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UNIVERSITY OF ROCHESTER  
SCHOOL OF ARTS & SCIENCES AND  
THE HAJIM SCHOOL OF ENGINEERING & APPLIED SCIENCES  
GRADUATE RESEARCH DAY  
**PARTICIPANT ABSTRACTS**

April 2nd, 2026

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## GRADUATE RESEARCH TALKS

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**Teona Taseska**

*Chemical Engineering*

“Next Generation Electrodes Based on Hydrophilic Carbon Fiber Paper”

The transition from energy-intensive chemical processes to ethical, sustainable, and climate-friendly technologies is driving the development of next-generation electrodes for electrocatalysis. Electrocatalytic systems powered by renewable electricity offer a promising pathway, but their performance depends critically on electrode materials. [1, 2] Carbon fiber paper (CFP) is attractive due to its conductivity, mechanical robustness, and porous three-dimensional architecture, yet its intrinsic hydrophobicity limits electrolyte wetting and active-site accessibility. The Müller group has developed a green chemistry process that imparts long-lasting hydrophilicity to CFP, overcoming this limitation and enabling broad applicability. [3] Binder-free hydrophilic CFP electrodes function as catalysts for oxygen reduction to hydrogen peroxide, providing a clean, cost-effective, and energy-efficient production route. In addition, hydrophilic CFP serves as a binder- and surfactant-free macroscopic support for pulsed laser grafting of nanoparticle catalysts, enabling strong catalyst–support interactions, improved electrical contact, and enhanced long-term stability. This strategy offers a streamlined and lower-cost route to manufacturing high-performance nanocatalyst composites on freestanding supports. Collectively, these advances establish hydrophilic CFP as a versatile electrode platform for next generation electrocatalysis and catalyst integration. [4, 5]

References:

- [1] Taseska, Yu, Wilsey, Meng, Cox, Ngarnim, Müller, *Top. Catal.* 2023, 66, 338.
- [2] Wilsey, Taseska, Meng, Yu, Müller, *Chem. Commun.* 2023, 59, 11895.
- [3] Wilsey, Watson, Fasusi, Yegela, Cox, Raffaele, Cai, Müller, *Adv. Mater. Interfaces* 2023, 10, 2201684.
- [4] Wilsey, Taseska, Lyu, Cox, Müller, *Beilstein J. Nanotechnol.* 2025, 16, 349.
- [5] Wilsey, Taseska, Schultz, Perez, Müller, *J. Phys. Chem. C* 2025, 129, 8730.

**Huang, Songsong**

*Social-Personality Psychology*

“Metamotivation: Joint effects of personal achievement goals and classroom goal climate”

Motivation research often assumes that outcomes depend on the joint effects of personal motivation and contextual factors. However, it remains unclear how laypeople understand such joint effects. From a metamotivational perspective, this research examined laypeople’s understanding of the interactions between students’ achievement goals and classroom goal climates. We focus on two types of achievement goals: a) mastery-approach (MAP) goals that focus on learning, improvement, and mastery, and b) performance-approach (PAP) goals that focus on outperforming others. Across two studies (Ns = 428, 437), participants evaluated the likelihood of academic and emotional outcomes across

four scenarios that varied student achievement goals and classroom achievement goal emphasis. Results revealed an asymmetry in laypeople's understanding of motivation-context fit. Participants consistently believed that the student with MAP goals would have favorable outcomes in a MAP focused classroom, indicating a matching effect: the student was rated as achieving and enjoying the class more, and cheating and experiencing anxiety less than in a PAP focused classroom. In contrast, no matching effect was observed for PAP goals. Together, these findings highlight the importance of understanding how lay beliefs about motivation are formed and how these beliefs may meaningfully shape educational judgments and motivation-related practices (e.g., motivation regulation).

### **Anushka Jain**

*Biology*

#### “Structural proteomics of the human ubiquitinome”

The proteasome maintains the integrity of eukaryotic proteomes by selectively degrading ubiquitinated protein substrates. Ubiquitination targets a wide range of substrates for degradation, including translationally stalled nascent chains, misfolded proteins, and properly folded but short-lived proteins destined for regulatory degradation. Distinct structural features and ubiquitination patterns across these classes of substrates remain largely undefined. In this study, we combine structural proteomics and time-resolved isotopic labeling to profile the modification sites, dynamics, and conformational properties of the human ubiquitinome. We show that proteins undergoing rapid proteasomal degradation are ubiquitinated at lysine residues that are normally buried within structured regions of their native conformations. We provide proteome-wide evidence that this high-flux subset of the ubiquitinome is enriched in newly synthesized proteins that have non-native conformations. Together, our findings demonstrate how the lack of structural integrity of misfolded nascent proteins influences their ubiquitination patterns and ensures proper proteasomal degradation.

### **Aida Gueye**

*Materials Science*

#### “Influence of A Metal Identity on Surface O-H Bond Dissociation Free Energy from Binary Oxides ( $A_xO_yH_z$ , $A = \text{Co, Fe, Ni, Zn}$ ) to Spinel Ferrite ( $A\text{Fe}_2\text{O}_4$ ) Nanoparticles”

Transition metal oxides are promising electrocatalysts for reactions with multiple proton coupled electron transfer (PCET) (i.e H atom transfer (HAT)) steps, such as the oxygen evolution reaction (OER) and oxygen reduction reaction (ORR). The activity of these electrocatalysts is often correlated with their metal-oxygen (M-O) bond strengths in volcano plots constructed from computational studies of pristine materials, which often fail to capture the chemical and structural complexity of metal oxide surfaces. The surface O-H bond dissociation free energy (BDFE) is a potential experimental descriptor for the capability of a metal oxide to participate in HAT reactions. In this talk, we explore how the identity of the A metal in binary oxides ( $A_xO_yH_z$ ,  $A = \text{Co, Fe, Ni, Zn}$ ) and spinel ferrite ( $A\text{Fe}_2\text{O}_4$ ) nanoparticles influences their surface O-H BDFE determined using aqueous open circuit potential measurements. Our results primarily show that the BDFE in binary oxides correlates with the d electron count of the A metal to form a volcano plot that peaks at Co (d7). Such correlation is significantly attenuated for the spinel ferrites, indicating that Fe dominates the surface reactivity.

**Ashley Labodda***Philosophy***“Big Brother: Journalism, Education, and Democracy”**

Journalism is an essential part of a democracy. Traditionally, the institution of journalism is considered separate from governmental, financial, and educational institutions. Contrary to this division, I demonstrate that the important aims of journalism are aligned with those of education by considering the role of both journalism and education in maintaining a democratic public. Thus, I argue the institution of journalism is a part of the institution of education in a democracy. I first offer some of the important epistemic, social, and political aims of both institutions in a democracy and establish their overlap. Following this discussion, I then consider what this educational role ought to look like in practice drawing on the philosophy of education and virtue epistemology. I offer an argument that journalists and the larger institution of journalism are analogous to a big brother. Different from the role of “Big Brother” in George Orwell’s novel 1984, journalists, and the media, are epistemic role models for the democratic public akin to the use of epistemic role models in education. I then discuss some practices that could help journalism accomplish or potentially abuse this role and conclude by addressing the anticipated charge of paternalism.

**Irin Aby***Chemistry***“Metal Organic Frameworks for PFAS Capture and Abatement”**

Per- and polyfluoroalkyl substances (e.g., PFOA, PFHxA, GenX, PFOS) are a range of chemicals with unique thermal and chemical properties. Being utilized in a wide range of industries, these recalcitrant chemicals pose a threat due to their xenobiotic nature. Accordingly, there is a pressing need for materials that can mediate the selective capture and degradation of these chemicals from aqueous systems. This proposal addresses this challenge through using a class of sorbent materials known as metal–organic frameworks (MOFs); specifically, the capture of perfluorooctanoic acid (PFOA) using two zinc-based MOFs. Uptake of PFOA has been monitored using techniques like <sup>19</sup>F NMR and LC-MS. These MOFs capture PFOA at low concentrations (parts per billion) from water and degrade PFOA into carbon dioxide and an alkane byproduct at fairly low temperatures. The work also focuses on efforts to regenerate the material after adsorption and insights into the mechanisms of PFOA degradation.

**Adam Roberts***Political Science***“Beyond Borders: Evaluating the Efficacy of Sub-National Informational Comparisons”**

Assessing the performance of incumbent politicians can be difficult for voters. Most easily observable performance indicators are noisy measures of the effort put in by a politician to work towards their campaign promises. Comparisons to other incumbent politicians may control for some of this noise, but little research has been done to understand what comparisons are most important to voters. I propose a survey experiment that experimentally tests different informational comparisons to shed light on how voters think about these comparisons. In the same survey, I propose asking respondents to directly identify the municipalities they consider most relevant for comparison to their own municipal president. The study will provide experimental evidence to guide the selection of comparisons in informational campaigns and will offer insight into how voters process electoral information.

**Sydney Louden***Geosciences*

“Aerobic methane oxidation in the Great Lakes: Investigating the controls on methane removal in the world's largest group of lakes”

Freshwater systems are globally significant, natural sources of methane to the atmosphere. However, the North American Great Lakes, the largest liquid freshwater system by area, emits relatively small amounts of methane to the atmosphere, indicating the presence of an effective removal process. Aerobic methane oxidation by methanotrophic bacteria in lake water columns can remove methane, thereby limiting the atmospheric emission of this greenhouse gas from lake surfaces. This process is an important control on lake-atmosphere methane flux, but what determines the rate and capacity of methane removal by methanotrophic bacteria in these lakes is not well understood. This research investigates the individual and combined effects of several biogeochemical parameters, including temperature, methane concentration, and nutrients, on aerobic methane oxidation rates. The Great Lakes system has natural variations in these biogeochemical parameters, so our experiments take advantage of this natural gradient, in addition to laboratory manipulations of these parameters. This talk will explore the dominant controls on methane oxidation in each of the five Great Lakes and the Great Lakes system as a whole. In addition to determining what factors explain observed rates of methane oxidation, this talk will also explore how methane oxidation responds to changes in temperature and methane and nutrient concentrations. Climate change is already and will continue altering biogeochemical conditions in the Great Lakes, so it is important to understand the impact these changes could have on methane removal in the world's largest group of freshwater lakes.

