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Summer Undergraduate Research Expo

August 6, 2026
McNamara Alumni Center
Memorial Hall
2:30 – 4:30 PM

Undergraduate Poster Presentations
Listed Alphabetically by Presenting Author

Presenters should be at their posters at the following times:
2:30 – 3:30 even numbered posters
3:30 – 4:30 odd numbered posters

1.	**Mubarak Abdi** *Macro-Scale Experimental Study of Torque-Induced Precession in a Flagellar Hook Analog* **Advisor:** Xiang Cheng **Mentor:** Chijing Zang **Sponsoring Program**: MRSEC **Home Institution:** Augsburg University **Abstract:** Bacteria such as Escherichia coli swim by rotating helical flagellar filaments connected to a molecular rotary motor via a flexible hook acting as a universal joint. This hook transmits torque to the filament while allowing it to spin at a tilt angle. A single tethered helical filament produces precessional motion due to the torque projection caused by hook bending, a simultaneous spin and revolution fundamental to bacterial propulsion at low Reynolds number, as explored by Shimogonya et al. (2015). Direct experimental observation remains challenging due to the nanometer scale of the flagellar system. Building on prior experiments demonstrating a relationship between fixed tilt angle and filament tip orbital radius in air, we present a macro-scale experimental analog submerged in high-viscosity silicone oil (μ=100 Pa·s) to introduce hydrodynamic conditions necessary for precession. Our apparatus consisted of a stepper motor driving a helical filament through a brass universal joint, with 3D-printed angle restrictors controlling the tilt angle at 10° and 20°. Filament tip trajectories were recorded using a Basler camera and analyzed via tip tracking in TrackMate/ImageJ. We confirmed efficient torque transfer through the universal joint and observed precession-like orbital drift, enabling direct comparison with theoretical predictions from Shimogonya et al. (2015).
2.	**Emily Alexander, Kaining Zhang** *On the Two-Step Syntheses of 3,3-Diarylpropanoate Methyl Esters* **Advisor:** Jessica Hoover **Mentor:** Benedict Andal **Sponsoring Program**: UMN Chemistry - Hoover Lab Blake HS Summer Research Experience **Home Institution:** The Blake School **Abstract:** The introduction of degrees of unsaturation to organic molecules via dehydrogenation is a useful transformation as the resulting alkene can be leveraged in upstream organic reactions to construct complex molecules. Current methodologies are limited by their reliance on strong bases, use of toxic reagents, and/or super stoichiometric additives motivate the search for alternative strategies. In our laboratory, ongoing work has been focused toward the development of a Cu-catalyzed dehydrogenation system. This poster will describe the synthesis and characterization of target substrates used to study the mechanism of our Cu-catalyzed system. The two-step synthesis of target 3,3-diarylpropanoate methyl esters follows from Pd-catalyzed conjugate addition of aryl boronic acids to 4-nitrocinnamic acid and the MeI Sn2-type esterification of the resultant propanoic acid. The synthesis of these substrates will allow for their use in Hammett competition experiments to investigate the mechanism of our Cu-catalyzed dehydrogenation conditions.
3.	**Anushka Aravindan** *Engineering and Characterizing Polymeric Micelles for Nucleic Acid Delivery* **Advisor:** Theresa Reineke **Mentor:** John Hutchinson **Sponsoring Program**: MRSEC **Home Institution:** Case Western Reserve University **Abstract:** Nucleic acid therapeutics, such as the COVID-19 mRNA vaccine and gene therapies, deliver DNA or RNA into cells to treat or prevent disease. These therapies have gained significant attention because of their potential to treat genetic disorders and cancer. However, nucleic acids are easily degraded before reaching target cells and cannot cross cell membranes. Polymeric micelles can serve as delivery systems because they protect nucleic acids while their properties can be tailored to improve delivery. Cationic groups on the polymer promote binding to negatively charged nucleic acids, while neutral groups help reduce toxicity and damage to cells. This project focuses on developing and characterizing a polymer library for future machine learning studies to identify relationships between polymer properties and delivery performance. A poly(n-butyl-acrylate) (PnBA) scaffold is first synthesized using reversible addition-fragmentation chain transfer (RAFT) polymerization, which promotes uniform polymer chain lengths. The polymer is then chain-extended with pentafluorophenyl-acrylate (PFPA). These PFPA groups serve as reactive leaving groups for neutral and cationic groups incorporated at various ratios to create statistical copolymers. Nuclear magnetic resonance (NMR) spectroscopy is then used to characterize polymer composition, creating a polymer library that can be assembled into micelles and evaluated for nucleic acid delivery.

4.	**Michael Arndorfer** *Investigating CDTa Structure and Stability via Native Ion Mobility-Mass Spectrometry and Collision-Induced Unfolding* **Advisor:** Varun Gadkari **Mentor:** Gabrielle Blake **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Carleton College **Abstract:** Clostridiodes difficile is a gram-positive bacterium commonly acquired in hospital settings. C. difficile produces three toxins that damage epithelial cells, Toxin A, Toxin B, and the C. difficile transferase (CDT). CDT is assembled from two proteins, CDTa and CDTb, that deliver CDTa into the host cell. Once inside, CDTa ADP-ribosylates actin resulting in the disassembly of the cytoskeleton. Although the role of CDTa in intoxication is well defined, questions about its structure, stability, and activity remain. Native ion mobility-mass spectrometry (IM-MS) is a powerful analytical technique that preserves the solution-phase structure of biomolecules in the gas phase, enabling their structural characterization. Collision induced unfolding (CIU) was used to probe the gas phase stability of CDTa. In this study, we present experimental data that show the difference in stability between ADP-ribosylated proteoforms of wild type (WT) CDTa and a mutant. This work serves as a basis for future experiments to determine how ADP-ribosylation affects CDTa and where it occurs, providing insights as to how it functions in a biological system.
5.	**Banu Arunachalam** *What Should a Robot Say?: Colapse, Recovery and Value of Information Communication in Swarm Robotics* **Advisor:** Dr. Maria Gini **Sponsoring Program**: UROP/URS **Home Institution:** College of Science & Engineering, University of Minnesota **Abstract:** Swarm robotic systems rely on effective communication to coordinate collective behaviors such as swarm aggregation, formation and task allocation. However, real-world robotics swarms often operate under limited bandwidth, where continuous communication is not feasible. This project investigates how communication constraints affect swarm behavior by addressing three questions: (1) When does a swarm lose coordination? (2) How does it recover when communication is restored? (3) Can selective communication improve performance under limited bandwidth? Using the Vectorized Multi-Agent Simulator (VMAS) framework, we simulate a swarm of robots performing coordinated tasks under varying communication bandwidths. We compare a baseline communication strategy with a Value-of-Information (VoI) inspired approach. In VoI robots prioritize transmitting only the most valuable information that is important for swarm coordination. Swarm performance is evaluated using metrics such as coordination accuracy, communication cost, collapse threshold and recovery time. This project explores whether communicating fewer but most informative messages between swarm robots can improve resilience and efficiency. The findings contribute to scalable communication strategies for multi-robot systems in real-world applications such as rescue operations during emergency response, environmental monitoring and autonomous multi-robot exploration.
6.	**Ilana Berlin** *Spin-Phonon Driven Decoherence of Molecular Qubits in an Open Quantum System* **Advisor:** Kade Head-Marsden **Mentor:** Mikayla Fahrenbruch, Anthony Schlimgen **Sponsoring Program**: MRSEC **Home Institution:** Lake Forest College **Abstract:** Molecular spin are promising candidates for quantum information science (QIS) due to their high tunability and potential to operate at ambient temperatures. A key feature for a successful qubit is its coherence, or its ability to maintain superposition. In the low temperature limit, coherence loss, or decoherence, is dominated by pure dephasing while, at moderate temperatures, the mechanism is more complex. An open quantum system framework is beneficial for modeling environmentally driven decoherence as it considers the interaction between the molecular system and its environment. Phonon interactions are of particular interest as they contribute to population relaxation, which limits coherence lifetimes. We rely on ab initio electronic structure methods to parameterize open quantum system methods and then obtain environmentally driven dynamics. The leading approach in computing papulation relaxation times involves finite differences methods, which include a large number of electronic structure calculations. Alternatively, linear vibronic coupling (LVC) has been proposed as a cheaper alternative. This work aims to adapt a LVC model, previously used for single molecule magnets, and compare it to the finite differences method for decoherence in molecular spin qubits. Investigating how spin-phonon driven population relaxation contributes to decoherence can help inform molecular design principles.

7.	**Lila Branchaw** *Can dry brush polymers increase recyclability of mixed plastic waste streams?* **Advisor:** Matthew Tirrell, Kevin Dorfman **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota **Abstract:** Triblock copolymers have previously been shown to reduce interfacial tension in mixed plastic waste streams, enabling two immiscible polymers to melt together and form a stronger material. This improves the material's performance and broadens its potential applications, thereby increasing its recyclability. However, the effects of wet and dry brush polymer systems on mixed plastic waste recycling have not been investigated. This project examined whether dry brush polymer systems—systems in which homopolymers are excluded from the copolymer folds at the interface—could further improve the recyclability of mixed plastic waste. Using PSCF simulations to model ternary blends containing triblock copolymers of varying lengths, we found that as the copolymer length decreased (and dry brush behavior became more pronounced), the interfacial saturation concentration increased. These results suggest that shorter copolymers may serve as more effective compatibilizers in mixed plastic recycling streams. However, this conclusion does not account for micelle formation at very low copolymer lengths (N_c < 0.8), which may limit their practical effectiveness.
8.	**Anette Brecko** *HydroParse: Robust Command Validation for Underwater Human-Robot Interaction* **Advisor:** Junaed Sattar **Sponsoring Program**: Human-Centered Computing **Home Institution:** UC Berkeley **Abstract:** Autonomous underwater vehicles (AUVs) have seen rapid growth in usage for many underwater tasks, including invasive species removal, scuba diver assistance, and trash pickup. Many such applications require close collaboration with human scuba divers, which necessitates that these robots are able to understand instructions communicated by divers via hand gestures. HydroParse is a grammar that provides a hierarchical structure for relaying complex strings of commands to an AUV using hand gestures. The grammar is responsible for validating the syntax of a scuba diver's inputs, and providing intuitive feedback to the diver if their commands are ungrammatical. The hierarchical structure is beneficial in the context of underwater human-robot communication, as only allowing certain inputs at each stage allows for error minimization in gesture recognition within environments where computer vision may be challenging. In addition to an input that consists of a string of commands, HydroParse allows the user to program conditional statements and loops. Finally, the grammar is input agnostic, meaning that a hand gesture can be mapped to any of the possible inputs at each level of the hierarchy, allowing for the use of maximally different hand gestures at each stage to avoid incorrect gesture detections.
9.	**Tarryn Brumley** *Synthesis Of A Strained Oxazolidinone Fused ROMP Monomer* **Advisor:** Jessica Lamb **Mentor:** Luc Wetherbee **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Drury University **Abstract:** Polyoxazolidinones (POxa) are a class of polyurethanes embedded into a five-member heterocycle that possess both a strongly oriented dipole and high thermal stability, features that make them attractive candidates for aerospace, electronic, and other high performance applications. Previous work has accessed POxa through controlled polymerization, utilizing ring opening metathesis polymerization (ROMP) of a trans-fused oxazolidinone monomer (Oxa^{t}). Since ROMP is driven by the release of ring strain energy, Oxa^{t} reaches incomplete conversion due to its low ring strain. It was hypothesized that a cis-fused structural analog to Oxa^{t} (Oxa^{c}) will reach full conversion because it has a higher calculated ring strain energy than Oxa^{t}. To synthesize Oxa^{c}, which is a novel compound, a Mitsunobu Reaction was employed as an additional step of the Oxa monomer synthesis to invert the monomer precursor's stereochemistry from trans to cis.
10.	**Minh-An Bui** *Compatibilization of poly(lactide) and poly(butylene adipate-co-terephthalate) with an epoxy-based chain extender* **Advisor:** Christopher Ellison **Mentor:** Kathryn Medrow **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Mount Holyoke College **Abstract:** Poly(lactide) (PLA), a widely used compostable polymer, is limited in broader applications due to its brittleness. To improve this mechanical property, amorphous-grade PLA was blended with a ductile and biodegradable polymer, poly(butylene adipate-co-terephthalate) (PBAT). However, PLA and PBAT are immiscible, resulting in inferior mechanical properties. This study investigated the compatibilization of these polymers, using an epoxy-based chain extender (Joncryl® ADR-4468) to form chemical linkages between polymer chains. Varied ratios of PLA/PBAT, compatibilizer loadings, and processing temperatures were explored. Using ^{1}H NMR and FT-IR spectroscopy, changes in molecular structure due to Joncryl addition were not detected. Preliminary PLA/PBAT (80/20 wt%) blends with Joncryl showed no improvement in tensile properties compared to its non-compatibilized counterpart, regardless of processing temperatures and Joncryl loading (160 °C with 5 wt% and 195 °C with 0.5 wt%). A higher PBAT content exacerbated deficiencies in tensile properties. These results suggest that, at the lower temperature, Joncryl's reactivity is limited. This study challenges previously reported results, which show enhanced tensile performance at similar reaction conditions. Optimal processing conditions for the compatibilization of PLA and PBAT using Joncryl are still under investigation.

