

Presentation Number: 400

Presentation Title: Reversing fibroblast-to-myofibroblast transition using surface-engineered nanoparticles to potentially ameliorate fibrotic diseases

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Advisor: Dr. Congzhou Wang

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Abstract: Fibroblast-to-myofibroblast transition (FMT) is a cellular transformation process driving the pathogenesis of fibrotic disorders such as pulmonary fibrosis and scleroderma. Despite advances in anti-fibrotic therapies, existing treatments primarily slow disease progression rather than directly targeting extracellular matrix (ECM)-secreting myofibroblasts, and cannot reverse established fibrosis. In this work, a nanoparticle-enabled, anti-fibrotic approach is demonstrated to reverse the FMT in myofibroblasts via targeting cadherin-2 (CDH2), a cell-surface marker of myofibroblasts, using melanin nanoparticles with surface-engineered CDH2 antibody (CDH2-MeINPs). Treatment with CDH2-MeINPs promotes myofibroblast-to-fibroblast transition (MFT, reversed FMT), significantly suppressing ECM deposition, proliferation, migration, and invasive behavior of myofibroblasts, while concurrently mitigating tissue contractility and stiffness, the hallmarks of fibrosis. Mechanistic studies reveal that this nanoparticle-driven MFT is regulated by the inhibition of the Rho signaling, a critical regulator of FMT. Overall, these findings propose an alternative therapeutic avenue to potentially halt or reverse a broad spectrum of fibrotic diseases. The manipulation of fibroblast/myofibroblast phenotype using nanoparticles may also serve as a promising tool in tissue engineering, enabling precise control over tissue remodeling.

Oral Presentation

Graduate Student

Presentation Number: 401

Presentation Title: Level Ancestors and Tree Accumulations: Simplification and Parallelization

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Computer Science

Abstract: Preprocess a rooted tree then answer queries requesting the ancestor of a specified node on a specified level. We present the second ever $O(n)$ preprocessing, $O(1)$ query algorithm which does not use Method of Four Russians; the first ever was given by Hagerup [1]. We describe how to parallelize both our and Hagerup's [1] preprocessing algorithm to run in $O(n/P)$ time on P , $P \leq n/\log(n)$, processors on a CREW PRAM. We give ideas for calculating parallel tree accumulations over one binary operator which does not rely on tree contraction.

[1] Hagerup, Torben. "Still simpler static level ancestors." arXiv preprint arXiv:2005.11188 (2020).

Oral Presentation

Graduate Student

Presentation Number: 402

Presentation Title: The Influence of Beaver Dammed Reaches on Stream Temperature, Specific Conductance, and Algal Communities in the Black Hills of Western South Dakota

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Chemistry, Biology, and Health Science

Advisor: Dr. Racz-Brunner

Chemistry, Biology, and Health Science

Abstract: Beaver dams are increasingly recognized as ecosystem engineering structures capable of modifying stream hydrology, water chemistry, and downstream biological conditions. In Black Hills freshwater systems, stream temperature and specific conductance (SPC, $\mu\text{S}/\text{cm}$) are important drivers of algal productivity and may influence the prevalence of nuisance and potentially toxin-producing taxa. While prior research suggests beaver dams can reduce stream temperatures and influence water quality, the extent to which beaver-driven physicochemical changes correspond with shifts in algal communities remains under-characterized. This study evaluates whether naturally maintained, bank-to-bank beaver dammed reaches in the Black Hills are associated with changes in stream temperature and SPC, and how these shifts may influence algal community structure.

Field sites were selected based on dam morphology, with sampling stations established upstream, within, and downstream of each dammed reach. Water chemistry was measured in situ using a calibrated YSI multiparameter probe. Algal communities were sampled upstream within the beaver pond and downstream of each dammed reach for laboratory identification and enumeration. Across sites and sampling visits to date, downstream patterns indicate consistent decreases in stream temperature and SPC, consistent with prior work that beaver dams can influence thermal regimes and ionic conditions in running waters. Algal enumeration will illuminate whether these downstream physicochemical shifts correspond with changes in algal biovolume and taxa composition, including potentially harmful or nuisance-associated groups. By linking beaver-induced changes in water chemistry with algal community responses, this research addresses a key knowledge gap relevant to stream restoration, conservation planning, and water quality management in the Black Hills under shifting hydrologic and climatic conditions.

Oral Presentation

Graduate Student

Presentation Number: 403

Presentation Title: Probing the energy and mass dependence of cosmic-ray anisotropy with deep neural networks in IceCube

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Physics

Advisor: Matthias Plum

Physics

Abstract: Cosmic rays are energetic particles thought to originate from explosive astrophysical events like supernovae and quasars. Upon their collision with Earth's atmosphere, a cascade of secondary particles is created and is measurable by instruments like the IceCube Neutrino Observatory, a large ground-based detector array located at the geographic South Pole. The collected data for a given cascade helps reconstruct the incident energy, arrival direction, and mass of the cosmic ray. Recently, an energy-dependent anisotropy in cosmic-ray arrival directions across the Southern Hemisphere has suggested an influence of features in the local interstellar medium on cosmic-ray flux in the TeV-PeV range. Leveraging modern machine learning techniques, we now additionally seek to probe the mass dependence of the arrival direction distribution. Using a convolutional neural network-based reconstruction framework, we expect to increase our understanding of the phenomenology responsible for past anisotropic observations. Jointly, the mass dependence of the arrival directions will shed light on the role of turbulent interstellar magnetic fields in shaping cosmic-ray propagation within our local galactic environment.

Oral Presentation

Graduate Student

Presentation Number: 404

Presentation Title: Dual Substitution in Cationic and Anionic Sublattices of Lithium Indium Chloride for High-Performance Solid-State Lithium Metal Batteries

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Abstract: Solid-state electrolytes play a crucial role in advancing high-energy-density lithium-metal batteries by providing enhanced safety, electrochemical stability, and environmental sustainability compared to conventional liquid electrolytes. Among these, metal-based lithium chlorides, particularly Li_3InCl_6 , have emerged as promising superionic conductors. However, their practical application remains constrained by factors such as low room-temperature ionic conductivity, interfacial instability with lithium metal, and sensitivity to moisture. This study introduces a dual-doping strategy to overcome these limitations by simultaneously modifying its cationic and anionic sublattices. The singly doped $\text{Li}_3\text{In}_{1-x}\text{Zr}_x\text{Cl}_6$ ($0 \leq x \leq 0.5$) electrolytes exhibit enhanced ionic conductivity, while fluorine-substituted $\text{Li}_3\text{InCl}_{6-y}\text{F}_y$ ($0 \leq y \leq 0.5$) electrolytes demonstrated improved oxidation stability at the electrolyte-lithium metal interfaces. The synergistic effect of dual substitution results in an optimized $\text{Li}_{2.6}\text{In}_{0.6}\text{Zr}_{0.4}\text{Cl}_{5.9}\text{F}_{0.1}$ electrolyte with superior electrochemical performance compared to both undoped and singly doped counterparts. This novel electrolyte demonstrated several favorable properties, such as high ionic conductivity (1.7 mS cm^{-1}), broad electrochemical stability window, enhanced moisture tolerance. Additionally, it facilitates the formation of an artificial protective layer of LiF , resulting in stable lithium stripping/plating performance. Solid-state electrochemical cells incorporating this electrolyte and NMC811 cathode achieve a high specific capacity of 216 mAh g^{-1} at 0.1C . The dual-doping strategy enhances the properties of inorganic solid-state electrolytes, provides critical insights into lithium-ion transport at interfaces, and reveals key transformations in structure-property relationships with progressing from undoped to singly doped, and further to dual-doped superionic conductors for next-generation energy storage systems.

Oral Presentation

Graduate Student

Presentation Number: 405

Presentation Title: Laser Ablation for Efficient Space Debris Removal

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Prasoon Diwakar

Leslie A. Rose Department of Mechanical Engineering

Abstract: Laser ablation is a promising solution to the growing space debris removal problem. Laser-induced plasma can be used to adjust debris trajectory in order to push the debris into Earth's atmosphere for termination or send the debris into a graveyard orbit. This presentation will explore the use of nanosecond-pulsed laser ablation to change the trajectory of space debris through momentum transfer. It will focus on the firing angle and material sensitivity to move the debris to a lower altitude, thereby expediting natural deorbit.

