/cm^2, which is effective to inhibit bacterial growth. Due to the low toxicity, deep-tissue penetration, good stability of the UCNP-Pdot nanohybrid materials, this novel approach potentially addresses key challenges in treating biofilms and antibiotic resistant bacterial infections.

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

Microstructure and Corrosion Properties of Cu-Ti-Y_2O_3 Alloys Produced Using High Energy Ball Milling — 52a — Sophia Isacco

Abstract: Cu-Ti alloys are a safer and cheaper alternative to Cu-Be alloys for electrical applications, and the addition of Ti and Y_2O_3 improve corrosion behavior while maintaining desirable mechanical properties. The main objective of this work is to investigate the microstructure and corrosion properties of Cu-Ti-Y_2O_3 alloys produced using high energy ball milling process. Cu-7.5 wt% Ti and Cu-7.5wt%Ti-0.8wt%Y_2O_3 powders were ball milled to create mechanically alloyed powders. The milled powders were cold compacted at 6 tons of pressure and sintered at 800°C to generate ~3 mm thick compacts. Laser particle size analysis, X-ray diffraction and scanning electron microscopy was performed to characterize the powders before and after ball milling. Electrochemical testing was performed in 3.5 wt% NaCl solution to evaluate the corrosion properties of the compacts and the effect of Ti and Y_2O_3 addition to Cu on the corrosion potentials and corrosion rates was analyzed and discussed.

REU North Carolina State University
Advisor(s): Dr. Bharat K. Jasthi

Speciation and Nucleation of Novel Uranyl-Peroxide Nanocapsules for Improving the Treatment of Nuclear Waste — 53a — Dori Jal, Dr. Korey Carter

Abstract: The aqueous speciation of actinides is very complex, and relatively little is known regarding the composition, structure, and properties of transient species present during the formation of actinide materials in basic peroxidic environments. Uranyl-peroxide nanocapsules are a unique family of self-assembled actinide species that self-assemble in basic peroxidic media through a complex reaction network involving a myriad of intermediate species to form nanometric capsules. The preferred product, nucleation pathway, and speciation is highly influenced by concentration, species in solution, temperature, and pH, which usually makes key intermediates difficult to characterize experimentally, thus the imperative need of studies using modern quantum mechanical studies in conjunction with supercomputers to streamline the exploration such vast chemical space. Here, we present our initial results on the computational study of the speciation and assembly of a uranyl-peroxide nanocapsule containing 96 uranyl units, which was recently synthesized by our experimental collaborators at the University of Iowa.

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

3D reconstruction of Biofilm formation from image dataset using Machine Learning — 54a — Rishi Kamojjala, Bichar Dip Shrestha Gurung, Manish Rayamajhi, Tuyen Do, Tim Hartman, Etienne Gnimpieba

Abstract: Biofilm formation is a multifaceted occurrence that has large-scale impacts in fields like medical research, industry, and environmental sciences. Reconstruction and visualization of these biofilm structures in a 3D will allow one to observe the spatial distribution and how these microbes interact with each other. By following this procedure, the 3D biofilms are reconstructed from 2D microscopic images. While traditional methods like scanning electron microscopy do exist, these methodologies are only capable of providing a thin slice of the overall spatial distribution of the biofilm and tend to be time-consuming and allow for human bias. We propose here to reconstruct biofilm in 3 dimensions with the use of machine learning by combining image analysis, deep learning algorithms, and computer vision. Our machine learning-based approach consists of 4 steps, including Image Preparation, Image Preprocessing, Segmentation, and Reconstruction using the Open-source geometry library (Meshlib) to generate 3D models of the biofilm from the 2D mask slices. The image preparation involves the ordering of the slices and image preprocessing is done for noise removal. For segmentation, we use methods like custom Unet segmentation and Otsu-thresholding. The 3D mesh that is produced accurately captures the shape and spatial distribution of the 2D biofilm initially provided. Initial results show the effectiveness of this approach in the reconstruction of 3D biofilm structures. In conclusion, through the machine-based learning approach analyzed in this paper, it is feasible to reconstruct biofilm structures from 2D microscopy images. Biofilm formation can be studied accurately and more in-depth, which will advance research across multiple different fields. In the future, this algorithm will be refined to work more efficiently and the application of the 3D models will also be analyzed. Furthermore, work will be done to include it in existing image analysis tools.

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

Wobbleboard 3D Labyrinth — 1p — Gabriel Jerome

Johnson Space Center is working on a project called the “Wobbleboard,” which is designed to train an astronaut’s mind and body to balance properly. The goal is to maintain their ability to balance with a practical approach. On average, crewmembers spend about six months in microgravity for one mission, and it only takes a few days for them to experience muscle atrophy. They follow rigorous training plans to combat this effect, but it does not work perfectly. Crewmembers must perform workouts in unnatural positions to accommodate for microgravity, which can lead to abnormal physical and mental development. The Wobbleboard is more effective than other techniques because it involves real balancing. The crewmember stands on a circular board that can pivot in any direction about the center. It uses actuators attached to either side of a person that pull them down at a given percent of their body weight. Then, they can lean in any direction and try to stay balanced. This uses stabilizing muscles all over the body that are typically naturally developed in Earth Gravity. It also calibrates the mind to maintain the ability to stay upright. The crewmembers will play a game as their balance training on the Wobbleboard. They need to balance without thinking about it just like a person on Earth does. A game is meant to distract them from the real reason they are using the Wobbleboard. It makes the training feel more natural, and like a competition rather than a chore. The only game designed specifically for the Wobbleboard as of now is 3D Labyrinth where they tilt a maze by leaning in any direction and navigating a ball to the end. The Wobbleboard is an effective way to train an astronaut to balance naturally and avoid stabilizing muscle deterioration.

REU South Dakota Mines
Advisor(s): Jeevan Perera

Determining responses to competition between Bradyrhizobium strains — 2p —

Hazem Khalaf Mohammed, Athira Madhavan, Lilia Montanez Hernandez, and Dr. Senthil Subramanian

Abstract: Nitrogen is a crucial element required for plant growth and development. Legumes develop symbiotic associations with a group of soil bacteria called Rhizobia that can reduce inert nitrogen into assimilable ammonia to obtain nitrogen nutrition. Competition between *Rhizobium* strains with different nitrogen fixation capacities for nodule occupancy often leads to a reduction in overall symbiotic efficiency and thus nitrogen nutrition in host plants. Here we aim to determine how soybeans respond to two species of *Bradyrhizobium* (*B.diazoefficiens* and *B.elkanii*) with different nitrogen fixation capacities. We used a split root system approach to study plant responses by simultaneously inoculating the separate root halves with different strains. We tested two combinations of *Bradyrhizobium* strains, one with a high-capacity and a low-capacity nitrogen fixer (*B. diazoefficiens* USDA 110 and *B. elkanii* USDA 26) and the other using two low-capacity fixers (*B. diazoefficiens* USDA 126 and USDA 26). Our previous experiments with *B.diazoefficiens* strains (USDA 110 and USDA 126) showed that host plants can select and favor high-capacity fixers. However, split root assays using *B.elkanii* strains (high-capacity fixer USDA 83 and USDA 26) showed no selection towards either of these strains in terms of nodule counts. In this study, we aimed to address if similar host responses can be seen with different combinations of *Bradyrhizobium* species. Results from this study indicated that soybeans could sanction USDA 126 when in competition with USDA 26 in terms of nodule formation. With USDA 110 vs. USDA 26 combination, we observed a difference in nodule numbers suggesting that the host plants do not select against USDA 26 at the nodule formation stage although it is a low-capacity nitrogen fixer. Additional levels of sanctions, for example at the level of carbon supply to the rhizobium need to be evaluated to determine if USDA26 is able to overcome plant sanctions.

REU South Dakota State University
Advisor(s): Athira Madhavan and Dr. Senthil Subramanian

Generating synthetic data for material corrosion using Variational Autoencoders (VAEs) — 3p — Varun Kommareddy, Tuyen Do

Abstract: Generating synthetic data based on real, tangible lab data allows researchers to identify accurate patterns in data which are balanced, unbiased, and high quality. Scaling projects become far more accessible as synthetic data fills the gaps in experimental data and provides information at a larger scale. The three main use cases are testing and development of new software, training machine learning models to provide more accurate prediction, and removing biases in present datasets. There are multiple libraries and tools to generate synthetic data in Python, but the two main ones that are used are Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs). To generate synthetic data for material corrosion, which is tabular data containing both numerical and categorical values, the best method to use is VAEs. VAEs operate on an encoder/decoder system and can reconstruct missing data by using latent spaces and decoding them to the original data points; this is specifically because the material corrosion data set has many missing values. VAEs also make generating synthetic data very simple as they can learn from unspecified data and apply it to many different use cases such as data compression, dimensionality reduction, and visualization. The type of library we use for our case is Deep Tabular Augmentation, which uses deep neural networks to understand the patterns behind the original dataset. When using these deep learning models, it is always important to make sure that the synthetic data adhere to the patterns and relationships found in the original data.

REU Indiana University
Advisor(s): Dr. Gnimpieba

In Situ Peroxide Generation in Actinide Phosphate Species — 4p — Mololuwa Faithful Lasekan

Abstract: The synthesis of uranyl peroxide materials involves high initial concentrations of aqueous hydrogen peroxide that decline over time. An example of this approach is uranyl-peroxide nanocapsules in which uranyl ions rapidly self-assemble in basic peroxidic media through a myriad of reactions to coalesce into a single nanocapsule. A wide variety of capsules can be formed, and it has been proposed that square, pentagonal, and hexagonal building blocks assemble prior to nanocapsule formation. Recently an alternative approach has been used in the generation of hexagonal uranyl-peroxide phosphates, where phosphates prevent the formation of nanocapsules, and peroxide was generated in situ thus maintaining a constant peroxide concentration over time. The experimentally proposed mechanism involves the autoxidation of benzaldehyde in the presence of uranyl which results in the in-situ generation of organic peroxide. Here, we present our initial results on the computational study of the peroxide generation mechanism in the synthesis of uranyl-peroxide phosphate species.