11.	**Alexis Carroll** *Identifying and Characterizing Galaxy Mergers with Galaxy Zoo: Tidal Tales* **Advisor:** Hayley Roberts **Sponsoring Program**: Physics REU **Home Institution:** Haverford College **Abstract:** The capability of modern telescopes is increasing far beyond astrophysicists' ability to individually inspect galaxies, and this flood of data has made citizen science and machine learning both effective in classifying features of galaxies. A wide range of complex and varied morphological features are produced when multiple galaxies interact or collide, broadly categorized as galaxy mergers. While human classifiers handle merger identification well, machine learning models struggle to consistently detect mergers and their features. Launched in March of 2026, Galaxy Zoo: Tidal Tales is a citizen science project in which volunteers classify and characterize mergers from ESA's Euclid telescope, specifically whether the galaxy is undergoing a merger, how many galaxies are interacting, and which tidal features are present. Across more than 52,000 galaxies, we now have over 600,000 detailed classifications, each galaxy having been classified by at least eight different volunteers. We have investigated and applied techniques to combine classifications per galaxy to develop optimal merger identifications, including user weightings and filters that target unreliable classifications. This work will contribute to the largest ever human-classified merger catalog, which can be used to improve machine learning algorithms and will help researchers better understand galaxy mergers.
12.	**Braxton Carter** *Can Flow Stabilize a Bowser Soliton? Q-Tensor Simulations of Confined Nematic Liquid Crystals* **Advisor:** Jorge Vinals **Sponsoring Program**: Physics REU **Home Institution:** Utah Valley University **Abstract:** Nematic liquid crystals are fluids whose elongated molecules tend to align in a common direction. When a nematic flows through a narrow channel, the flow bends this alignment while the channel walls and the material's elasticity resist the deformation. If twist is sufficiently inexpensive compared with splay and bend, the mirror-symmetric Bowser state may separate into two oppositely twisted states, called Bowser− and Bowser+. The boundary between these states is an achiral wall that may behave as a soliton: a localized structure that maintains a finite shape and width. This project investigates whether that wall can exist as a stationary configuration under pressure-driven Poiseuille flow. The simplified linear equations predict the flow-induced bowing of the nematic but do not support a Bowser−/Bowser+ wall, indicating that nonlinear behavior is necessary. I investigate this nonlinear problem by representing the nematic alignment with a Q-tensor and evolving it numerically under imposed Poiseuille flow, bulk nematic ordering, and anisotropic elasticity. The simulation begins with a trial Bowser−/Bowser+ wall and evolves toward a steady flow-orientation balance. The calculation tests whether distinct chiral Bowser states exist and whether the wall between them remains localized or disappears.
13.	**Ziyu Chen** *Vibrational Solvatochromism of 7,7,8,8-tetracyanoquinodimethane (TCNQ) in Various Solvents* **Advisor:** Aaron Massari **Mentor:** Alexandra Atchison **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota Twin Cities **Abstract:** Vibrational solvatochromism explores how solvent environments influence molecular electronic structure. 7,7,8,8-tetracyanoquinodimethane (TCNQ) is a versatile acceptor of electrons, so it is easily affected by the environment. In this study, Fourier transform infrared (FTIR) spectroscopy was used to investigate the solvent-dependent C≡N stretching vibrations of TCNQ in a series of solvents with varying acceptor numbers, donor numbers, and polarizability. The wavenumber of the anion TCNQ decreases with decreasing donor numbers and polarizabilities. And since the wavenumbers of the neutral TCNQ only change by 3 cm-1, we would say that neutral TCNQ is not very affected by the solution.
14.	**Liam Clift** *Stepping into an Illusion: A Penrose Staircase in Virtual Reality* **Advisor:** Evan Suma Rosenberg **Sponsoring Program**: Human-Centered Computing **Home Institution:** Augsburg University **Abstract:** Virtual reality enables experiences that cannot be physically realized in the real world, including impossible geometry and spatial illusions. This project explores how such environments can be made embodied and walkable through the development of a virtual Penrose staircase. Over the course of the summer, a proof-of-concept prototype was developed that allows users to traverse a circular staircase that appears to rise (or fall) continuously while physically walking on flat ground. This work establishes a foundation for future studies examining how exposure to impossible geometry affects users' spatial perception, orientation, and understanding of virtual environments.

15. **Sara Conti**
Reconstructing Short Muon Tracks in TMS for DUNE
Advisor: Andrew Furmanski
Sponsoring Program: Physics REU
Home Institution: Hamilton College
Abstract: The Deep Underground Neutrino Experiment will send a beam of neutrinos through the earth and compare the flavor composition of the neutrino beam before and after the neutrinos travel 1300 kilometers to better understand the way neutrinos change flavor as they travel. To determine the initial composition of the neutrino beam, the near detector array uses a liquid argon time projection chamber (ND-LAr). Muon neutrinos interact with the argon, producing muons. The Muon Spectrometer (TMS) is placed downstream from ND-LAr to measure high energy muons that do not stop within ND-LAr. However, the algorithm that reconstructs muon tracks in TMS often misses muons that stop just after entering TMS. In this poster I introduce a strategy for recovering these short muon trajectories in TMS using the position and momentum of the muon when it leaves ND-LAr to predict where the muon will enter TMS. A trajectory can be reconstructed by searching for signals in TMS in a region around the predicted muon position. This increases the range of neutrino energies that can be detected, and in turn, the precision of the experiment.

16. **Carlos Diaz**
Development of Modified ZIF-8 Membranes for Improved Carbon Dioxide Separation
Advisor: Andreas Stein
Mentor: Bella McGrath, Protity Saha
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Metal–organic frameworks (MOFs) are highly porous materials composed of metal ions and organic linkers that can selectively absorb and separate gases. In this project, MOF materials for a hybrid membrane were developed with the ultimate goal to improve CO_2 separation from gas mixtures. We explored two approaches to control particle morphology of the MOF ZIF-8 and one to modify its surface chemistry. For morphological control, a core–shell structure was synthesized by growing a thin ZIF-8 layer on ZIF-L crystals, producing nanosheet-like particles with improved surface accessibility and shorter diffusion pathways. Sodium dodecyl sulfate (SDS) was also investigated as a surfactant template to generate layered structures that could be exfoliated into thin MOF sheets. For surface modification, post-synthetic ligand exchange was used to introduce amine functional groups that strengthen CO_2 interactions and enhance CO_2 selectivity. X-ray diffraction (XRD) was used to characterize the crystal structures of the synthesized MOF materials, providing hands-on training in XRD analysis and materials characterization. The modified ZIF materials were dispersed in a polymeric membrane to facilitate selective CO_2 capture. Overall, this work aims to improve CO_2 separation by controlling MOF particle morphology and introducing functional groups with strong CO_2 interactions.

17. **Nathan Elango**
Error Correction in Quantum Computing with the S3 Quantum Double Model
Advisor: Fiona Burnell
Mentor: Bo-Han Lin
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota, Twin Cities
Abstract: Quantum computation is able to complete many tasks with better time complexity than the best known classical algorithms, notably prime factorization. Hence, quantum computers may be better suited than classical computers for certain large tasks. However, just like classical computers, quantum computers are prone to errors in their hardware which affect their accuracy. An active area of research in quantum computation is how to minimize the frequency of these errors, how to find them, and how to correct them via quantum error correction (QEC). The S3 quantum double model grants ways to physically encode and manipulate logical states using quantum systems (qudits). One may encode information through excitations at particular points on a lattice of qudits. The model is error resistant; it's designed so that some, but not all, errors on qudits won't affect the encoded logical states. These errors often cause unwanted excitations on the lattice. To correct errors that may affect logical computation, we must find them and implement QEC. In practice, this involves finding and moving erroneous excitations towards each other along particular classes of paths, annihilating them like particles and antiparticles. We investigate error location and QEC procedures in the S3 quantum double model.

18. **Angela Enciso**
Did We Skip a Step? Impact of Field-of-View Restrictors on Translation Gain Detection Thresholds
Advisor: Evan Suma Rosenberg
Mentor: Tongyu Nie
Sponsoring Program: Human-Centered Computing
Home Institution: California State University, Long Beach
Abstract: Cybersickness remains a significant barrier to user comfort during virtual reality immersion. While field-of-view (FOV) restriction is a widely used cybersickness mitigation strategy that reduces overall optical flow by blocking the peripheral visual field, its impact on motion perception when navigating virtual environments is not fully understood. This study proposes to examine the effects of different FOV restriction techniques, specifically symmetric and ground-visible restrictors, on translation gain detection thresholds. It is hypothesized that restrictors limiting larger portions of the periphery will allow users to walk over greater virtual distances without noticing, allowing for higher gains without user detection, while less restrictive methods will result in more accurate motion estimation. These findings will inform the design and development of more accessible and effective virtual reality experiences in various industries.

19.	**Alex Euphosin** *Investigating The Hairy Ball Theorem In Biological Tissues* **Advisor:** Aashrith Saraswathibhatla **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota Twin Cities **Abstract:** Spherical surfaces, when wrapped with a uniform orientation field, either longitudinal or latitudinal, will result in two opposite points or poles (e.g., North and South Poles). This phenomenon is caused by the intrinsic geometry of a sphere, which is explained by the Poincaré–Hopf theorem (or the Hairy Ball Theorem). Elongated biological cells are known to exhibit orientation fields on 2D surfaces, and this alignment has been shown to affect many biological processes such as apoptosis, proliferation, tissue growth, and invasion by cancer cells. However, whether biological cells that exhibit long-range orientational order abide by the Hairy Ball Theorem is unknown. My project investigates the orientation field in a confluent monolayer of elongated cells, such as retinal pigment epithelium and myoblasts, that is confined to a 200μm polyacrylamide sphere. Using 3D high-resolution confocal imaging and algorithms for computing 3D orientational fields, I developed a pipeline to measure the orientational fields of cells confined to a spherical surface. In the future, I will use the developed pipeline to quantify orientational fields and topological defects on spheres of varying diameters, and investigate the biological relevance of the orientational field in controlling cell migration and tissue growth.
20.	**Victoria Finizio** *Substituent Effect on Aminopyridine Transient Directing Groups for Rh-Catalyzed Inert Bond Activation* **Advisor:** Christopher Douglas **Mentor:** Nitha Puthalath **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** The College of Wooster **Abstract:** Inert bonds, such as C–H and C–C single bonds, can be directly functionalized by transition-metal-catalyzed inert bond activation. Regioselectivity is often achieved using embedded directing groups (DGs), which require additional steps to install and remove. Transient directing groups (TDGs) offer an alternative to DGs by enabling in situ installation and removal of the directing motif. For substrates with ketones or aldehydes near the target inert bond, aminopyridines such as 2-amino-3-picoline can serve as a TDG by condensing with the carbonyl, forming an imine while the pyridine nitrogen directs the metal. Previous work in the Douglas group showed that introducing an electron-donating group (EDG) onto the fifth position of 2-amino-3-picoline enhanced the efficiency of the skeletal rearrangement of 3-phenylcyclobutanones to indanones via a Rh-catalyzed C–C bond activation. This project aimed to test the hypothesis that EDGs make the amino group a stronger nucleophile, speeding up the imine condensation and therefore the overall reaction. Several 2-amino-3-picoline derivatives containing substituents with varying levels of electron-donating and -withdrawing abilities were synthesized. Reaction kinetics were studied using variable-temperature NMR experiments, allowing for the effects of different substituents on the TDG in the skeletal rearrangement reaction to be compared.
21.	**Lauren Flores** *Stabilizing co-continuous structures utilizing interfacial transesterification in polyester blends* **Advisor:** Christopher Ellison **Mentor:** Yukti Bharde **Sponsoring Program**: MRSEC **Home Institution:** University of Texas- Rio Grande Valley **Abstract:** Porous polymers provide high surface area, permeability, a lightweight framework, and pore size tunability for applications like drug delivery and advanced filtration. A cost-effective and industrially viable approach to fabricating porous polymers involves the incorporation and subsequent extraction of a sacrificial template to form pores. This research utilizes an immiscible polymer blend featuring a water-soluble sacrificial phase to generate a porous network. Specifically, a co-continuous morphology is employed, characterized by two interpenetrating polymer phases that span the entire volume. This architecture facilitates the formation of interconnected pores. However, co-continuous structures are unstable, typically transitioning toward a thermodynamically favored droplet-matrix morphology upon annealing. Consequently, block copolymers that migrate to the interface are utilized to reduce interfacial tension and stabilize the co-continuous morphology. This study investigates a sulfonated polyester and polybutylene terephthalate melt blend to achieve co-continuity. At elevated temperatures, block copolymers form at the interface due to transesterification reactions between the polymer phases. Processing parameters such as temperature, screw rotation speed, and blending time control the blend morphology in addition to the rate and extent of the transesterification reaction. This project aims to identify the parameters that maximize block copolymer formation to stabilize the co-continuous structure and minimize domain size.

22.	**Pauline Fouts** *Spatiotemporal Analysis of Organic Peroxy Radical Fates in a Changing NO_x Emission Landscape Using Chemical Ionization Mass Spectrometry* **Advisor:** Hannah Kenagy **Mentor:** Elinor Caballero **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Drury University **Abstract:** Within the atmosphere, organic peroxy radicals (RO_2), produced from the oxidation of volatile organic compounds (VOCs), and their subsequent reaction with atmospheric species, or their fates, affect the composition and abundance of secondary organic aerosols (SOA). Due to the negative health impact of SOA exposure, efforts to understand their formation have resulted in studies focused on RO_2 fates. There are multiple RO_2 fates, but bimolecular reactions are dominated by RO_2 + HO_2 and RO_2 + NO, distinguished by chemical regimes of low-NO_x and high-NO_x, respectively. Over time, the atmosphere has shifted from a high NO_x environment to an intermediate chemical regime, which enables for more RO_2 isomerization that can compete with the bimolecular reactions. To understand the changing atmosphere, we conducted a spaciotemporal analysis that utilized chemical ionization mass spectrometry (CIMS) measurements from three distinct field campaigns—Southern Oxidant and Aerosol Study (SOAS), Korea-United States Air Quality (KORUS-AQ), and Atmospheric Emissions and Reactions Observed from Megacities to Marine Areas (AEROMMA). From these field campaigns, we examined the fluctuations in RO_2 fates across changing chemical regimes and demonstrated that gas-phase species can be used to inform future work aiming to replicate the intermediate NO_x conditions that have scarcely been explored.
23.	**Olivia Franken** *Universally Restorative or Demographically Divergent? Nature Biomes and Realism in XR* **Advisor:** Victoria Interrante **Sponsoring Program**: Human-Centered Computing **Home Institution:** University of Missouri - Columbia **Abstract:** Virtual reality (VR) offers a promising medium for delivering nature-based restorative experiences, with prior work demonstrating that VR nature content can reduce anxiety in clinical settings [1, 2]. However, design guidance regarding which environmental features drive restorativeness in immersive environments remains limited. Guided by Attention Restoration Theory, this project investigates the extent to which preferences for natural environments and perceived restorativeness vary systematically across demographics and whether certain environmental characteristics are universally restorative. To address these questions, we have curated a collection of virtual nature environments, built-in Unreal Engine and spanning diverse biomes, for inclusion in an online preference survey currently being prepared for IRB approval and deployment on Prolific. This preliminary survey will inform a follow-up VR study examining how well the restorative potential of virtual environments can be predicted from representative images versus full immersive experiences and what factors contribute to any differences. In parallel, we are constructing photogrammetric models of real and artificial plants for a mixed reality Apple Vision Pro workspace study investigating how suspended disbelief influences restorative responses across physical and virtual foliage conditions. Together, these studies aim to translate environmental psychology research into actionable design recommendations for restorative VR and mixed reality applications.
24.	**Julia Gelfond** *Extracting the Full Conductivity Tensor in a Rectangular Sample* **Advisor:** Oskar Vafek **Sponsoring Program**: Physics REU **Home Institution:** Johns Hopkins University **Abstract:** In atomically thin 2D materials, the conductivity can vary greatly depending on the direction it is measured, even when it is spatially uniform. Therefore, conductivity is represented as a matrix (tensor) and is best understood in a special choice of coordinate system known as the principal axes frame. This frame may be rotated from the physical edges of a sample by some unknown angle, a. Currently, there is no methodology that easily measures the conductivity matrix and a in rectangular samples. The goal of this project is to develop an easy method to do this by solving a differential equation for the voltage. We show how this allows the full conductivity matrix and a to be extracted with four simple measurements. Our solution agrees very well with numerical simulations and with previous work for the limiting case when a vanishes.