Oral Presentation

Graduate Student

Presentation Number: 406

Presentation Title: Photon Detection System Calibration for DUNE

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Physics

Advisor: David Martinez

David Martinez

Abstract: The Deep Underground Neutrino Experiment (DUNE) relies on a precise Photon Detection System (PDS) to provide accurate timing information, enhance sensitivity to low-energy and non-beam events, and support detector performance studies in liquid argon time projection chambers. Achieving these goals requires a well-understood and stable optical calibration strategy that operates reliably under cryogenic conditions.

In this talk, I will present Photon Detection System calibration studies performed in ProtoDUNE, focusing on the characterization of the ultraviolet (UV) light calibration system and key optical components in the light-delivery chain. I will discuss measurements of optical fiber transmission, SMA-to-SMA connector and feedthrough interface losses, and diffuser assemblies, emphasizing wavelength dependence, attenuation, and performance under cryogenic thermal cycling and stability tests.

These studies provide quantitative inputs for understanding light transport, uniformity, and long-term reliability of the PDS in large-scale liquid argon detectors, and they directly inform calibration strategies for the DUNE Far Detector.

Oral Presentation

Graduate Student

Presentation Number: 407

Presentation Title: SuperCDMS Radon Purge System

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Advisor: Richard Schnee

Physics

Abstract: SuperCDMS is a direct dark matter detection experiment at SNOLAB in Canada set to start taking data this year. As a rare-event search, the experiment requires background sources and signals to be well understood and mitigated to reach the experiment's design sensitivity. One significant background arises from radon progeny originating from ambient radon in the underground cavern. Without mitigation, gamma decays from radon daughters near the detectors would dominate the signal region. Our group has designed and begun installing the Radon Purge System to address this challenge. This system operates by flowing low-Radon nitrogen gas into the shield volume surrounding the detector cryostat, with an adjustable rate that responds to cavern pressure variations. Pressure differentials resulting from these variations are large enough to damage the shield materials if not compensated for by the adjustable gas flow. Our approach regulates shield pressure, suppresses radon accumulation near the detectors, and provides continuous monitoring of radon concentration within the shield volume to inform data quality in real time. This presentation will describe the design, testing, and installation of the SuperCDMS Radon Purge System.

Oral Presentation

Graduate Student

Presentation Number: 408

Presentation Title: An experimental calibration between dual carbonate clumped isotope ($\Delta 47$ and $\Delta 48$) in dolomite and temperature

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Abstract: The dual carbonate clumped isotope proxies ($\Delta 47$ and $\Delta 48$) have emerged as powerful tools to reconstruct palaeotemperature, investigate diagenetic processes, and equilibrium in Modern and ancient carbonates. While it is currently believed that the relationship between temperature and $\Delta 47$ is similar for calcite and dolomite, there is still some skepticism that could lead to significant uncertainty in the reconstruction of dolomitisation temperatures – and, by extension, the oxygen-isotopic composition of the diagenetic fluid ($\delta^{18}\text{O}_{\text{FLUID}}$) – in ancient carbonate rocks. Such uncertainty extends to $\Delta 48$ values, on which there has been significantly less research. In this study, we dolomitised aragonite between 150–250 °C and produced a suite of dolomite reaction products with variable $\Delta 47$ and $\Delta 48$ values, and mineralogical properties. Only samples with >99% dolomite were analysed for dual clumped isotope ($\Delta 47$ and $\Delta 48$) analysis. Results suggest that the $\Delta 47$ and $\Delta 48$ values may be sensitive to mineralogical properties such as dolomite stoichiometry, cation ordering, and unit cell volume. Further investigation is needed to identify relationships. This study demonstrates the importance of the dual clumped isotope approach for dolomite research and provides an empirical calibration between $\Delta 47$, $\Delta 48$, and temperature. The relationship further provides a framework for using $\Delta 48$ to validate $\Delta 47$ -based temperature reconstructions. The approach enables the identification of mineralogical artifacts and controls, thereby improving confidence in temperature reconstructions.

Oral Presentation
Graduate Student

Presentation Number: 409

Presentation Title: Enhanced Magnetization in Metastable Disordered Fe-Ga Nanocomposites

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Advisor: Tula Paudel

Physics

Abstract: Recent research has focused on developing soft magnetic materials with superior magnetic properties for next-generation inductor cores in electrified vehicles. We explored an alternative alloy to the traditional Fe-Nb-Cu-Si-B alloy using Ga substitution for Si. The novel Fe-Nb-Cu-Ga-B alloys were found to have a ~35% larger magnetization from VSM measurements. Structural characterization performed with XRD and SAED determined the crystal structure and microstructure. The diffraction patterns show a competition between the stable ordered Fe₃Ga (sp. gr. 225) phase and metastable disordered Fe-Ga (sp. gr. 229) phase. From the complex microstructure, we were able to determine that the Fe-Ga phase formed as an intermediate step as the Fe₃Ga phase was crystallizing due to the rapid cooling rate ~106 °C/s. First principles calculations found that the Fe magnetic moment increased by 35% in the disordered Fe-Ga phase compared to the ordered Fe₃Ga phase, correlating with the experimentally measured increase in magnetization. Our findings show a significant increase in magnetization due to the presence of metastable disordered nanocrystalline phases, which may be the future of soft magnetic materials.

Oral Presentation

Graduate Student

Presentation Number: 410

Presentation Title: In-situ Calibration of the 61-Pixel IceAct Camera Using Single-Muon Signals

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Physics

Advisor: Matthias Plum

Physics

Abstract: IceAct is an array of compact imaging air-Cherenkov telescopes located at the surface of the IceCube Neutrino Observatory at the South Pole, which can withstand the harsh environment. Each telescope contains 61 highly sensitive light sensors, called silicon photomultipliers, which are coupled to cone-shaped light guides made of Polymethyl Methacrylate (PMMA) to collect light signals. Two IceAct telescopes have been taking data since 2019 and show promising capabilities for improving current studies of low-energy cosmic ray induced air showers.

For accurate measurements, the response of each sensor pixel must remain stable. However, aging and environmental conditions can cause changes in the optical opacity and signal response of the pixels. In this study, we calibrate all 61 pixels using single-muon signals and normalize the response of each pixel by assuming that a single muon generates an identical signal in every pixel.

Oral Presentation

Graduate Student

Presentation Number: 411

Presentation Title: Effect of Friction Stir Processing on the Microstructure and Mechanical Performance of Low-Carbon Steel under Arctic Temperature

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Abstract: Cold-climate infrastructure and defense systems operating in Arctic conditions require structural materials that maintain high strength and ductility at sub-zero temperatures. This work investigates the effect of FSP on the microstructural evolution and mechanical performance of low-carbon steel at both ambient and sub-zero temperatures. FSP was used to refine the microstructure through severe plastic deformation and dynamic recrystallization. At sub-zero temperature ($-60 \pm 2^\circ\text{C}$), mechanical testing showed a significant increase in both yield and tensile strength while preserving good ductility. Both yield and tensile strength increased in the processed samples from 375 and 529 MPa to about 485 and 700 MPa, respectively, at room temperature. At -60°C , both yield and tensile strength increased from 392 and 588 MPa to about 516 and 773 MPa, respectively. Ductility was observed to decrease after FSP at room temperature and -60°C , from 40.8 and 49.6% to about 49.6 and 35.5%. A detailed characterization was conducted to evaluate microstructural evolution and post-fracture analysis to clarify the structure–property relationship. The improved mechanical properties at room and sub-zero temperatures demonstrate the effectiveness of FSP in tailoring microstructures for Arctic environments. The development of a uniform, recrystallized microstructure contributed to improved strain accommodation at sub-zero temperatures. These findings confirm that FSP-modified low-carbon steel is a promising material for lightweight armor used in Arctic applications.

Oral Presentation
Graduate Student

Presentation Number: 412

Presentation Title: Investigation of HiPIMS-Deposited Multilayer Nitride Coatings for Extreme Arctic Environments

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Department of Materials and Metallurgical Engineering

Advisor: Dr. Forest Thompson

Department of Materials and Metallurgical Engineering

Abstract: Increasing Army operations in Arctic environments demands the development of material systems that can handle extreme cold, thermal cycling, and icing. Protective coatings for these applications must also be hard, durable, and have reduced ice adhesion strength. Current anti-icing coatings struggle to meet these requirements, so a multilayer transition metal (TM) nitride architecture, centered on aluminum nitride (AlN) was proposed. AlN has a uniquely high thermal conductivity, and good wear properties, both of which can be tuned through the choice of multilayer co-material and deposition parameters.