**Hamed Ajorlou***Electrical Engineering*

“BUILD with Precision: Bottom-Up Inference of Linear DAGs”

Learning the structure of directed acyclic graphs (DAGs) from observational data is a central problem in causal discovery, statistical signal processing, and machine learning. Under a linear Gaussian structural equation model (SEM) with equal noise variances, the problem is identifiable and we show that the ensemble precision matrix of the observations exhibits a distinctive structure that facilitates DAG recovery. Exploiting this property, we propose BUILD (Bottom-Up Inference of Linear DAGs), a deterministic stepwise algorithm that identifies leaf nodes and their parents, then prunes the leaves by removing incident edges to proceed to the next step, exactly reconstructing the DAG from the true precision matrix. In practice, precision matrices must be estimated from finite data, and ill-conditioning may lead to error accumulation across BUILD steps. As a mitigation strategy, we periodically re-estimate the precision matrix (with less variables as leaves are pruned), trading off runtime for enhanced robustness. Reproducible results on challenging synthetic benchmarks demonstrate that BUILD compares favorably to state-of-the-art DAG learning algorithms, while offering an explicit handle on complexity.

**Yasaman Baghban***Visual & Cultural Studies*

“Censorship and the Formation of Underground Cinema in Contemporary Iranian Cinema”

Contemporary Iranian non-mainstream cinema exists within a distorted ecosystem shaped by censorship, a system of production and screening permissions, contradictory Islamic cinematic regulations, and the politics of international funding and film festivals. Within this ecosystem, an ongoing confusion around the definition of underground cinema has contributed to a situation in which global visibility is increasingly structured by political legibility rather than by cinematic innovation or formal complexity alone. The state's arbitrary and inconsistently enforced regulations force filmmakers into artificial positions such as compliance, symbolic resistance, or strategic ambiguity, while international festival economies often reinforce these dynamics. Together, these forces marginalize some non-mainstream films made inside Iran and weaken the conditions necessary for sustaining authenticity and artistic integrity in Iranian cinema. Focusing on feature narrative films, this paper historicizes Iranian cinema from the emergence of the New Wave in the 1960s through the post-revolutionary reconfiguration of censorship and the rise of internationally recognized cinema after 2000. It then turns to the period following the Woman, Life, Freedom movement in 2022 and argues that recent underground filmmaking represents a shift away from negotiation and self-censorship toward refusal. In this new context, filmmakers abandon the logic of permission altogether. This transformation reveals the political, material, and ethical limits of filmmaking under authoritarian rule.

### **Karishma Ramesh**

*Chemistry*

#### “Structural Effects of Two Mini-Proteins for Photochemical CO<sub>2</sub> Reduction in Water”

Nature has mastered the art of CO<sub>2</sub> reduction through photosynthesis, where plants efficiently harness sunlight to reduce CO<sub>2</sub> into energy-rich organic molecules. Despite significant advances in catalysis, replicating this process remains a major challenge due to the inherent thermodynamic and kinetic barriers to CO<sub>2</sub> activation. In this context, biomolecular catalysts offer an exciting nature-inspired approach, as they employ the active site architecture and secondary coordination environments of natural enzymes to enable selective transformations under mild conditions. Inspired by this principle, we compare how proton donor identity and availability govern photochemical CO<sub>2</sub> reduction pathways in two cobalt-substituted metalloproteins, cobalt mimochrome VIa (CoMC6\*a), a synthetic mini enzyme and a cobalt-substituted microperoxidase-11 derivative (CoMP11), which provides distinct biomolecular environments around an identical cobalt porphyrin center. Paired with [Ru(bpy)<sub>3</sub>]<sup>2+</sup> as a photosensitizer, CoMC6\*a and CoMP11, demonstrates selective CO production in optimized conditions, achieving turnover numbers of up to 1000 and 4700 respectively. This poster presents activity of these protein catalysts with a parallel aim of understanding the factors that influence their catalytic selectivity. Specifically, we demonstrate how variables such as pK<sub>a</sub> of the exogenous proton donor, light intensity, and the concentrations of key system components affect the catalytic behavior to control selectivity of CO over H<sub>2</sub> production. In parallel, this work also demonstrates mechanistic studies to elucidate the proton coupled electron transfer (PCET) pathways leading to each product, providing molecular-level insight into how the interplay between catalyst structure, redox dynamics, and proton availability dictates product distribution in aqueous photochemical CO<sub>2</sub> reduction.

## GRADUATE RESEARCH POSTERS

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**T M Tariq Adnan**

*Computer Science*

“Multimodal Remote Digital Phenotyping for Detecting and Tracking Early Parkinsonian Change in LRRK2 Carriers”

**Background:** Early identification of prodromal Parkinson’s disease (PD) in LRRK2 carriers is critical for neuroprotective trials yet remains a central challenge. Remote digital phenotyping offers a scalable solution to detect subtle motor deficits prior to clinical diagnosis. Here, we present a remote, multimodal video framework designed to address two key challenges in the LRRK2 G2019S population: identifying high-risk carriers and tracking the onset of disease.

**Methods:** We curated a multimodal dataset of 829 participants, including 158 LRRK2 G2019S carriers (122 non-manifest, 36 manifest) from the longitudinal VALOR-PD study, alongside 100 PD patients and 571 controls. Participants completed standardized webcam-based tasks: bilateral finger tapping, smile expression, and a pangram utterance. We employed a dual-modeling approach: first, we adapted UFNet—a multimodal fusion architecture—as a binary classifier to distinguish non-manifest carriers from controls. Second, we developed PD Weigh-In, a continuous severity metric trained to estimate Parkinsonian motor burden (MDS-UPDRS Part III).

**Results:** The UFNet model distinguished non-manifest carriers from controls with 92% accuracy (AUROC 0.94, AUPRC 0.84). Calibration analysis demonstrated highly reliable uncertainty quantification (“traffic light” stratification), where low-uncertainty predictions achieved 96.8% accuracy. In parallel, the continuous PD Weigh-In score demonstrated strong validity, achieving a Pearson correlation of  $r=0.88$  on the general independent test set and  $r=0.74$  (Spearman  $\rho=0.76$ ) specifically within the held-out LRRK2 test cohort. Notably, longitudinal analysis captured clinical decline in two carriers who subsequently developed PD, mirroring the trajectory of clinically observed worsening.

**Conclusions:** These findings validate a scalable, objective digital biomarker for risk stratification and longitudinal monitoring. By combining accurate screening with sensitive progression tracking, this framework offers a low-burden solution to support prodromal clinical trials.

**Nimmy Sarah Alex**

*Physics*

“Ghost in the Machine: Neutrino Interactions Without Nuclear Rupture”

Neutrinos are the universe’s most elusive messengers. Every second, 100 trillion of these ‘ghost particles’ stream through your body, yet they rarely interact with matter. To capture them, we use massive detectors like MINERvA — a massive, fine-grained detector designed to capture and identify the subatomic debris left behind when a neutrino finally strikes a nucleus.

This study explores a rare event: Neutral Current (NC) Coherent Pion Production. While most interactions shatter a nucleus, in this channel a neutrino communicates with the entire nucleus as a single, unified entity via the weak force.

The nucleus remains in its ground state — completely unruptured — while a single, high-energy particle called a neutral pion is shaken into existence and ejected forward.

Why does this matter? For flagship experiments like DUNE, which seek to explain why the universe is made of matter rather than antimatter, these coherent pions are a double-edged sword. They can perfectly mimic the signals of rare neutrino oscillations, creating a noise (background) in the detector and mislead our judgment. By mapping this cross-section at MINERvA, we are providing ways to quantify these noises accurately, ensuring that when we finally solve the mysteries of the early universe, we aren't being fooled by a 'ghost in the machine'.

### **Brennan Arnold**

*Physics*

“The microscopic physics of freezing stars”

When stars like the sun run out of fuel and die, they collapse into hot white dwarf (WD) stars. Over billions of years, these stars cool and eventually freeze into crystals. The freezing process seemed simple until astronomical surveys became powerful enough to see that stellar evolution theories were wrong, and some WD cool and freeze more slowly than expected. Recently, it was proposed that the disagreement between theory and observation is caused by unexpected large amounts of neon that can heat the stars from the inside by settling downwards into the core. This neon distillation hypothesis is compelling, but its fundamental assumption has never been verified. Somehow, the neon must segregate from the bulk stellar material upon freezing so it can flow down to the core and release energy. Since the mechanism of this segregation is unknown, we use advanced molecular dynamics techniques to simulate freezing at a microscopic level. The resolution of our simulations is orders of magnitude finer than the standard macroscopic models of WD cooling; we model the formation of single crystals containing hundreds of atoms. We calculate the rate that crystals can form in WD and observe the composition of those crystals. By studying these stars on an atomic scale, our simulations provide a new microphysical grounding for WD cooling theory.