25.	**Rowan George** *Toward Predictive Vitrification: Thermal Diffusivity Characterization of Cryoprotective Agents and CPA-Permeated Rat Liver Tissue* **Advisor:** John Bischof **Mentor:** Ayaka Moriyama Lakshya Gangwar **Sponsoring Program**: ATP-Bio **Home Institution:** University of California, Berkeley **Abstract:** Vitrification is the current most robust method for preserving biological specimens. For organ preservation, cooling tissue into a glass-like state without forming damaging ice requires understanding and control of thermal properties. Although cryoprotective agents (CPAs) such as PD, VMP, and Ethylene Glycol–Sucrose are used frequently for vitrification, their thermal properties in tissue remain poorly characterized. Characterization is also essential for evaluating new candidate CPAs with lower toxicity and improved vitrification performance. This study establishes a laser flash analyzer (LFA) method for measuring thermal diffusivity in CPAs and CPA-permeated rat liver tissue. Thermal diffusivity can be combined with measured density and specific heat measured by differential scanning calorimetry to calculate thermal conductivity. The thermal diffusivity of water, PD, VMP, and ethylene glycol–sucrose formulations was measured at 25°C to evaluate the LFA method against expected values. Rat liver slices 15 mm in diameter and 1.5 mm thick were then permeated with full-strength CPA formulations or 95% CPA formulation with 5% carrier solution, weighed, and measured. Room-temperature measurements established thermal diffusivity values for all liver conditions, although reproducibility varied. These results demonstrate the feasibility of using LFA to characterize CPAs and CPA-permeated tissues and provide a foundation for measurements down to −100°C.
26.	**Lanqi Guo** *Nonlinear Eigenvector Problems on the Grassmann Manifold: Formulation, Convergence, and Applications* **Advisor:** Mitchell Luskin **Mentor:** Jack Thomas **Sponsoring Program**: UROP/URS **Home Institution:** UMN-CLA **Abstract:** Nonlinear eigenvector problems arise when the Hamiltonian depends on the occupied subspace generated by its own eigenvectors. We formulate these problems as the minimization of a smooth energy functional over the Grassmann manifold, represented by fixed-rank orthogonal projectors. At a constrained critical point, the first-order condition implies that the effective Hamiltonian and the projector commute, leading to a self-consistent eigenvector formulation. We consider projected gradient descent and several SCF-based schemes, including undamped and damped iterations, a non-retracted damped variant, and an optimal damping algorithm for the relaxed problem. Near a solution, projected gradient descent and fixed-step SCF iterations can be linearized, with local convergence governed by the spectral radius of the resulting linearized updates. This analysis clarifies how the occupied–virtual spectral gap affects the stability of simple SCF iterations. Finally, we apply this framework to the Gross–Pitaevskii equation and Hartree–Fock models, where the effective Hamiltonian depends on the density and the density matrix, respectively.
27.	**Preston Hammons** *Optimization of CPA Formulation for Cardiac Organoid Cryopreservation* **Mentor:** Mohammed Shameem **Sponsoring Program**: ATP-Bio **Home Institution:** Florida Institute of Technology **Abstract:** Heart disease is the leading cause of death worldwide. Human induced pluripotent stem cell-derived cardiomyocytes (hiPSC-CMs) have emerged as a powerful platform for drug discovery and disease modeling. Although advances in cryopreservation and vitrification have shown promise, effective preservation of human induced pluripotent stem cell (hiPSC)-derived cardiac organoids remains challenging because of their complex multicellular architecture and susceptibility to cryoinjury. In this study, we propose that supplementing our recently developed cryoprotective agent (CPA) formulation with non-permeating cryoprotective agents could further improve the morphological and functional preservation of cardiac organoids. We plan to expose the hiPSC-derived cardiac organoids with modified CPA formulation, and assess morphology and contractile function following treatment. We predict that the optimized CPA formulation will significantly improve the preservation of organoid morphology and contractile function compared with the existing CPA formulation. While this study will evaluate the optimized CPA formulation before vitrification, the findings could provide a foundation for future studies of vitrification and rewarming in mature cardiac organoids. Ultimately, improved cryopreservation protocols could advance cardiac disease modeling, regenerative medicine, and tissue preservation for transplantation and research.

28. **Madison Hanrahan**
Developing a Data-Driven Neutrino Oscillation Analysis for the Deep Underground Neutrino Experiment (DUNE)
Advisor: Mike Wilking
Mentor: Allison Schroeder
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota- Twin Cities
Abstract: The Deep Underground Neutrino Experiment (DUNE) is a long-baseline particle physics experiment designed to make precise measurements of neutrino oscillations. In this experiment, the flux of the beam of muon neutrinos is measured at the near detector (ND) before traveling approximately 1300 km to the far detector (FD), where the oscillated flux is observed. Because the ND and FD differ significantly in size and geometry, they have different selection efficiencies that must be accounted for to make a direct comparison between the ND and FD data. Currently, these differences in selection efficiency are being corrected for using Monte Carlo (MC) simulations; however, this can introduce bias to the neutrino oscillation parameter measurements. The Geometric Efficiency Correction (GEC) has been developed as a data-driven method to correct for this difference by propagating FD events into the ND and applying symmetry transformations to determine their selection efficiency, allowing them to be appropriately weighted in the oscillation analysis. While this method works well for oscillated MC simulated data, discrepancies remain between the ND and FD neutrino energy spectra. This project investigates these remaining inconsistencies and contributes to ongoing efforts to improve DUNE's eventual neutrino oscillation measurements.

29. **Genevieve Hauglie**
Design and Synthesis of Hydrogen-Bonding Molecular Cage Ligands for Fe_4S_4 Cluster Encapsulation
Advisor: Gwendolyn Bailey
Mentor: Brett Schneider
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Iron-sulfur (Fe_4S_4) clusters are essential biological cofactors that facilitate electron transfer and catalysis in a wide range of enzymes, yet their instability and limited tunability present challenges for developing biomimetic catalytic systems. This project investigates the design and synthesis of next-generation molecular cage ligands that better mimic enzyme active sites by incorporating hydrogen-bonding functionality into the secondary coordination sphere of encapsulated Fe_4S_4 clusters. Modified pyrene-based ligands were synthesized using established organic synthetic methods to replace the previously developed naphthalene diimide (NDI)-based linker. Reaction progress and product formation were monitored using thin-layer chromatography (TLC), and intermediates and products were characterized by proton nuclear magnetic resonance (^{1}H NMR) spectroscopy. The new ligand design incorporates robust triazole linkages, a redox-inert pyrene panel, and functionalization sites for hydrogen-bond donors to create a more tunable cage environment. Initial synthetic efforts established a pathway toward constructing hydrogen-bonding molecular cages capable of providing a more enzyme-like environment for Fe_4S_4 clusters. These next-generation ligands are expected to improve cage stability while enabling systematic control over host-guest interactions and cluster redox properties. This work contributes to the development of biomimetic molecular cages for studying iron-sulfur chemistry and advancing catalyst design for future applications in sustainable chemical transformations.

30. **Autumn Herrington**
A Geometric Algebra Formulation of Rotational Optimization for Autonomous Underwater Robots
Advisor: Junaed Sattar
Mentor: David Widham
Sponsoring Program: Human-Centered Computing
Home Institution: California State University Long Beach
Abstract: This research investigates geometric algebra as a representation for transportation in autonomous underwater vehicles (AUVs). The approach represents vehicle orientation, commanded orientation, and orientation error with geometric algebra rotors, providing a unified framework for describing underwater robotic motion. The work reformulates an existing quaternion-based rotational optimization process in geometric algebra, preserving orientation-error bounds, control masks, and dynamic behavior. Quaternions provide an efficient representation of three-dimensional rotation and avoid the gimbal-lock singularities associated with Euler angles. However, difficulties can arise constantly converting rotational errors into quantities for constraint handling, controller tuning, or interpretation. Such conversions depend on a selected reference frame and can complicate the analysis of large, coupled rotations, while geometric algebra makes what frame you are working in apparent. Geometric algebra offers an alternative formulation in which rotations, rotational errors, and spatial relationships are expressed through rotors and multivectors. This retains decomposition along selected principal axes for direct comparison with axis-based quantities, while making the geometric relationship and reference frame of each rotation explicit. Comparing this formulation with the existing quaternion method as vehicle orientations change over time will evaluate whether geometric algebra improves the clarity and structure of rotational constraints and optimization in AUVs.

31.	**Lyndon Hess** *Optimizing Functionals for One-Electron Reduced Density Matrix Functional Theory* **Advisor:** Jan-Niklas Boyn **Mentor:** Daniel Gibney **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Cornell University **Abstract:** Density Functional Theory (DFT) remains one of the most widely used electronic structure methods in computational chemistry. However, it fails to describe systems with strongly correlated electrons. Previous works have transformed DFT into a one-electron reduced density matrix theory (1-RDMFT) by including a one-electron reduced density matrix (1-RDM) correction which enables an explicit treatment of strongly correlated electrons. Here we make progress on optimizing a functional specialized for 1-RDMFT. By analyzing the importance of parameters of the Minnesota 2006 function (M06-L) and optimizing these parameters on a dataset containing strongly correlated systems we attempt to make a functional that performs well on both strongly and weakly correlated systems.
32.	**Caleb Hilsher** *Polymer-Bound Ferrocenium Derivatives as Effective Lewis Acid Catalysts* **Advisor:** Steven Kass **Mentor:** Cal Mergendahl **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Houghton University **Abstract:** Lewis acids can be utilized to facilitate Friedel-Crafts alkylations by making part of a molecule more electropositive by accepting a pair of electrons from a Lewis basic site. However, traditional Lewis acids such as AlCl3 or FeCl3 are ineffective for the Friedel-Crafts alkylation of N-methylindole with trans-β-nitrostyrene and must be used at stoichiometric or very high loadings. The Kass group has previously found that ferrocenium derivatives are effective Lewis acid catalysts for this transformation. Ferrocenium derivatives are soluble in organic solvents which is useful, but this can lead to difficulties including reaction purification and catalyst recyclability. To mitigate this issue, ferrocenium can be bound to cross linked polystyrene, making the catalyst heterogeneous. Then, the polymer beads can easily be removed from the reaction by filtration and recycled. This summer, various linkages to the polystyrene backbone were explored. An ester linkage was effectively synthesized, and small-molecule analogs were made to compare their reactivity to the polymer catalysts in the aforementioned Friedel-Crafts reaction. The ester-linked polymer yields promising results, as well as the small molecule analogs at 10 mol% loading. Future efforts will include exploring different linkage strategies to the polymer and assessing catalytic activity.
33.	**Thien Kim Huynh** *Synthetic Development of Designed Aryne Precursors and Nickel-Bound Arynes* **Advisor:** Courtney Roberts **Mentor:** George Hernandez **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** University of Toledo **Abstract:** Arynes, highly reactive intermediates derived from aromatic rings, are powerful synthetic tools for building complex, highly functionalized molecules. However, their instability has limited access to many strained heteroarynes, particularly five-membered indolynes. The Roberts Group has developed a nickel-mediated strategy that stabilizes these reactive intermediates through organometallic interactions, enabling isolation and study of previously inaccessible heteroarynes. This project focused on expanding this platform through synthesis of designed aryne precursors and nickel-bound intermediates. Aryne precursors were prepared through bromination, N-methylation, and borylation of heteroaromatic substrates. The resulting ortho boryl aryl bromides were converted to nickel σ-aryl complexes, followed by ligand exchange to generate complexes suitable for intramolecular transmetallation. Each synthetic transformation was confirmed by nuclear magnetic resonance spectroscopy. In parallel, a synthetic route toward 4,7-dimethoxyindole was developed. Future work will focus on converting this intermediate into the corresponding aryne precursor and subsequently its nickel-bound aryne complex, expanding the aryne precursor platform and probing how electron-donating groups influence reactivity and scope. Together, these studies expand the substrate scope of an established nickel-mediated aryne platform, providing new synthetic intermediates and precursors towards development of nickel-bound heteroaryne chemistry.