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

Lipid droplet formation upon cholesterol dysregulation: protective or pathogenic cellular response? — 5p — Amelia Lawver, Jazmine D. W. Yaeger, Sonali Sengupta, Kevin R. Francis

Abstract: Cholesterol balance is necessary for cellular health, and the cell's ability to produce cholesterol serves as a vital process for maintaining homeostasis. Diseases upsetting cholesterol regulation frequently affect the central nervous system as dietary cholesterol cannot cross the blood-brain-barrier. For example, Smith-Lemli-Opitz Syndrome (SLOS), a genetic disorder impairing cholesterol biosynthesis, results in learning deficits, intellectual delay, and/or autism. A common characteristic of diseases affecting cholesterol balance, including SLOS, is the accumulation of cellular structures known as lipid droplets (LDs). Acting as neutral lipid storage compartments, LDs protect cells against lipotoxicity by preventing cholesterol and fatty acids from being oxidized, which can lead to damage of cell structures and DNA. While it is clear LD formation is related to disruptions in cholesterol homeostasis, identifying where these structures localize within the cell remains unclear. Further, it is unknown if LDs serve as a critical part of disease pathologies or a symptom of cellular stress. We hypothesized LDs to be localized to the endoplasmic reticulum (ER) and possess the protein marker perilipin-3. We also predicted various forms of cellular stress to promote LDs, but possess unique qualities dependent on the stress encountered. In these studies, we used neural cells from both human and mouse models of SLOS to quantify and define LD accumulation and localization using BODIPY, a neutral lipid stain. Additionally, we exposed human immortalized microglia to various forms of stress before quantifying LD formation. Genetic and pharmacological models of SLOS showed an increase in LDs relative to controls. In mouse astrocytes, we defined LD accumulation to be mostly within the ER and to be colocalized with perilipin-3. Human microglia exposed to various forms of stress responded by accumulating LDs, but treatment with oleic acid resulted in large LDs surrounded by perilipin-3 aggregates. Together, these findings uncover important information related to disease-derived LDs and their role in maintaining cellular health.

REU Bethel University
Advisor(s): Kevin Francis, PhD

Assembly of Gold Nanoparticles via Metal-Organic Supercontainers for Surface-Enhanced Raman Spectroscopy (SERS) — 6p — Mathew Leininger, Kriti Chitrakar, Robyn Cook, Shrijana DC, Abraham Tillquist

Abstract: The rapid rise in illicit drug use and new studies of the adverse health effects and socio-economic consequences have proliferated society over the last decade. Surface-enhanced Raman scattering (SERS) is a favorable analytical tool for the detection of low drug dosage in liquid and solid samples due to its sensitivity and accessibility. However, two drawbacks of this technique are the signal strength and reproducibility. This presentation focuses on using metal-organic supercontainers (MOSCs) as linking agents to assemble gold nanoparticle (AuNP) substrates into ordered arrays, which is expected to generate SERS hotspots and produce enhanced and reproducible SERS signals. MOSCs are supramolecular host molecules constructed from three parts: container precursor, metal ions, and carboxylate linker. They feature endo- and exo- cavities typically suitable for binding small molecules and ions. In this project, we showed that prototypal MOSCs can be modified with carbonyl groups by using a suitable carboxylate linker. Ultraviolet-visible (UV-Vis) spectroscopic study indicated that the carbonyl-functionalized MOSCs have the ability to bind to AuNPs - one of the most common substrates used in SERS. Integrating the MOSCs and AuNPs has potential to enhance SERS signal strength, provide reproducible results and improve target selectivity. Future studies will examine the potential of the MOSC/AuNP assembly for illicit substance detection via SERS sensing.

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

Effects of Carbon Dioxide on Nitrogenase Activity in Cyanobacteria — 7p — Matthew Lettow, Liping Gu, Taufiq Nawaz, Cayden Budd, Isha Hooda

Abstract: The conversion of dinitrogen (N_2) gas into ammonia (NH_3) is a key process for life on Earth. Currently, industrial production of NH_3 utilizes the Haber-Bosch process, which combines N_2 with H_2 at high-temperature and pressure, consuming substantial amounts of natural gas. In contrast, some bacteria use the enzyme nitrogenase to catalyze the production of NH_3 from N_2 at ambient temperature and pressures. Among nitrogen-fixing bacteria, cyanobacteria are photosynthetic, allowing them to grow with only air, water, and light. If the activity of cyanobacterial nitrogenase can be sufficiently increased, it may provide a viable supplement to reduce dependence on the Haber-Bosch process. This project studied the effects of carbon dioxide (CO_2) on the nitrogenase activity of two cyanobacteria species, *Anabaena*, a filamentous, heterocyst-forming species, and *Cyanothece*, a unicellular species. We chose CO_2 because it is the primary nutrient of cyanobacteria. We hypothesized that increasing levels of CO_2 would lead to increased nitrogenase activity, as the cells would have more nutrients and thus more energy. To test this, we performed an acetylene reduction assay, commonly used in nitrogenase activity studies. Cyanobacteria were grown in sealed tubes containing 5% acetylene and 0% to 5% additional CO_2 for 1 to 3 days. Then, a sample of the gas in the tube was analyzed with GC-MS to assess the rates of acetylene reduction to ethylene. We found that increased levels of CO_2 increased nitrogenase activity in *Cyanothece*, but decreased activity in *Anabaena*. This data suggests that *Cyanothece* could be a viable candidate for large-scale nitrogen fixation, as its activity can be increased significantly with a small amount of additional CO_2. This also indicates a need for further investigation to determine why the response of *Anabaena* was so different.

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

Investigating Cancer-Specific Microbiomes: A Comprehensive Analysis of Tumor-Microenvironment Interactions — 8p — Margaret Lindner, Jessica Zylla, Vincent Peta, Etienne Gnimpieba

Abstract: The tumor microenvironment (TME) encompasses a vast array of normal cells, microbes, and molecules existing within the tumor. The relationship between cancer progression and microbes is an emerging field, with a thorough understanding of the interplay between microbes and tumor cells being a promising avenue for the development of novel therapeutic interventions. Our goal was to use data mining to create a curated dataset of different cancer types and the microbiota discovered to occupy each tumor type. We used this dataset to identify a microbial species capable of thriving in the TME for designing a future coculture protocol. Our methodology included a literature review using keywords such as “tumor microbiome,” “tumor 16S sequencing,” etc. Then a comprehensive data mining of the thirteen relevant tumor microbiome studies was completed encompassing twelve different cancer types. We discovered that tumor microbiome composition varies by location, with ovarian tumors having the most unique composition. Bacterial beta diversity between tumor and adjacent nontumor tissues was provided for nine of the twelve tumor types. Our dataset identified nine bacterial genera enriched in multiple tumor/adjacent tissues, six in three or more tumor tissues, one in three or more adjacent nontumor tissues, and five species enriched in two or more tumor tissues. Even though different regions of the body contain vastly different microbiomes; we identified several microbes that were enriched in multiple tumor tissues across the body. In future research, we plan to focus on identifying the mechanisms through which these enriched species interact with tumor cells.

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

Catalytic Oxidation with Hollow Mn_3O_4 — 9p — Rheannon Loth, Pranab Nandy, Sable Schultz

Abstract: Epoxides are valuable intermediates in the industrial production of many pharmaceuticals, surfactants, solvents, and polymers. But in traditional industrial-scale epoxidation of alkenes, the oxygen donors are peroxides, which are hazardous and expensive. We investigate the catalytic activity of Mn_3O_4 hollow nanoparticles for the selective oxidation of organic substrates using molecular oxygen as the oxygen donor. The substrates investigated include cyclohexene, cyclohexane, toluene, and trans-stilbene, the most successful oxidation occurring with cyclohexene. Little to no oxidation occurred with cyclohexane, toluene, or *trans*-stilbene, but GC-MS characterization showed highly effective oxidation of cyclohexene to the epoxide, allylic alcohol, and allylic ketone products. We report quantitative analysis of the catalysis reaction mixture toward understanding its kinetic parameters.

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

Development of an Ice Concentration Linked with Extractive Stirrer method for the Analysis of Pesticide Contaminants in Sparkling Water — 10p — Mary Matya

Abstract: Pesticides are an emerging threat in water sources around the world. Due to slow degradation, pesticides can persist in water sources for long periods of time, and some may evade common purification strategies for municipal water sources. This is important because some sparkling water companies carbonate spring water or use municipal water. Therefore, a method to detect pesticides in sparkling water is critical to consumer safety. In order to utilize standard pesticide screening methods, carbonation must be removed from water, but this is time-consuming. Therefore, Ice Concentration Linked with Extractive Stirrer (ICECLES) will be used to prepare sparkling water samples while removing carbonation. ICECLES was conducted at with atrazine as a probe molecule to evaluate the usefulness of ICECLES to prepare sparkling water for pesticide analysis. ICECLES performed well for atrazine analysis with clear LC-MS/MS detection of parts per billion levels. A pesticide screen (300 pesticides) is currently being tested for use with multiple brands of sparkling water.

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

Optimizing Neutrino Detection: Investigating Scintillation and Cherenkov Light in Liquid Argon — 11p — Baily May

Abstract: Neutrinos, abundant yet weakly interacting particles, hold great value in our understanding of the universe. Advancing neutrino detection methods can teach us more about a vaguely known section of the Standard Model of particle physics, help advance different branches of physics, and potentially have practical applications in various scientific and technological domains. Traditional neutrino detectors analyze either Cherenkov photons or scintillation photons, or are Time Projection Chambers which collect ionized charges in an applied electric field. In this research, Archers is a simple detector concept that is being developed in which both the directional Cherenkov photons and the abundant scintillation photons are collected distinctly and then analyzed. Our studies use GPU- accelerated simulations to enable studies of a large number of photons across a large detector volume. We simulate a ~20-kt liquid argon neutrino detector with about 60,000 10-inch photomultiplier tubes (PMTs). The primary objective is to understand and explore the capabilities of a liquid argon detector that is optimized to detect photons. First, we are establishing a basic design of the detector and incorporating it into the simulation. I have helped with adding the time response of a wavelength shifting coating. The performance of this detector is illustrated through the numbers of detected scintillation and Cherenkov photons, and the purity of each type (with particular emphasis on the less abundant Cherenkov light). In summary, research done on the Archers concept aims to advance our understanding of liquid argon detectors optimized for photon detection. By developing the simulation and analyzing quantities such as photon counts and their purity, we learn more about the performance and capabilities of the detector. The implications of this research can expand our understanding of neutrino properties.

REU Black Hills State University
Advisor(s): Logan Lebanowski

Security Printing of Silicon to Prevent Fake IDs — 12p — Hannah Meehan

Abstract: Counterfeit IDs are a domestic safety concern. Specifically, counterfeit IDs can be used to steal the identities of others, as well as gain entrance to government buildings or airports. Counterfeiters have become adept at making fraudulent documents to pass through the security systems. Developing a new type of security would prevent counterfeit IDs from being used in the United States. In this research, a spectroscopic-based method was developed to help secure documents. Raman spectroscopy is a way of producing an individual spectrum for materials based on how the molecules interact with a laser. To produce this spectrum the material is scanned by the Raman's laser and a spectrum is reported back to the user. In applying this to prevent counterfeit IDs silicon particles were added to an offset ink. After mixing the particles in, a proofer was used to print the silicon-based ink onto Teslin and PVC to simulate a driver's license. Both Teslin and PVC are substrates used to make real IDs. The Raman spectrometer can scan the printed ink and produce a unique spectrum. If the spectrum shows evidence of silicon without the silicon being visible, then it can be implemented into real IDs. Counterfeiters would not know to look for or add silicon to their cards and official scanners can look for the specific silicon spectrum. Without the addition of silicon ink, counterfeit IDs will be easily identifiable and removed from circulation. The research presented will show the viability of the Raman spectroscopy-based authentication method.