It is hypothesized that controlled multilayering of AlN and TM nitride co-material will produce anisotropic thermal conductivity through phonon scattering via layer interface. Such anisotropy may promote lateral heat spreading while limiting cross-plane heat loss, providing enhanced resistance to ice accumulation. Additionally, layer thickness and composition can be tuned for erosion resistance, and optical absorption, enabling solar assisted ice melting.

This study seeks to develop multilayer AlN/TM nitride coatings using reactive High-Power Impulse Magnetron Sputtering (HiPIMS) to engineer defect density, layer interfaces, and optical absorption. Deposition parameters including pulse length, kick voltage, substrate bias, and pulse frequency will be systematically varied to tailor ion energy and film density. Defect density will be characterized through Scanning Electron Microscopy, X-Ray Diffraction, Transmission Electron Microscopy and Raman spectroscopy, while Time Domain Thermal Reflectance will be used to measure thermal transport properties. The processing-structure-property relationships for AlN/TM nitride multilayer coatings for Arctic environments will be established as an outcome of this research.

Oral Presentation

Graduate Student

Presentation Number: 413

Presentation Title: Influence of Surface Heterogeneity on Biofilm Attachment and Stability on Patterned 2D hBN-Cu Systems

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Joseph John Thalakkottor

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Abstract: This study explores the preferential attachment and biofilm development of *Citrobacter freundii* on a chemically heterogeneous surface composed of hexagonal boron nitride (hBN) patterns embedded in a copper (Cu) layer deposited on a silicon (Si) substrate. The heterogeneity arises from the contrasting chemical reactivity of inert hBN and reactive Cu regions. The objective is to assess whether such patterned 2D material systems can influence microbial colonization behavior.

Biofilm formation was first evaluated under static conditions using Scanning Electron Microscopy (SEM) and Confocal Laser Scanning Microscopy (CLSM). These techniques quantified bacterial coverage, surface roughness, and biofilm thickness across hBN and Cu domains. Results revealed substrate-specific differences in biofilm morphology and density, suggesting that surface chemistry governs microbial attachment dynamics.

To examine environmental resilience, a dynamic exposure experiment was conducted using a custom-built setup that simulated hydrodynamic shear stresses and introduced environmental constituents such as ions, organic matter, and native microorganisms. The dynamic study assessed biofilm adhesion strength, mechanical stability, and redistribution under flow conditions.

These combined investigations—static and dynamic—offer insights into microbial behavior on chemically heterogeneous surfaces, with implications for designing antifouling coatings and bio functional materials for real-world applications.

Oral Presentation

Graduate Student

Presentation Number: 414

Presentation Title: Stem cell derived nanoparticles for Bone Regeneration

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Abstract: Stem cell-derived nanoparticles, such as extracellular vesicles (EVs), play critical roles in intercellular communication and tissue regeneration. Among them, apoptotic extracellular vesicles (ApoEVs) have attracted increasing attention due to their unique biological properties, including the ability to transfer bioactive molecules and modulate recipient cell behavior; however, their role in osteogenic regulation remains incompletely understood. In this study, we generated ApoEVs from human bone marrow–derived mesenchymal stem cells (hBMSCs), human adipose-derived stem cells (hADSCs), and human gingival fibroblasts (hGFs) using different induction methods. We characterized stem cell-derived ApoEVs and treated hADSCs with different doses. We found that hGFs produced the highest concentration of ApoEVs under optimized induction conditions. Our results showed that ApoEVs were successfully internalized by hADSCs and macrophages and induced osteogenic differentiation of hADSCs in a dose-dependent manner. These findings indicate that ApoEVs possess great potential in regulating mesenchymal stem cell osteogenic differentiation and provide experimental evidence and theoretical support for further MSC-EV development and future clinical translation of innovative and effective cell-free therapies, offering new opportunities for large craniofacial defect repair and other tissue regeneration.

Keywords: apoptotic extracellular vesicles; hADSCs; osteogenic differentiation; tissue regeneration

Oral Presentation

Graduate Student

Presentation Number: 415

Presentation Title: Meta-Analysis of GHG emissions measured under different crop productions methods.

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Abstract: Background: Reported agricultural greenhouse gas(GHG) fluxes differ widely across field studies due to variation in measurement methods.

Objective: To evaluate how management and methodological choices influence inferred emissions.

Methods: A control-treatment percent-change approach was applied across studies examining tillage, cover crops, fertilizer and irrigation regimes, chamber configurations, and statistical modeling.

Results: Emissions of CO₂, N₂O, CH₄, and reactive nitrogen species (NO, NH₃) were highly sensitive to methodological decisions. Differences in chamber type and model specification produced large shifts in estimated fluxes, occasionally exceeding 100%.

Conclusions: Percent change is an interpretable, decision-relevant effect size that improves cross-study comparability, particularly when controls have low or negative baselines.

Measurement methods matter and can substantially alter the results of GHG emissions within field studies

Oral Presentation
Graduate Student

Presentation Number: 416

Presentation Title: Leveraging Extensional Rheology for Mapping of Predictive Diameters in Electrospun Fibers

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Abstract: Electrospinning is a commonly used technique to create micro- and nano-scale fibers with high surface area and functionality, which can then be used to create, amongst other items, high-value ultrafiltration membranes. However, creating fibers with both predictive and reproducible diameters can vary based on the characteristics of the solution, such as surface tension, fluid elasticity, and viscoelastic jet stability. The aim of this research is to create a rheological framework to predict and generate consistent fiber diameters during electrospinning. Fluid elasticity and surface tension can be measured via DoS and contact angle measurements. Surface tension measurements help us determine the threshold between electro spraying and electrospinning. If fluid elasticity increases, then the jet stability will increase yielding more uniform fibers and less bead formation based on the timescale for electrospinning. The results can give an overview of material behavior within different regimes that can reduce the continuous trial and error of electrospinning parameters.

Oral Presentation

Graduate Student

Presentation Number: 417

Presentation Title: Process Engineering of Thermophilic Exopolysaccharides for Sustainable Metal Recovery

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Abstract: Thermophilic bacterial exopolysaccharides (EPS) present a compelling platform for coupling high-temperature fermentation with the production of structurally robust, bio-based polymers. Operation at elevated temperatures inherently reduces contamination risk and enhances process resilience; however, EPS fermentation poses significant engineering challenges, including viscosity-driven oxygen transfer limitations, mixing constraints, and metabolic competition between biomass formation and polymer synthesis. This study investigates both batch and fed-batch bioreactor production of EPS from a thermophilic bacterium, coupled with systematic process optimization to enhance titer and volumetric productivity while maintaining stable rheological performance. Critical operational parameters were refined through a sequential engineering strategy: (i) temperature and pH were calibrated to balance biomass accumulation with polymer synthesis rates, (ii) substrate type and concentration were optimized to mitigate carbon inhibition and oxygen transfer constraints prevalent in highly viscous broths, and (iii) the carbon-to-nitrogen ratio was adjusted to redirect metabolic flux toward polysaccharide biosynthesis. These insights were integrated into a controlled fed-batch feeding strategy that maintained low residual substrate concentrations, stabilized pH and dissolved oxygen profiles, and alleviated viscosity-induced mixing limitations. Our ongoing experiments evaluate thermophilic EPS for heavy metal extraction from coal fly ash, positioning this work as a biologically driven and environmentally responsible alternative to conventional chemical extraction methods. By integrating high-temperature fermentation with targeted metal recovery, this study advances a sustainable pathway for valorizing industrial residues while reinforcing the role of thermophilic bioprocess engineering in next-generation resource recovery technologies.