34.	**Pearl Jain** *How Much Data Does a Robot Need? Understanding Demonstration Requirements and Model Capacity in Generative Imitation Learning* **Advisor:** Karthik Desingh **Mentor:** Nirshal Chandra Sekar **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota **Abstract:** Learning robot manipulation from demonstrations has achieved impressive success, but most imitation learning policies are trained on large datasets of expert demonstrations that exhibit consistent demonstration strategies. In real-world settings, however, demonstrations may be scarce, noisy, and collected from non-experts, making policy learning substantially more challenging. This raises a fundamental question: Is the success of these paradigms driven by model capacity or data quality? Moreover, while Diffusion Policy is a dominant approach for imitation learning, newer methods such as Flow Matching promise more efficiency, yet their behavior under low-data, high-variance conditions remains largely unexplored. To answer the question, we evaluated Diffusion Policy and Flow Matching across varying model architectures and data regimes. We first used toy models to gain explicit control over data variability. We then evaluated performance on complex manipulation tasks, using RoboMimic and MimicGen benchmarks to represent short- and long-horizon, contact-rich environments. Primary results indicate that larger model architectures can compensate for low demonstration counts and data variance; conversely, smaller models failed to refine performance, even for larger data regimes. These insights establish a foundation for our ongoing work: training robust manipulation policies on a low-regime dataset of 200 non-expert human demonstrations collected at the Minnesota State Fair.
35.	**Jana Jandric** *Visible-Light-Induced Copper-Catalyzed Alkynylation and Alkylation of Allenes* **Advisor:** Melissa Ramirez **Mentor:** Ashley Palecek **Sponsoring Program**: Independent Research **Home Institution:** University of Minnesota, Twin Cities **Abstract:** Radical multicomponent coupling has great potential to serve as a sustainable and step-economical approach to the synthesis of valuable building blocks in both pharmaceuticals and natural products. However, the formation of C-C bonds with high regio-, chemo-, and enantioselectivity in radical multi-component coupling reactions remains a challenge. As such, we report an experimental study of a photoinduced, Cu-catalyzed, three-component coupling of allenes, alkyl halides, and alkynes, resulting in the formation of two new C-C bonds. The reaction of interest provides opportunity to utilize commercially available alkyl halides and alkynes for difunctionalization of an allene. In the proposed mechanism of this reaction, a ligand structure will enable (1) the use of a key Cu(I) intermediate photosensitizer and (2) enantioselective C-Cu bond formation. While reactions of this type have been studied for alkenes, there are currently no examples of allenes being used as radical acceptors in Cu-mediated multicomponent coupling reactions. Thus, through the development of this reaction we seek to establish photochemical radical additions to allenes in the context of Cu photochemistry, as well as provide access to products that contain alkene functional handles for facile derivatization in the synthesis of complex small molecule targets.
36.	**Samuel Kenney** *Exploring Proton Transfer in Carboxylic Sulfuric Anhydride - Ammonia Complexes and their Atmospheric Implication* **Advisor:** Kenneth Leopold **Mentor:** Luis Padilla, Victor Drewanz G. E. **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota Twin Cities **Abstract:** Aerosols in the atmosphere play an important role in driving climate through their influence on the Earth's albedo and by facilitating the nucleation of water molecules into droplets. It is theorized that carboxylic sulfuric anhydrides (CSAs, $RCOOSO_2OH$) may play a role in atmospheric chemical processes by assisting in new aerosol formation. Classically, H_2SO_4 – NH_3 complexes are recognized as a key driver of aerosol formation. Similarly, CSAs contain an SO_3H group, warranting the investigation of their complexes with NH_3 as well. Quantum chemical calculations were performed at varying levels of theory on a slate of CSA – NH_3 structures. In all calculations, the proton transferred complexes were lower in energy when compared to non-proton transferred configurations. It appears the ammonia's ability to hydrogen bond with both the sulfonate oxygens and carbonyl oxygen may stabilize this proton transfer. The predicted favorability of proton transfer in these cases further suggests that CSA – NH_3 complexes may serve as nucleators in the atmosphere due to enhanced intermolecular interactions. In preparation to study acetic sulfuric anhydride – NH_3, we sought to collect the rotational spectrum of the related acetic acid – NH_3 complex. However, large amplitude motions from quantum tunneling render the spectrum complex, and our analysis is ongoing.

37.	**Trenton Kiernan** *Calorimetry of Aqueous Emulsions* **Advisor:** Chris Hogan **Mentor:** Joseph Kangas **Sponsoring Program**: ATP-Bio **Home Institution:** Brown University **Abstract:** Successful cryopreservation depends on controlling ice nucleation and growth, though existing measurements of nucleation rates with cryoprotective agents (CPAs) remain poorly characterized because nucleation is difficult to observe experimentally. Differential scanning calorimetry (DSC) measures the latent heat of crystallization, allowing for the characterization of crystallization behavior. Samples of aqueous emulsions were prepared via probe sonication with a fluorinated oil, partitioning aqueous solutions of 2.5–12.5wt% ethanol, sucrose, and dimethyl sulfoxide into micron-scale droplets to allow for the measurement of many reproducible nucleation events simultaneously, while reducing the variability from heterogeneous crystallization. DSC heat-flow measurements were analyzed using a novel theory devised by Kangas and Hogan to estimate nucleation and growth rates. Growth rate increased with lower temperatures for all concentrations, while nucleation rate decreased with increased solution concentration. These results demonstrate that DSC combined with monodisperse aqueous emulsions provides a means for measuring ice nucleation and growth in systems with CPAs.
38.	**Jonathan King** *Building a Better View: Live 3D Reconstruction for Autonomous Robotic Mapping* **Advisor:** Zhu-Tian Chen **Mentor:** Harshvardhan Chandirasekar **Sponsoring Program**: Human-Centered Computing **Home Institution:** Howard University **Abstract:** Autonomous reconstruction requires a robot to build a 3D model of an unfamiliar environment while deciding where additional observations are needed for further improvement. This work contributes to an autonomous reconstruction robot in which users launch missions through natural-language commands. An onboard Jetson does navigation and mapping using ROS 2, Nav2, and RTAB-Map. The existing system autonomously conducted duration-based mapping. However, its high-level mission supervisor lacked access to a three-dimensional representation to evaluate reconstruction coverage. To improve this, we integrate a 3D point cloud representation by streaming RGB-D observations and pose information from a ZED 2i camera to an Nvidia DGX Spark server for live 3D point-cloud reconstruction via lingbot-map. The DGX evaluates the reconstruction and identifies low-confidence and sparsely observed regions that may need further exploration. We develop a browser-based monitoring interface that visualizes the live point cloud, 2D navigation costmap, and robot pose within the reconstructed environment. This work establishes the reconstruction, analysis, and visualization infrastructure needed to advance the system toward closed-loop active reconstruction.
39.	**Anthony King** *Simulating Self-Assembly of Linear and Bottlebrush Copolymers* **Advisor:** Kevin Dorfman **Mentor:** Lakshita Gopalani, Luyang Li **Sponsoring Program**: MRSEC **Home Institution:** Normandale Community College **Abstract:** Flexible homopolymers adopt a vast number of configurations to maximize their entropy. A simple block polymer contains two homopolymers linked by a covalent bond. Our work examines the self-assembly behavior of linear block copolymers and bottlebrush block copolymers. Bottlebrush architectures contain densely grafted side chains along their backbone, which grants the potential to form self-assembled structures of large sizes. The production of materials described above can give us breakthroughs in areas such as photonics and separation. Molecular dynamics simulations allow us to study the self-assembly of these chains. When performing computational experiments, we can predict the phase separation of polymer systems consisting of distinct monomers. Using an open-source molecular dynamics simulation package LAMMPS, we can analyze trajectories to observe phase separation of homopolymer blends and self-assembly of block copolymers. Additionally, we can use the χ parameter extracted from simulations and compare the phase separation behavior to the predictions of Flory-Huggins/self-consistent field theory.

40. **Jacob Ali Korde**
The Effects of Nanocrystal Composition on Organic Dye Adsorption
Advisor: David Blank
Mentor: Becca Macgillvray
Sponsoring Program: MRSEC
Home Institution: Macalester College
Abstract: Dye-sensitized nanocrystal systems have uses in photovoltaics due to dye-to-nanocrystal electron transfer from the dye's excited state. Previous research in the Blank Lab has investigated these systems using the dye (E)-2-cyano-3-[5-[4-(diethylamino)phenyl]thiophen-2-yl]-2-propenoic acid (1) bound to ZnO nanocrystal. They successfully bound dye 1 to the nanocrystal at approximately 100 molecules per nanocrystal. In2O3 and indium tin oxide (ITO) have better conductivity than ZnO, among other material properties, leading to their widespread use in optoelectronics such as thin film photovoltaics, making them an ideal candidate for investigation. Dye 1 has previously been shown to undergo quenching when bound to the nanocrystal, as electron transfer will outcompete emission. Fluorescence spectroscopy is used to assess the emission quenching in dye-nanocrystal systems. A competitive exchange Langmuir adsorption model is used to quantify the quenching. This is achieved by comparing dye 1's emission with and without nanocrystals to determine the maximum surface coverage of dyes on the nanocrystal as well as the favorability of the binding process. Our research on dye-nanocrystal binding as well as future research regarding the kinetics of the electron transfer will guide the use of dye-sensitized In2O3/ITO systems and their usage in photovoltaics.

41. **Siri Kotonias**
The Bromodomain Linker Region of Epigenetic Regulator Protein BRD4 Forms Electrostatic Interactions with Double-Stranded DNA
Advisor: William Pomerantz
Mentor: Vivian Jiang, Jacklyn Artymiuk
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota-Twin Cities
Abstract: The bromodomain and extraterminal domain (BET) family is made up of the BRD2, BRD3, BRD4, and BRDT epigenetic regulator proteins. Each has two bromodomains, which bind to acetylated lysines in histone tails to initiate chromatin remodeling. In addition to histones, BRD4 also interacts with double-stranded DNA (dsDNA). Prior work indicates that these interactions involve additional sites to the bromodomain-1 (BD1) binding pocket, but they remain uncharacterized. While BRDT interacts strongly with dsDNA through positively charged BD1 regions, BRD4 only participates in weak electrostatic interactions via BD1, but contains additional basic patches on the bromodomain-connecting polypeptide linker. We hypothesized that basic patches on the BRD4 bromodomain linker interact with dsDNA. This project investigates noncovalent binding between the tandem BRD4 bromodomains (BRD4-T) and a 40 base-pair (bp) dsDNA sequence from the SMYD1 gene using protein-observed fluorine nuclear magnetic resonance (PrOF-NMR) spectroscopy and electrophoretic mobility shift assays (EMSAs). Site-directed mutagenesis was employed to create a BRD4-T variant with a tryptophan near the first basic patch to enable PrOF-NMR. While an EMSA confirmed protein-dsDNA complex formation, the basic patch mutant was titrated with dsDNA, where chemical shift perturbation suggested an interaction at this site. Further studies are in progress to support this interaction.

42. **Aurell Kusuma**
Synthesizing Multinary Metal Chalcogenide Clusters for Catalytic Applications
Advisor: Gwendolyn Bailey
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Washington
Abstract: Conventional catalysts are costly due to their reliance on scarce noble metals such as Pt, Ir, and Pd, motivating the development of earth-abundant alternatives. Multinary metal chalcogenide clusters incorporating group 6 metals such as Mo or W, chalcogens (sulfur), and late transition metal promoters (TM = Mn, Fe, Co, Ni, or Cu) represent an underexplored class of materials with compositional tunability. These clusters are promising in applications of electrocatalytic hydrogen evolution reaction (HER), ortho-to-para hydrogen spin-state conversion, and hydroprocessing of distiller's corn oil to produce sustainable aviation fuel. Herein, we synthesize clusters by reacting [Tp*MoS5][NEt4] with low-valent transition metal precursors, M(0/I), including Ni(0) and Co(0). The materials are characterized using 1H and 31P nuclear magnetic resonance spectroscopy (NMR), single-crystal X-ray diffraction (SC-XRD), and cyclic voltammetry (CV) to evaluate their structures and redox behavior. We conducted the reactions under an inert atmosphere because the precursors and clusters are air- and moisture-sensitive. Using this approach, we successfully synthesized a diamagnetic Mo–Ni cluster containing a nickel center with square-planar geometry. Building on this result, we aim to expand the cluster library by varying the transition metal and determining how periodic and electronic trends influence HER activity.

43. **Charlotte Lindeman**
Synthesis and Characterization of Epitaxial $La_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ *Thin Films for Electrolyte-Gate Transistors*
Advisor: Chris Leighton
Mentor: Hyunsol Son
Sponsoring Program: MRSEC
Home Institution: Utah State University
Abstract: Electrolyte-gate transistors utilize a small gate voltage to induce a strong interfacial electric field that drives reversible ion migration to electrochemically modulate physical properties. This capability provides an energy-efficient route to novel spintronic, neuromorphic, and other devices. Of particular interest is the electrochemically induced topotactic transformation between perovskite (P) and oxygen-vacancy-ordered brownmillerite (BM) phases in electrolyte-gated cobaltite films (*e.g.* $La_{1-x}Sr_xCoO_{3-\delta}$ (LSCO)), which drives exceptionally large changes in electronic, magnetic, thermal, and optical properties. In LSCO films, the speed of gating between phases is limited by the diffusivity of oxygen vacancies (Dv_O). While previous studies investigated how gating speed depends on the device geometry, LSCO thickness, ion-gel thickness, and gate voltage, this study focuses on Fe substitution for Co in LSCO to improve gating speed by increasing Dv_O. We have synthesized a $La_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (LSCFO) sputtering target and grown epitaxial LSCFO films *via* high-pressure-oxygen sputtering. X-ray diffraction and energy dispersive X-ray spectroscopy confirm phase-pure targets and films, with the expected stoichiometry. Magnetic and electronic transport properties have also been measured, and vacuum annealing has been performed to probe the perovskite-brownmillerite transformations. The results will be compared with LSCO films to determine the impact of Fe substitution.

44. **Ally Malin**
Increasing the Double Gyroid Thermal Stability of Guerbet Glycolipid Blends
Advisor: Michelle Calabrese
Mentor: Jackson Cleveland
Sponsoring Program: MRSEC
Home Institution: University of Delaware
Abstract: The double gyroid (DG), a bicontinuous network structure, has applications in drug delivery and filtration, but these applications often require domain sizes under 5 nm. Guerbet glycolipids, a type of biobased surfactant with a disaccharide sugar headgroup and a branched tail, can self-assemble into DG structures within the size constraints. However, DG structures in most glycolipids exhibit low thermal stability, and increasing DG thermal stability is challenging. To understand the impact of different molecular changes on DG thermal stability, blends of glycolipids were synthesized with various sugar headgroups, tail lengths, and anomeric stereochemistry. The blends were tested with small angle x-ray scattering (SAXS) to confirm the phase behavior and polarized optical microscopy (POM) to identify DG thermal stability, melting point, disorder temperature, and additional transitions. Notably, several glycolipid blends achieved greater DG thermal stability than their constituent glycolipids alone, with the maximum DG thermal stability surpassing 90 °C. Insights on the impact of shape, hydrogen bonding, and blend composition can be used to guide the synthesis of new materials with greater DG thermal stability at the smaller scales necessary for applications in drug delivery and filtration.