REU South Dakota Mines
Advisor(s): Dr. Jon Kellar

Comparative genome analysis of *Bradyrhizobium* strains with different nitrogen fixing capacities — 13p — Lilia Ernestina Montanez Hernandez, Armaan Kaur Sandhu, Ram Nageena Singh, Etienne Gnimpieba, Volker Brozel & Rajesh Sani

Abstract: The genus *Bradyrhizobium* comprises slow growing bacteria that can induce nodulation in leguminous plants such as soybean. In contrast to other nodule-forming rhizobia, members of *Bradyrhizobium* are characterized for containing all symbiosis and nitrogen-fixing related genes inserted into the chromosome instead of plasmids. This feature and the inability to retain broad-host plasmids have made difficult the development of molecular tagging systems for this genus, which in turn has limited the study of the mechanisms mediating their symbiosis with soybean. We previously characterized the symbiotic properties (*e.g.*, nodule numbers, nitrogenase activity, plant biomass and chlorophyll content) of nine *Bradyrhizobium* strains on soybean and classified them into high, intermediate, and low nitrogen-fixing capacity groups. We then performed whole genome sequencing, assembly, and analysis to evaluate if specific genomic features or genetic elements can be attributed to differences in nitrogen fixing capacity on soybean and to determine specific insertion sites for genetic tagging. Our preliminary analysis identified distinct organization of nodulation and nitrogen fixing genes, which may explain the symbiotic traits. Overall, the comparative genome analysis can be used to identify chromosomal insertion sites or single nucleotide polymorphisms (SNPs) that will help to develop efficient molecular tagging systems for *Bradyrhizobium*. Results from this work will facilitate genetic tagging of different strains and enable direct competition assays and molecular analysis using the soybean-*Bradyrhizobium* system at different stages during root colonization and nodulation.

REU South Dakota State University
Advisor(s): Dr. Senthil Subramanian

Predicting NMR Chemical Shifts in Trivalent Lanthanide and Actinide Phosphinodiboranate complexes — 14p — Ngan (Christina) Nguyen

Abstract: Lanthanide and actinide molecules present intriguing challenges in understanding their chemical reactivity due to the presence of *f* orbitals that results in a combination of relativistic effects, strong electronic correlation, and weak crystal field environments. Additionally, the separation of spent nuclear fuel, predominantly stored at the Hanford site, WA as remnants of the Manhattan project and nuclear reactors, necessitates a more comprehensive characterization of the reactivity of these elements in order to design approaches for separation. The project aims to conduct a theoretical study focusing on calculating the spectroscopic parameter, specifically the ^{1}H Nuclear Magnetic Resonance (NMR) and ^{11}B NMR chemical shifts, to characterize the reactivity of the trivalent lanthanide and actinide phosphinodiboranate (^{t}Bu-PDB) complexes in organic solutions. The metals investigated include lanthanum, cerium, praseodymium, neodymium, uranium, neptunium, and plutonium. To achieve this, Density Functional Theory (DFT), as implemented in the Amsterdam Density Functional (ADF) program, was utilized to calculate the chemical shifts of the proton and boron nuclei for both monomeric and dimeric structures of these complexes. Additionally, to characterize the difference in chemical bonding between lanthanide/actinide metal ion and ligand, the energy decomposition analysis (EDA) calculations were performed for each of these complexes. The analysis provides insights into the contributions from electrostatic and orbitalic interactions, aiding in the understanding of bonding nature and factors influencing reactivity.

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

Open-Source Screening for Security Tagging of Refrigerant Solutions — 15p — Jackson Nolder

Abstract: Select hydrofluorocarbons, commonly used as refrigerants, are being phased out due to their high global warming potential (GWP). This phase-out necessitates the availability of an accessible means to identify legally manufactured products. To address this, we propose a method for security tagging of refrigerant solutions by including an additive that can be detected by a change in solution resistance. We present a comprehensive approach to identifying suitable chemical compounds. Using only open-source tools such as Python, RDKit, JRGUI, and OPERA, we screened the PubChem compound database based on criteria including lower flammability limit, low critical temperature, long-term stability, and low toxicity. Structural motifs inspired by Sanger's Reagent were computationally analyzed to assess their potential as candidate molecules. Our computational analysis used GAMESS for DFT calculations at the B3LYP/6-31G(d) level of theory for structural optimization and ORCA for coupled-cluster calculations at the QCISD/cc-pVDZ level of theory for orbital density optimization. JANPA was used with these calculations to perform natural population analysis to identify charge through electron population, a method known to correlate SNAr reactivity for electron-deficient haloaryls like Sanger's reagent. By using charge-neutral nucleophiles, selected Sanger's-like reagent electron-deficient haloaryl additives are expected to transform into charged molecules, resulting in change of reaction solution conductivity which may be read out by simple conductivity measurements. The proposed method for security tagging of refrigerant solutions by incorporating a detectable additive has the potential to provide an accessible means for identifying legally manufactured products, ensuring compliance with the phased-out hydrofluorocarbons of high GWP.

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

Implementation of Numerical Analysis and High-Performance Computing to Physics Field Theory — 16p — Samara Overvaag, Jax Wysong

Abstract: The use of high-performance computing and numerical analysis is essential to solving complicated physics problems efficiently. For example, this research involves what are known in field theory as ghost-ridden systems. This term describes a system that has a negative kinetic energy value within a degree of freedom. Systems such as these contain time derivatives higher than two; they can appear in subjects related to high-energy physics and cosmology, for example. Traditionally, ghost systems have been considered dynamically unstable; however, recent studies have shown that some can be stable. Thus, to further study these phenomena, a numerical method called the fully implicit space-time finite element method was implemented to numerically solve the system. This method allows for domain approximation at a finite number of nodes, or locations. Next, the approximation was used to create a parallelizable simulation with PETSc (The Portable, Extensible Toolkit for Scientific Computation). PETSc is a vast library of data structures and solvers and was created by Argonne National Laboratory. It allows for the creation of parallel simulations; the term parallel refers to allocating a program over multiple processors to efficiently run a simulation. In this study, a parallelizable simulation model was created in a 1+1-dimensional (one spatial and one temporal) case. In the future, 2+1 and 3+1-dimensional large-scale simulations will be created to further study ghost systems. Previous non-parallel, small-scale simulations created by collaborators showed that the 1+1 and 2+1 cases exhibit dynamically unstable numerical behavior; however, it is unknown whether the 3+1 case will exhibit similar behavior. Thus, a large-scale parallelizable simulation model of the 2+1 and 3+1 cases will be created and parallelized to observe their stability. These numerical simulations could someday be applied to current knowledge of electromagnetic and gravitational waves to ultimately create a different perspective to observe the universe from.

REU South Dakota State University
Advisor(s): Dr. Jung-Han Kimn (South Dakota State University) and Dr. Hyun Lim (Los Alamos National Laboratory)

Shoots and Roots Importance in Dictating Winter Wheat Yield — 17p — Yuriani Palomino, Pradeep Kumar

Abstract: In recent years, global food security has become an increasingly alarming concern due to the increasing human population which has given rise to selective breeding of cereals. In my research, I investigate how winter wheat length of shoots and roots impact the success of the plant and crop yield. Shoots and roots length are an essential factor in successful winter wheat production. In each section of a divided plate, 8 seeds in good condition from the previous year were selected and sprayed with an antifungal solution on a damp germination paper for 24 hrs. Seeds were then “cigar rolled” into a bucket of DI water and labeled with the genotype’s name. The seeds stayed in the greenhouse at 80°F with 16 hrs of light and data was collected 15 days after rolled with a hoagland solution being added to the buckets placed on the 7th day. GWAS and R code was used to analyze the data and figure out similarities between genes. We found that genotypes that have longer roots and short shoots, are more likely to germinate compared to those with longer shoots and small roots. In respect to shoot and root association. GWAS found the genotypes with longer roots and short shoots were closely related to winter wheat whose harvest has been successful. Finding the genotypes with genes associated with best yield production will help wheat growers find a solution to food security and a way to create wheat that can resist the harsh winters.

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

Effects of the Calcineurin Mediated Immunosuppressant Cyclosporine A on Binge Alcohol Drinking in Conditional Corticotropin Releasing Factor Neuron Specific Calcineurin Knockout Mice — 18p — Katherine Pardy[1], Patrick Ronan[1], Emily Dorn[1], Jenny Agar[1], Brock Goeden[1], Alysandra Fedde[1], Liam Porter[1], Ryan Burdine[1], Thomas P. Beresford[2];
[1]Sioux Falls VA/USD Sch. of Med., Sioux Falls, SD;
[2]RMRVAMC-SOM U Colorado, Denver, CO"

Abstract: We have found that the calcineurin mediated immunosuppressants cyclosporine A (CsA) and tacrolimus inhibit binge alcohol drinking in mice. Further, we have shown that this effect is mediated directly in brain, as intracerebroventricular administration also significantly decreases drinking. As these immunosuppressants have severe systemic toxic effects, our goal is to determine proximal mechanisms by which these immunosuppressants are working in order to develop effective treatments for alcohol use disorder (AUD) with fewer side effects. To this end, we are employing genomic, molecular, transcriptomic, metabolomic, anatomic, and behavioral approaches to explore the relationship between binge alcohol drinking and calcineurin mediated immunosuppressants in signaling and neuroinflammatory suppression. Calcineurin is a somewhat ubiquitous phosphatase, involved in a wide range of signaling pathways — both in neurons and glia. One major question is whether immunosuppressants are acting through neuronal signaling pathways, regulating reward and stress/anxiety pathways, or in glia, mediating neuroinflammatory effects. To address this, we have developed multiple transgenic models using a floxed calcineurin line (C57BL/6-Ppp3r1tm1Stl/J) crossed with various Cre driver lines to knockout CN in various neuronal or glial populations. Here we report results for a conditional corticotropin releasing factor (CRF) neuronal CN knockout line (CRF-Cre). Corticotropin releasing factor plays a key role in driving drinking behaviors and calcineurin has a direct effect on its transcription and signaling. We characterized effects of the knockout alone on binge like drinking in the Drinking in the Dark (DID) model of limited access drinking. Knockout of CN in CRF neurons had no effect on alcohol consumption in either a chronic or acute DID model. Furthermore, CsA was still highly effective in inhibiting ethanol consumption. These and molecular data showing immunosuppressant effects on a range of neuroinflammatory and stress signaling are converging to suggest that immunosuppressants are acting through glial mediated neuroinflammatory mechanisms to reduce binge-like alcohol consumption in mice.