Oral Presentation

Graduate Student

Presentation Number: 418

Presentation Title: NO CELLS, NO PROBLEM: EXPLORING THE POTENTIAL OF CELL-FREE SYSTEMS

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Abstract: Polyhydroxyalkanoates (PHAs) are biodegradable biopolymers with strong potential as sustainable alternatives to petroleum-derived plastics. However, widespread industrial adoption remains limited by high production costs, cellular variability, and the complexity of downstream processing. To overcome these barriers, we are developing a cell-free biomanufacturing platform that decouples polymer synthesis from cellular growth constraints and enables precise enzymatic control over PHA production. Our approach integrates a multi-enzyme cascade designed to complement a thermophilic corn stover-to-acetate conversion pathway, establishing a modular framework for controlled polymer biosynthesis. The required enzymes were successfully expressed in *E. coli* BL21 using IPTG-inducible vectors, and SDS-PAGE analysis confirmed protein expression at expected molecular weights. Enzymatic functionality was validated through a refined HPLC method employing calibrated standards to confirm substrate conversion, intermediate formation, and cofactor cycling with reproducible retention profiles. Ongoing efforts focus on kinetic optimization and full cascade integration, with reactions transitioning to the BioLector XT microreactor system for controlled, real-time monitoring and scalability assessment. Parallel work aims to enhance yield, recovery efficiency, and reproducibility of cell-free-produced PHAs. By accelerating the shift towards a sustainable biopolymer industry, our efforts contribute to global initiatives aimed at curbing the projected accumulation of 12 billion metric tons of plastic waste in landfills by 2050. Through strategic manipulation of synthetic multi-enzyme pathways, our work paves the way for the establishment of "Bio-Precursor Industries" worldwide, marking a significant step towards a more environmentally conscious future.

Oral Presentation

Graduate Student

Presentation Number: 419

Presentation Title: Extending Agricultural Life Cycle Assessment: A Framework for Quantifying Cross-Boundary Impacts and Evaluating Novel Mitigation Strategies in Midwest Cropping Systems

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Advisor: Dr. Heidi Sieverding
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Abstract: Agricultural impacts are often evaluated independently, ignoring how cross-boundary transport depresses adjacent yields. This study develops a two-farm life cycle assessment for maize, coupling an upwind source farm to a downwind neighbor farm via cross-boundary flows and yield penalties. Impacts (per 1 kg grain) were modeled using ReCiPe 2016 (H) midpoint impact method to capture climate-stressed yield-denominator amplification. Drought/rewetting increased the source's global warming 21.6% (0.45 kg CO₂ eq) and marine eutrophication 36.4% (0.0012 kg N eq). Imported burdens and steeper yield penalties (15-28% neighbor vs. 10-18% source) caused the neighbor's global warming and marine eutrophication to exceed the source by 4.4% (0.47 kg CO₂ eq) and 8.3% (0.0013 kg N eq). Intensified herbicides caused drift-driven toxicity inequity, yielding higher freshwater ecotoxicity on the neighbor (0.19 vs. 0.14 kg 1,4-DCB eq). Compounded vulnerabilities spiked neighbor global warming 55% above the source (1.50 vs. 0.97 kg CO₂ eq) alongside 57.7% neighbor yield losses. Heavy rainfall with unmitigated drainage raised neighbor marine eutrophication 80.9% over the source (0.0038 vs. 0.0021 kg N eq), whereas edge mitigation reduced delivered nitrate 80%, restoring near-parity. An emergent biopolymer mulch reduced particulate transfer but raised source global warming 8.9% (0.49 vs. 0.45 kg CO₂ eq), making benefits conditional on high-vulnerability settings. Future work should extend this to multi-field networks for targeted mitigation screening.

Oral Presentation
Graduate Student

Presentation Number: 420

Presentation Title: Development of a Craniofacial Implant-on-a-Chip Model to Evaluate Cell Migration and Osteogenesis on 3D Scaffolds

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Advisor: Dr. Jue Hu

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Abstract: Currently, craniofacial defects remain a big challenge in clinic due to the limited availability of donor graft. The increasing demand for bone grafting has led to a focus on alternative bioengineering approaches. Biomaterial-mediated tissue engineering scaffolds are promising alternatives for autologous bone grafts. To test the function of those scaffolds, animal models have been largely used. However, serious concerns persist due to the variability among preclinical animal models from different genetic backgrounds, as well as the complicated biology interactions that hinder the mechanistic understanding. Thus, there is an urgent need to develop in-vitro model systems to better evaluate these scaffolds under microphysiological environment. We recently developed an innovative craniofacial implant-on-a-chip platform to support the pre-clinic evaluation process. The device mimics a microenvironment experienced by a transplanted craniofacial bone scaffold, which contains a circular space at the center for a scaffold insert and a microfluidic channel that encloses the space. We hypothesize that this device will enable monitoring of cell behavior at the blood-scaffold interphase. Both mouse and human cells will be cultured on the scaffold inserts to test platform's broad applicability as an evaluation platform. Cellular behaviors, including cell migration, cell proliferation, and osteogenic differentiation, will be analyzed. Hydrogel and nanofiber-modified 3D printed scaffolds will be used as model scaffolds to test our device. The scaffold will be used not only to support cell attachment but also as a drug delivery system. Our preliminary data revealed that our platform could support mice cell proliferation and migration. This research is in response to the NIH and FDA's new initiative, which aims to reduce the use of animal experiments. Ultimately, our craniofacial implant-on-a-chip is expected to offer validation, equivalence, and perhaps outperform animal testing.

Oral Presentation

Graduate Student

Presentation Number: 421

Presentation Title: 4140 Steel Cold Spray Depositions via Heat Treatment of Feedstock Powder and In-Situ Self Peening

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Materials Science and Engineering Program

Advisor: Grant Crawford

Metallurgy

Abstract: As high costs and manufacturing time overruns become increasingly common, efficient repair of steel components using cold spray deposition technology is gaining importance. However, producing high-strength cold-sprayed materials suitable for structural steel repairs remains challenging due to intrinsic material system limitations and the cost for helium carrier gas for cold spray processing. This work aims to produce and characterize stable 4140 steel cold spray coatings for structural repair applications using nitrogen carrier gas. 4140 steel powders were heat treated under vacuum at various temperatures to evaluate how processing parameters influence mechanical properties and, consequently, cold spray-ability. To improve deposition characteristics, heat-treated powders were blended with in-situ 4140 steel peening agents. Mechanical performance was assessed using tensile strength testing, three-lug shear strength testing, microhardness testing, and nanoindentation. Powder and deposition microstructures were characterized through optical microscopy, scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and transmission electron microscopy (TEM).

Oral Presentation

Graduate Student

Presentation Number: 422

Presentation Title: Influence of CrN Coating Architecture on Tribological Behavior in Arctic Conditions

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Advisor: Forest Thompson

Materials & Metallurgical Engineering

Abstract: Wear and friction are system responses, not material properties, meaning operating conditions and environmental conditions can affect material behavior. In simulated Arctic environment testing, past studies have observed that the friction coefficient of chromium nitride (CrN) coatings deposited by physical vapor deposition (PVD) techniques is sensitive to the combinations of water vapor availability and coating surface temperature.

This study focuses on understanding how CrN coating adhesion layer composition affects friction and wear in Arctic conditions. CrN coatings were deposited with chromium, titanium, and CrN bond layers using reactive magnetron sputtering. The coating microstructure was characterized using scanning electron and transmission electron microscopy. Elemental and phase compositions were acquired using energy dispersive x-ray spectroscopy and x-ray diffraction. The mechanical properties and surface topography were investigated with nanoindentation testing, indentation adhesion testing, scratch adhesion testing, and laser scanning confocal microscopy. To investigate the tribological performance of the CrN coatings in simulated Arctic environments, CrN-coated high strength stainless steel flats were tested against alumina ball bearings using a modified low temperature ball-on-flat tribology geometry capable of controlling dewpoint. Dry sliding wear tests were conducted at both cold (-20 °C) and warm (30 °C) surface temperatures in low dew point (<-20 °C) air. Post-wear analysis was conducted using optical and laser scanning confocal microscopy on the resulting wear scars of the ball and flat.

Data collected was used to correlate the CrN coating architecture and properties with tribological behavior. The results of this research provided insight into how various CrN coatings perform in simulated Arctic conditions and give insight into how CrN coatings may be better developed or utilized in oscillating sliding wear applications in cold regions.