45. **Noah Martell**
Configuration Interaction Approaches with the Contracted Schroedinger Equation
Advisor: Kade Head-Marsden
Mentor: Anthony Schlimgen, Koray Aydogan
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Iowa State University
Abstract: Excited states of molecular systems are important for a range of chemical areas, including spectroscopy, catalysis, photochemistry, as well as understanding transition states and mechanisms. The proper calculation of these excited states stands as a necessary utility not just for expanding our theoretical knowledge, but also for experimental guidance. Traditionally, solving the excited state has relied on optimizing determinant coefficients and diagonalizing the Hamiltonian. These methods come with significant drawbacks – the Hamiltonian scales exponentially with your defined active space, solving for an excited state means solving for multiple eigenpairs as opposed to just one, the near-degeneracy of excited states often causes convergence issues, and to solve for the n^{th} excited state, you must solve the first $n-1$ excited states as well. In contrast, methods involving the Anti-Hermitian Contracted Schrödinger Equation (ACSE) differ by optimizing Reduced Density Matrices (RDMs), which the ACSE is built from, until the ACSE residual, R_{kl}^{ij}, goes to zero. The authors present a series of methods improvements to CI approaches with the ACSE, including bit-wise determinant comparison, as well as explicit construction of 1,2,3-RDMs as well as the reduced Hamiltonian in the spatial-basis. Developed methods are applied to an excited state Beryllium atom.

46.	**Sophia Mehlhoff** *Biodegradation of Fluorinated Pharmaceuticals in Wastewater Activated Sludge* **Advisor:** William Arnold **Mentor:** Laurinda Nyarko, Drew Schlaff **Sponsoring Program**: UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota **Abstract:** Fluorinated pharmaceuticals are widely used and persist in water systems due to their strong carbon-fluorine bonds. Although these compounds are often detected in aquatic environments, their biodegradation pathways remain poorly understood. This study investigated the biodegradation of fluoxetine, 5-fluorouracil, and gemcitabine by the microbial communities in wastewater activated sludge. Wastewater activated sludge samples were incubated with each pharmaceutical and monitored over time. The concentration of each compound was measured using reverse-phase liquid chromatography, while the fluoride release was quantified using a coumarin-based fluorescence assay. Fluorine nuclear magnetic resonance spectroscopy (19F NMR) was used to identify the different transformation products that were formed as the compounds degraded. Results showed complete degradation of 5-fluorouracil with 89% stoichiometric fluoride release. In contrast, gemcitabine and fluoxetine exhibited partial degradation, yielding low fluoride release of 11% and 9%, respectively. For all these compounds, the percentage of parent-compound loss observed by liquid chromatography exceeded the amount of fluoride release, indicating the formation of other fluorinated byproducts. These findings improve understanding of the environmental fate of fluorinated pharmaceuticals and provide insight into the transformation pathways that influence their persistence in water.
47.	**Rebecca Meyer** *Plastic Deformation and Anisotropic Resistivity of* $SrTiO_3$ **Advisor:** Martin Greven **Mentor:** Issam Khayr **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota Twin Cities **Abstract:** We measure and evaluate the effects of plastic deformation and oxygen-vacancy doping of strontium titanate ($SrTiO_3$, STO). This is done by annealing insulating crystals to make them metallic and deforming them uniaxially to strain levels of 2–8%. We conduct transport measurements both parallel and perpendicular to the deformation axis of the sample from 300 K down to 2 K, and conduct Hall measurements at 2 K to determine carrier concentration. From these measurements, we aim to better understand how the annealing process affects bulk STO crystals, and how uniaxial, plastic deformation leads to anisotropic resistivity effects in STO.
48.	**Sabirin Mohamud** *Co-Evolve: Designing Feedback Mechanisms for Human-AI Collaboration* **Advisor:** Qianwen Wang **Mentor:** Pan Hao **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota Twin Cities **Abstract:** Agentic AI enables domain practitioners to analyze large-scale datasets more efficiently by automating end-to-end analytical workflows and rapidly generating a broad range of insights and patterns. However, due to the scale of a dataset, it would be difficult for domain experts to oversee and provide feedback for every generated insight. This UROP project seeks to develop user-intuitive mechanisms to enable domain experts to give scalable feedback and to lower the amount of work needed to be done by the user, through the interactive visualizations of the co-evolve dashboard. We present a system that separates feedback mechanisms into levels of granularity: local-based, which applies to a single artifact, cluster-based, which applies to candidates who share similar traits, and global, which applies to the entire dataset. Clusters are generated from mixed modality embeddings and are labeled by an LLM, and as the user provides feedback at the local and cluster level, the system extracts any general preferences and patterns of the user and adds it to the global preferences list for the agent. We hope to demonstrate that this multi-level feedback system can steer the agent toward higher quality insights in the solution space with little effort.
49.	**Kelvin Moresi** *Control and Charge Trapping Dynamics in Gate-Defined Monolayer MoS2 Quantum Point Contacts* **Advisor:** Ke Wang **Mentor:** Shiyu Guo **Sponsoring Program**: Physics REU **Home Institution:** Macalester College **Abstract:** Two dimensional semiconductors such as monolayer molybdenum disulfide (MoS2) offer an exceptional platform for next generation nanoelectronics due to their direct energy bandgap and high sensitivity to external electric fields. In this work, we investigate low temperature (4 Kelvin) electronic transport through gate defined quantum point contacts, narrow one dimensional channels used to probe nanoscale electron behavior. Using a four probe measurement technique with graphite contact pads, we eliminate contact resistance to isolate the intrinsic property of the channel. By applying voltages to bottom gates, we tune local energy barriers and shift the activation threshold by over 70 Volts along the primary back gate. Conductance heatmaps clearly map the boundary between insulating and conducting states. Gate voltage sweeps exhibit reproducible hysteresis that scales systematically with sweep range, while remaining invariant across three orders of magnitude in sweep rate.

50. **Miranda Mosqueda**
Investigating the Effects of Spacer Layer Thickness on Chirality Transfer from Chiral Gold Nanoparticles
Advisor: Vivian Ferry
Mentor: Sri Aashrita Boddu
Sponsoring Program: MRSEC
Home Institution: Hamilton College
Abstract: Chirality describes a symmetry property of a chemical or material whose mirror image is nonsuperimposable on itself. Due to this asymmetry, chiral materials interact differently with right versus left circularly polarized light (CPL), a response quantified by circular dichroism (CD) spectroscopy. Chiral materials can induce their handedness and associated optical properties to adjacent achiral materials, a phenomenon known as chirality transfer. It leads to applications in emerging technologies, including optical communications and polarization imaging, where control over CPL is critical for device performance.This project investigated how chirality transfer depends on the thickness of an achiral alumina spacer layer deposited on chiral gold nanoparticles via atomic layer deposition (ALD). Nanoparticles were synthesized and deposited onto glass substrates using several methods, with drop casting proving the most reliable. Lower nanoparticle concentrations led to more monolayer-like surface coverage and stronger CD. To monitor the effects of spacer layer thickness on chirality transfer, CD measurements were taken before and after ALD. While consistent thickness dependent trends were not observed, spacer layer deposition significantly reduced the CD response. Further characterization of spacer layer quality and investigation of additional spacer layer thicknesses and chemistries may clarify the interactions between the nanoparticles and the spacer layer.

51. **Zachary Naumovski**
Synthesis and Characterization of the Candidate Altermagnet Gd_2CuO_4
Advisor: Xianghan Xu
Sponsoring Program: Physics REU
Home Institution: Ohio State University
Abstract: Ferromagnetism and antiferromagnetism are two important categories of long-range magnetic order. In ferromagnets, magnetic moments are aligned, creating a net magnetization, whereas antiferromagnets exhibit zero net magnetization as the antiparallel moments cancel each out. Altermagnetism has recently been introduced as a new concept where the spin-only moments exhibit an antiferromagnetic arrangement while the orbital degree of freedom enables a non-relativistic spin band splitting, making altermagnets combine the merits of both ferromagnetism and antiferromagnetism. In this study, we propose Gd_2CuO_4 as a candidate altermagnet. High-quality single crystals of Gd_2CuO_4 were grown using a flux method. The crystallinity was confirmed by powder x-ray diffraction and Laue diffraction. Magnetization and heat capacity measurement results reveal a long-range order of Cu moments below 285 K and a development of an in-plane weak ferromagnetic moment, which is consistent with symmetry analysis that the altermagnetism together with spin-orbit coupling induces this moment. Longitudinal magnetoresistance measurements unveil anomalies coincident with magnetic domain switching, indicating that the net magnetization couples to the underlying spin band structure. These findings suggest that Gd_2CuO_4 is a rich platform for further exploring altermagnetic functionalities such as the piezomagnetic effect and the anomalous Hall effect.

52. **Sophia Owen**
Analytical Cross Correlation of the Anisotropic Stochastic Gravitational Wave Background with Weak Gravitational Lensing
Advisor: Vuk Mandic
Mentor: Kelsey Henry, Alex Granados
Sponsoring Program: Physics REU
Home Institution: Montana State University - Bozeman
Abstract: The stochastic gravitational wave background (SGWB) is composed of weak, unresolved gravitational wave (GW) signals from all over the universe, generated by both astrophysical and cosmological sources. Astrophysical sources are expected to be correlated with electromagnetic (EM) tracers of universe structure, such as galaxy counts (GCs) and weak gravitational lensing (WL). While current detectors are not sensitive enough to detect the SGWB, we expect the SGWB to be anisotropic. These anisotropies could provide a new way to study the evolution of the matter structure of the universe. Cross-correlation of the SGWB with EM tracers provides a probe of the sources of anisotropy while simultaneously aiding in indirect detection sooner than direct detection. In this work, we utilize linear perturbation theory to model the first order anisotropic contributions of the SGWB and WL with the goal of setting up the theoretical framework to study the cross-correlation between the SGWB and WL once detection becomes possible. We generate theoretical angular power spectra for the auto- and cross-correlations of the SGWB and WL across eight GW frequency bands in preparation for parameter estimation.

53. **Chris Pate**
Applying Clumpy Dust Models to Reestimate Galaxy Light Emission
Advisor: Claudia Scarlata
Mentor: Annalisa Citro, Alexandra Le Reste
Sponsoring Program: Physics REU
Home Institution: University of Wisconsin - Madison
Abstract: Before the first stars and galaxies existed, all the gas in the universe was cold. Once galaxies began to form, their light reheated this gas. However, the gas had to absorb the light in order to be reheated, meaning that light can no longer be observed by astronomers on Earth. As a result, we cannot directly tell which types of galaxies were most responsible for this warming. Instead, astronomers study much younger, nearby galaxies to see which ones allow the most light to escape. To measure how much light actually escapes a galaxy, astronomers must account for dust, which absorbs and blocks light. However, most dust models assume that dust forms a simple, uniform layer, but real galaxies likely have patchy, clumpy dust with gaps that let more light through. In this project, we introduce two different ways to model the clumpy structure of dust within a galaxy. We incorporate these models into a software tool that reestimates how much light escapes from nearby galaxies. On average, we find that our escape estimates are double those made under the assumption of a uniform dust layer.

54. **Shardul Pathrikar**
Using Ion Mobility-Mass Spectroscopy to characterize the protein Cereblon
Advisor: Varun Gadkari
Mentor: Pete Gabriel Ledesma
Sponsoring Program: Independent Research
Home Institution: University of Minnesota Twin Cities
Abstract: Proteolysis-targeting chimeras (PROTACs) are bifunctional small molecules that induce the choice degradation of problematic proteins by targeting the protein and recruiting an E3 ligase, which promotes ubiquitination. Unlike traditional occupancy driven therapeutics, which require sustained target binding to inhibit protein function, targeted protein degradation uses the cell's ubiquitin-proteosome system in order to eliminate the protein entirely, offering advantages such as prolonged degradation after degrader dissociation. PROTAC mediated degradation starts with the formation of the ternary complex between the protein of interest, the PROTAC, and the E3 ligase. The E3 ligase brings in an E2 ligase in close proximity in order to initiate ubiquitination. Ubiquitination ultimately marks the target protein for degradation by the 26S proteosome. Molecular glue degraders are an alternative targeted degradation strategy by binding directly to the E3 ligase and inducing a neosurface that promotes the recruitment of a target protein without the need of the bifunctional linker. In this study, the E3 ligase and Cereblon are investigated in a complex with a series of molecular glue degraders using ion mobility mass spectrometry to characterize complex formation and gain insight into the molecular interactions that drive targeted protein degradation.

55. **Caitriona Patterson**
The Presence of a Predictable Path of Motion in VR Environments as it Relates to Cybersickness
Advisor: Victoria Interrante
Sponsoring Program: Human-Centered Computing
Home Institution: Iowa State University
Abstract: One of the biggest caveats to VR usability is the risk of experiencing a form of motion sickness known as cybersickness. It is hypothesized that a dissonance in what the user expects to see based on other sensory signals versus what they actually see (incongruent optical flow) can contribute to cybersickness. This study intends to dive deeper into this theory through testing subjects under two conditions of a rollercoaster simulation: a rollercoaster environment with a visible track, and one without a visible track. It is hypothesized that participants in the visible-track condition will experience less cybersickness than those in the non-visible-track condition. The user is also predicted to make anticipatory adjustments to their head position, thereby affecting the optical flow they receive and privileging the central point of expansion. If this assumption is true, further analysis of the data will be run to analyze the differences in optical flow at the points where head position differs.

56. **Dakshesh Ravi**
Studies of prenyltransferase inhibitor selectivity in mammalian versus fungal cells
Advisor: Mark Distefano
Mentor: Anjana P Sundaresan
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Michigan State University
Abstract: Protein prenylation is a ubiquitous post-translational modification found in all eukaryotic cells. It involves the attachment of a hydrophobic isoprenoid group to a cysteine residue at the C-termini of certain proteins and serves various functions in processes such as cell division and receptor trafficking. However, its dysregulation has been found to play a key role in various diseases such as cancer and progeria. Moreover, drugs targeting prenylating enzymes could play a key role in managing various parasitic and fungal diseases including Malaria and African sleeping sickness. Previously, the Distefano lab developed a derivative of Merck compound L-778,123 that exhibited potent antifungal properties against C. neoformans with minimum inhibitory concentrations lower than Fluconazole, a commonly used antifungal in the clinic. Here, I report in vitro assays to test the efficacy of our derivative against mammalian FTase. These experiments are essential to determine the species selectivity of the new inhibitor. We found that our derivative binds ~30 times stronger to C. neoformans FTase and ~20 times weaker to rat FTase compared to L-778,123. In the future we plan to perform in cellulo fluorescence experiments to evaluate the toxicity of our derivative against mammalian cell lines.