### **Noah Bader**

*Chemistry*

“Bi-Directional Peptide Design: Investigating Chirality and Backbone Flexibility in Supramolecular Self-Assembly”

Peptidic supramolecular self-assemblies have long been exploited due to their potential as biomaterials and therapeutics making them a valuable research interest. Amphipathic sequences – alternating hydrophobic and hydrophilic residues – have been known to strongly self-assemble into secondary structures making them strong targets for research. To further investigate the structures and properties that can be achieved via self-assembly, we have designed 3 unique multi-directional sequences to observe the effects that chirality and backbone flexibility have on the self-assembly propensity of peptides. Conventionally peptides are designed unidirectionally (N-terminus to C-terminus); herein, we explore the synthesis and potential of two amphipathic tetramers coupled via a succinimide or glutaramide linker at the respective N-terminus of each fragment. Self-assembly of these peptides are compared to unidirectional control peptides with similar sequences in order to understand the impact of bi-directional peptides in the context of self-assembly processes. Preliminary spectroscopic analysis indicates that the first bi-directional peptide with a succinimide linker (NH<sub>2</sub>-FEFK-suc-EFKF-NH<sub>2</sub>) along with the unidirectional control (Ac-FEFK-βA-EFKF-NH<sub>2</sub>) forms a β-sheet secondary structure. Transition Electron Microscopy shows that the multi-directional peptide shows distinct morphologies unlike that of the conventional N→C directional peptides. Further investigation on other bi-directional variants with

glutaramide linkers, L/D tetramers and their controls are ongoing to elucidate the impact that chirality, and backbone flexibility could have on the supramolecular self-assembly properties.

### **Charles Chimera**

*Electrical Engineering*

#### “Detection of Chemical Treatment and Frequency Filtering in Multilayer Copy Paper Samples Using Terahertz Time-Domain Spectroscopy”

Terahertz (THz) radiation is non-ionizing electromagnetic radiation, with frequencies between microwaves and infrared light. Its unique interaction with matter allows the characterization of samples based on their intrinsic spectral response. Utilizing THz time-domain spectroscopy (THz TDS), it is possible to directly measure a material’s absorption coefficient and refractive index; properties that act as substance “fingerprints”, allowing them to be distinguished and detected without the need for sample destruction or chemical preparation. This work examines multilayer treated and untreated paper samples to show distinct absorption features for hemp oil treatments on copier paper, as well as the rise of standing waves created from the multilayer sample structure which acts as a frequency filter. Both three and five sheet stacks were measured. For hemp oil treated paper, there were distinct absorption peaks in the 0.25 – 0.6 THz range. For untreated paper, there were multiple broad absorption peaks with nearly identical peak widths from standing wave modes acting as frequency filters. This work shows the ability of THz TDS to resolve chemical and structural differences in common materials. Outside of fundamental spectroscopy, these observations highlight potential applications in non-destructive testing, security screening, and chemical threat detection. These applications align with NATO’s ongoing initiatives in chemical, biological, radiological, and nuclear (CBRN) defense for NATO populations.

### **Madeline Every**

*Geosciences*

#### “A Low-Cost, Automated, and Adaptable System for Field-Based Measurement of PCO<sub>2</sub>, PCH<sub>4</sub>, and Associated Variables in Groundwater”

The Groundwater Automated Chemical Examiner (GrACE) is an automated analytical system of integrated sensors for the field-based measurement of chemical and physical properties of groundwater. The GrACE system was designed to explore parameters influencing the dissolved concentrations of carbon dioxide (pCO<sub>2</sub>) and methane (pCH<sub>4</sub>) in groundwater, incorporating one of two equilibrator designs to measure dissolved gas partial pressures. The pCO<sub>2</sub> sensor has an operating range of 200–100,000 uatm with an accuracy of 17% and a precision of 27.5%, while the pCH<sub>4</sub> sensor has a range of 800–8000 uatm and an accuracy of 3% and a precision of 3.2%, over a month-long measurement campaign without recalibration. The e-folding response times to changes in pCO<sub>2</sub> and pCH<sub>4</sub> are 41.7-50.3 s and 103-173 s, respectively. Field trials using the GrACE system found fluctuations in CO<sub>2</sub> and CH<sub>4</sub> over 1270 and 12 umol/L, respectively, in a 24-h period correlated with variability in groundwater volume. This reveals that the response times of the system are >30 times shorter than measured environmental variations. Complementary measurements of water temperature, electrical conductivity, pH, turbidity, water depth, and dissolved oxygen are also recorded. The GrACE system uses open-source code and relatively low-cost, low-power 5V sensors, with several being “plug-and-play,” enabling modifications to the design presented here and enabling deployments in remote locations lasting weeks to

months using solar powered batteries so both short-term (hours to days) and longer-term (seasonal) processes can be explored.

**Eloise Fadiel**

*Biomedical Engineering*

“PRDM16 Coordinates Genetic and Epigenetic Programs Governing Chondrogenesis and Chondrocyte Phenotype Specification in the Knee Joint”

Cartilage development and homeostasis require precise regulation by transcriptional and epigenetic networks. PRDM16 is a transcription factor containing zinc finger domains that enable protein-DNA and protein-protein interactions, as well as domains with the capacity for histone methyltransferase activity. However, the detailed molecular mechanisms by which PRDM16 regulates chondrogenesis and chondrocyte identities remain largely unknown. Using our osteochondral lineage-specific, conditional knockout mouse model (Col2a1Cre;Prdm16flox/flox, Prdm16 cKO), we found that loss of Prdm16 in osteochondral lineage cells delays, but does not fully inhibit, endochondral ossification and bone formation in the knee joint. Furthermore, Prdm16 cKO male mice exhibit comparable OA severity between injured and non-injured joints, suggesting that PRDM16 may exert a chondroprotective function. In our hiPSC-derived chondrocyte model, we observed significantly reduced pellet size and DNA content in cells with modulated PRDM16 expression compared to Control, implying a link between PRDM16 and chondrocyte viability. Integrated analysis of single cell RNA-sequencing and CUT&RUN-sequencing revealed that PRDM16 regulates chondrocyte cell fate decisions by altering chromatin accessibility and DNA binding at promoter/enhancer regions of genes essential for chondrogenesis and chondrocyte hypertrophy. Indeed, PRDM16 governs the expression of key chondrogenic regulators including SOX9, ARID5A, SMOC2, HAND2, and hypertrophic driver MEF2C. Overall, our results provide evidence that PRDM16 serves as an essential genetic and epigenetic regulator of chondrogenesis and chondrocyte phenotype specification in the knee joint through DNA binding and by modulating H3K4me3 histone mark deposition.

**Xingzhong Fan**

*Computer Science*

“SEEDSCAN: Interactive Brain Region Discovery over Voxel-level Correlation”

We present SEEDSCAN, an interactive system for seed-driven region discovery in functional magnetic resonance imaging (fMRI) data. SEEDSCAN allows users to identify compact, spatially contiguous functional regions associated with a given seed region based on voxel-level correlations. SEEDSCAN formulates region discovery as a spatially constrained set optimization problem and employs heuristic search with pruning to focus on seed-related candidate regions without whole-brain enumeration. The system supports interactive visualization, configurable region discovery, and user-in-the-loop iteration. Discovered regions can be inspected through summary statistics and visualizations, and exported for downstream analysis. Video: <https://youtu.be/r0-gSTmzrKc>

**Erfan Farhadi**

*Computer Science*

“Beetrap-MC: A Minecraft-Based AI Literacy Tool for Teaching Filter Bubbles to Middle School Students”

Recommendation systems shape much of what people, including youth, encounter online, influencing their exposure to information and ideas. Understanding their workings and potential downsides, such as filter bubbles, is increasingly important. At the same time, Minecraft remains one of the most popular and accessible game platforms among students worldwide, making it a promising medium for AI literacy outreach. Building on a previous in-person augmented reality application called BeeTrap, in which players, acting as bees, pollinate flowers and see how similar choices narrow their environment, we created BeeTrap-MC, a Minecraft-based version aimed at broader reach and accessibility. Unlike the original facilitator-led group workshop, BeeTrap-MC is designed for students individual playthrough. We conducted a study with nine middle school participants, using pre-/post-assessments and qualitative interviews to evaluate its effectiveness. Results showed significant learning gains in key AI concepts, such as understanding filter bubbles and their consequences. We also discuss key differences in design, usability and outcomes between BeeTrap-MC and the original, reflecting on trade-offs in adapting a group-based embodied experience into a shorter, self-guided digital format.

**Sergio E. Garcia-Hernandez**

*Biomedical Engineering*

“Role of Cell-Matrix Mechanical Communication During Lumen and Tubule Formation”

Lumen formation is a fundamental step in embryonic development. Lumenogenesis is the process of generating internal cavities lined by epithelial cells that compartmentalize tissue function. Defects in lumen morphogenesis during embryogenesis can lead to vascular and neurodevelopmental congenital diseases. While extracellular matrix (ECM) cues are known to regulate apical–basal polarity and lumen positioning, how ECM mechanical properties dynamically interface with focal adhesion (FA) signaling to balance external forces with epithelial contractility during lumen formation and expansion remains poorly understood. FA signaling allows integrins to transmit mechanical and biochemical cues between the ECM and the actin cytoskeleton. To address this gap, we will use Madin–Darby Canine Kidney (MDCK) cells, which form spherical cysts in Matrigel and undergo tubulogenesis upon hepatocyte growth factor (HGF) stimulation. We will combine 3D epithelial culture models with optogenetic tools based on the iLID–SspB system fused to Talin-1 and Kindlin-2 to achieve spatiotemporal control of FA formation through light-induced activation. Using live cell and embryo confocal imaging, we will test how optogenetic FA activation alters lumen size, shape, and polarity. By varying light patterns and timing, we will determine how spatial and temporal adhesion dynamics regulate cytoskeletal tension and ECM remodeling. Extending these studies to tubulogenesis in vivo, we will apply patterned light stimulation during branching morphogenesis and assess conserved mechanisms in *Drosophila* tracheal development. We hypothesize that optogenetic, spatiotemporal activation of focal adhesions through Talin-1 and Kindlin-2 recruitment regulates the balance between ECM-derived forces and epithelial contractility, thereby controlling lumen and tubule size, shape, and polarity.