Oral Presentation

Graduate Student

Presentation Number: 423

Presentation Title: Tributary Macroinvertebrate Drift Providing Food Resources to the Mainstem Kootenai River

Student Name: Aisling Hall

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Chemistry, Biology, and Health Sciences

Advisor: Dr. Lisa Kunza

Chemistry, Biology, and Health Sciences

Abstract: The Kootenai River is a large, oligotrophic river that relies on tributary resources to sustain the mainstem food web dynamics. Among these critical food resources are macroinvertebrates, particularly for higher-level consumers like fish. We examined the diel abundance of macroinvertebrate drift on three tributaries during three consecutive summers. Expected diel trends would follow cyclic patterns with peaks in drift abundance occurring at night. In this research, only a few samples conformed with what was expected. The remaining samples have peaks at different times of the day, either not following a clear cyclic pattern or having peak drift occur during the day. Site characteristics tend to influence the composition of macroinvertebrates present. The sites with lower water velocity have higher numbers of the mayfly *Paraleptophlebia* sp. and members of the family Corixidae, both macroinvertebrates that prefer slower-moving waters. Although there are differences in composition among site locations, some key taxa remain similar among all samples. The *Baetis* sp. mayfly is the most abundant macroinvertebrate for all but two samples, with an average abundance of 40.4% and a range of 1.7% - 71.2%. Macroinvertebrate drift is a critical component to understanding food resource availability in large oligotrophic rivers and promotes informed conservation strategies.

Oral Presentation

Graduate Student

Presentation Number: 424

Presentation Title: Electronic States and Optical Response in 2D Layered Lead-Halide Perovskites

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Advisor: Steve Smith/Tula R. Paudel

Nanoscience & Biomedical Engineering/Physics

Abstract: Two-dimensional organic-inorganic layered lead-halide perovskites (Benzylammonium)₂PbX₄ (X=Cl,Br,I) offer a simple route to study how composition and thickness control electronic and optical behavior in bulk crystals and exfoliated flakes. Using first-principles density functional theory, we calculated the band structure, projected density of states and charge-density maps for monolayer and bilayer (Benzylammonium)₂PbBr₄. We identify optically inactive surface states that appear in few-layer slabs. These states arise from carbon p-orbitals on surface organic groups; the relevant carbon atoms are separated by more than 10 Å and their wavefunctions do not overlap with the Pb s/p states that form the valence bands. As a result, these surface states do not produce a measurable signal in linear optical spectra. Calculations of band structure and optical response for X=Cl, and I reveal systematic, halide-dependent trends across the series. Experimentally, bulk X=Cl, and I crystals are characterized for surface morphology and elemental composition by SEM/EDX. While X=Br is exfoliated into thin flakes (confirmed by optical imaging) and examined by SEM/EDX and AFM to verify composition and determine thickness after exfoliation. Optical reflectance is measured for both bulk and exfoliated samples using a custom setup that was designed, assembled, and commissioned in our lab, probing the thickness- and composition-dependent optical transitions for comparison with theory. Future work will extend the study to linear and nonlinear electronic and optical properties in both bulk and exfoliated samples.

Oral Presentation

Graduate Student

Presentation Number: 425

Presentation Title: A New Self-Peening Approach to Enhance Microstructure and Mechanical Properties of Cold Sprayed 316L Stainless Steel.

Student Name: Kyrian Odo

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Material Science and Engineering

Advisor: Dr. Grant Crawford

Material Science and Engineering

Abstract: Cold spray deposition of 316L stainless steel often produces porous coatings due to limited particle deformation and weak inter-particle bonding, leading to inferior performance compared to wrought 316L. While post-treatments such as annealing, HIP, and laser re-melting enhance bonding and reduce porosity, they increase cost and complexity, limiting scalability. In-situ densification with foreign shot-peening media improves coating properties but risks contamination and material incompatibility. This study presents a novel in-situ self-peening approach using the same 316L powder as both deposit and peening media. Mechanical milling enhances the hardness and size of the peening powder, which is then blended with gas-atomized powder for cold spray deposition. This technique markedly improves particle deformation and metallurgical bonding, yielding coatings with lower porosity, higher hardness, and increased strength. The self-peening method offers a contamination-free, scalable solution for dense, high-integrity 316L coatings, potentially eliminating the need for extensive post-processing.

Oral Presentation

Graduate Student

Presentation Number: 426

Presentation Title: Physics Informed Inverse Design and Crashworthiness Optimization of Hexagonal Composite Ring Structures

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Chemical and Biological Engineering

Advisor: Monzure Kazi-Khoda

Chemical and Biological Engineering

Abstract: Crashworthy composite energy absorbers require designs that maximize energy absorption (EA) while limiting initial peak force (IPF), yet optimization remains challenging due to complex failure mechanisms and limited experimental data. This study presents a physics-informed inverse design framework for hexagonal fiberglass/epoxy composite rings under quasi-static compression. Composite specimens were fabricated and tested under two loading configurations to obtain force–displacement responses for model development and validation. A physics-informed neural surrogate was developed that predicts absorbed energy and derives crushing force through automatic differentiation, enforcing exact work-energy consistency and improving physical reliability. Three variants, a data-driven network (DDNS), a soft-constraint, and a hard-constraint PINN, are trained as 20-member bootstrap ensembles and evaluated under interpolation and unseen-angle extrapolation protocols. On extrapolation to an untrained fiber orientation, the hard-constraint PINN achieves load $R^2 \geq 0.85$ and the soft-constraint PINN $R^2 \geq 0.80$, both significantly outperforming the DDNS ($R^2 = 0.70$, $p < 0.001$) and conventional surrogates, including Random Forest ($R^2 = 0.26$) and Gaussian Process ($R^2 = 0.30$). The hard-constraint PINN produces the best-calibrated uncertainty among all variants (conformal factor = 2.14 vs 3.99 for DDNS), indicating that its wider confidence bands honestly reflect prediction difficulty. For inverse design, the surrogate is coupled with Gaussian process Bayesian optimization jointly across loading configurations, supported by a probabilistic classifier penalizing implausible combinations. All optimizers recover target EA and IPF within 3% error; GP-BO achieves comparable accuracy using 3.3× fewer surrogate evaluations than per-configuration methods.

Oral Presentation

Graduate Student

Presentation Number: 427

Presentation Title: Comparative Evaluation of High-Order Finite-Volume Methods for Unsteady Laser-Induced Plasma Flows

Student Name: Lucas Pierce

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Leslie A. Rose Department of Mechanical Engineering

Advisor: Dr. Prasoon Diwakar, Dr. Sonya Dick

Leslie A. Rose Department of Mechanical Engineering

Abstract: Nanosecond laser ablation generates highly transient compressible flow characterized by rapid energy deposition, steep pressure gradients, and shock formation. Accurate numerical simulation of these laser-driven flows requires robust high-order spatial discretization capable of resolving discontinuities while preserving smooth solution features. This thesis presents the development and verification of a two-dimensional finite-volume solver for modeling laser-induced gas dynamics, with emphasis on evaluating high-order reconstruction schemes in shock-dominated regimes.

The compressible Euler equations are solved using a conservative formulation with explicit Runge–Kutta time integration and Rusanov flux evaluation. Spatial discretization is performed using first-order upwinding, WENO3, WENO5, and TENO5 reconstruction schemes to systematically assess accuracy, stability, and computational cost. Verification is conducted through density advection and grid-refinement studies using L2 error norms to confirm formal order of accuracy. Comparative simulations of shock formation and plume expansion are performed to evaluate shock resolution, numerical dissipation, and solution robustness across schemes.

An idealized high-pressure, high-temperature gas bubble expanding into quiescent ambient conditions is used to model the early hydrodynamic response of laser energy deposition. Quantitative metrics include shock location, gradient resolution, convergence behavior, and computational performance. Results demonstrate that higher-order schemes significantly improve shock capturing and reduce numerical dissipation relative to first-order methods, with TENO5 providing improved robustness in strong gradient regions.

This work establishes quantitative relationships between spatial scheme order and solution fidelity in laser-driven compressible flows, providing guidance for high-order CFD modeling of transient laser ablation phenomena.