REU University of Notre Dame
Advisor(s): Patrick Ronan

Assessing Various Pathways for Creating CFD Models Derived from MicroCT Scan Data — 19p — Jace Parliament, Sydnee Tuuk

Abstract: Stents are small medical devices designed to treat certain vascular disorders. They can be used in a variety of ways, such as holding open weak or narrowed arteries, or diverting flow from an aneurysm. In the design process of these stents, Computational Fluid Dynamic simulations are often required to get a full picture of the design's effectiveness. The results of these simulations are used to improve the design of the stent. This process involves generating CT scans of stents within molds of patient geometry involving aneurysms and converting those scans to viable models for CFD simulations. The overall goal of this project is to optimize this process by making it faster, reliable, and more replicable. To do this, we investigated both commercially available and open-source software tools, Mimics Innovation Suite and 3D Slicer. We conducted a time-based comparison of processes between commercially available Mimics and the open-source software currently being used, 3D slicer. We then evaluated the various models from both Mimics and 3D Slicer in Star-CCM+ to obtain a quantifiable difference between the two programs' results. We concluded that even though Mimics offered a robust suite of tools to clean the DICOM files and 3D models in a timely manner, the model produced by 3D slicer and manual reduction of noise were as effective and less costly. With this research, we now know there is not a single software that can easily optimize this process. Furthermore, we now have a greater understanding of the gaps that exist within this field. Filling those gaps could greatly benefit research of this kind and increase the capabilities of stent research and design.

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

Electromagnet Design for Cellular Mechanotransduction Studies — 20p — Nicholas Radliff, Matthew Holler

Abstract: Osteoarthritis is a condition in which the cartilage cells within a joint wear down and the bones from the joints start to rub together, creating immense pain, a stiffness of the joint, and a significantly decreased range of motion. Little research has been done on mechanoreceptors of osteoarthritis cells on the microscopic level. Of the research that has been done, only a handful of the many proteins in the mechanoreceptors have been studied. This is due to the difficulty in working with the osteoarthritis cells, and the problems that arise in the logistics of meaningfully affecting the cells. However, these mechanoreceptors are very important to our cells. If we could learn more about the mechanoreceptors of osteoarthritis cells, it may be possible to eventually treat osteoarthritis, or even cure it if enough research is done. To begin the process of affecting the cells, we designed, modeled, and constructed an electromagnet to stimulate the cells in a controlled manor. Several electromagnet options with 9-20 V inputs were designed and evaluated using engineering design principles based on COMSOL results for magnetic flux density magnitudes and profiles and maximum current magnitudes. In future studies, cells will be strategically placed within the field of the electromagnet, and mechanoreceptor-targeted magnetic vortex micro-discs will be placed on the cells to apply small, complex forces and movements to the cells.

REU South Dakota Mines
Advisor(s): Dr. Scott Wood

Applying Corrections to the Efficiency of Neutron Source Tagging for an AmBe Radioisotope — 21p — Anh Ramirez

Abstract: The universe is dominated by a non-baryonic, low-luminosity substance known as dark matter. Detecting it has been the central goal of the Lux-Zeplin(LZ) experiment at Sanford Lab in Lead, South Dakota since 2012. At present, the leading candidate for dark matter takes form in Weakly Interacting Massive Particles (WIMPs). The ten ton liquid xenon detector housed a mile underground at Sanford lab is designed to record electrons and photons generated from a collision between a WIMP and a xenon atom. To detect such small signals requires extensive calibration and background characterization of the detector. Using specially made deployment apparatus located above the detector, radioactive samples can be lowered between detector walls to expose the time projection chamber (TPC) to various radioisotopes. In the case of neutron emitting sources, detector behavior is especially important to establish as incident neutrons deposit a similar amount of energy upon interaction with the xenon medium relative to the amount predicted for that of WIMPs. Using ROOT data analysis software in combination with applied statistics, the neutron tagging efficiency of the TPC can be calculated. This rate is crucial in profiling the behavior of the TPC in response to background neutron radiation and in distinguishing neutron signals from candidate WIMP signals.

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

Transformative Approaches to Combat White Mold in Oil Seed Crops — 22p — Kyle Reese, Sachin Sharma, Jose Gonzalez, Christopher Graham, Gazala Ameen

Abstract: The necrotrophic generalist fungi including *Sclerotinia sclerotiorum* are important pathogens of crop plants worldwide and due to the lack of effective genetic resistance have been difficult to manage in an economically feasible and sustainable manner. *S. sclerotiorum* causes white mold disease on diverse crops including economically important soybean and sunflower and relatively new oilseed bioenergy cover crop pennycress. Soybean is one of the top three important crops harvested in South Dakota (SD), and pennycress has the potential to be incorporated as a winter annual cash cover crop in the state. During my research training, I am learning and deploying transformative research approaches involving lab and field-based methodologies with the goal of addressing the issue of white mold in South Dakota. Our research group has contacted and visited several farmers to address their white mold concerns in past seasons and surveyed soybean fields. We have collected field samples to get SD-specific pathogen isolates for subsequent lab-based disease phenotyping, pathogen diversity analysis, and identification of genetic resistance in soybean and pennycress. Our preliminary disease severity data on pennycress using a previously collected isolate MN102 suggests high pathogen virulence. We conclude that it is important to address the issue of white mold if we are interested in incorporating pennycress into the current cropping system. We are growing soybeans and sunflowers in the greenhouse for further disease severity testing using local isolates. For functional studies, I am also designing primers for CRISPR/Cas9-based targeted disruption of pathogen candidate virulence genes, previously identified in a genome-wide association (GWAS) study conducted in the lab. This research will add to what is known about the diversity and virulence of *S. sclerotiorum* in South Dakota, allowing for future research to manage the white mold disease on important field crops.

REU South Dakota State University
Advisor(s): Shyam Solanki

Analyzing the Nature of Chemical Bonding in Lanthanide-Containing Solid-State Structures — 23p — Naomi Rehberg, Dr. Matthew Polinski

Abstract: Lanthanides are *f*-block elements found in the earth's crust and commonly used in the oil industry, security applications, the creation of technology devices, energy systems, and medical work. The elements are naturally abundant and increasingly popular in modern development; however, open experimental questions remain about how their electronic structure changes upon incorporation in material, in part due to difficulty isolating them. Understanding mineral phases in environments with mixed metals is important for the disposal of nuclear waste in a geological repository. Therefore, the analysis of chemical bonding within solid-state structures containing trivalent lanthanide cations using computational methods is a necessary first step since synthetic efforts with transuranic elements is more challenging. Our goal is to investigate the electronic structure of solid-state lanthanide structures with the chemical formula $Ln[B_6O_{12}(OH)(H_2O)_2(CrO_4)]$ (Ln = La, Ce, Pr, Nd, Sm, and Eu). Periodic density functional theory was utilized as implemented in the Vienna ab Initio Simulation Package (VASP) to understand bonding in the materials and how the electrons occupying the unfilled *f*-block couple with one another to understand spin-pairing within the complexes. This project will continue in the future analyzing another class of lanthanide containing solid-state structures with the chemical formula $[Ln_2(C_4O_4)_4(CuO_2(H_2O)_2)(H_2O)_{12}]*2H_2O$ (Ln = La, Ce, Pr, and Nd) to understand why these complexes have been observed in experiment to appear yellow, a rare color for lanthanides.

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

Bioleaching Manganese from Pierre Shale Ore — 24p — Elizabeth Rehwinkel

Abstract: Manganese is a key element in the production of steel and other industrial products such as batteries leading to it being designated as a critical mineral by the U.S. Department of the Interior. However, domestic sources of manganese ore are of a lower grade than foreign ores making it uneconomical to process domestic manganese ores with traditional methods. Bioleaching, the extraction of metals from ore using microorganisms, could provide a more economical and environmentally friendly method of leaching manganese from domestic sources of ore. This research investigates the use of microbial cultures used to produce kombucha and vinegar to generate organic acids to leach manganese from a low-grade ore from the Pierre Shale in South Dakota. First, the production of acetic acid by microbial cultures from kombucha and vinegar under different growth conditions was investigated and quantified using ion chromatography. Second, leaching experiments were conducted by adding crushed and ground manganese ore to kombucha or vinegar cultures and quantifying the amount of manganese leached using inductively coupled plasma-mass spectrometry. The results of this study may assist in developing an economically viable method of extracting manganese from the Pierre Shale ore allowing the United States to be less dependent on imported manganese.

REU Smith College
Advisor(s): Scott Beeler

Estimating Temporal Electrical Load Due to Air Conditioning Using Functional Principal Component Analysis — 25p — Titus Roesler, Dr. Jung-Han Kimn, Sheroze Liaquat

Abstract: The increasing frequency of extreme weather events (e.g., heat domes) due to climate change is leading to unprecedented electric demand peaks. Because electricity cannot be efficiently stored, it is critical that electricity production match energy consumption. To optimize the scheduling of energy production to match consumption and curtail usage of electricity during peak demand hours, large-scale data sets of load models are needed. Though energy usage for individual consumers is highly sensitive, aggregate energy data is readily available. Using methods from queueing theory, Hansen et al. devised a method to construct a known electrical load curve from individual consumer appliances using a queueing model. However, appliances account for only a fraction of building electricity usage. Cooling loads consume a substantial amount of energy, and these loads must be accounted for in synthetic data sets. This study aims to estimate the electrical load due to air conditioning over time using building thermal parameters and historical climate data. We use EnergyPlus to simulate a data center using data for a typical meteorological year in Tampa, Florida, for the months of January and July and perform functional principal component analysis. We discuss the error between simulated data and our estimates and note that, with forecasted meteorological data, we can accurately estimate future electrical loads due to air conditioning. As climate stressors and rising cooling loads force the electric grid to be re-engineered to support climate resilience, these energy estimates will ensure more reliable and equitable access to electricity as communities plan for, respond to, and recover from severe weather events brought about by climate change.