**Tanya Garg**

*Clinical Psychology*

“Skin Conductance in Trauma and PTSD: A Systematic Review of Clinical Outcomes and Experimental Paradigms”

Individuals with trauma exposure and post-traumatic stress disorder (PTSD) have been known to display changes in arousal, prompting interest in biomarkers such as skin conductance (SC). Yet a qualitative comparison of SC findings related to the nature of this dysfunction across those with PTSD, trauma-exposed healthy controls (TEHC), and trauma-naïve healthy controls (TNHC) remains limited. This systematic review synthesized SC outcomes across 41 studies to clarify the physiological profiles of the three aforementioned participant groups across various experimental paradigms that used trauma-related stimuli. The most consistent finding was heightened autonomic reactivity, as indexed by skin conductance level and skin conductance response, to trauma-related stimuli, but not trauma-unrelated stimuli, for PTSD and TEHC groups. Findings regarding the physiological profiles of individuals with PTSD and TEHC were mixed, such that an approximately equal number of studies demonstrated significant group differences compared to those that did not. Results further indicated that TNHC generally differ from individuals with PTSD on SC measures, but not from TEHC. Additionally, most studies used symptom evocation tasks, specifically script-driven imagery, to study SC outcomes. Still, there was substantial methodological heterogeneity across studies. This review highlights both the value and limitations of SC in trauma and PTSD research, and provides recommendations for more precise future investigations.

### **Shruti Ghosh**

*Chemistry*

#### “Low-Molecular-Weight Phenylalanine Hydrogels as Antibacterial Agents”

Low-molecular-weight (LMW) hydrogels are comprised of supramolecular networks formed in aqueous media due to the self-assembly of small organic molecules. Amino acid-derived LMW hydrogels have emerged as next-generation biomaterials for several applications such as localized therapeutic delivery, tissue engineering, antimicrobials, wound healing, and regenerative medicine. Phenylalanine functionalized hydrogels are mostly studied due to their biocompatibility and unique self-assembly properties. We have previously designed a series of cationic phenylalanine derivatives with fluorenylmethyloxycarbonyl (Fmoc) at the N-terminus and diaminopropane (DAP) at the C-terminus for developing LMW hydrogels. These cationic derivatives are soluble in water and self-assemble to form hydrogels in the presence of screening counterions. These hydrogels have ideal properties for biological applications. Herein, we explore the potential applications of these hydrogels as inherent antibacterial agents for development of novel therapeutics as alternatives of antibiotics.

### **Masum Hasan**

*Computer Science*

#### “HAL: Inducing Human-likeness in LLMs with Alignment”

Conversational human-likeness plays a central role in human-AI interaction, yet it has remained difficult to define, measure, and optimize. As a result, improvements in human-like behavior are largely driven by scale or broad supervised training, rather than targeted alignment. We introduce Human Aligning LLMs (HAL), a framework for aligning

language models to conversational human-likeness using an interpretable, data-driven reward. HAL derives explicit conversational traits from contrastive dialogue data, combines them into a compact scalar score, and uses this score as a transparent reward signal for alignment with standard preference optimization methods. Using this approach, we align models of varying sizes without affecting their overall performance. In large-scale human evaluations, a model aligned with HAL is more frequently perceived as human-like in conversation. Because HAL operates over explicit, interpretable traits, it enables inspection of alignment behavior and diagnosis of unintended effects. More broadly, HAL demonstrates how soft, qualitative properties of language--previously outside the scope for alignment--can be made measurable and aligned in an interpretable and explainable way.

**Karine Holmes**

*Geosciences*

“Deconstructing Signals from the Coastal Carbon Cycle”

Coastal regions host ~20% of marine primary production and influence biogeochemical cycles on a global scale. Yet, their inclusion in marine carbon budgets remains complicated. One key metric with significant uncertainty in coastal regions is carbon export originating in surface waters. Since export-impacting processes (e.g. production, resuspension) can converge in the shortened coastal water column, well-established open ocean export methods, such as  $^{238}\text{U}$ - $^{234}\text{Th}$  disequilibrium and sediment traps, often find larger apparent export at depths where  $^{234}\text{Th}$  and particulate organic carbon (POC) fluxes should be low. To determine the drivers of these deep  $^{234}\text{Th}$  fluxes and isolate surface biological export, we employed a novel combination of methods including size-fractionated high-volume pumping, a novel resuspension proxy (RAp $^{234}$ ), and a 1-D biogeochemical model to consider factors that could be influencing  $^{234}\text{Th}$  budgets. Results from our first investigation in the Gulf of Maine are in agreement with previous studies and show pronounced, full water column deficits of  $^{234}\text{Th}$  relative to its parent  $^{238}\text{U}$ , suggesting carbon export could persist below the euphotic zone. However, our model-data comparisons reveal that deep  $^{234}\text{Th}$  deficits cannot be explained by surface export alone, and RAp $^{234}$  results indicate the presence of resuspension at depth. To further explore these findings and evaluate the potential for resuspension scavenging, we extend this approach to include the longer-lived  $^{234}\text{U}$ - $^{230}\text{Th}$  isotope system and a modeled resuspension process, with the goal of providing a new estimate of coastal POC export without the influence of bottom processes. To further refine our methodology, we will expand this work and investigate additional coastal sites by integrating observational data with modeling techniques to deepen our understanding of the factors contributing to thorium flux and inform future modeling efforts seeking to assess coastal zones globally.

**Jinfa (Jerry) Huanag**

*Computer Science*

“SpecEyes: Accelerating Agentic Multimodal LLMs via Speculative Perception and Planning”

Agentic multimodal large language models (MLLMs) (e.g., OpenAI o3 and Gemini Agentic Vision) achieve remarkable reasoning capabilities through iterative visual tool invocation. However, the cascaded perception, reasoning, and tool-calling loops introduce significant sequential overhead. This overhead, termed agentic depth, incurs prohibitive latency

and seriously limits system-level concurrency. To this end, we propose SpecEyes, an agentic-level speculative acceleration framework that breaks this sequential bottleneck.

Our key insight is that a lightweight, tool-free MLLM can serve as a speculative planner to predict the execution trajectory, enabling early termination of expensive tool chains without sacrificing accuracy. To regulate this speculative planning, we introduce a cognitive gating mechanism based on answer separability, which quantifies the model's confidence for self-verification without requiring oracle labels. Furthermore, we design a heterogeneous parallel funnel that exploits the stateless concurrency of the small model to mask the stateful serial execution of the large model, maximizing system throughput.

Extensive experiments on V\* Bench, HR-Bench, and POPE demonstrate that SpecEyes achieves 1.1-3.35x speedup over the agentic baseline while preserving or even improving accuracy (up to +6.7%), boosting serving throughput under concurrent workloads.

### **Lucy Huffman**

*Chemistry*

“Light and dark reactivity of a room temperature stable, high-spin iron(IV)-oxo”

The Barnett group's cavitand-inspired tris(amidate)amine ligand allows for the isolation of the most kinetically stable high-spin Fe(IV)-oxo reported to date. We have previously reported on the reaction of this complex with 2,4,6-tri-tert-butylphenol. Here, we expand the substrate scope and discuss targeted mechanistic studies of proton-coupled electron transfer (PCET). Furthermore, our group has begun investigating light-promoted C–H activation. In both cases various spectroscopic techniques are employed to determine the light and dark mechanisms and identify the products of these reactions.

### **Lauren Hutson**

*Clinical Psychology*

“Child maltreatment and accelerated brain aging in mid-adulthood: a prospective investigation”

Child maltreatment (CM) disrupts neurodevelopment and may affect later-life health through accelerated neurobiological aging. Brain age models index deviations from normative structural aging. Prior studies examining CM and brain aging are limited by cross-sectional designs and restricted sociodemographic diversity. We examined prospective associations between CM, global brain aging, and regional brain structure. Participants from this study (N=39; Mage=35.2; 63% female) were drawn from a longitudinal cohort in which participants were enrolled in childhood (Mage=9 years). In childhood, all participants were living <200% of the federal poverty line and 59% had experienced Child Protective Services records of CM exposure. In mid-adulthood, eligible participants completed structural MRI. Brain-predicted age was estimated using the brainageR algorithm, with residualized brain age gap (brainAGE) scores adjusted for chronological age. Cortical thickness from regions implicated in age-related brain disease was extracted using FreeSurfer and summarized by a single, previously studied neural signature. Sensitivity analyses

incorporated adult retrospective self-reported CM. Results indicated a small-medium sized difference between those with and without CM exposure that was non-significant and indicative of greater accelerated aging among those with CM exposures. CM was not significantly associated with the brain disease neural signature, although adults with CM history demonstrated significant cortical hypertrophy in the rostral middle frontal gyrus. Findings suggest CM-related neurobiological aging in mid-adulthood and underscore the need to identify circuit-level signatures of accelerated aging following CM. Despite modest sample size, by leveraging a socioeconomically high-risk longitudinal cohort and multi-method CM assessment, this study addresses key methodological gaps and strengthens inference.

**Vartika Jaiswal**

*Chemistry*

“Controlling Ion Transport via Oriented MOF Thin Films Modified Electrodes”

Electrocatalysts are a class of catalysts used to modify rates of electrochemical reactions. Facile interactions between electrocatalysts, electrode surface, and reactive species lead to efficient and selective reactions. Current heterogeneous electrocatalysts suffer from non-uniform distribution of active sites of the catalysts on the electrode surface (also known as a non-uniform electrocatalyst microenvironment) and poor mass transport control. Lack of uniformity in active site distribution hinders both efficiency and reaction selectivity. Careful control of the electrocatalyst microenvironment mitigates the non-uniformity of the active sites and facilitates mass transport control. As such, my research focuses on designing well-defined electrocatalyst microenvironments for improving the efficiency and selectivity of select electrochemical reactions.