57. **Alivia Roerdink**
Investigation of the Mechanism and Origins of Regioselectivity in Catalytic and Non-Catalytic Hetero-ene Reactions of Sulfur Imides with Unactivated Alkenes
Advisor: Melissa Ramirez
Mentor: Clarence Pan, Lyisa Liu
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Central College
Abstract: Allylic functionalization of unactivated alkenes is an important chemical transformation that provides building blocks in the synthesis of pharmaceuticals, natural products, and fine chemicals. In 2017, enantioselective allylic oxidation of unactivated internal alkenes using a chalcogen-based oxidant and a co-catalytic antimony-BINOL system was developed by Tambar and coworkers. Despite the value of this reaction, the origins of regioselectivity in hetero-ene reactions involving non-symmetric internal alkenes remain elusive. As such, we report a computational study on the mechanism and origins of regioselectivity in hetero-ene reactions of sulfur imides with unactivated alkenes in both catalytic and non-catalytic transformations. Density functional theory (DFT) calculations have been performed to compare the reactivity of (Z)-7-chloro-3-heptene versus (Z)-1-chloro-3-heptene in the Lewis acid-assisted Bronsted acid-catalyzed reaction and the non-catalyzed reaction. While both substrates undergo the reaction with high stereoselectivity (93%–96% enantiomeric excess), experiments observe that (Z)-7-chloro-3-heptene undergoes the reaction with lower regioselectivity (1.2:1 ratio of products) than (Z)-1-chloro-3-heptene (>20:1 ratio of products) under catalyzed conditions. Overall, this study provides insights on the mechanism of the hetero-ene reactions between sulfur imides and unactivated alkenes and
insights into the regioselectivity with the goal of broadening the substrate scope and the design of new co-catalytic systems and oxidants.

58. **Benito Salinas**
Enhancing Protein Creation of a Cell Free System
Advisor: Vincent Noireaux
Mentor: Seth Thompson
Sponsoring Program: Physics REU
Home Institution: The University of Texas at Austin
Abstract: Cell Free Gene Expression (CFE) is a method of creating proteins without directly using a cell, with applications in making pharmaceuticals, artificial cell attempts, genetic circuits, detecting diseases, and educational opportunities. Our lab uses a CFE transcription-translation (TXTL) system using cell extracts, DNA, an energy source, and additional chemicals to produce a green fluorescent protein (deGFP) to measure the protein output of our system. In order to test how different chemicals affect our system, we plan out the concentrations of the chemicals we would like to test, put them in a well plate, program the LABCYTE Echo 650 Acoustic Liquid Handler to dispense the chemicals as 2 microliter solutions into 96-well plates. These plates are incubated at 29 degrees Celsius and can be put into the Synergy H1 Hybrid Reader to obtain fluorescence readings of the deGFP. Out tests have led to us finding out that by increasing the magnesium in the solution and adding a mix of potassium phosphates, the deGFP output of our system can be increased by 1.85±0.41 compared to the previous system optimum.

59. **Katelynn Schwantz**
Synthesis of Aurora Kinase A Inhibitor Analogues as a Therapeutic Strategy for High-Risk Neuroblastoma
Advisor: Daniel Harki
Mentor: Alondra López Colón
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Minnesota - Twin Cities
Abstract: Neuroblastoma (NB) is an extracranial tumor responsible for 15% of childhood cancer deaths. In high-risk NB, amplification of the *MYCN* oncogene, which encodes for the N-Myc protein, is the strongest biomarker of poor prognosis. Despite its clinical significance, there are no direct N-Myc inhibitors available. One strategy to modulate N-Myc stability is to disrupt its interaction with Aurora Kinase A (AURKA), a scaffolding protein that prevents it from proteasomal degradation. The Harki lab developed **HLB-0532259**, the first AURKA/N-Myc degrader based on a ribociclib analogue. However, although it showed potency in *MYCN*-amplified NB cells, it also exhibited acute *in vivo* toxicity and poor metabolic stability, requiring the development of improved analogues. To address these issues, we hypothesized that increasing AURKA selectivity and chemical stability will improve upon the drug-like properties of **HLB-0532259**. However, in unpublished data we find that initial ribociclib analogues with enhanced AURKA selectivity and less hydrolytically labile moieties were inactive in *MYCN*-amplified NB cells. Therefore, this work developed a new series of ribociclib analogues using 2-methoxybenzamides to restore the molecular features for N-Myc degradation. **HLB-0536019** was synthesized successfully and ongoing efforts focus on completing the library for in *cellulo* evaluation to guide the design of next-generation degraders with improved efficacy and chemical stability.

60. **Charlie Schwieters**
Charge Detection Mass Spectrometry (CDMS) Optimization for Self-Assembled RNA Measurements
Advisor: Varun Gadkari
Mentor: Emmanuel Ayobe
Sponsoring Program: Independent Research
Home Institution: University of Minnesota
Abstract: Recent groundbreaking cryogenic electron microscopy (cryo-EM) studies have demonstrated the existence of self-assembling RNA-only complexes. These complexes represent the first observation of RNA-only self-assembly in nature, and little is known about what factors drive this process. Although cryo-EM has provided atomic-resolution structural details about fully formed megadalton-scale multimers, limited focus has been directed to the characterization of subcomplexes in the self-assembly pathway. To better understand these complexes, this study employs charge detection mass spectrometry (CDMS) to characterize the self-assembly of giant, ornate, lake-, and lactobacillales-derived RNA (GOLLD). Characterization of GOLLD self-assembly will yield key insights into the general chemical and biophysical principles which drive RNA only self-assembly and enable the identification and development of new self-assembling RNAs. CDMS is an individual ion mass spectrometry method which enables accurate mass determination of large (>1 MDa), heterogeneous analytes which elude analysis via conventional mass spectrometry. Before initiating these studies, significant optimization was required in terms of sample preparation, and instrument tuning, to obtain mass spectra which accurately represent the mixture of RNA complexes in solution. The results of these optimizations will be presented, along with the application of the optimized methods to evaluate changes in GOLLD self-assembly as we perturb assembly conditions.

61. **Alitza Soiffer**
Titanium-Mediated Synthesis of N-N Heterocycles
Advisor: Ian Tonks
Mentor: Zoe Fish
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Chicago
Abstract: Heterocycles containing N-N bonds are ubiquitous in pharmaceuticals. For example, tetrazine-based drugs have widespread medical applications in tumor imaging, drug delivery, and as fluorogenic probes. Additionally, many cinnolines have anticancer and antibacterial activities, yet few have reached clinical trials due to the difficulty of synthesizing such compounds. In particular, the N-N bonds in these heterocycles are notoriously difficult to make due to their low bond strengths. As a result, current syntheses of N-N heterocycles often rely on hazardous reagents that already contain an N-N bond, such as hydrazines. This research uses cheap, earth-abundant titanium and other relatively benign reagents to mediate N-N bond formation for heterocycles such as tetrazine-like compounds and cinnolines. We present the dimerization of a commercially available 1,2-diamino-benzene for the first reported synthesis of a 5,6-dihydrodibenzo[c,g][1,2,5,6]tetrazocine. Our novel compound is somewhat similar in structure to tetrazines and photoswitchable dibenzodiazocines, indicating potential biomedical applications. This study has also successfully synthesized benzo(c)cinnoline from 1,1'-biphenyl-2,2'-diamine. These compounds have been characterized using NMR spectroscopy and electrospray ionization mass spectrometry. Ongoing efforts aim to optimize these reactions, determine the mechanism of titanium-mediated N-N bond formation, and apply this method to the synthesis of other medically-relevant N-N heterocycles.

62. **David Sung**
Modular Synthesis and Self-Assembly Behavior of Amide-Containing Dicarboxylate Gemini Surfactants
Advisor: Mahesh Mahanthappa
Mentor: Giselle Campos
Sponsoring Program: MRSEC
Home Institution: Macalester College
Abstract: Surfactants, molecules comprising a hydrophilic head and hydrophobic tail, self-assemble into ordered lyotropic liquid crystals on the addition of water to make nanoporous materials for applications including drug delivery, catalysis, and ion transport. Network phases are of particular interest in these applications because of their interpenetrating aqueous and hydrophobic domains; however, single-tail ionic surfactants form such structures only in narrow composition windows since they cannot accommodate the necessary deviations from a constant mean curvature. Gemini surfactants, twin-head and twin-tail surfactants, exhibit wider network phase composition windows, yet their molecular structure/self-assembly relationships are underexplored. This work synthesized dicarboxylate gemini surfactants with varied linker-to-tail length ratios by a modular ring-opening reaction of alkyl succinic anhydrides with alkyl diamines. The self-assembly behavior of these gemini surfactants in water was characterized via polarized light microscopy and small-angle X-ray scattering, identifying molecular characteristics of gemini surfactants for the formation of stable network phases.

63. **George Tang**
From Redistribution to Inequality: Wealth Distribution in a Kinetic Exchange Model
Advisor: Scot Adams
Sponsoring Program: Summer Research supervised by Professsor
Home Institution: University of Minnesota, Twin Cities
Abstract: We study a stochastic wealth-redistribution model inspired by interacting particle systems. In a system of n professors holding a conserved total of n dollars, each professor may hold only 0, 1, or 10 dollars. Randomly formed committees generate local transitions between wealth configurations. We formulate the dynamics as a finite-state Markov chain and prove the existence of a unique stationary distribution and convergence to equilibrium. Using generating functions and saddle-point asymptotics, we derive the limiting marginal probabilities that an individual professor holds 0, 1, or 10 dollars. In the large-population limit, the one-professor marginal converges to a Gibbs–Boltzmann distribution. This model demonstrates how microscopic exchange rules can produce macroscopic inequality under a conservation constraint.

64. **Una Tarpey**
Quantification of Small Organic Acids in Prairie Pothole Wetlands
Advisor: Rene Boiteau
Mentor: Aiden Berndt
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota-Twin Cities
Abstract: The Prairie Pothole Region is the largest wetland system in North America and has some of the largest methane fluxes ever recorded in terrestrial ecosystems. Within wetlands, the form of anaerobic respiration dictates the amount and form of carbon flux. Small organic acids are a primary substrate of anaerobic microbes and consequently the concentration of these acids is expected to correlate with carbon emission. Therefore, determining the correlation between organic acid concentration and the form of carbon flux is critical to predicting long term carbon sequestration or emission. To quantify the organic acids, we developed a reverse phase-anion exchange liquid chromatography method coupled to a triple quad mass spectrometer (HPLC-MS), additionally derivatization to improve extraction efficiency as well as ionization efficiencies were tested. Utilizing existing HPLC-MS methods resulted in limited detection in wetland samples. Improvements were made by broadening the single ion monitoring method to include collision-induced dissociation reactions and subsequent detection of target fragment ions, resulting in the limit of detection (LOD) decreasing from 239.7 µM to 69.6 µM. Ongoing work involves developing derivatization methods to improve ionization, thus further lowering the LOD to environmentally relevant concentrations and enabling the quantification of organic acids in wetland systems.

65. **Daniel Tetteh**
Visualizing Human-Chatbot Interaction
Advisor: Qianwen Wang
Sponsoring Program: Human-Centered Computing
Home Institution: University of Richmond
Abstract: As chatbots become a ubiquitous feature of digital life, understanding how people use them has become an increasingly important research question. Building on emerging research on consumer chatbot use since late 2022, this project analyzes the public WildChat dataset of over 830,000 conversations between users and ChatGPT to investigate three hypotheses: (1) users speaking different languages tend to produce different toxicity scores, (2) users speaking different languages tend to discuss different topics with the AI, and (3) users speaking different languages tend to have conversations of different lengths. Key methods of the project include multilingual toxicity analysis, conversation-length analysis, and LLM-based topic labeling. These analyses serve as the foundation for a series of static and interactive visualizations exploring human-chatbot interaction.

66. **Minh Tran**
Nickel-Mediated Decarbonylation of Naphthalic Anhydrides
Advisor: Jessica Hoover
Mentor: Nandha Karthikeyan
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Lawrence University
Abstract: The ubiquity of carbonyl functionalities across organic syntheses makes decarbonylative carbon-carbon bond activation a promising method to strategically access a variety of chemical scaffolds. However, while examples of nickel-mediated decarbonylation reactions are precedented in the literature, the substrate-driven reactivity profile of this metal hinders the development of broadly applicable catalyst systems. This work aims to further a fundamental understanding of substituent effects on decarbonylative nickel catalysis by surveying the chemo- and regioselectivity of nickel-mediated decarbonylation across a range of functionalized naphthalic anhydrides. Preliminary results indicate that selective decarbonylation is diminished with increased distance between the carbonyl and the substituent, as well as competitive oxidative addition from aryl-heteroatom bonds, suggesting that selectivity is controlled by the relative position and identity of the substituent.