REU Massachusetts Institute of Technology
Advisor(s): Dr. Timothy M. Hansen, Dr. Hossein Moradi

Predicting Crop Yield Using Remote Sensing Data — 26p — Mary Row

Abstract: Accurate crop yield predictions can help farmers make adjustments or changes in their farming practices to optimize their harvest. Remote sensing data is an inexpensive approach to collecting massive amounts of data that could be utilized for predicting crop yield. This study employed linear regression and spatial linear models were used to predict soybean yield with data from Landsat 8 OLI. Each model was built using only spectral bands of the satellite, only vegetation indices, and both spectral bands and vegetation indices. All analysis was based on data collected from two fields in South Dakota from the 2019 and 2021 harvest years. The 2019 yield data was used as the training data set and the 2021 data was used as the test data. The models were compared based on their computing time, mean squared error (MSE), mean squared prediction error (MSPE), residual prediction deviation (RPD), and r-squared values. In terms of MSE, RPD, and r-squared for 2019 data, the best model was the Bayesian spatial model, which was built using vegetation indices. For 2021 data, the Bayesian spatial model using bands outperformed the other models in terms of MSPE. It is worth noting that the Bayesian spatial linear model always outperformed the Bayesian linear regression in all criteria except computation time. Although the spatial model built with bands is not the best model in terms of fit for the training data, the difference is negligible. Furthermore, since prediction is the main purpose, the Bayesian spatial regression model based on bands is recommended for future use. The Bayesian spatial regression model built with bands has an r-squared of 0.8912, an MSE of 6.9068, and an RPD of 3.0317 for 2019 data and an MSPE of 586.1094 for 2021 data.

REU Saint Mary's University of Minnesota
Advisor(s): Dr. Hossein Moradi

Investigating the Thermal Cycling Durability of Protective CrWN Coatings — 27p — Lucia Ruiz

Abstract: Thin-film ceramic coatings, such as CrN, may be used to reduce friction, abrasion, and environmental deterioration of mechanical parts. However, ceramics can be too brittle to be effective protective coatings in some severe service environments. The addition of tungsten and other transition metals to nitrides can improve the overall toughness and hardness of these new coating compositions. However, most prior research and development in this area has focused on high-temperature applications. Harsh and cold environments pose unique challenges for materials, such as icing and thermal shock, both of which can compromise safety and performance. Therefore, this work aimed to investigate protective CrN coatings alloyed with tungsten in arctic conditions to determine and document their response to these environments. CrN (0 at.% W) and CrWN (23.11 at.% W) coatings were deposited by reactive magnetron sputtering. Characterization of the coatings was accomplished with the use of scanning electron microscopy, energy dispersive X-ray spectroscopy, X-ray diffraction, Rockwell indentation, optical microscopy, and nanoindentation. To investigate these coatings under arctic environments, the coatings were subjected to thermal cycling between 35 °C and -60 °C in an environmental chamber. After thermal cycling, Rockwell adhesion testing and nanoindentation were conducted to assess the durability of the CrN and CrWN coatings. This work developed a better understanding of the characteristics of novel transition metal nitride coatings and explored the durability of these coatings in under-investigated conditions.

REU University of North Texas
Advisor(s): Dr. Grant Crawford and Dr. Forest Thompson

Friction Stir Lap-Butt Welding of Aluminum to Steel — A New Joint Design to Improve Mechanical Properties — 28p — Olivia Russell, Dr. Amlan Kar

Abstract: The welding of dissimilar materials with variation in thickness and composition has been a focus in industries such as automotive, shipbuilding, and others. This is due to their complex design requirements that need to be strong and lightweight. Conventional fusion based methods are unable to join dissimilar metals well due to physical and thermal material properties. Friction stir welding, a solid-state welding process, has been used to weld dissimilar materials, such as A572 steel and 6061-T6 aluminum. On the other hand, friction stir welding has often resulted in low joint efficiency, mainly because of root defects in butt welding and hook features in lap welding. To address these issues to increase joint efficiency, this research utilizes a lap-butt configuration. After welding with this configuration, microstructural characterization and mechanical testing were performed on samples from the weld joints. The results reveal this configuration promotes uniform material mixing in weld nugget, leading to improved joint efficiency. The enhancement in mechanical properties may be attributed to the controlled interaction of the tool with steel, the formation of fragmented intermetallic compounds, a larger welding area, and superior interface quality.

REU LeTourneau University
Advisor(s): Dr. Michael West

Aerial Fire Detection with Semantic Segmentation — 29p — Samantha Schiefen, Yangxiao Bai, Dr. Jung-Han Kimn

Abstract: The importance of real-time fire detection has grown significantly in recent years due to the increasing devastation caused by wildfires. This research project aims to promote the advancement of rapid-fire detection technology, by utilizing semantic segmentation and aerial imagery analysis. Rapid detection plays a crucial role in preventing fire-related injuries and fatalities while reducing severe damage to the environment and communities, as well as improving firefighting efforts. Semantic segmentation has emerged as a powerful technique for fire detection. It classifies every pixel within an image into a specific class and can distinguish fire regions from the surrounding environment in real time. Additionally, the use of unmanned aerial vehicles (UAVs) has also gained popularity for monitoring and predicting potential fire regions, highlighting the need for fire detection models that can effectively analyze aerial imagery. Our research focuses on examining and investigating efficient real-time fire detection methods by employing semantic segmentation of aerial images captured by UAVs. To achieve this, we employ a modified deep learning model called DeepLab, known for its impressive performance in image segmentation tasks. To enhance the speed of segmentation, we incorporate a lightweight encoder network called MobileNet. Additionally, our project utilizes the Fire Luminosity Airborne-based Machine learning Evaluation dataset (FLAME), a widely recognized collection of labeled aerial imagery specifically designed for fire-related analysis. In our analysis of experimental results, we evaluate the model's performance using mean intersection over union (mIoU) and mean pixel average (mPA), commonly employed evaluation metrics in the field of semantic segmentation. We have chosen several semantic segmentation models (e.g., U-Net, EfficientSeg, and ERFNet) to identify the most effective ones for fire detection based on their performance. Additional goals of this study are to aid in the improvement of early fire detection systems, enable timely responses, and support the development of preventive measures.

REU Morningside University
Advisor(s): Dr. Kaiqun Fu

Structural Optimization of Triazole Analogs Targeting Prostate Cancer Resistance to Chemotherapy — 30p — Kiara Schilling

Abstract: Prostate cancer is the second leading cause of cancer death in American men. Prostate cancer has started to become resistant to therapies like hormone therapy, chemotherapy, and targeted therapy. Prostate cancer drug-resistant proteins such as P-glycoprotein (P-gp), multidrug resistance-associated protein 1 (MRP1), bromodomain and extra terminal protein (BRD4), and breast cancer resistance protein (BCRP) are the main protein targets for treatment of resistant prostate cancer. A current study of estrone-triazole analogs were redesigned targeting these four key proteins associated with drug resistance in prostate cancer. The triazole compounds that we previously synthesized in our lab were found to have log values higher than 5 which influence compound absorption negatively. The goal of this project is to redesign current estrone-triazole analogs previously synthesized in Dr. Halaweish's lab to install more polar chromophores which will lower the logP and will enhance the biological activities of these compounds toward molecular targets. The research methods employed in this study involve a combination of computational modeling and experimental synthesis. Eleven compounds were designed and docked on the EGFR, ERK, MAPK, mTOR, PI3K, PK-B, RAF, RAS, and STAT3 proteins. In designing and synthesizing these compounds, it was found that more polar compounds are more favorable. In the EGFR pathway, a more polar compound had a consensus score of 38 compared to Erlotinib, the highest scoring standard of 78. Organic synthesis of these compounds are in progress and will be identified by 1H and 13C-NMR and MS. Successfully synthesized estrone-triazole analog will be further evaluated by biological techniques like MTT, cell cycle analysis, and in cell western. Improved biological activities and reduced logP values would provide potential candidates for further development as therapeutic agents for prostate cancer. These compounds may offer new treatment options that can overcome drug resistance in prostate cancer, potentially improving patient outcomes and quality of life.

REU South Dakota State University
Advisor(s): Fathi T. Halaweish, Ph.D.

Oxidation Reactions using Mn_3O_4 as a Catalyst — 31p — Sable Schulz

Abstract: The ability to create well-defined nanostructures allows the study of structure-property relationships in catalysis. We investigate the use of hollow Mn_3O_4 nanoparticles in selective oxidation of organic molecules. Manganese oxides are earth-abundant, with tunable redox centers, and the hollow Mn_3O_4 nanoparticles present a new frontier to investigate the role of hollow nanoscale morphology in catalysis. Preliminary results in the selective oxidation of alkenes in air (molecular oxygen) in the presence of catalytic amounts of hollow Mn_3O_4 nanoparticles suggest a major advantage over conventional catalysts that utilize expensive and hazardous peroxides. We are developing quantitative analytical methods for to investigate the catalytic oxidation of a range of organic substrates in O_2 atmosphere under mild conditions. Results to date show high activity for the conversion of cyclohexene to epoxide and allylic oxidation products.

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

Midwest Maternal Health and Depression Disparities throughout the COVID-19 Pandemic — 32p — Alyssa Schumacher, SPUR Program Research Student, Strahm Lab, Sanford Research, SD, USA; Hilla I. Sang PhD, Director, Research Design and Biostatistics Core, Sanford Research, Fargo, ND, USA; Anna M. Strahm PhD, Behavioral Sciences, Sanford Research, Sioux Falls, SD, USA; Department of Obstetrics & Gynecology; Department of Pediatrics, Sanford School of Medicine, University of South Dakota, Sioux Falls, SD, USA

Throughout the COVID-19 pandemic, marginalized racial/ethnic groups were at higher risk of worsening mental health and potentially associated adverse pregnancy outcomes. Prior to COVID-19, pregnant individuals of marginalized backgrounds were more likely to have smaller neonates for gestational age. Additionally, psychosocial stress and depressive symptoms during pregnancy are positively associated with adverse birth outcomes. The addition of psychosocial stress during the COVID-19 pandemic for individuals of marginalized backgrounds, including those with depression diagnoses, may have further exacerbated adverse pregnancy outcomes.

We aim to describe birthweight and preterm birth outcomes throughout the psychosocial impact of COVID-19 among pregnant Black, Indigenous American, and White individuals with and without depressive disorders.

Our data set consisted of de-identified Midwestern medical records spanning 2011-2022. These included primigravida pregnancies with a maternal age of 18-45, who gave birth at <43 gestational weeks, and were identified as Black (N=262), Indigenous American (IA; N=294), and White (N=8,985). COVID-19 epochs were defined by pregnancies during periods “Before,” “Transitional,” and “After” February 25th, 2020 (CDC, 2023).

The gestational length was shorter for both Black pregnancies and IA pregnancies compared to White pregnancies ($p<.05$). Neonates of Black mothers had significantly lower birthweight than those of White mothers ($p<.001$). In separate models including race, maternal age, and BMI, mothers with depression diagnosis had lower birthweight ($p\leq.001$) but did not differ in gestational length ($p=.17$). The relationships between maternal race and birthweight, or gestational length, were not mediated by depression diagnosis ($ps>.10$), regardless of COVID-19 epoch.