Metal–organic frameworks (MOFs) are a class of porous materials that are crystalline extended frameworks with porosity, structure, and properties that can be tuned to meet specific applications. MOF thin films are attracting interest as membranes for ion transport, separation, and sieving, with pore orientations controllable through synthetic design. Oriented MOF thin films perform better at ion and molecular transport and separation than randomly oriented MOF powders due to their ordered, well-defined nature. Accordingly, oriented MOF thin films grown on electrode surfaces would provide transport channels for better mass transport for electrocatalysts to the electrode surface. Moreover, the pores in the frameworks have well-defined aperture size that can offer size-selective transport of ions and molecules. Readily tunable pore functionalization also allows for interaction-based ion and molecular separation.

Here, I will discuss using MOFs as electrocatalyst microenvironment.

**Alex Jasko**

*Geosciences*

“High-Pressure Electrical Conductivity Estimates for Ferropericlase and Implications for Dynamo Generation in Earth-Like Basal Magma Oceans”

Rocky planets are assembled through impacts between progressively larger planetesimals as these collisions combine rocky material together to eventually reach the size of planets today. This phase of planetary evolution is very energetic and melts the silicate mantle, forming a magma ocean that can reach high pressures, up to 130 GPa in Earth-sized bodies. The properties of these high-pressure magma oceans are not fully constrained but play a pivotal role in the origin of life by buffering the composition of planetary atmospheres through degassing and by producing magnetic fields through

the convection of electrically conductive magma. Magnetic fields are paramount in protecting planetary atmospheres and life as they deflect cosmic rays and solar winds that strip atmospheres and harm living organisms. Through the use of laser-driven shock compression experiments conducted at the University of Rochester's Laboratory for Laser Energetics, I aim to determine the electrical conductivity of Fe-rich (Mg,Fe)O, with compositions between 7 to 40 mol% FeO, to study whether a basal magma ocean at Earth's core mantle boundary pressure is capable of producing its own magnetic field and studying how this magnetic field would influence the origin of life on Earth.

### **Liuyuan Jiang**

*Electrical Engineering*

#### “Beyond Value Functions: Single-Loop Bilevel Optimization under Flatness Conditions”

Bilevel optimization, a hierarchical optimization paradigm, has gained significant attention in a wide range of practical applications, notably in the fine-tuning of generative models. However, due to the nested problem structure, most existing algorithms require either the Hessian vector calculation or the nested loop updates, which are computationally inefficient in large language model (LLM) fine-tuning. In this paper, building upon the fully first-order penalty-based approach, we propose an efficient value function-free (PBGD-Free) algorithm that eliminates the loop of solving the lower-level problem and admits fully single-loop updates. Inspired by the landscape analysis of representation learning-based LLM fine-tuning problem, we propose a relaxed flatness condition for the upper-level function and

prove the convergence of the proposed value-function-free algorithm. We test the performance of the proposed algorithm in various applications and demonstrate its superior computational efficiency over the state-of-the-art bilevel methods.

### **Hanna Karlin**

*Chemistry*

#### “Rational Design of a Stimuli-Responsive Amphipathic Peptide Assembly”

Amphipathic peptides composed of alternating hydrophobic and hydrophilic amino acid residues have a strong propensity to self-assemble into beta-sheet fibrils. This secondary structure is a privileged motif due to its role in amyloid pathology and the exploitation of amyloid as a functional biomaterial. Metal ions have also been identified as key factors modulating amyloid aggregation. The Ac-(FKFE)<sub>2</sub>-NH<sub>2</sub> peptide, or KFE8, has been studied extensively as a model amphipathic peptide that forms beta-sheet fibrils. Herein, we developed an amphipathic peptide derivative of KFE8 that undergoes metal-induced folding and assembly. We replaced two central residues of the model peptide with Fmoc-beta-(4-pyridyl)-L-alanine, or 4Py. The substitution of the two central hydrophobic residues with 4Py creates a more

hydrophilic peptide, disrupting peptide self-assembly such that divalent metal coordination (CoCl<sub>2</sub> or NiCl<sub>2</sub>) to the pyridine residues is required to trigger peptide assembly. The substitution of the two central hydrophilic residues with 4Py will allow for metal coordination to the pyridine residues while maintaining the capacity for peptide self-assembly. The emergent secondary structures were characterized in water with and without the addition of metal ions at pH ~7 using Fourier transform infrared (FTIR) spectroscopy and transmission electron microscopy (TEM). This work expands the scope of biocompatible, stimuli-responsive peptides and offers a valuable strategy for the rational design of amyloid-inspired peptides for biomaterial applications.

**George Kassis**

*Biomedical Engineering*

“Shared-Control Robotic Ultrasound for Otolaryngologic Diagnostic Imaging of the Head and Neck with Safe Continual Learning”

Delayed access to diagnostic imaging remains a critical bottleneck in healthcare delivery, contributing to disease progression and preventable mortality in cancer and cardiovascular disease. Although ultrasonography promises more accessible imaging, its utility is constrained by operator-dependent skill requirements, limiting access in frontline settings including primary care clinics, urgent cares, nursing homes, and school health programs. Existing solutions such as protocol-driven scanning and portable ultrasound expanded reach but still rely on expert sonographers or repeated retraining of non-expert users.

This work proposes a Shared-Control Robotic Ultrasound System (SC-RUSS) to reduce operator dependency while preserving safety and trust. Rather than full autonomy, SC-RUSS provides task-aware guidance that assists non-expert operators in maintaining diagnostically relevant scanning trajectories while allowing continuous human oversight and deviation. The system employs a neural control architecture mapping real-time ultrasound images to corrective end-effector motions, enhancing image quality without removing human authority.

To address anatomical variability and operator scanning patterns, this project introduces a continual learning framework for online adaptation of control policies. Learning is selectively enabled only under verified safe contact conditions and elevated epistemic uncertainty, with operator corrections treated as informative feedback to prevent unsafe exploration and catastrophic forgetting.

Applicability will be prospectively evaluated in the head and neck region, a clinically high yield but technically demanding ultrasound domain characterized by dense anatomy, small target structures, and strong operator dependence. By integrating shared control with continual learning, this research establishes a framework for learning-enabled robotic ultrasound scanning that improves diagnostic performance without increasing provider workload.

**Biraj Khadka**

*Mechanical Engineering*

“Bayesian Inference for Parameter Estimation in Perivascular Cerebrospinal Fluid Flow”

Cerebrospinal fluid (CSF) plays a critical role in clearing metabolic waste from the brain. Several studies hypothesize that the astrocyte endfeet function as a flexible valve to regulate the CSF flow within penetrating perivascular spaces

(PVSs). However, the values of key parameters governing this system, including the material properties of endfeet walls and the flow resistances of the pial PVS, extracellular space (ECS), and endfeet walls, are still unknown. We apply Bayesian inference to an endfoot valve mechanism model to estimate these parameters while quantifying their uncertainty using in vivo measurements of arterial pulsations of penetrating artery and CSF flow velocity in pial PVS.

**Tasin Khan**

*Computer Science*

“Toward Accessible Video Conferencing for Blind and Low-Vision Users: A Multimodal, Role-Aware Assistive Framework”

Most video conferencing platforms still fall short when it comes to meaningful accessibility for blind and low-vision (BLV) users, particularly in presentation settings. Sighted presenters routinely rely on visual cues from their audience, such as facial expressions or visible reactions, to adjust pacing, clarify points, or gauge engagement. For BLV speakers, this feedback is largely inaccessible, creating a gap in participation and awareness.

In this ongoing project, we are designing an assistive system that supports BLV users in both presenter and audience roles during live online meetings. When a BLV user is presenting, the system uses computer vision and large language models (LLMs) to interpret audience facial expressions and summarize high-level emotions, such as confusion, interest, or agreement. This information is conveyed through real-time audio cues, which will allow the BLV presenter to adapt as they speak. The system also offers camera-positioning guidance to help presenters remain centered and visible on screen. For BLV users attending as audience members, the system provides audio descriptions of slide content at select moments, timed around natural pauses in speech or slide transitions to reduce overlap with the presenter’s voice.

Rather than replacing existing video conferencing platforms, our approach is designed as a lightweight add-on accessibility layer. By supporting both presenting and listening roles, this work moves BLV accessibility beyond basic accommodations and supports more active, two-way participation, helping BLV users follow presentations more easily and present with greater confidence.

**Megan Kibler**

*Brain & Cognitive Sciences*

“Communicative Intent Changes Structural Characteristics of Jazz Solos”

When conceptualizing jazz improvisation, few studies have examined potential differences in structural output in solo improvisations and within the context of a trading fours interaction. Therefore, the current study compared structural features of musical improvisations produced under solo and social conditions. Twenty experienced improvisers improvised alone over a backing track, and also played in a social condition (duos, trading fours). We hypothesized that higher entropy values could be associated with a sense of artistic freedom that musicians may experience when playing music in a live jazz performance setting (Monson, 1996). Alternatively, the communicative demands of the social condition may motivate musicians to reduce overall entropy and increase patterned-ness (proportion of 3, 4, 5, or 6-grams repeated three or more times) to aid mutual musical comprehension. Results showed that there were several significant differences between the solo and social conditions. Social improvisations had higher pitch-class entropy than solo improvisations. However, the same test for the entropy values calculated from the interval distributions was non-significant. For interval 4-gram and interval 5-gram patterns, there was a significant difference in

the proportion of 4-grams and 5-grams played, with a greater proportion of repeated 4-gram and 5-gram interval patterns played in the social versus solo conditions. Furthermore, in the social condition, duo partners who were more familiar with each other produced improvisations with greater interval entropy. We explain these findings with reference to theoretical work in linguistics.