Oral Presentation

Graduate Student

Presentation Number: 428

Presentation Title: Role of Matrix Effect in Laser Produced Plasma Spectroscopy for Soil Nutrient Quantification

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Advisor: Prasoon Diwakar
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Abstract: Laser-produced plasmas exhibit significant variation depending on the composition and physical properties of the target material. This variability presents substantial challenges in the analysis of organic materials, as environmental and matrix-related factors strongly influence plasma characteristics. This study demonstrates that matrix effects in organic soils significantly affect plasma temperature, leading to deviations in laser-induced plasma formation. These findings emphasize the need to develop robust machine learning algorithms capable of accounting for matrix effects in organic soils. Incorporating such approaches can enhance the accuracy and reliability of laser-based analytical techniques for soil nutrient quantification.

Oral Presentation
Graduate Student

Presentation Number: 429

Presentation Title: AVS-FE Simulations of Hard Magnetic Soft Materials subject to Steady State Electromagnetic Fields

Student Name: Joshua Rath

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Mechanical Engineering Department

Advisor: Dr. Albert Romkes

Mechanical Engineering Department

Abstract: In recent decades, a significant portion of research has been dedicated toward the development of a novel class of smart materials: magneto-active elastomers. Magneto-active elastomers are composite materials that are constructed by embedding magnetic materials into a rubber-like polymer such as silicone. The mathematical models of these materials involve the coupling of the Maxwell equations with near incompressible hyperelasticity. As a result, solving the equations that govern magneto-active elastomers is quite challenging. To overcome this challenge, we present an unconditionally stable finite element formulation, known as the automatic variationally stable finite element (AVS-FE) method, for solving a steady state ideal hard-magnetic soft material model. Following the discontinuous Petrov-Galerkin method (DPG) methodology, the AVS-FE method requires the computation of optimal test functions to guarantee stability. Unlike the DPG method, the AVS variational statement is formulated such that the trial functions are kept in a conforming, weakly continuous Sobolev space. Not only does this reduce the computational cost of the AVS-FE method, it also ensures that the field variables, such as stress and displacement, are continuous throughout the domain. Herein, we present several numerical verification experiments that show the AVS-FE method yields optimal convergence rates for the steady state Maxwell equations, and stable, locking free solutions for the near incompressible hyperelastic equations. Then, we utilize AVS to solve a model of a cardiac catheter made of a hard-magnetic elastomer that is subject to a steady-state magnetic field.

Oral Presentation

Graduate Student

Presentation Number: 430

Presentation Title: Palladium Copper Alloy Nanoparticles with Novel Five-Fold Symmetric Structure

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Nanoscience and Biomedical Engineering

Advisor: Dr. Shan Zhou

Nanoscience and Biomedical Engineering

Abstract: Five-fold symmetry exhibited in nanoparticles is a rare geometrical structure and thus has unique and valuable properties for optoelectronic and catalytic applications. Although five-fold symmetry occurs in nature, especially in flowers and crustaceans, at the nanoscale, this symmetry is forbidden by classic crystallographic rules. Decahedrons, icosahedrons, and similar geometrical shapes have five-fold rotational symmetry but do not have translational symmetry. Both of these qualities are possible simultaneously with the introduction of atomic strain formed along five twinned boundaries. These boundaries separate each of the five crystal domains. Atomic strain provides highly active sites that are useful in many catalytic applications. This project focuses on the unique five-fold symmetric branched structure of palladium-copper alloy nanoparticles. This five-fold symmetric nanoparticle appears to grow from the seed of a decahedron, where atomic deposition forms branches at each of the five corners. The resulting structure resembles a flower with five petal-like branches that are radially symmetric. The combination of copper, palladium, and the twinned strain is expected to give the particle promising performance in catalysis and other applications.

Oral Presentation

Graduate Student

Presentation Number: 431

Presentation Title: Computational Validation of Tolyporphin Derivatives as P-Glycoprotein Inhibitors to Overcome Multidrug Resistance: Quantum Calculations and Molecular Docking

Student Name: Hung Nguyen

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Department of Chemistry, Biology, and Health Sciences

Advisor: Haiden Nguyen

Department of Chemistry, Biology, and Health Sciences

Abstract: Multidrug resistance (MDR) driven by P-glycoprotein (P-gp) significantly limits the efficacy of many chemotherapeutic agents. P-gp is an ATP-binding cassette transporter, composed of two distinct domains: nucleotide-binding domains (NBDs) and a transmembrane domain (TMD). The TMD features a large central binding cavity, a vestibule, and an access tunnel, resulting in a broad substrate binding pocket. Despite decades of research, a clinically FDA-approved P-gp inhibitor remains elusive. Tolyporphin A (TppA), a tetrapyrrole-based natural product, has been reported as a P-gp MDR reverser. We hypothesized that conjugating TppA to small organic ligands would enhance targeting of the TMD binding region, particularly the access tunnel. In this study, we evaluated a library of TppA-ligand conjugates using quantum-mechanical (QM) optimization and molecular docking approaches. The results from density functional theory (DFT) calculations at the B3LYP/6-31G(d,p) level revealed that one of the TppA-ligand conjugates exhibits favorable chemical stability and an electronic free energy. Docking studies against apo P-gp conformation indicated enhanced binding affinity of selected TppA-ligand conjugates. Collectively, these findings support the hypothesis that TppA derivatives can effectively engage the P-gp access tunnel, highlighting this region as a promising therapeutic target for overcoming MDR.

Oral Presentation

Graduate Student

Presentation Number: 432

Presentation Title: Roles of Scaffold Topography and Hyaluronic Acid Binding Peptides on Macrophage Differentiation in an Artificial Synovial Membrane Model

Student Name: Abby Krumpus
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Biomedical Engineering

Advisor: Dr. Tugba Ozdemir
Biomedical Engineering

Abstract: Introduction:

Osteoarthritis (OA) and Rheumatoid Arthritis (RA) are debilitating diseases that significantly impact quality of life, causing joint pain, stiffness, inflammation and reduced range of motion. The synovial membrane is a critical component of the joint, mainly consisting of macrophages and fibroblasts lined adjacent to a thin matrix. Both cell types have altered functions during OA and RA. In their attempt to heal the joint, macrophages tend to take a pro-inflammatory role, contributing to inflammation and tissue damage. Hyaluronic acid (HA), a key component of synovial fluid plays a vital role in lubrication and reducing inflammation. During arthritis the molecular weight and concentration of HA is altered, leading to decreased lubrication and increased inflammation. Tissue Engineering aims to build sacrificial scaffolds that can elicit desired cellular outcomes. We hypothesized that scaffold topography and its ability to attract and enhance HA can play significant roles in macrophage differentiation.

Methods/materials:

Using electrospinning, we created nano and microfiber synthetic membranes. To attract HA to these synthetic membranes, we chemically conjugated novel Hyaluronic acid binding peptides (HABPs). THP-1 cells were differentiated into M0 macrophages and cultured on synthetic surfaces. Cell differentiation was tracked using Presto Blue, Pico Green, ELISA (TGF-beta, TNF-alpha, IL-10, IL-1beta, Cellular morphology).

Goals:

We successfully developed nano and microfibrillar scaffolds and functionalized with HABPs onto the scaffolds. We established reproducible and rigorous methodologies to control M0-like macrophages and seeding densities to observe cell response reminiscent of physiological scenarios. The ongoing experiments are focusing on understanding the macrophage responses. The goal of this study is to find a relationship between surface topography, immobilized endogenous HA and macrophage cellular responses in the context of arthritis.

Oral Presentation
Graduate Student

Presentation Number: 433

Presentation Title: Advanced Pretreatment Strategies for Structural Modification of Corn Stover Toward Enhanced Bioconversion to Lactic Acid

Student Name: Daniel Tobias Soria
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Chemical and Biological Engineering (CBE)

Advisor: Dr. Ivan Salmeron Ochoa
Chemical and Biological Engineering (CBE)

Abstract: Lignocellulosic biomass has been representing a promising renewable carbon source for sustainable bioprocessing; however, its complex and recalcitrant structure limits efficient sugar recovery and downstream fermentation for that purpose. The present work evaluates advanced pretreatment strategies with the objective of modifying the structural organization of corn stover to enhance carbohydrate accessibility and support further lactic acid production. Pretreatment was run under controlled thermal conditions to induce matrix rearrangement, followed by mild chemical processing. Structural modifications were evaluated using Fourier-transform infrared spectroscopy (FTIR), while carbohydrate profiles were quantified through HPLC analysis. Spectroscopic results showed temperature-dependent changes in hydroxyl and aromatic functional groups, suggesting dehydration reactions, lignin reorganization, and partial deacetylation. These structural alterations or rearrangements directly influenced sugar recovery trends.