67.	**Evan Truman** *Classification of Light Curves from Photometric Data* **Advisor:** Michael Coughlin **Mentor:** Sushant Chaudhary **Sponsoring Program**: Physics REU **Home Institution:** Saint John's University **Abstract:** By measuring the intensity of the light being emitted by an astronomical phenomenon every few days, data is collected that can be displayed as a light curve, which is the intensity of light as a function of time. By then comparing the light curve of some unknown astronomical event to specific parameterized functions, the function which the light curve best fits can be identified to classify the type of astronomical phenomenon being observed and the values of the parameters that best model the light curve can provide additional information regarding the phenomenon, such as mass involved or distance from Earth.
68.	**Alexander Uribe** ***Machine Learning-Assisted Studies of Oxygen Transport in $La_{1-x}Sr_xCo_{1-y}Fe_yO_{3-\delta}$*** **Advisor:** Chris Bartel **Mentor:** Armand Lannerd **Sponsoring Program**: MRSEC **Home Institution:** University of California, Berkeley **Abstract:** Some metal oxides reversibly form and annihilate oxygen vacancies in electrochemical devices. One such material, $La_{1-x}Sr_xCoO_{3-\delta}$ (LSCO), undergoes a reversible perovskite ($\delta = 0$)-to-brownmillerite ($\delta = 0.5$) phase transition accompanied by broad modulation of its electronic, magnetic, optical, and thermal properties. Despite this high degree of tunability, wider deployment of LSCO is constrained by oxygen diffusivity, which dictates practical film thicknesses and achievable switching speeds. We analyze the Fe-doped analog, $La_{1-x}Sr_xCo_{1-y}Fe_yO_{3-\delta}$ (LSCFO), to investigate how Fe-doping and oxygen off-stoichiometry influence oxygen diffusivity. Prior work on LSCO found that molecular dynamics (MD) studies using universal machine learning interatomic potentials (uMLIPs) can provide accurate predictions of oxygen diffusivity. However, the uMLIPs were too computationally expensive for the long MD runs necessary to fully model low temperature oxygen diffusivity behavior. To overcome this limitation, we instead train Moment Tensor Potentials (MTPs) on selected uMLIP data, reproducing the reference potential energy surface and enabling substantially longer MD simulations. We first train several MTPs on existing LSCO data to validate their performance and identify optimal hyperparameters. After generating uMLIP training data for LSCFO, we train a final MTP using the optimized hyperparameters. We then take $La_{0.5}Sr_{0.5}Co_{1-y}Fe_yO_{3-\delta}$ and run MD simulations across a range of y values as a first step towards understanding the effect of Fe-doping on oxygen diffusivity, establishing an efficient computational framework for further investigations.
69.	**Veronika Voss** *Power-Varied Depositions of Fe-Doped Pt_3Sn, a Weyl Semimetal, for Efficient Spin-Orbit Torque Switching* \ **Advisor:** Jian-Ping Wang **Mentor:** Zach Cresswell Onri Benally, Christian Bren **Sponsoring Program**: MRSEC **Home Institution:** California Institute of Technology **Abstract:** Emerging spintronic devices are competing non-volatile devices beyond CMOS architectures. While Magnetic Tunnel Junctions (MTJs) are foundational to non-volatile logic, conventional spin-transfer torque (STT) MTJs require high write current densities, which degrade the ultra-thin insulating barrier necessary for quantum tunneling. Alternative spin-orbit torque (SOT) MTJ architectures overcome barrier degradation, but suffer from low energy efficiency. Dirac semimetals emerge as a promising solution. Here, we investigate Pt_3Sn, a known Dirac semimetal, doped with up to 21% Iron (Fe) to drive its transition into a potential magnetic Weyl semimetal. Four batches of four thin-film depositions are prepared on MgO substrates via co-sputtering from Pt, $PtSn_4$, and Fe targets at 350°C. While Pt and $PtSn_4$ target powers are maintained at 10W across all batches, the Fe target power increases from 10W to 40W in 10W increments to increase the doping concentration. Afterward, a ferromagnet layer (CoFeB) is deposited, varying in thickness across a batch's samples. Post-fabrication, we use X-Ray Diffraction (XRD) to verify crystal structure. Then, lithographically patterned Hall bars undergo spin-torque ferromagnetic resonance (ST-FMR) to evaluate the spin Hall efficiency, which is anticipated to positively correlate with Fe concentration. This work aims to demonstrate a viable pathway to engineer ultra-high-efficiency SOT materials.
70.	**Alex Walk** *How big is a photon?* **Advisor:** Dan Dahlberg **Sponsoring Program**: Physics REU **Home Institution:** St. Olaf College **Abstract:** Photons are particles of electromagnetic energy that make up visible light, microwaves, radio waves, and X-rays. The size of a photon in the direction of travel is usually described by its wavelength. While the wavelengths of different types of electromagnetic energy are well known, little research has been done on the interaction size of a photon in the direction perpendicular to travel. We investigated the transverse interaction size of the photon using a 10 GHz microwave and a single slit of adjustable width. We directed a beam of microwave radiation through the slit and recorded intensity as a function of slit width, allowing us to determine the transverse size of the photon. By improving our understanding of how photons interact with matter, this work helps us better understand quantum mechanics, particle interactions, and the behavior of light.

71.	**Alexander Weimer** *Attribution Modeling for Complex Decision Systems Using Cooperative Game Theory* **Advisor:** Donatello Materassi **Sponsoring Program**: Directed Study **Home Institution:** University of Minnesota **Abstract:** Quantifying the contribution of individual features to the output of a learned system requires accounting for complex interactions among those features. Cooperative game theory formalizes this problem through attribution schemes such as Shapley and Banzhaf values, yet these schemes differ fundamentally in how they weigh coalition participation. This research applies both methods to decompose the outputs of a neural evaluation function, treating the problem as a controlled case study for attributing system-level decisions to constituent components. This investigation uses Leela Chess Zero (LC0), a GPU-accelerated convolutional chess evaluation engine, to compare Shapley and Banzhaf values for positions from a large database of tournament games spanning multiple opening structures. For each position, active chess pieces and their configurations are treated as input features, and the network's scalar evaluation serves as the global output. The analysis compares attribution distributions across opening families to identify systemic strategic priorities encoded in the network. Beyond the chess domain, this case study demonstrates that game-theoretic attribution provides a transferable framework for any modular decision architecture. Ultimately, this work establishes a comparative benchmark for attribution stability in complex decision systems, offering insights that complement standard performance metrics in engineering applications.
72.	**Maria Williams** *Characterization of a Non-Heme Iron Based Oxindolalanine Generating Enzyme* **Advisor:** Ambika Bhagi-Damodaran **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** New York University **Abstract:** The 2-oxindole is an oxidized indole ring and a prominent structural motif in many useful biomolecules, such as antimicrobials like maremycins and chemotherapeutics like spirooxindoles. However, because the current chemoenzymatic synthesis of these compounds via P450 and FPMO enzymes involves the use of cost-ineffective cofactors, enzymatic synthesis of these compounds is not an industrially viable option. Our lab has recently demonstrated the capability of Hydrox, a 2-oxoglutarate-dependent non-heme iron (2OG-NHFe) enzyme, to perform the regioselective oxidation of L-Tryptophan, an indole-containing amino acid, and generate oxindolalanine. In this poster, I will discuss our recent results demonstrating the catalytic promiscuity of Hydrox towards substituted variants of L-Tryptophan, such as 5-Bromo L-Tryptophan, 5-Methyl L-Tryptophan, and 5-Fluoro L-Tryptophan with substrate conversion percentages relative to that of unsubstituted L-tryptophan. Using techniques such as recombinant protein expression, end-point assay, and High Performance Liquid Chromatography (HPLC), we have demonstrated that Hydrox displays activity towards substrates 7-Bromo L-Tryptophan (an electron withdrawing substituent) and 5-Methoxy L-Tryptophan (an electron donating substituent) and displays no significant activity towards 2-Methyl Tryptophan (a substituent in the position of hydroxylation), further characterizing the substrate tolerances of Hydrox. Overall, our studies establish Hydrox as a viable candidate for biocatalytic synthesis of varied 2-oxindole containing molecules.
73.	**Clifford Yen** *Magnetically Activating Chiral Phonons: A Magneto-Raman Study of Chiral Copper Oxide* **Advisor:** Renee Frontiera **Mentor:** Aritra Das **Sponsoring Program**: UMN Chemistry- Lando **Home Institution:** Hamilton College **Abstract:** Chiral copper oxide has been shown to exhibit the Chiral-Induced Spin Selectivity (CISS) effect, where electron spins are transmitted preferentially based on the handedness of the material. The leading candidate mechanism for this effect involves coupling between spins and chiral phonons, which carry angular momentum and should, in theory, interact with a magnetic field. Thus, a magnetic field could act as a switch for turning on certain reaction pathways or changing electron transport properties by activating these phonons and transferring energy into the system to break bonds or overcome activation energy barriers. In this work, using spontaneous Raman spectroscopy under varying magnetic biases, I measured the intensity, width, and energies of vibrations within chiral copper oxide to quantify the magnitude of coupling between chiral phonons and the magnetic field, probing the feasibility of magnetically-controlled reactions.

74. **Max Zahirovic**
Directed Evolution of Myoglobin for Asymmetric α-Cyanohydrin Synthesis
Advisor: Ambika Bhagi-Damodaran
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota - Twin Cities
Abstract: Specific enantiomers of α-cyanohydrins are vital precursors for important pharmaceuticals and insecticides. Current synthetic methods for α-cyanohydrins produce racemic mixtures or require chiral auxiliaries for enantioselectivity with little scalability to industrial production. Myoglobin is a greener alternative which is easier to produce and use for biocatalysis, and has been established to remove cyanide from α-cyanohydrins to produce ketones. My research focuses on engineering myoglobin to perform the enantioselective addition reaction using a combination of high throughput expression and purification techniques and synthetic metal-porphyrin cofactor incorporation. In the poster, I will present my recent results that focus on development of procedures for incorporation of manganese and gallium substituted protoporphyrin IX in myoglobin. To explore using directed evolution methods with myoglobin, I expressed and purified a recombinant plasmid for native sperm whale myoglobin with a His10 tag. I then further developed procedures for high throughput heme protein expression, purification, and activity assays by assessing method compatibility with GcHK, another heme protein. These steps helped in establishing an overall protocol for developing and testing new myoglobin mutants for enantiomeric α-cyanohydrin synthesis.

75. **Xuanrui Zhang**
Uncertainty Quantification for Astronomical Light-Curve Classification Using Bayesian Deep Learning
Advisor: Michael Coughlin
Mentor: Argyro Sasli
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota Twin Cities
Abstract: Large astronomical surveys need automated classifiers, but predicted labels do not show how reliable they are. This project evaluates uncertainty quantification for Transformer-based classification of simulated ELAsTiCC light curves. Experiments progressed from stellar/non-stellar binary classification to 14 physical families and full 32-class classification. Training-data fraction c increased from 0.04 to 0.10 and 0.20. We compared a deterministic baseline with Monte Carlo (MC) Dropout using confidence, predictive entropy, and the top-1/top-2 probability margin. MC Dropout was also evaluated with mutual information, predicted-probability spread, and prediction disagreement. We measured whether these signals identified incorrect predictions using error-detection AUROC and selective classification. Standard confidence and entropy already identified unreliable predictions effectively. MC Dropout provided only small improvements on shared measures, while its additional uncertainty signals did not consistently outperform simpler scores. Exploratory Laplace approximation on selected layers also showed no stable improvement. Overall, uncertainty filtering improved the reliability of retained classifications, but more complex approximate Bayesian methods did not automatically yield better uncertainty estimates for this dataset.

76. **Alex Zhao**
Investigation of Drop Impact for Eco-Friendly Insect Control
Advisor: Xiang Cheng
Mentor: Anahita Mobaseri, Shih-Yuan Chen
Sponsoring Program: UROP/URS
Home Institution: University of Minnesota, Twin Cities
Abstract: Flying insects can survive raindrop collisions because these impacts produce relatively small forces on their lightweight bodies, yet interactions between fluid droplets and insects have not been extensively studied. This project investigates how cornstarch-based droplets interact with fruit flies to better understand droplet-insect interactions, with the long-term goal of developing more sustainable approaches to insect control. Fruit flies were exposed to droplets containing varying concentrations of cornstarch, and high-speed imaging was used to capture their responses before, during, and after impact. Recorded videos were analyzed to evaluate how cornstarch concentration and impact velocities influenced droplet behavior and insect response. Preliminary results showed that cornstarch concentrations of 50% by weight or higher were associated with increased fruit fly mortality at the higher end of the tested impact velocity range, which reached approximately 5.0 m/s. At lower velocities, impacts demonstrated solid-like droplet behavior, which may concentrate impact stresses on the insect, while higher velocities may contribute to mortality through increased impact forces. These findings motivate future work using force sensors to quantify the impact forces associated with fruit fly mortality and eventually extending the experiments to mosquitoes.

77.	**Minghao Zou** *Visual Large-Object Rearrangement for Legged Mobile Manipulators* **Advisor:** Karthik Desingh **Mentor:** Xun Tu **Sponsoring Program**: UROP/URS **Home Institution:** University of Minnesota, Twin Cities **Abstract:** As intelligent robots increasingly integrate into human society, they have the potential to assist with a wide range of everyday tasks, especially for physically demanding applications involving the movement and rearrangement of large objects, such as chairs and tables. This project develops a visual reinforcement learning framework for large-object rearrangement with a legged mobile manipulator. We first train an oracle teacher policy using proprioception, privileged ground-truth object poses, and state-based goal poses. The teacher achieves 89.88% task success and is then distilled into visually informed student policies. The student policies observe partial point clouds generated from two front-facing depth cameras. A point-cloud encoder trained end-to-end enables the standard visual student to reach approximately 86.26% success. We further introduce an object-centric world action model with an auxiliary prediction head that estimates the object pose at the next state. Supervised by ground-truth poses during training, this objective encourages the policy to learn both control features and object-transition dynamics. The resulting model reaches approximately 87.32% success, requiring 1.88 hours of training, compared with 2.25 hours for the standard point-cloud student. These results demonstrate that visual policy distillation can support accurate and computationally efficient large-object rearrangement.
78	**Madison Cereno** *Development & Investigation of Glutathione Carbon Dots as Biosensors for in vitro Oxidative Stress Monitoring in Cells* **Advisor:** Christy Haynes **Mentor:** Rhea Caldwell **Sponsoring Program**: UMN Chemistry-Heisig Gleysteen **Home Institution:** University of Minnesota, Twin Cities **Abstract:** Affecting over 7 million people in the US, Alzheimer's disease (AD) is a progressive neurodegenerative disorder that includes symptoms of judgement and memory impairment, cognitive dysfunction, and inability to perform daily tasks. The production of dopamine quinone, the highly reactive, oxidized form of dopamine (DA), is correlated with AD progression. To develop sensitive nontoxic fluorescence sensors for studying AD, we aimed to synthesize various formulations of glutathione (GSH)-incorporated carbon dots (CDs) as well as investigate their sensitivity and selectivity for DA. To characterize these CDs, fluorescence, size, and surface charge measurements were taken using a fluorimeter and Zetasizer. Fluorescence data of various CD samples with and without DA were collected using a wellplate reader. After comparing the fluorescence data of the CDs with and without DA, it was found that GSH CDs have an affinity for DA as a result of fluorescence emission quenched in the presence of DA.
79	**Daniel Mascarenhas** *Analyzing Coating Recession on Microneedles* **Advisor:** Andreas Stein **Mentor:** Elena Fujiwara, Maria Komal **Sponsoring Program**: UMN Chemistry-Heisig Gleysteen **Home Institution:** University of Minnesota, Twin Cities **Abstract:** Nano-porous carbon-coated micro-needles enable ion-selective sensing of calcium, hydrogen, and potassium ions in the interstitial fluid. However, particularly on sharp needles, the carbon and ion-selective membrane (ISM) coatings can recede from the tip, creating an exposure defect that skews results and could lead to harmful consequences. Here we investigate needle recession on sharp and blunted micro-needles and examine the effects of conditioning solution and air exposure. Needles were coated with carbon ink and a PVC-BEHS membrane to replicate an ISM lacking ionophore. They were then imaged over time to track tip recession. Sharp needles usually showed an initial exposure defect that remained constant over time, while blunted needles showed little to no coating damage, and any exposure did not progress further. Results suggest that eliminating initial coating effects would likely be most effective in preventing micro-needle exposure, rather than addressing recession after it occurs. The composition of the needle also affected coating durability, with gold-coated stainless-steel needles easily succumbing to damage when pierced into gloves. Future work will focus on eliminating initial coating defects and the effect of needle composition to enhance coating durability during skin insertion.