**Roberto Leon Baxin**

*Chemistry*

“Palladium-Catalyzed Synthesis of sp<sup>3</sup>-rich Nitrogen Heterocycles Enabled by Urea Ligands”

Palladium-catalyzed cross-coupling reactions are commonly used in the synthesis of biologically active compounds. To date, most reports that involve the incorporation of fundamental cyclic motifs are hindered by the reliance on aryl-activating groups, outcompeting the incorporation of saturated rings when in search of novel pharmaceutical candidates. Nitrogen heterocycles have distinguishing themselves among its saturated cyclic counterparts by their increasing prominence in FDA-approved pharmaceuticals, with current state-of-the-art heteroannulative methodologies rendering relatively simple and semi-saturated products. Herein, I report the palladium-catalyzed synthesis of pyrrolidine derivatives via a convergent, fragment-coupled methodology between easily accessible vinylogous ambiphiles and an array of  $\sigma$ -coupling partners. This work applies our user-friendly, urea-ligand platform to synthesize a series of structurally complex nitrogen heterocycles from novel aliphatic nitrogen atom ambiphiles and a series of representative dienes. Moreover, the synthetic utility of this methodology is exhibited via downstream functionalization of the desired product. The outcomes of this work advance the utility of urea ligands, enabling the development of palladium-catalyzed reactions with a broader range of unrealized substrates.

**Shiquan (Sophus) Li**

*Mathematics*

“Stretching of Polyelectrolytes”

Polyelectrolytes are polymers whose repeating units bear electrolyte groups. These groups dissociate in aqueous solutions, making the polymers charged. When the counterions move relatively freely in the solvent, Coulomb repulsion between the ionized groups induces a stretching of the polymer chain. This stretching phenomenon was heuristically discussed by the Nobel Laureate Pierre-Gilles de Gennes.

To further de Gennes' question, we use Brownian motion as a probabilistic model for polymer chains and give a mathematical analysis to de Gennes' assertion. The result is based on joint work with Carl Mueller.

**Jiayun Li**

*Chemistry*

“Synthesis, Characterization, and Structure Determination of Fused Oxazolidine Complexes of Molybdenum”

Two fused-bisoxazolidine ligands (FOXOH and FOXOMe) are used to coordinate to molybdenum carbonyl, producing Mo(CO)<sub>3</sub>(FOXOMe). The ligands bind in a  $\kappa^3$ -NNN fashion to the metal center creating an octahedral complex. Difficulty in further substitution of CO and the lack of reactivity prompted research into alternative starting

materials. This resulted in the synthesis of a  $\text{MoIIICl}_3(\text{FOXOMe})$  complex. All complexes are characterized by single crystal X-ray crystallography.

### **Ziyi Meng**

*Materials Science*

“Complete Aqueous Defluorination of Per- and Polyfluoroalkyl Substances by Pulsed Electrolysis with Tailored Potential Modulation”

Per- and poly-fluoroalkyl substances (PFAS) are synthetic chemicals used widely because their properties enable oil-, stain-, and heat-resistant products. Decades of heavy use have led to global contamination and bioaccumulation affecting water, soil, wildlife, and human health. The exceptional thermodynamic stability of carbon–fluorine bonds makes PFAS difficult to destroy, and many defluorination strategies remain limited by capital cost or energy intensity [1]. Hexafluoropropylene oxide dimer acid (GenX), a replacement for legacy PFAS, shows higher chronic toxicity than the perfluorooctanoic acid (PFOA) it replaced [2]. In addition, aqueous film-forming foams (AFFF), which contain complex mixtures of proprietary PFAS, have been extensively used for firefighting worldwide, leaving a substantial legacy of environmental contamination. [3]. Building on mechanistic understanding of electrochemical defluorination of perfluorooctane sulfonate (PFOS), we achieved complete PFOS defluorination in aqueous LiOH under ultraviolet irradiation using laser-synthesized  $[\text{NiFe}]-(\text{OH})_2$  nanocatalysts immobilized on hydrophilic carbon fiber paper anodes [4,5]. Based on this mechanistic understanding, we engineered pulse trains with polarity reversal to achieve complete defluorination of GenX and AFFF under UV light-assisted electrocatalysis with  $[\text{NiFe}]-(\text{OH})_2$ –hydrophilic carbon fiber paper anodes [2,3]. This scalable method offers remediation for diverse PFAS contaminants [6].

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### **Jacqueline Morin**

*Biology*

“Sft2 is a conserved membrane regulator for autophagy and the secretory pathway”

Autophagy is an evolutionarily conserved process that targets damaged organelles and protein aggregates for degradation in lysosomes during times of cellular stress or starvation. Dysregulation of autophagy is implicated in many diseases including neurodegeneration, cardiovascular disease, and cancer. Targeting of specific organelles or proteins is controlled through cargo-specific interactions with Atg8 family members. These interactions are mediated by an Atg8-interacting motif (AIM); however, sequence-based analyses alone often failed to reliably identify authentic AIM motifs. With new protein structure prediction tools, we used AlphaFold to screen over 800 membrane proteins in fission yeast, *S. pombe*, to identify new potential autophagy receptors. From this screen, we identified Sft2 as not

only a receptor of Golgiphagy but also a broader regulator of autophagy. In addition to autophagy-related defects, *sft2Δ* mutants exhibit autophagy-independent defects in the secretory pathway. Furthermore, Sft2 has three homologs in humans, SFT2D1-3. Using human osteosarcoma cells, we determined that SFT2D2 is the conserved form of Sft2 in *S. pombe*. SFT2D2 knockdown cells share both the autophagy and secretory phenotypes identified in yeast. Our preliminary data also suggest that SFT2D2 regulates the invasive and aggressive behavior of breast cancer cells. Furthermore, using in vitro cell models, we found that SFT2D2 modulates autophagic activity and lysosomal function during red blood cell maturation, thereby linking SFT2D2 to hematopoietic system development. Collectively, these results highlight SFT2D2 as a conserved membrane regulator that integrates autophagy and secretion to influence both cellular homeostasis and disease progression.

### **Andressa Nauter-Alves**

*Geosciences*

“Evaluating temperature and carbonate chemistry effects on benthic foraminiferal Mg/Ca, Mg/Li, Sr/Ca, and B/Ca:  
A global coretop compilation and revised calibrations”

Benthic foraminifera are single-cell marine protists that inhabit a range of seafloor environments. Among benthic foraminifera, calcareous species (i.e., species characterized by a calcium carbonate shell) are particularly useful in paleoceanography studies as their shell geochemistry records information about past ocean conditions at the time of shell precipitation. In this study, we focus on the benthic foraminiferal (bf) Mg/Ca and Mg/Li, used to estimate past deep-sea temperature, and Sr/Ca and B/Ca, applied to reconstruct deep-sea carbonate chemistry (e.g., the calcite saturation state -  $\Omega_{\text{calcite}}$ ). Even so, the application of these element/Ca ratios is complex because they are not controlled by only a single variable. Instead, they are influenced by secondary effects, complicating their environmental interpretation. To address this, we compiled data from several coretop studies spanning a wide range of environmental conditions to assess species-specific element/Ca sensitivity to in situ temperature and to  $\Omega_{\text{calcite}}$  using a multivariate linear regression analysis. Our results demonstrate that Mg/Ca is less sensitive to temperature when the  $\Omega_{\text{calcite}}$  is included in the model and that Mg/Li yields more precise temperature reconstruction compared to Mg/Ca. In general, Sr/Ca and B/Ca are primarily controlled by  $\Omega_{\text{calcite}}$ , although Sr/Ca also exhibits a temperature influence in some of the species considered. Our data also show that temperature and carbonate chemistry reconstructions depend on the species-specific calibrations. Based on our multivariate regression results, we developed a software (ElCarBenthic) to reconstruct temperature and  $\Omega_{\text{calcite}}$  from fossil benthic foraminiferal species by combining Mg/Ca or Mg/Li with Sr/Ca or B/Ca, while propagating uncertainties.

### **Dennis Nimoh**

*Biomedical Engineering*

“Automatic TMJ Segmentation to Facilitate Patient-Specific Chairside Kinematic Analysis”

Temporomandibular disorders (TMDs) are the second most prevalent chronic musculoskeletal condition, affecting approximately 5–12% of the population. These disorders involve altered temporomandibular joint (TMJ) mechanics; however, quantitative clinical assessment of jaw motion remains limited. Current pipelines estimate joint motion by

combining 3D models of the mandible and maxilla with motion capture data. These workflows rely on time-consuming manual CT segmentation, which limits scalability and slows clinical translation of TMJ motion analysis. This study develops an automated TMJ segmentation method to enable routine motion assessment.

An automated CT processing algorithm was developed to generate paired image and label volumes for deep-learning segmentation. For each whole-head CT volume, craniofacial bone was extracted and used as an alignment reference. The mandible and maxilla were then aligned and voxelized to produce three-class label volumes. Seventy-two (72) CT image-label pairs (48 training, 12 validation, and 12 testing) were used to train a 3D nnUNet segmentation model. Data augmentation was applied to increase variability, and the model was trained for 1000 training cycles using a supervised learning framework.

The model achieved mean Dice scores of  $0.85 \pm 0.14$  for the mandible and  $0.76 \pm 0.13$  for the skull (maxilla) segmentation. Mean 95th-percentile Hausdorff distances were  $3.17 \pm 2.68$  mm for the mandible and  $5.27 \pm 1.59$  mm for the skull segmentation. Predicted boundaries showed strong agreement with ground-truth, with only minor deviations in low-contrast regions. This automated method reduces manual CT processing and produces subject-specific TMJ structure for motion analysis and clinical assessment.

### **Kaley Pagnotta**

*Biomedical Engineering*

“Integration of Quantitative Biomechanical Analysis in Non-Research Settings via an Automated Pipeline”

Biomechanical data can identify movement patterns related to injury risk and performance but requires a high level of expertise to collect and interpret. Automated pipelines for data collection, processing, and analysis, paired with training materials can enable the integration of biomechanical data into everyday athletic training. The goal of this study was to develop and validate an automated motion analysis pipeline combining motion and loading forces that could be used independently by coaches in a real-world athletic setting.