Our findings, similar to prior research, suggest a further need for interventions to improve pregnancy outcomes among Black and IA pregnancies and for pregnant individuals with depression. Further research identifying additional pathways (e.g., socioeconomic status) may clarify how COVID-19 impacted pregnancy-related health disparities and potential methods to ameliorate them.

REU St. Olaf College
Advisor(s): Anna Strahm

Understanding Rhizobial competition for nodulation using split root assays — 33p —
Athira Sethu Madhavan, Lilia Montanez Hernandez, Hazem Khalaf Mohammed

Abstract: Symbiotic nitrogen fixation contributes to the majority of legume crop nitrogen needs and thus reduces the need for synthetic fertilizers. A bottleneck associated with increasing nitrogen fixation in legume crops is the rhizobial competition for nodule occupancy. Nitrogen-fixing capacity varies among Rhizobium strains and often the inoculant strains must compete with the indigenous strains in soil for nodule occupancy. Thus, legume hosts might be infected by both efficient and inefficient strains, reducing the overall nodule nitrogen supply to the plant. Host plants may employ sanction mechanisms to favor nodules with high-capacity nitrogen-fixing strains, but the timelines or types of sanction mechanisms are not well understood. We evaluated rhizobial competition in soybean using combinations of high, medium, and low nitrogen-fixing capacity *Bradyrhizobium* strains. A split root system where each root half was inoculated with a different *Bradyrhizobium* strain was employed to evaluate host-based selection. Number of nodules were counted at three time points to determine if soybean favored colonization by one strain over the other based on their nitrogen fixation capacity. Results from our time course analysis indicated that soybeans might impose sanctions on poor-fixing strain (USDA 126) over high-capacity nitrogen-fixing strain (USDA 110) between 7- and 14-days post-inoculation. Results from other comparisons showed that soybean plants may not show preference for nodulation between high- and intermediate-capacity fixers (USDA110 and USDA140) or between intermediate- and poor-capacity fixers (USDA140 and USDA126). Interestingly, we observed differences in the infection zone and bacteroid density in nodules from USDA 126 and USDA 140 combinations. This suggests that the host sanctions might be implemented against poor nitrogen-fixing strain post nodulation (during nitrogen fixation). Our results show that soybeans may employ host sanctioning mechanisms against poor nitrogen fixers at different levels and stages depending on the strain combinations.

REU South Dakota State University
Advisor(s): Dr. Senthil Subramanian

Exploring a corn field isolate as Biofertilizer for Sustainable Agriculture — 34p — Richa Shah, Dr. Tanvi Govil

Abstract: Modern agriculture needs to be sustainable while also achieving high crop yields. For the same, agriculturally beneficial microorganisms can be used as biofertilizers. These contribute to plant growth by increasing nutrient availability, biosynthesizing phytohormones, and producing antimicrobial compounds. In the current study, various microbes from corn fields across South Dakota were isolated in our laboratory and a microbe of significance, *Pseudomonas stutzeri*, was identified amongst the isolates. *P. stutzeri* is being studied for its ability to fix nitrogen using Nitrogen free Bromothymol Blue Agar and Broth and to solubilize phosphates using Pikovskaya agar. Its genome was also annotated to establish genetic evidence for these abilities. Recent studies also suggest that *P. stutzeri* biofilms can degrade environmental pollutants. Therefore, as a further adornment to this work, the ability of *P. stutzeri* to degrade common soil organic pollutants (that disturb soils' health and therefore negatively impact plant growth) like BTEX (Benzene, Toluene, Ethylbenzene, Xylene) and Polycyclic Aromatic Hydrocarbons (PAHs) example, naphthalene is being investigated. Further, experiments are underway to identify using 16S Sanger sequencing, 97 bacterial microbes isolated using a culture-dependent technique from the decaying corn stover from a corn stalk bale and of silage from the silage pile at agricultural farms in South Dakota. Subsequently, these isolates will be tested for their plant growth-promoting traits.

REU South Dakota Mines
Advisor(s): Dr. Rajesh Sani

Manganese Nodule Processing Utilizing an Ammonia-Based Leach Solution — 35p —
Daniel Start, Dr. Scott Beeler

Abstract: Manganese is heavily used in steel production and is classified as a critical mineral by the Department of Defense. There is no domestic production currently in the United States, and the entire supply is imported, mostly from South Africa. There is a deposit of low yield manganese nodules in South Dakota that formed in the prehistoric sea and are an ideal source of domestic manganese for U. S. use and export. The primary issue with the nodules is their chemical makeup, as each nodule has a relatively small amount of manganese and high amounts of elements that prevent easy processing, like calcium carbonate. These compounds work in direct competition to traditional purification methods that typically use sulfuric acid, as they react and raise the pH of any mixture used. The amount of acid needed is not cost effective, and an alternative purification method needs to be created. The research in this project will follow a method based on an ammonium hydroxide and ammonium carbonate solution that will attempt to leach out an acceptable manganese quantity from the nodules. The nodules will be ground into a powder and subjected to the ammonia solution at changing temperatures and concentrations. Liquid samples will be taken throughout the test and the remaining powder will be analyzed as well. Currently, scans of the powder reveal no substantial change in the chemical makeup of the powder. Further analysis of the samples is to continue via ICP-MS, and more conclusions will be drawn. As of now, further research with higher concentrations of solution is recommended.

REU South Dakota Mines
Advisor(s): Dr. Brett Carlson

Valorization of Thin Stillage into High Value Product Via Microbial Fermentation — 36p
— Brady Steffen, Santosh Thapa, Ruchita Bhattarai, Ram Bhattarai, Bishnu Karki

Abstract: Thin stillage (TS) is a major co-product of dry grind ethanol process and constitutes protein, fat, carbohydrates, etc. therefore can be used as a source of energy for livestock feed. TS is primarily liquid with high concentrations of soluble particles. Currently, ethanol plants evaporate the liquid and add the solids back into distillers' grain, but this process is energy consuming. The use of fungal fermentation can add an increased value while being a sustainable, efficient way to deal with this waste stream. The study aimed to develop an environmentally friendly process to manage thin stillage while fully utilizing its value. Trials were carried out with uninoculated control and *Aureobasidium pullulans* (yeast-like fungi) under submerged fermentation conditions. The fermentation proceeded for 5 days at 30°C with samples processed every 24 hours. Post fermentation processing included centrifugation to separate the solids from the liquid, then drying and grinding prior to analyzing crude protein, total phenolic acid content, phytic acid. While data is currently pending analysis, it is expected that post fermentation TS nutritional composition will be improved with high levels of protein and low levels of antinutritional factors such as phytic acid and crude fiber content. Fermented samples also contained a large amount of oil that made processing and analysis difficult. Hence, to make the downstream processing easier and to recover the oil in TS, we co-fermented the TS with soybean hulls. Preliminary results have shown that soybean hulls addition during fermentation helps in recovering the oil in the TS in the solid fraction and improves the overall downstream processing. Future experiments can explore this combination. As ethanol production increases, fermentation provides us with a better alternative to dealing with the waste stream while adding a nutritional product to the livestock feed supply chain.

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

Xylazine in Wastewater Epidemiology — 37p — Abigail Stelling

Abstract: There are rising concerns over a dangerous new “zombie drug,” xylazine, that has been infiltrating the illicit drug supply. Xylazine is a common veterinary medication used to tranquilize large animals such as horses and cows but has not been approved by the FDA for human use because it is known to cause serious side effects. The illicit use of xylazine in the United States began in 2010 in Philadelphia and has since begun spreading across the United States. The drug is rapidly metabolized by liver cytochrome P450, and most is excreted through the urine. Since xylazine is excreted in urine, we can use xylazine test strips to find traces of xylazine in wastewater. We studied wastewater from three communities in South Dakota. We used lateral flow immunoassay to test wastewater, either straight or spiked with known concentrations of xylazine, to assess wastewater levels. We found that there were trace amounts of xylazine in the wastewater from all three communities we studied. We calculated that there was a concentration of xylazine approximating 1000 ng/ml in the wastewater samples studied. While these results do not tell us if xylazine is being used illicitly in these communities, with continued monitoring, changes in wastewater levels can become an indicator of the emergence of xylazine entering the community drug supply. This information can provide critical warnings for healthcare providers and communities of potential increases in xylazine-associated overdose risks. Our study provides a method for an affordable, anonymous, unbiased surveillance of xylazine use in communities. There is a growing need for harm reduction in illicit usage of xylazine, and this method has the potential to address this need.

REU University of South Dakota
Advisor(s): Dr. Lisa McFadden

Biological control of Bacterial Leaf Streak (BLS) of Barley using *Bacillus spp*. — 38p — Ryan Sullivan, Ashley Frederickson, Madalyn Shires

Abstract: Bacterial Leaf Streak (BLS) of barley is caused by the bacterium *Xanthomonas translucens* pv. *translucens* (Xtt). This disease has become more prevalent in the Midwest as of recent years, with very few management strategies available for controlling infection. Significant yield reduction of 10-15% has been attributed to BLS on barley cultivars. This research aims to evaluate biological control using antagonistic bacteria as an effective way to aid in managing BLS. Three commercial biologicals, Serenade ASO (Bayer Crop Science), Sonata (BASF), and Serifel (BASF), were chosen as preliminary biologicals to use for an in vitro antagonistic assay, along with six known biologicals isolated from soil in South Dakota. The in vitro antagonistic assay followed a Modified Kirby Bauer Antibiotic Disc Sensitivity Assay, using the zone of inhibition as an indication of antagonism against Xtt. The biologicals which displayed the greatest zone of inhibition were chosen from the in vitro assay to be screened for the effects on Xtt in vivo on a cultivar of winter barley. Two species of *Bacillus* were chosen: *Bacillus amyloliquefaciens*, trade name Serifel, and *Bacillus velezensis*, isolated from South Dakota soil. The greenhouse trials were conducted through two series of aerial inoculations one week apart. The biologicals, *B. amyloliquefaciens* and *B. velezensis* were applied at three weeks of growth followed by inoculation of *X. translucens* pv. *translucens* at four weeks of growth. Koch's postulate was conducted one week after each inoculation to confirm the applied biologicals were colonizing within the leaf as the leaf symptoms of BLS were inadequate.