80	**Julien Cooper** *NOx Lifetime and Concentration Trends in Minneapolis Over Time via Ground-Based Monitoring Stations* **Advisor:** Hannah Kenagy **Mentor:** Renee Nicholson **Sponsoring Program**: UMN Chemistry-Heisig Gleysteen **Home Institution:** University of Minnesota Twin Cities **Abstract:** NO_x (≡ NO + NO_2) are anthropogenic radicals that contribute to the production of ground O_3, a toxic pollutant at high levels. Since the Clean Air Act of 1970, NO_x emissions have greatly decreased across the US. With these lowered emissions, there are complex changes to the chemical regimes in urban environments and surrounding areas, due to the nonlinear relationship between NO_2 lifetime and NO_2 concentration. Previous studies have characterized these trends via satellite data, but ground-based analysis has not yet been attempted, though it offers finer spatial resolution than typical satellites. By combining ERA5 wind vector data with NO_2 concentrations from three EPA air quality monitoring stations across Minneapolis, average NO_2 lifetime was calculated from 2014 to 2024, and the data was plotted over NO_2 concentration. Results showed that Minneapolis is in a chemical regime where NO_2 lifetime increases as concentration decreases, or a low-NO_x regime. These results indicate that ground-based measurements are capable of producing lifetime data that is consistent with theoretical models based on satellite measurements. Increasing NO_2 lifetime indicates that NO_2 travels further from its emission source over time, affecting air quality further from the local plume.
81	**Gabriella Cesena** *WONDERing Where the Patterns Lie: Using CDC WONDER to Map Pediatric Cancer Incidence by Race and Ethnicity Across the United States* **Advisor:** Michelle Roesler, Cassandra Clark, Erin Marcotte **Mentor:** Renee Nicholson **Sponsoring Program**: University of Minnesota Medical School, Department of Pediatrics, Division of Epidemiology and Clinical Research **Home Institution:** Northwestern University **Abstract: Background:** Pediatric cancer incidence varies by race and ethnicity, but the geographic distribution of these disparities remains poorly characterized. This ecological study aims to describe geographic variation in pediatric cancer incidence across racial and ethnic groups in the United States. Pediatric cancer incidence data (1999–2022) were obtained from the CDC WONDER *United States and Puerto Rico Cancer Statistics* database. Analyses included individuals aged 0–19 years and all 12 major diagnostic groups defined by the *International Classification of Childhood Cancer, Third Edition* (ICCC-3). Separate CDC WONDER queries were conducted for non-Hispanic White, non-Hispanic Black, and Hispanic populations because these groups provided sufficient case counts for reliable population-level estimates. Age-adjusted and crude incidence rates, case counts, standard errors, and 95% confidence intervals were extracted by state and Census division. This study will characterize geographic variation in pediatric cancer incidence by race and ethnicity and establish a reproducible framework for pediatric cancer surveillance using CDC WONDER. The findings may inform future investigations of geographic disparities and factors contributing to differences in pediatric cancer incidence.
82	**Shruti Balachander** *Analyzing the Association Between Ambient Temperature and the Incidence of Pediatric Cancer in Infants* **Advisor:** Michelle Roesler, Logan Spector, Cassandra Clark **Mentor:** Ryan Fahey **Sponsoring Program**: University of Minnesota Medical School, Department of Pediatrics, Division of Epidemiology and Clinical Research **Home Institution:** University of Minnesota Twin Cities **Abstract:** This study investigates the association between ambient heat exposure and the incidence of pediatric cancer in infants under one year of age in the United States. Despite pediatric cancer being the leading cause of disease-related mortality in children, infants remain underrepresented in epidemiologic analyses due to conventional age group aggregation in Surveillance, Epidemiology, and End Results (SEER) data. To address this gap, this study utilizes single-year incidence data from SEER (1975–2025) alongside county-level temperature metrics derived from NASA's Daymet dataset (1980–2025), enabling high-resolution temporal and spatial analysis. Heat exposure was quantified using a derived heat index incorporating vapor pressure, relative humidity, and ambient temperature through established meteorological metrics. A Poisson regression framework was utilized to evaluate associations between heat index and cancer incidence, with outcomes including leukemia, neuroblastoma, lymphoma, sarcomas, and central nervous system tumors. A systematic literature review supplemented the analysis, applying PECOS-based inclusion criteria to identify relevant observational studies. The literature searches revealed that higher heat index levels are associated with increased pediatric cancer incidence in infants. By integrating granular environmental and epidemiologic data, this research aims to clarify potential climate-related risk factors and contribute to understanding early-life environmental determinants of cancer.

83	**Blake A. Thackeray** *A GOLD Mine: Study Design and Population Characteristics of the Germ Cell Tumor Outcomes and Late Effects Data Study* **Advisor:** Dr. Jen N. Poynter, Michelle A. Roesler **Sponsoring Program**: Alex's Lemonade Stand Fund **Home Institution:** University of Minnesota Twin Cities **Abstract:** Pediatric germ cell tumor (GCT) survivors make up the third largest group of childhood cancer survivors. Due to the considerable number of survivors and the many long term effects of treatment, including hearing loss and neuropathy, there is a need to better understand the impact on patient quality of life and find new ways to predict which patients are most susceptible. The GCT Outcomes and Late Effects Data (GOLD) Study brings together these goals by building a cohort of GCT survivors and collecting medical, quality of life, and genetic information to better understand the late effects of this disease. To do this, participants were recruited from Children's Oncology Group protocols APEC14B1 and ACCRN07, developing a cohort of 764 participants, requesting they fill out a questionnaire (85.8% participation), provide a biological sample (89.4% participation), and complete an at-home hearing assessment (68.6% participation). Pilot results demonstrate higher average serum platinum concentrations in participants that had hearing loss after chemotherapy compared to those who did not ($p = 0.10$). Future directions will include providing patients, families and providers more information on the late effects and finding genetic variants linked to ototoxicity and methylation profiles that predict poor outcomes of treatment.
84	**Angela Sun** *Alphabet Soup for the Epidemiologist's Soul: Decoding Area-Level Metrics* **Advisor:** Dr. Erin Marcotte, Michelle A. Roesler **Sponsoring Program**: Carleton College Endowed Internship **Home Institution:** Carleton College **Abstract:** Health research increasingly relies on area-based composite indices for many reasons including individual-level socioeconomic metrics that fail to capture the multidimensional impacts of structural disadvantage on health outcomes. This literature review provides an evolving comparative framework that evaluates prominent area-based indices, focusing initially on six widely used tools: the Social Vulnerability Index, the Area Deprivation Index, Index of Concentration at the Extremes, Neighborhood Deprivation Index, Child Opportunity Index, and Yost Index, with ongoing analysis identifying additional indices for inclusion. We trace their conceptual origins, structural inputs, spatial resolutions, and weighting methodologies. Our analysis contrasts metrics that measure neighborhood hardship against those that measure community resources and economic segregation. Crucially, indices diverge in how they address factors, either incorporating demographics, isolating racialized-economic segregation, or deliberately omitting variables to evaluate physical environment independently. We highlight domain-specific applications across clinical medicine and public health while evaluating key methodological hurdles—such as temporal data lag, ecological fallacies, and urban versus rural accuracy.
85	**Noman Haque** *Charge Transfer and Conductivity in PANiCNQ* **Advisor:** Aaron Massari **Sponsoring Program**: UMN Chemistry- Lando/NSF Heisig **Home Institution:** University of Minnesota **Abstract:** I studied charge transfer and conductivity in PANiCNQ, a synthesized polymer from emeraldine base Polyaniline (PANi) and Tetracyanoquinodimethane (TCNQ). My goal was to synthesize an organic semiconductor, which would provide many advantages over traditional silicon. I used three techniques in my experimentation. FTIR, UV-Vis, and Conductivity testing. Key shifts in FTIR and UV vis alongside a nonzero slope in conductivity strongly support charge transfer and conductivity in PANiCNQ, and additionally its potential as an organic semiconductor. It is not yet as effective as traditional metal semiconductors, but provides promise for the future of organics in electricity and current potential in bio electronics and solar cells.

Teacher Poster Presentations
Listed Alphabetically by Presenting Author

Presenters should be at their posters at the following times:
2:30 – 3:30 even numbered posters
3:30 – 4:30 odd numbered posters

86.	**Cassandra Lydon** *Exploring Passive Daytime Radiative Cooling Through Porous Polymers: A Student Experiment in Climate-Conscious Materials Science* **Advisor:** Chris Ellison **Mentor:** Emily McGuiness **Sponsoring Program**: MRSEC **Home Institution:** White Bear Lake High School **Abstract:** Sustainable materials and climate technologies are becoming increasingly important topics in chemistry, yet students rarely encounter these emerging areas in undergraduate or high school laboratory courses. Additionally, polymer laboratory experiments emphasize synthesis and characterization, but do not demonstrate how processing influences material structure and functional properties. In this experiment, students fabricate porous and nonporous polylactic acid (PLA) films using different processing techniques and investigate their emissivity and reflectivity to relate pore structure to optical properties. They then connect their findings to passive daytime radiative cooling (PDRC) materials, an emerging technology for reducing cooling energy demands. During the 2025-2026 academic year, 15 students from White Bear Lake High School completed the experiment along with a pre- and post-assessment. Students demonstrated statistically significant gains in understanding core PDRC concepts, specifically the essential qualities for PDRC materials to function effectively and polymer processing techniques used to create light reflecting materials. Student feedback confirmed that the real-world sustainability context increased engagement and relevance. Aligned with Next Generation Science Standards (NGSS) and Minnesota Science Standards, this accessible experiment enables educators to introduce sustainable materials and technologies while reinforcing core principles in polymers, optical properties and structure-property relationships.
87.	**Jake Pundsack** *Why so Fe-w Phytoplankton? A Storyline-Driven Oceanography Unit for High School Classrooms* **Advisor:** Rene Boiteau **Mentor:** Anil Timilsina, Nicole Coffey **Sponsoring Program**: MRSEC **Home Institution:** University of Minnesota **Abstract:** The Southern Ocean has abundant nitrogen yet insufficient iron, limiting phytoplankton growth. Though many curricula have been designed to demonstrate the importance of nitrogen in algal growth, no secondary-level experiences exist to show the importance of micronutrients, such as iron, in nutrient cycling. This NGSS-aligned oceanography unit tested with Melrose High School 2025/26 biology students engages students in investigating John Martin's provocative claim that fertilizing the Southern Ocean with iron could draw down atmospheric carbon dioxide and induce a cooling event. Through a series of five lessons, students blend hands-on laboratory experimentation with digital data analysis. Using hemocytometers, students track phytoplankton population growth in response to iron fertilization. They then scale up their findings by analyzing global oceanographic datasets from the eGEOTRACES initiative to understand nutrient distributions, upwelling, and iron transport via atmospheric dust and hydrothermal vents. By integrating mathematical modeling, such as the 10% energy transfer rule, elementary stoichiometry, and the Redfield Ratio, students construct models of carbon and nitrogen cycling to critically evaluate the feasibility and ecological limits of ocean iron fertilization. This leads to a more authentic understanding of ocean ecosystems while promoting students to adopt an environmental engineering mindset.
88.	**Mia Troska** *An Introduction to Materials Science and Heat Transfer at the Middle School Level* **Advisor:** Vivian Ferry **Sponsoring Program**: MRSEC **Home Institution:** Westwood Intermediate and Middle School **Abstract:** This curriculum seeks to expose 6th grade students to materials science, a branch of STEM they are typically not familiar with, and to empower them with the ability to think critically about how textiles are made and the implications this has for a warming climate. One effective approach to engaging students in scientific learning is to connect content to topics that are relevant and meaningful to them. Clothing provides an accessible entry point for students of this level. Drawing on research from the Ferry Lab Group on light interactions with nanostructured materials, students will examine and analyze different materials and their interaction with infrared light. Students will examine a variety of textiles in different colors and observe the change in temperature these materials have when exposed to heat. After making quantitative measurements of surface temperature, they will develop a claim about what material would be best given a certain set of conditions. This curriculum demonstrates how materials science can contribute to more sustainable solutions and equips students with the scientific literacy needed to make informed decisions about the products they choose and the challenges posed by a warming climate.

89.	**Nita Worthley** *Decoding the Plastic Degradation Odyssey: A Novel High School Science Curriculum* **Advisor:** Boya Xiong **Mentor:** Sarah Ziemann **Sponsoring Program**: MRSEC **Home Institution:** North Branch Area High School **Abstract:** A novel curriculum is described for the secondary classroom setting based on the degradation of different types of plastics in different environments. The curriculum contains three modules that can be adapted to fit Next Generation Science Standards or the 2019 Minnesota State Science Standards. Module 1 contains an introduction to polymers and plastics chemistry. It includes resin codes, chemical structures, and characteristics of different plastic types, as well as an analysis on how chemical structure impacts the properties of the polymers. Module 2 is an inquiry-based experiment where students create an environment to test the degradation of different plastic types.This hands-on laboratory experience allows students to test and compare various degradation techniques, including photoweathering, mechanical abrasion, and biochemical degradation. Students collect and analyze experimental data with their classmates to evaluate how distinct physical and chemical properties of different plastic types influence environmental persistence. Module 3 contains an assessment using Claim/Evidence/Reasoning and a real-world application of the plastic cycle in the environment. This curriculum promotes critical thinking, peer collaboration, environmental literacy, and core scientific practices. Furthermore, the modules emphasize sustainability and biodegradable plastic alternatives, making environmental chemistry relevant while empowering students as informed environmental stewards.