Working with the CHAMPP program at the URMFC Fitness Science Center, an automated analysis pipeline was developed using multiple biomechanical platforms to generate skeletal pose estimations, perform kinematic and kinetic analyses, and produce easy-to-read reports. Coaches were trained to set up the equipment and collect and interpret data. The coaches independently collected data at 4 time points and completed surveys assessing their confidence level with equipment use and data interpretation. The CHAMPP athletes also completed surveys on their perception of the data as well as the coaches’ explanations.

The automated pipeline was compared to traditional, manual data processing methods to validate the data analysis integrity. The automated reports generated results comparable to the manual processing results, indicating the automated pipeline processes data accurately. Survey responses trended positively or stayed high throughout the study, and all data met research-quality standards.

Overall, this study showed that automated analysis pipelines can increase accessibility to biomechanical data in athletic settings, supporting injury prevention and performance training without the need for expertise or a laboratory.

### **Rishab Panda**

*Chemistry*

## “Study of the interactions of novel antimicrobial and amphipathic peptides with lipid membranes”

Antimicrobial peptides kill bacterial cells primarily by disrupting lipid membranes, yet the molecular mechanisms of membrane selectivity and disruption remain an area of active research. Here, we examine the interactions of a series of novel amphipathic peptides with model membranes composed of the lipids POPC/POPG using an integrated biophysical and computational approach to elucidate their mechanism of action. We use two sets of peptides - positively charged antimicrobial peptides based on Melittin and neutral charged amphipathic peptides that have a propensity to self-assemble into supramolecular fibers. Using Circular dichroism (CD) and Fourier-transform infrared spectroscopy (FTIR), we found that the peptides undergo lipid-induced folding, adopting random coil, alpha-helical or beta sheet conformations based on their amino acid composition and sequence patterning. Fluorescence based leakage experiments and Dynamic light scattering (DLS) were used to study the disruption of the membranes in the presence of the peptides. All-atom molecular dynamics simulations corroborate the experimental findings and help us capture the membrane interaction dynamics of the peptides by studying binding and water translocation across the lipid bilayers. Using the above-mentioned techniques, we were able to elucidate a mostly carpet-like mechanism of liposome damage rather than traditional pore formation and higher disruption in the case of peptides with a higher hydrophobic moment. Collectively, these results help us define a clear mechanistic link between peptide physicochemical properties and membrane-disruptive behavior in POPC/POPG systems. This study can guide us to rationally design antimicrobial peptides with improved potency and selectivity toward bacterial membranes.

**Nicole Park***Developmental Psychology*

## “Deciding Together or Alone?: Children’s Expectations of Leaders’ Decision-Making Behaviors”

Leaders shape collective futures—prioritizing issues and amplifying voices. Recent work shows that mental representations of leaders emerge early in life, revealing intuitive ways of thinking that help explain what societies see as legitimate versus intolerable in those who lead. Here, we examined children’s expectations about leaders’ decision-making behaviors and whether expectations vary by the type of leader construed. We randomly assigned 96 children (4- to 9-years old) and 96 adults in the U.S. to learn about a novel group with either a dominant or prestigious leader. Participants then predicted whether that leader would a) ask the group and then make a decision, or b) take charge and make a decision right away. Next, all participants learned that the leader took charge—confirming or violating expectations—and rated the group’s affective responses (how “okay” and “mad” the group felt). With age, children increasingly expected both leader types to consult the group ( $\beta = -.45$ ,  $p = .002$ ). In contrast, adults expected leaders, especially dominant ones ( $\beta = 2.15$ ,  $p < .001$ ), to take charge. Affective predictions reflected expectations: children whose expectations for consultation were violated predicted the group would feel less “okay” ( $p = .044$ ). Adults also predicted stronger negative reactions when dominant leaders took charge, despite fulfilled expectations ( $ps < .001$ ). Together, these findings suggest an expectation that leaders honor a social contract, especially prestigious leaders whose authority is group-conferred. Differences between children and adults raise questions about when and why children begin to license leaders to diverge from group preferences.

**Neeley Pate***Computer Science*

## “Replicating Human Motivated Reasoning Studies with Large Language Models”

Motivated reasoning -- the idea that individuals processing information may be motivated to reach a certain conclusion, whether it be accurate or predetermined -- has been well-explored as a human phenomenon. However, it is unclear whether base LLMs mimic these motivational changes. Replicating 4 prior political motivated reasoning studies, we find that base LLM behavior does not align with expected human behavior. Furthermore, base LLM behavior across models shares some similarities, such as smaller standard deviations and inaccurate argument strength assessments. We emphasize the importance of these findings for researchers using LLMs to automate tasks such as survey data collection and argument assessment.

**Swastik Paul***Chemical Engineering*

## “Deciphering the Role of Cations in the CO oxidation reaction pathway”

CO poisoning on platinum surfaces affects many electrochemical reactions, including alcohol oxidation, fuel cells, CO<sub>2</sub> reduction (CO<sub>2</sub>RR), and Fischer Tropsch synthesis, by increasing their onset potentials and the associated energy costs. Previous studies have shown that adding alkali metal cations such as Li<sup>+</sup>, Na<sup>+</sup>, and K<sup>+</sup> to the electrolyte can significantly reduce the onset potential for CO oxidation. However, the reaction mechanism of CO oxidation in the presence of these cations remains poorly understood. Here, we investigate the effect of Li<sup>+</sup> cations on CO oxidation at a defective Pt step surface. We employed ab initio molecular dynamics (AIMD) to sample configurations in which Li<sup>+</sup> is arranged in the electrolyte. We considered three Li<sup>+</sup> environments: (i) Li<sup>+</sup> in the bulk electrolyte, (ii) Li<sup>+</sup> in the electrical double layer (EDL), and (iii) Li<sup>+</sup> adsorbed on two step CO. Our Potential of mean force (PMF) calculations show that the CO electrooxidation barrier is 0.80 eV for the third case when Li<sup>+</sup> is adsorbed on two step CO, which is 0.14 eV lower than in the EDL configuration and 0.32 eV lower than in the bulk configuration. We attribute this lower barrier to Li's ability to interact with CO to maintain its solvation shell when a water molecule from the Li<sup>+</sup> solvation shell attacks a CO to form COOH. Moreover, the CO–Li<sup>+</sup> interaction weakens the Pt–CO bond, making CO more susceptible to oxidation. This study reveals a unique pathway in which cations can alter a CO oxidation reaction mechanism and contribute to a lower onset potential.

**Santanu Poddar***Chemistry*

## “Making Excitons Move Ballistically Using Polaritons”

Excitonic transport plays a critical role in various natural and engineered systems. This may range from light harvesting in photosynthetic complexes to optoelectronic devices such as LEDs (Light Emitting Diodes) and solar cells. The overall efficiency of these devices often depends on the speed and the mechanism of the exciton migration, which typically falls

within a diffusive or subdiffusive regime. Coupling excitons to quantized cavity photonic modes can significantly enhance the spatial and temporal range of excitonic transport. The formation of hybrid light-matter states, known as polaritons, plays a central role in this enhancement. Polaritons, owing to their photonic character, can greatly amplify coherent energy flow in excitonic systems, prolong their lifetimes, and lead to ultrafast ballistic excitonic transport. In Bloch surface wave (BSW) cavities, the group velocity of these polaritonic wavepackets has been theoretically predicted to approach the speed of light in the medium, though experiments suggest a renormalized value. In this work, we use quantum dynamics simulations and theoretical analysis of group-velocity renormalization and wavepacket evolution to elucidate the transport dynamics in a Bloch Surface Wave Cavity. We show that polaritonic states facilitate ballistic flow directly through their photonic character, and that below a critical photonic fraction the ballistic component is suppressed, and yet even then, transport remains four to eight orders of magnitude faster than purely excitonic diffusion. These results show qualitative, and in some cases near-quantitative, agreement with experimental trends, providing microscopic insight into the origin of fast transport in BSW polariton systems.

### **Jabale Rahmat**

*Biology*

“Targeted editing of pericentromeric satellite DNA alters sensitivity to meiotic drive”

Eukaryotic genomes are abundant in satellite DNA (satDNA): large blocks of tandemly-repeated sequences that accumulate in heterochromatic genome regions. SatDNAs are dynamic in their genomic location and abundance across species. Some satDNAs overlap essential genome regions such as centromeres and telomeres, but even pericentromeric satDNA can have effects on phenotypes, raising questions about their functional significance. However, it remains unclear whether these effects depend on satDNA sequence, copy number, higher-order structural organization, or genomic context. The highly repetitive nature of satDNA arrays has long hindered detailed genomic and genetic analyses. Recent advances in long-read sequencing now facilitate both the detailed characterization of satDNA structure and the development of more targeted approaches to genetic analysis. Here we present a sequential CRISPR/Cas9- based strategy to make mutations in satDNA arrays and demonstrate its utility using an autosomal pericentromeric satDNA in *Drosophila melanogaster* called Responder (Rsp). Rsp is the target of a sperm-killing male meiotic driver, Segregation Distorter (SD), where sensitivity to sperm killing positively correlates with Rsp copy number. Using our CRISPR/Cas9 approach, we generated an allelic series of Rsp deletion and expansion variants in two genetic backgrounds and examined their effects on spermatogenesis. Our approach produced precise satDNA variants efficiently, with minimal detectable off-target effects. The resulting mutations affect sensitivity to SD that scale with Rsp copy number. This work establishes a new framework for experimentally dissecting satDNA function and provides insights into the evolutionary and functional roles of satDNA in genome organization.