Compositional analysis identified moderate-temperature treatment as “more suitable”, yielding approximately 5 g/L xylose while preserving fermentable sugars. More severe conditions resulted in carbohydrate degradation and reduced recovery. To evaluate feasibility of these sugar profiles, a synthetic hydrolysate medium was formulated based on the recovered sugar composition and screened using five lactic acid producing bacterial strains. Where, *Lactobacillus plantarum* demonstrated the highest LA yield, demonstrating effective utilization of the pretreatment-derived carbohydrate profile.

These findings demonstrate that controlled pretreatment can strategically alter lignocellulosic structure to improve sugar accessibility while maintaining fermentability. Ongoing research includes the evaluation of supercritical fluid processing as a complementary, low-energy approach for enhanced biomass deconstruction and integration into sustainable biorefinery platforms.

Oral Presentation
Graduate Student

Presentation Number: 434

Presentation Title: Optimization of ultrafast low-temperature Ti₃C₂T_x MXene synthesis via molten NH₄HF₂ salt etching

Student Name: Venera Alimova

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CBHS

Advisor: Dr. Alexey Lipatov

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Abstract: Two-dimensional transition metal carbides and nitrides known as MXenes attract significant scientific attention due to their high electrical conductivity, large specific surface area and tunable surface terminal groups. Among them, Ti₃C₂T_x is known as promising for sensing and electrochemical energy storage applications. In this work, MXene Ti₃C₂T_x was synthesized by an ultrafast and low-temperature method via selective etching of aluminum from the MAX phase Ti₃AlC₂ using molten NH₄HF₂ salt. The process is performed at 160°C and enables the formation of MXene within only 5–10 minutes. Enhanced diffusion in the molten salt significantly accelerates the etching kinetics compared to conventional aqueous approaches. Importantly, HF is generated in situ during the reaction, improving operational safety. Repeated centrifugation of the MXene suspension in hot water effectively removes residual aluminum oxides and increases overall yield. SEM analysis demonstrates the characteristic layered “accordion-like” morphology of Ti₃C₂T_x. EDS confirms a uniform elemental distribution, and XPS verifies the presence of Ti–O and Ti–F bonds on the surface. The demonstrated molten-salt approach provides a rapid and efficient synthesis route which also may be extended to other MXene compositions, following by systematic investigation of their structure–property relationships, and opens up prospects for a wide range of MXene applications.

Oral Presentation

Graduate Student

Presentation Number: 435

Presentation Title: Experimental and Computational Investigation of Supersonic Retro-propulsion Under Unsteady Conditions

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Advisor: Dr Joseph John Thalakkottor
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Abstract: Supersonic retropropulsion (SRP) has emerged as a critical technology for entry, descent, and landing (EDL) of spacecraft, particularly for future Mars missions where delivering large payloads for human missions remains a significant challenge. While many prior computational and experimental investigations have assumed steady freestream conditions, atmospheric entry is inherently unsteady, with continuously varying Mach number and flow properties. The influence of these temporal variations on shock structure and overall aerodynamic behavior has not been fully characterized. This work experimentally and computationally investigates the effects of unsteady supersonic freestream conditions on SRP flowfields. Physical testing was conducted in a supersonic wind tunnel that naturally produces a decelerating freestream over time, enabling examination of plume shock interactions under varying Mach number conditions. Complementary computational fluid dynamics (CFD) simulations were performed and validated against established baseline data. Schlieren imaging was used to visualize shockwave structures and assess flow stability. Results demonstrate that bow shock stability is strongly dependent on nozzle expansion regime. The over-expanded configuration exhibited significant unsteadiness at higher Mach numbers, followed by a transition to a more stable interaction as Mach number decreased. In contrast, moderately and highly under-expanded configurations maintained comparatively steady bow shock structures throughout the test range. These findings contribute to more accurate modeling of retropropulsion systems and support the development of safer and more reliable planetary landing architectures.

Oral Presentation
Graduate Student

Presentation Number: 436

Presentation Title: COSMIC-RAY MASS COMPOSITION CLASSIFICATION WITH MUON-BUNDLE ENERGY LOSS PARAMETERIZATION IN ICECUBE-DETECTOR.

Student Name: Amar Thakuri
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Physics

Advisor: Xinhua Bai
Physics

Abstract: When a high-energy cosmic ray interacts in the atmosphere, it triggers a cascade of secondary particles, including mesons that decay into muons, neutrinos and other particles. These high energy muons are collectively known as a muon bundle. The number and energy of muons in a bundle are linked to the primary energy and mass of the cosmic ray particle. In our model, we account for both the primary energy and the zenith angle of the incoming cosmic ray. We also consider spatial separation between muons as they move through the ice, which lets us include new parameters to better describe the bundle's energy loss. Based on the parameters obtained for various simulated cosmic ray particles for different primary energies and masses, we employ machine learning techniques to determine how effectively these parameters can distinguish between four cosmic ray primary types: proton, helium, oxygen, and iron. By applying the theoretical model to simulated data, we explore how far we can push the limits of identifying cosmic ray types through the energy loss patterns of muon bundles deep within the ice.

Oral Presentation
Graduate Student

Presentation Number: 437

Presentation Title: Adaptation of Endothelial Cells to Chemically Defined Media and Assessment of Phenotype Retention

Student Name: Lora Ortega

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Karen M. Swindler Department of Chemical & Biological Engineering

Advisor: Travis Walker

Karen M. Swindler Department of Chemical & Biological Engineering

Abstract: Endothelial cells (ECs) are widely used in vascular biology, regenerative medicine, drug screening, and tissue engineering, mostly from their roles in angiogenesis, barrier function, and cell signaling. For many applications, in vitro expansion is essential. However, traditional culture methods rely on serum-containing media that introduce variability from undefined compositions and batch inconsistencies. This impacts reproducibility and creates challenges when scaling or commercializing projects. The creation of a chemically defined media (CDM) provides a controlled and standardized alternative, but ECs must retain their phenotype after adaptation. The goal of this research is to reproduce the fact that ECs can be grown in CDM while maintaining phenotype with the objective of developing a commercially available media. ECs were gradually transitioned from a serum-containing medium to a CDM using a stepwise adaptation protocol. Cells were monitored over multiple passages to assess morphology, proliferation, and phenotypic stability. Assessments of morphology, proliferation trends, and expression of endothelial-associated characteristics were conducted to determine whether adaptation affected EC identity.

ECs were successfully adapted to the CDM and maintained viability through the process. Minor changes in growth kinetics were observed early in adaptation, but proliferation stabilized in later passages. Morphology assessments showed preservation of the characteristic monolayer structure and phenotypic assessments indicated retention of endothelial traits under defined conditions.

These findings suggest that ECs can maintain phenotypic stability following CDM adaptation. By minimizing variability and improving standardization, CDMs can enhance experimental consistency. While future work needs to validate the scalability of the CDM, this work provides foundational evidence supporting the need for a commercially available, chemically defined culture media for ECs.

Oral Presentation

Graduate Student

Presentation Number: 438

Presentation Title: Probing Polarization-Controlled Transport in a Mixed-Dimensional Ferroelectric/Quasi-1D Semiconductor Heterostructure

Student Name: Ilya Mikhailov
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Advisor: Dr. Alexey Lipatov
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Abstract: The integration of ferroelectric materials with low-dimensional semiconductors provides a route to compact electronic memory elements where polarization controls conductivity without continuous power which is particularly important for next-generation low-power and non-volatile electronic devices. Quasi-one-dimensional (1D) semiconductor channels are attractive because they enable further device miniaturization and their small cross-section can reduce electron scattering, supporting more efficient carrier transport. In this work, we fabricate a mixed-dimensional van der Waals heterostructure combining a quasi-1D semiconductor TiS₃ with the layered ferroelectric CuInP₂S₆ (CIPS). To further enhance the device performance, the heterostructure was encapsulated with a thin dielectric h-BN flake and annealed in a controlled environment. After encapsulation and annealing, the device showed improved performance and stronger polarization-channel coupling between the CIPS substrate and the TiS₃ channel, demonstrating clear polarization-dependent transport and memory-like behavior, while also revealing that interfacial effects and environmental sensitivity remain important factors for device stability. Overall, the results confirm the potential of mixed-dimensional ferroelectric devices, while indicating that further interface optimization will be important for achieving more reliable and reproducible ferroelectric memory based on quasi-1D semiconductors.