REU South Dakota State University
Advisor(s): Madalyn Shires

Analyzing and Managing Environmental Monitoring Data — 40p — Andrea Thomas, Hank Miller

Abstract: The environmental monitoring through Native Prairie restoration research project is a long-term project to collect and compare local weather data with biological markers different sites including the Santee Campus of the Nebraska Indian Community College. The biological markers come from: satellite images, weekly time lapse photography, plant inventories, and soil analysis. All this will be done while implementing our native prairie restoration management plan. We hope to gain knowledge about how weather influences biodiversity and successional changes by examining the fauna and soil composition under these management conditions. As part of this project, we aim to develop tools to analyze the generated data as well as implement a data management platform. We analyzed the weather data, plant inventory, and soil analysis form the past 6 years using Python notebooks that can be easily used to analyze the data generated in future years. Furthermore, we installed and used the Repository for Archiving and MAnaging Diverse DAta (RAMADDA) platform as data management platform.

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

The Effects of Lessened Snow Cover on Cover Crop Photosynthesis Rates — 41p — Margaux Thompson

Abstract: Snow cover insulation creates a buffer between plants and the coldest temperatures of winter, preventing frost damage to valuable root systems that hold the sugars and starches needed by plants to survive in winter. During a time of unprecedented global change, seasonal snowfall and the duration of snow cover has shortened considerably in recent years. At the same time, many universities of the Midwest have been researching cover crops and the variety of benefits they may be able to deliver. In our investigation, we will examine the effects of lessened snow cover duration on the photosynthesis rates of cover crops the following spring using remote sensing data. The snow cover duration is provided by the MODIS snow and ice dataset from the National Snow and Ice Data Center and the spring photosynthesis rates provided by the red and NIR bands from satellite images obtained from daily PlanetScope.

REU South Dakota State University
Advisor(s): Dr. Hankui Zhang

Guanidinium Functionalized Metal-Organic Supercontainer for Selective Anion Binding — 42p — Abraham Tillquist, Kriti Chitrakar, Robyn Cook, Shrijana DC, Dr. Zhenqiang Wang

Abstract: Anions play an integral part in biological systems. The energy currency of eukaryotic cells, ATP, is anionic at physiological pH. Additionally, anions play an integral role in interactions between proteins and nucleic acids. Thus, understanding the biology and designing new chemistry of anion binding has broadly relevant basic and practical implications. However, synthesizing analogues of anion receptors that emulate their biological counterparts is a nontrivial task that presents various challenges. For example, anions have relatively weak electrostatic characteristics, making their targeted recognition elusive. Furthermore, many anions are pH sensitive, requiring the anion receptor to be adaptable in a broad range of *p*H. Metal-organic supercontainers (MOSCs) offer unique potentials to address these challenges. MOSCs are a new class of cage-like supramolecular hosts constructed from an organic precursor, various metal ions, and a diverse group of carboxylate linkers assembled through metal-ligand coordination bonds. One of the most salient features of MOSCs is their chemically tunable *endo* and *exo* cavities, which mimic the binding sites of biological receptors. We reasoned that by functionalizing the MOSC *endo* cavity with guanidinium group, which is known for its hydrogen-binding ability and Brønsted acidity, selective anion binding can be achieved. In this presentation, we report the synthesis and characterization of a new guanidium-functionalized MOSC. Ultraviolet-visible (UV-vis) and nuclear magnetic resonance (NMR) spectroscopic studies revealed that this new MOSC exhibits interesting fluoride-selective binding, which can be attributed to guanidium's ability to engage the fluoride anion through both hydrogen bonding and proton transfer. Future studies will focus on examining the *p*H-responsiveness of anion binding by this guanidium-based MOSC.

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

Bacterial Leaf Streak Genome Assembly and Analysis — 43p — Miguel Torres, Ahmed Alhusays, Ellen Fitzpatrick, Meenu Sengar, Jose Hernandez-Gonzalez, Shyam Solanki, and Gazala Ameen.

Abstract: Bacterial leaf streak (BLS) is a disease that affects primarily leaf, stem, and grains of wheat and barley plants, and it is caused by bacterium *Xanthomonas translucens*. Wheat and Barley are two very essential crops around the world and BLS can reduce yields by up to 40%. The BLS disease has become more prevalent in the great plains of the US and is threatening wheat and barley production. There are currently no chemical treatments available to mitigate this harmful pathogen and we also lack any resistant variety available to the growers. Due to the lack of information on the BLS-wheat pathosystem, our study aims to sequence the complete genome of multiple strains of *Xanthomonas translucens* and gain a better understanding of how they interact with the host plant. We isolated high molecular weight DNA from the four strains of *Xanthomonas translucens* isolated from BLS symptomatic wheat leaves and analyzed them for quality and quantity. The DNA was sequenced using nanopore sequencing platform. The data was then used in a multitude of programs such as flye, to assemble the genome, verify the quality of the reads, and visualize them for further use. The long-term goal of this study is to utilize the whole genome assemblies to identify and better understand the virulence factors that contribute to the pathogen's ability to cause disease and provide robust diagnostic markers for the identification of the bacterial pathogen.

REU South Dakota State University
Advisor(s): Ameen Gazala

Connecting CSNK2A1 to the Transition Zone Structure to Better Understand Pathogenic Primary Cilia — 44p — Catrina Tounjian, Elizabeth Menzel, Karama Hamdi

Abstract: Despite being a few microns in size, primary cilia (PC) are complex structures that are essential for embryonic development and tissue homeostasis. A key component of the cilium's structure is the transition zone (TZ), which is a selective barrier that mediates the trafficking of ciliary molecules. Although crucial for PC structure and permeability, little is known about the TZ and how it functions. However, we did previously identify Casein Kinase II subunit alpha 1 (CSNK2A1) as a critical modulator of the TZ. Additionally, Csnk2a1 is an essential gene for embryonic development and is mutated in a neurodevelopmental disorder called Okur-Chung Neurodevelopmental Syndrome (OCNDS). Our preliminary results showed that the levels of two TZ proteins, CEP290 and TMEM67, are reduced in Csnk2a1 knockout (KO) cells. These abnormal levels may indicate a structurally defective TZ. We therefore tested two other TZ proteins, TCTN2 and AHI1, using immunofluorescence. We found that the levels of both proteins were increased at the TZ in Csnk2a1 KO cells, which is consistent with our previous findings. To confirm these results, we evaluated the ciliary level of the signaling molecule, INPP5E, taken as an additional readout to assess the TZ function. Our results indicated that INPP5E is decreased in Csnk2a1 KO cilia. Overall, our findings identified a novel role for CSNK2A1 in mediating the structural integrity of the TZ. To assess the relevance of these results, we are currently analyzing the levels of INPP5E in OCNDS patient cells to determine whether mutations in the Csnk2a1 gene affect TZ function. Our findings gave valuable insight into the role of CSNK2A1 in PC and provided evidence that CSNK2A1 preserves the structure of the TZ. This link between CSNK2A1 and the TZ may provide a piece of the puzzle of why cilia are dysfunctional in OCNDS patients.

REU Sanford Research Center
Advisor(s): Dr. Abdelhalim Loukil

Inkjet Printing Covert QR Codes for Anti-Counterfeiting — 45p — Mary Tran, Erin Schnetzer

Abstract: Counterfeit items, a cheap price for a quickly and poorly manufactured item, are becoming more popular in society today. This can be harmful to consumers due to the poor-quality control and potential hazards. Furthermore, it can also have a detrimental impact on companies that are victims of forged products causing a decrease in revenue and credibility. To combat counterfeiters, several types of anti-counterfeiting methods have been developed, including holograms, watermarks, and QR codes. To increase complexity and security of QR codes, it would be valuable to make special QR codes which will be only scannable after a certain decoding process. Our research group explores surface-enhanced Raman spectroscopy (SERS) based covert QR codes. Through developing new Raman active security inks, we can produce covert QR codes. These QR codes will be invisible under ambient conditions but can be decoded using a confocal Raman microscope. Moreover, these QR codes can be fabricated using a simple Inkjet printer. Several Raman probes were tested and evaluated for their SERS performances. Preliminary results showed that the printed QR codes are covert, have strong SERS signals, and can be easily scanned after the SERS decoding. Our work demonstrated the potential of SERS-based covert QR codes for anti-counterfeiting applications.

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

Assessing Various Pathways for Creating CFD Models Derived from MicroCT Scan Data — 46p — Sydnee Tuuk, Jace Parliament

Abstract: Stents are small medical devices designed to treat certain vascular disorders. They can be used in a variety of ways, such as holding open weak or narrowed arteries, or diverting flow from an aneurysm. In the design process of these stents, Computational Fluid Dynamic simulations are often required to get a full picture of the design's effectiveness. The results of these simulations are used to improve the design of the stent. This process involves generating CT scans of stents within molds of patient geometry involving aneurysms and converting those scans to viable models for CFD simulations. The overall goal of this project is to optimize this process by making it faster, reliable, and more replicable. To do this, we investigated both commercially available and open-source software tools, Mimics Innovation Suite and 3D Slicer. We conducted a time-based comparison of processes between commercially available Mimics and the open-source software currently being used, 3D slicer. We then evaluated the various models from both Mimics and 3D Slicer in Star-CCM+ to obtain a quantifiable difference between the two programs' results. We concluded that even though Mimics offered a robust suite of tools to clean the DICOM files and 3D models in a timely manner, the model produced by 3D slicer and manual reduction of noise were as effective and less costly. With this research, we now know there is not a single software that can easily optimize this process. Furthermore, we now have a greater understanding of the gaps that exist within this field. Filling those gaps could greatly benefit research of this kind and increase the capabilities of stent research and design.

REU Dordt University
Advisor(s): Dr. Stephen Gent

Determining Electrostatic and Thermal Characteristics of Pulsed Stimulus Electro-Osmotic Flow — 47p — Xavier Uhrmacher, Ashley Jorgensen, Dr. Mark Messerli

Abstract: Electro-osmotic flow (EOF) is the flow of water resulting from an electrical stimulus (ES) at a microscopic scale. It occurs when the water's positively charged begin to migrate towards the channel's negatively charged walls causing a neutralizing of charge which in turn causes the fluid's negatively charged ions to be repelled through the center of the channel. The charge imbalance, when exposed to an external electric field, will react with charge of water molecules initiating the movement of the bulk fluid. This phenomenon is utilized through ES therapy, where the healing process of chronic wounds is accelerated by generating EOF within the tissue. However, this therapy method is limited, as methods of optimally inducing EOF are not greatly understood. Therefore, the objective of this research is to investigate the electrostatic and thermal effects of a pulsed ES on a microchannel.

This understanding is integral for the development of EOF technologies, as a pulsed stimulus may offer advantages over constant stimuli by overcoming thermal limitations that are apparent after long durations of constant ES. This study utilized COMSOL Multiphysics to simulate the effects of both constant and pulsed ES on generating EOF in a microchannel. These simulations used an applied voltage of 1000V/m within the channel, with pulse lengths ranging from 10ms to 100us at a 50% duty cycle in the pulsed models. These parameters were chosen based on previous studies and reflect real-world application conditions. The information gathered throughout this study provides a fundamental understanding of pulsed-stimulus EOF, which is essential for attempting to develop an optimal method of inducing EOF. Optimizing this process will lead to advancements in medical tools and treatments for promoting chronic wound healing.

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

Investigating sex as a factor in CEPO efficacy in an mouse model of autism — 48p
— Elizabeth Viehweg, Riggins Bundy, Vedant Thakkar, Monica Sathyanesan, Samuel Sathyanesan, Alexander Kloth

Abstract: According to the Centers for Disease Control and Prevention, about 1 in 44 children in the United States today are affected by autism spectrum disorder (ASD). This neurodevelopmental disorder is characterized by difficulty with social interactions, repetitive behaviors and activities, high anxiety, and intense reactions to sensory inputs, among other symptoms, and symptoms vary widely among patients. The etiology of ASD remains unknown but is hypothesized to be a combination of genetic and environmental factors, contributing to the lack of systematic and effective treatment for the core features of ASD. Erythropoietin (EPO) may be a potential pharmacological agent for treating ASD due to its neurotrophic and neurogenic properties that provide support and protection to the brain, however erythropoietic side effects make EPO as a neurological treatment unfavorable. Our previous studies observed that a Carbamoylated version of EPO with its erythropoietic function silenced known as CEPO rescued aspects of the antisocial and anxious behavior present in male BALB/c mice, an idiopathic model that displays some ASD-related social deficits. However, the presence sex-specific differences in behavior and response to drugs between males and females that show up with other models is unknown in CEPO administration in ASD models. Therefore, in this study, we investigated the effects of CEPO on ASD-like behavior in female BALB/c models. C57BL/6J mice were used as controls. Both strains of mice received 11 intraperitoneal injections of vehicle or CEPO (40 µg/kg) over 21 days. Subsequently, we assess behavior in the three-chamber social approach task, the open field, the elevated plus maze, and the forced swim task to measure sociability and anxiety. Our results will demonstrate whether there are sex-specific variations in behavior and treatment response in the BALB/c mice and will strengthen the evidence supporting CEPO as a potential therapeutic for ASD patients.

REU Augustana University
Advisor(s): Alexander Kloth

Securing Internet of Medical Things: Vulnerabilities, Threats and Attacks, Challenges, and Remediations — 49p — Matthew Wang

Abstract: The Internet of Medical Things (IoMT) is a network of medical devices and services that are used to connect health information technology systems through the Internet. IoMT offers benefits including accessibility, convenience, and efficiency. However, like many other internet-connected devices, IoMT devices also include software and hardware vulnerabilities which could be exploited by malicious actors. A security breach in an IoMT device may result in its functionalities disabled and thus put a patient's life in a critical situation. This project investigates vulnerabilities, threats and attacks, challenges, and remediations in securing the IoMT. An IoMT device may include a sensing unit, a processing unit, a networking component, a power unit, and a mechanical system. Patient data is collected on IoMT devices, routed through communication networks to servers, and diagnosed by health professionals. IoMT devices can also take commands remotely and treat patients in real-time. IoMT requires data to be trusted to ensure appropriate treatments are provided. However, ensuring data security is a challenging task. Many threats and attacks have been reported targeting data confidentiality, integrity, and availability in the IoMT. Challenges in securing the IoMT include but are not limited to: 1) There are large attack surfaces that malicious actors can exploit in the IoMT; 2) Multiple stakeholders including patients, auditors, hospitals, and manufacturers are involved in the IoMT and each plays an essential role in securing it; 3) IoMT devices should preserve their functionalities in case their security is breached. Adoption of IoMT is on the rise and IoMT security is essential for the healthcare industry. Both technical security controls and non-technical security controls should be utilized to secure the IoMT.

REU University of Nebraska Lincoln
Advisor(s): Yong Wang

Developing a Framework for Conducting Research on Traditional Plants on Tribal Lands — 50p — Eva Weddell

Abstract: Conducting ethical research that is culturally sensitive on tribal lands and entities can be a challenging process for researchers. Some tribal entities do not have a research review board or substitute it with approval from tribal governments. It is important to assess the ethics of collecting data on tribal lands before research Indigenous people have a cultural and spiritual connection with the land, especially the land in which they reside, and everything found within it. Therefore, when working with tribal lands and tribal entities it is essential for researchers to include culturally relevant methods of conducting research. Plant collection is one aspect where culturally relevant methods can be applied. Indigenous communities have specific methods for collecting plants, which is dependent on the plant in question. Often, there is a cultural protocol that indigenous communities have when using anything from the land. The protocol for collecting plants should be adapted into the methods of those working with tribal land and entities. Tiŋpsila (Pediomelum esculentum) is a traditional plant of the *Očéti Šakówiŋ* and is discussed in this poster to provide an example of using culturally relevant methods. Including culturally relevant methods in research is important ethically, can promote a positive relationship to continue research with tribal entities, and honors the culture of the indigenous communities in question.

REU Oglala Lakota College
Advisor(s): Camille Griffith

Genome-wide association analysis for protein content in oats (Avena sativa L.) — 51p —
Georgia Welton, Guilherme Oliveira and Sumandeep Bazzer

Abstract: Oat protein content is an important indicator of nutritional value for food and feed applications, becoming a target trait in modern oat breeding. However, selecting for high protein content poses challenges due to environmental factors directly affecting the phenotype trait. For breeding programs looking to select for this trait, genome-wide association studies (GWAS), which uncover genomic regions associated with the target trait, can assist in the breeding process through the use of genomic information. The aim of this study was to conduct a GWAS analysis to identify genomic regions associated with oat protein content. Around 230 lines were evaluated in 5 different locations for 2 years (2021 and 2022) within SDSU oat breeding program nurseries. NIR spectroscopy was used to calculate protein content. Descriptive statistics were calculated using base packages in R. BLUEs and heritability were calculated using the R package 'lme4'. Genotyping data (GBS) included 13,663 SNPs after quality control. GWAS analysis was conducted using the package 'GAPIT' and the model 'Blink' in RStudio. Candidate regions and genes were identified using the T3/oat database. Heritability ranged from 63% to 82% in 2021 and 45% to 78% in 2022. In 2021, 6 molecular markers associated with protein content were identified across 6 chromosomes. In 2022, GWAS detected 16 molecular markers across 11 chromosomes. Across years, 4 significant genomic regions on chromosomes on 3A, 5A, 4D, and 5D were consistent in at least 2 environments. Gene annotation revealed protein content to be a genetically complex trait with multiple genes and environmental interactions influencing expression. These insights should contribute to a better understanding of protein content genetics as well as enhanced efficiency of genomic breeding within SDSU's oat breeding program for advantageous protein content phenotypes.

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

Differentially Expressed Genes in Motile Ciliated Cells with Cilia Dysfunction — 52p — Reesa Wilcox, Casey Mckenzie, Mike Kareta, Lance Lee

Abstract: Primary ciliary dyskinesia (PCD) is a rare autosomal recessive syndrome that affects 1 in 16,000 live births, causing defects in the motile cilia that line various organ systems. Individuals suffering from this disease may experience infertility, hydrocephalus, recurring respiratory infections, and decline of lung function due to dyskinetic motile cilia. Defects in ciliary motility in mice lacking in proteins SPEF2 (*bgh*), CFAP221 (*nm1054*), and CFAP54 (*Cfap54*$^{gt/gt}$) have been shown to each have a phenotype of PCD. The biological mechanisms that regulate motile cilia are not fully understood; however, we completed a single-cell RNA-sequencing approach to identify how epithelial cells in the microenvironment of the airway are affected by dysfunction of ciliary motility. To validate cell-specific gene expression data, differentially expressed genes in early- and late-stage deuterosomal cells and ciliated cells were analyzed by using RNAscope probes in sections of trachea for each of our PCD models. We used fluorescent microscopy to image the genes of interest and quantified the signal intensity. By identifying altered pathways in gene expression, we hope to understand how cells in the airway are impacted and compensating for the dysfunctional cilia.

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

Explicit Computation of Cohomological Hodge Parameters for Calabi-Yau Threefolds in Type IIA and Type IIB String Theory — 53p — Steven Williams

Abstract: Throughout the twentieth century, two fundamental frameworks dominated our understanding of Physics: Einstein's General Theory of Relativity [GTR] and Quantum Mechanics [QM]. From Quantum Mechanics or to be more precise Quantum Field Theory came the now famous Standard Model [SM] of Particle Physics, which describes all of the known elementary particles and three of the four known fundamental forces. The missing force, gravity, is described by General Theory of Relativity. A theory which describes all four fundamental forces, sometimes called a Grand Unified Theory + GTR, has proven to be elusive; however, String Theory has emerged as a possible solution. In Type IIA and IIB String Theory, particles are described by strings residing in 10 dimensions: the four of Minkowski space-time and six dimensions of a Calabi-Yau manifold. Through an in-depth study of the works of Witten, Candelas, Katz, Kodaira, Hirzebruch and others, we have explicitly computed the cohomological Hodge parameters used to describe two different six-dimensional Calabi-Yau manifolds producing a framework in which Einstein's Field Equations in a vacuum are true, and where three and four generations of particles are predicted, thus combining General Theory of Relativity with the Standard Model.

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

Applications of Calcium Zinc Germanate Phosphor for Dynamic Anti-Counterfeiting — 54p — Huixin Zhang, Zishen (Shawn) Yang

Abstract: The counterfeit market is a global issue with pirated products amounting to as much as $464 billion in 2019, which is 2.5% of world trade. To combat this, anti-counterfeiting methods were developed to make the counterfeiting process more difficult. However, counterfeiters are improving their craft; traditional methods such as fluorescent labels and QR codes have become easily replicable. Thus, it is essential to develop advanced materials and technologies to complicate anti-counterfeiting labels. Recently, our lab focused on developing a novel phosphor material, $CaZnGe_2O_6$ (CZGO), for anti-counterfeiting applications using a synthesis of high-temperature solid reaction. Doped with a post- transition metal, CZGO demonstrates intense fluorescence, phosphorescence, dynamic fluorescence, and photochromism. In this work, the ability of CZGO to make anti-counterfeiting labels has been investigated by studying its interactions with artistic materials. This includes mixing the phosphor materials with acrylic, gel, or PDMS. Furthermore, we also applied various methods in label making such as dusting, painting, masking, and drop casting. Several anti-counterfeiting labels have been prepared and are then characterized through fluorescence emission, phosphorescence, and UV-vis reflection spectroscopies. Our results indicated that CZGO has an enormous potential in creating complex fluorescent labels that aid in anti-counterfeiting.

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

South Dakota

2D BEST

2-Dimensional Materials for Biofilm Engineering, Science and Technology

South Dakota is starting year five 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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