Oral Presentation
Graduate Student

Presentation Number: 439

Presentation Title: Controlled Delivery of Muscarinic Receptor Agonists to Aid Xerostomia After Head/Neck Radiotherapy

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Advisor: Dr. Tugba Ozdemir
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Abstract: Targeted drug delivery with controlled, sustained release offers a promising solution for managing chronic diseases requiring frequent drug administration while reducing the adverse effects associated with conventional delivery methods. We propose an injectable, composite hydrogel. This system delivers pilocarpine to stimulate gland secretion, offering controlled, prolonged drug release while minimizing side effects. This study optimizes microparticle formulation, release kinematics, and evaluates its impact on regulating amylase secretion in salivary gland epithelium.

Synthesis of Hydrogel Microparticles (HMP): The HMPs will be synthesized utilizing Hyaluronic acid (HA) via inverse emulsion polymerization. The HMPs will be embedded into an HA based commercial hydrogel system. Particles were imaged on a SEM and characterized using DLS and Zeta potential. To evaluate the in vitro drug loading and release, the particles in and out of the hydrogel will be tested for its pilocarpine release and load quantities via HPLC.

Concentration of Pilocarpine was tested on immortalized salivary gland epithelial cells (SGecs) in a 48 well plate treated with a collagen ECM. 3D and 2D SGecs were analyzed for amylase and Nuc-Blue. The SGecs were stained for M1 and M3 receptors for validation.

SEM results showed that utilizing a higher HA molecular weight, higher chemical quantity, longer reaction time for the crosslinking, additional washes, and improved techniques resulted in the best quality of HA microparticles. Utilizing DLS, most of the particles are found to be 1282 nm. The average charge of the particles was -57.6. Pilocarpine release study resulted in HA particles loading and releasing an average of 55% and about 1% per day respectively.

Hydrogels with particles were found to consistently release pilocarpine for 28 days. Between 1mg/mL and 0.1mg/mL is the most optimal dosage concentration. 3D cells secreted more amylase than 2D cells. M3 and M1 receptors were identified.

Oral Presentation
Graduate Student

Presentation Number: 440

Presentation Title: Controlling Background Radiation for Early Warning Supernova Detection with the Deep Underground Neutrino Experiment (DUNE) at Sanford Lab

Student Name: Tyler Rath

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Department of Physics

Advisor: Dr. Juergen Reichenbacher

Department of Physics

Abstract: When completed in the late 2020s, the Deep Underground Neutrino Experiment (DUNE) will be the most advanced neutrino detector built to date, consisting of a particle accelerator sending a neutrino beam from Chicago, IL, to a detector a mile underground at Sanford Lab in Lead, SD. Neutrinos are a fundamental particle with no electric charge, near-zero mass, and are the second most prevalent particles in the universe, with hundreds of trillions streaming through you every second. They also come in three 'flavors': electron, muon, and tau, with each having different masses. DUNE's primary purpose will be to measure the absolute values of the masses, but will also be able to detect neutrinos formed in the supernovae of distant stars, which arrive several hours before the visible light of the explosion, thus also serving a dual purpose as an early warning supernova detector. However, because supernova neutrinos are lower energy, unlike the high energy neutrino beam from Chicago, steps must be taken to reduce and manage similar energy background radiation inherent to every material in order to distinguish supernova neutrinos from it. This is done predominantly via gamma spectroscopy, the use of germanium detectors to measure the radioactivity content of detector components, concrete, rock, etc., as a form of radioactive quality control during the construction of DUNE. Details of these spectroscopic assay efforts will be the focus of this talk.

Oral Presentation

Graduate Student

Presentation Number: 441

Presentation Title: Comparative Study of Pyrolysis and Hydrothermal Liquefaction for the Production of KOH-Activated Pinewood-Derived Porous Carbon for Supercapacitor Applications

Student Name: Afolabi Abraham Odesanmi

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Karen M. Swindler Department of Chemical and Biological Engineering.

Advisor: Professor Rajesh Shende

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Abstract: Forest residues are an enormous and underused source of lignocellulosic biomass that could be used to make carbon materials in a way that is beneficial for the environment. Pyrolysis and hydrothermal liquefaction (HTL) are two very different thermochemical methods that work in dry, inert conditions and subcritical water environments, respectively. This leads to different carbonization pathways and material properties. This study undertook a systematic comparative analysis to assess the impact of thermochemical conversion pathways, pyrolysis versus hydrothermal liquefaction (HTL), on the structural development and energy storage capabilities of porous carbon derived from pinewood.

Biochar was produced through pyrolysis at temperatures between 600 and 1000 °C in an inert nitrogen atmosphere, whereas hydrochar was synthesized via HTL at 250, 275, and 300 °C under autogenous pressure. Experiments were conducted for both pathways, with and without a surfactant, to assess its impact on pore formation and surface alteration.

Potassium hydroxide (KOH) was used to chemically activate the char material for improving the formation of mesopores and the development of surface area in porous carbon systems. The char was then heated to 800 °C in an inert environment to prepare porous carbon and characterized using SEM, BET surface area analysis, FTIR, XRD, Raman spectroscopy, and elemental analysis to analyze the shape, porosity, crystallinity, and surface functionality.

A direct comparison showed that HTL-derived and pyrolysis-derived carbons have different pore structures and structural properties. These differences are caused by the chemistry of the precursors and the temperature at which they are processed. The optimized porous carbons were further evaluated for supercapacitor applications, given that biomass-derived nanoporous carbons have exhibited encouraging electrochemical performance in energy storage systems.

Oral Presentation

Graduate Student

Presentation Number: 442

Presentation Title: Investigating the post peak critical shear strength of lime stabilized mine tailings materials

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Abstract: Research focuses on the effect of lime stabilization on engineering properties with fine-grained soils. Lime content was added at 0.1%, 1%, 2%, and 4% by dry weight and cured for 7 and 28 days to assess strength development. Laboratory testing focused on shear strength and other relevant soil design parameters.

Results show an increase in sheer strength and a reduction in plasticity with higher Lime content and longer curing time. The pozzolanic reaction (chatted this) continued throughout the curing time which explained the increase in soil parameters. Overall, Lime content improved the soils response and increased the feasibility of lime being utilized in a slope stability scenario.

Oral Presentation
Graduate Student

Presentation Number: 443

Presentation Title: Machine Learning Based Prediction and Optimization of Flattening Ratio and Deposition Efficiency in Cold Spray Deposition of Metallic Powders

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Abstract: Cold spray is a solid-state additive manufacturing and coating process in which metallic powder particles are accelerated to very high velocities using a stream of compressed gas and deposited onto a substrate through impact induced plastic deformation. Unlike traditional thermal spray techniques, cold spray operates at temperatures lower than the melting point of the material, allowing it to be deposited by intense plastic deformation, and at the same time reducing oxidation, thermal degradation, and unwanted phase transformations. However, predicting deposition behavior remains challenging because key responses such as flattening ratio, which describes particle deformation after impact, and deposition efficiency, which represents the fraction of powder that successfully adheres to the substrate, depend on complex and nonlinear interactions between material properties and processing conditions.

The current study attempts to develop a predictive framework for cold spray deposition behavior using data driven modeling techniques. The experimental data obtained during the cold spray processing of four metallic powders, Al6061, tungsten, tantalum, and nickel, are used to train several supervised machine learning models capable of predicting the flattening ratio and the efficiency of deposition of the process based on the process parameters. The performance of the models will be assessed using evaluation metrics such as the coefficient of determination (R^2), mean absolute error (MAE), and root mean square error (RMSE) to quantify prediction accuracy and model reliability. In addition, genetic algorithm is used to identify optimal combinations of process parameters that maximize flattening ratio and deposition efficiency. The outcomes of this study are expected to improve the understanding of how processing conditions influence deposition behavior in cold spray and provide a systematic approach for selecting and optimizing process parameters.

Oral Presentation
Graduate Student