**Aditya Ranjan***Mechanical Engineering*

“Estimating the permeability of brain tissue through CFD simulations of flow in realistic geometries”

Cerebrospinal fluid enters the brain tissue where it mixes with the interstitial fluid in the extracellular space (ECS, i.e., the space between cells). This process leads to the clearance of metabolic waste products, whose accumulation contributes to neurological diseases such as Alzheimer’s. Hence, understanding the role of fluid flow in maintaining brain health is of critical importance, but fluid flow within the brain tissue cannot be directly measured, leaving many open questions. Brain tissue can be modelled as a porous medium with flow described by Darcy’s law, but the permeability is not well characterized, with different estimates spanning several orders of magnitude, which introduces significant uncertainty in any attempts to model the flow. In this study, we estimate the permeability of brain tissue using computational fluid dynamics simulations of flow through a realistic three-dimensional ECS geometry derived from publicly available data. We solved for the speeds resulting from an imposed pressure drop in Stokes flow since ECS flow is characterized by very low Reynolds numbers (estimated to be on the order of  $10^{-7}$ ) and then calculated the permeability using Darcy’s law. ECS volume fraction (ratio of the ECS volume to total volume) is known to vary between sleep and wakefulness, so we quantified how permeability varies with ECS volume fraction, providing insight into the corresponding variation in flow dynamics. We also quantified the degree of anisotropy in ECS permeability, which has implications for modeling.

**Noah Reger***Biology*

“From cell to self: dAnp32 functions with Jabba to promote early embryonic development”

After fertilization, the embryonic genome is largely silent. For an embryo to remain viable, the embryonic genome must be unsilenced; this requires the genome to undergo extensive remodeling. The genomic DNA is packaged via histones to form chromatin; remodeling involves the gain and loss of histone from various regions of chromatin. This process is mediated by multiple histone chaperones acting in an intricate network, disruptions of which has been shown to impact neurodevelopment and morphogenesis. The Anp32 family of histone chaperones is emerging as important regulators of embryonic development in vertebrates but their exact role remains unclear. To address this gap, we use *Drosophila* Anp32 (dAnp32) as a model. In early embryos, dAnp32 is present both in the cytoplasm and nuclei and shuttles between them, as assessed with multiple YFP/GFP trap lines. Using a proximity ligation assay, we found positive signal for dAnp32-H2A.Z in both the cytoplasm and nucleus, suggesting that dAnp32 interacts with H2A.Z in both compartments. These findings are consistent with previous observations in vertebrates. We thus generated mutants in dAnp32; while animals lacking either dAnp32 or Jabba—another histone chaperone—develop grossly normally, offspring of mothers lacking both are rarely viable. Additionally, we have uncovered evidence that these embryos also have increased DNA damage consistent with Anp32 function in human cancer. These data indicate that dAnp32 functions with Jabba to promote embryonic development. We currently hypothesize that dAnp32 sequesters and protects H2A.Z in the cytoplasm in a Jabba-like manner; future work will molecularly test this hypothesis.

**Jose Reynoso**

*Brain & Cognitive Sciences*

“On the efficacy of temporal visual speech cues for comprehending degraded speech and for solving the cocktail party problem.”

Audiovisual speech integration has been proposed to operate via two processing modes: a correlated mode – whereby temporally correlated visual speech cues enhance auditory cortical sensitivity; and a complementary mode – whereby complementary visual articulatory information enhances the categorization of auditory speech into linguistic units (Campbell, 2008). Here, we investigate under which listening conditions these modes aid in audiovisual integration. We hypothesize that a temporally correlated visual cue should aid in attending to a target speaker in a cocktail party scenario, but only minimally aid in comprehending degraded speech, where temporal correlations provide redundant information. Subjects ( $n = 19$ ) perform a word detection task as they are presented with either degraded speech or a cocktail party paradigm in three conditions: audio only (A), audio and video of the speaker with an overlaid ellipse tracking mouth movements (audiovisual ellipse, AVE), or audio and a clear video of the speaker (audiovisual full-face, AVFF). The ellipse serves to mask most articulatory cues from the mouth while retaining the temporal information of the speech. Preliminary data shows that presenting a speaker’s full-face aids both speaker detection in a cocktail party scenario ( $p < 0.01$ ) and comprehension of degraded speech ( $p < 0.01$ ). Similarly, a temporally correlated ellipse also aids in these two listening conditions (all  $p$ ’s  $< 0.01$ ). Further work using EEG will explore the neural correlates of these behavioral results. Using decoding models, we aim to investigate audiovisual speech integration in the correlated mode, and whether this integration differs based on listening condition.

**Jennika Robato***Chemistry*

“C-H Activation of Azine-Type Heterocycles via  $Cp^*Rh(PMe_3)PhH$  for Parahydrogen-Induced Polarization”

Parahydrogen induced polarization (PHIP) is a fast, low-cost method of enhancing magnetic resonance signals. According to preliminary studies, transition metal centers have been shown to promote PHIP through the attached ligands<sup>1</sup>. Our lab is interested in the activation of azine-type heterocyclic ligands. This class of molecules have potential uses in medicine, materials, and synthesis<sup>2</sup>. This study describes the scope of polarizable ligands by synthesizing azine-type pyridinyl and pyrazinyl  $Cp^*Rh(PMe_3)H$  complexes. Heating afforded pyridinyl and pyrazinyl complexes  $Cp^*Rh(PMe_3)(py)H$  and  $Cp^*Rh(PMe_3)(pz)H$ . While only one isomer of the pyrazinyl complex was formed, three regioisomers of the pyridinyl complex were formed, corresponding to activation at the ortho, meta, and para positions; after sustained irradiation or heating, the meta regioisomer is converted to its ortho or para analogues. These findings show potential in applications of PHIP studies on azine-type heterocycles and their derivatives.

**Abhishek Roy***Chemistry*

“Developing Photoswitchable GTP Analogs to Control Protein Assembly”

Biology employs out-of-equilibrium assembly to sustain highly ordered structures and accomplish meaningful work. Energy-rich molecules such as GTP and ATP can continually fuel the dissipative assembly of proteins, which are implicated in complex functions such as motility and signal transduction. One such prominent example is the GTP-fueled dissipative assembly of FtsZ, crucial for bacterial cytokinesis. Inspired by this dynamic and stimuli-responsive behavior, there has been a growing interest in mimicking dissipative assembly processes in synthetic systems. However, due to the constant need to supply GTP as an energy source, in vitro control over dissipative protein assembly remains underexplored. Our work is developing a light-responsive GTP (PhotoGTP) analogue that can control the assembly of FtsZ outside the cellular environment. PhotoGTP can toggle between the syn- and anti-conformations of the glycosidic bond upon irradiation. Since FtsZ preferentially binds to the anti-conformation of GTP, we explore how FtsZ assembly can be controlled via light-induced switching of PhotoGTP conformation. Additionally, chemical modifications of PhotoGTP are explored to modulate isomerization kinetics and photophysics. This study can help achieve control over the dissipative assembly of FtsZ and harness it as a tool to perform work outside the cellular environment using light as the energy source. Moreover, the widespread use of GTP by other proteins suggests that PhotoGTP may be applied to program the various functions of other GTP-ase proteins.

**Akza Sam**

*Physics*

“Streamer Crashes onto Young Protostar: Delivering Mass and Driving Shocks”

Accretion during the protostellar phase determines the mass reservoir and chemical composition available for later stages of stellar and planetary evolution. Recent observations have revealed narrow, asymmetric structures toward young protostars with kinematic signatures consistent with infall. These features, known as streamers, funnel material from a protostar’s parent cloud onto the disk, increasing the stellar mass supply and altering local chemistry through shocks. We detect a streamer toward Per-emb-62, a Class I protostar in the IC 348 region of the Perseus molecular cloud. The structure is observed in  $^{13}\text{CO}$  and  $\text{C}^{18}\text{O}$  with signal-to-noise ratios greater than 14 and 8, respectively. The detection of  $\text{SO}$ , a shock tracer, at the location where the streamer meets the disk indicates an active impact site. We derive a streamer mass of  $8.4 \times 10^{-4} M_{\odot}$  and a mass infall rate of  $2.9 \times 10^{-8} M_{\odot} \text{yr}^{-1}$ . We generate analytic trajectories for gas parcels falling toward a central mass that agree with the trajectory of the observed streamer in both position and velocity space. The detection of a streamer toward Per-emb-62 adds to growing evidence that streamers are common during the embedded phase and provides insight into how the protostar and its surrounding environment influence each other’s evolution.

**Bhupendra Sharma**

*Mechanical Engineering*

“Enhanced Nonlinear Hall Effect in a Designed  $\text{W}_{0.5}\text{Mo}_{0.5}\text{Te}_2$  Monolayer”

In conventional electronics, rectification - the conversion of alternating electrical signals into a direct current - is achieved using semiconductor components such as diodes. Quantum materials, however, offer a fundamentally different route to rectification, where the effect emerges intrinsically from the electronic structure of the material itself. One such mechanism is the nonlinear Hall effect, which is governed by a quantum-geometric property known as the Berry curvature dipole (BCD). In this work, we explore how chemical substitutions in a well-known materials’ class can

enhance this intrinsic quantum response. Using first-principles density functional theory, we design and study a two-dimensional monolayer formed by combining WTe<sub>2</sub> and MoTe<sub>2</sub> into W<sub>0.5</sub>Mo<sub>0.5</sub>Te<sub>2</sub> [1]. We show that this engineered monolayer is dynamically and mechanically stable and, most importantly, exhibits an exceptionally large intrinsic BCD, nearly two orders of magnitude larger than those of the parent materials. This enhancement originates from a reduced energy bandgap near the transport-active energy window, which amplifies the Berry curvature contributions near the Fermi level. As a result, the nonlinear Hall response is significantly strengthened, enabling efficient electrical rectification without the need for external semiconductor components. Because the bulk form of this material has already been synthesized, this study provides a realistic pathway toward atom-thin quantum rectifiers and low-power electronic and sensing devices that operate beyond conventional semiconductor paradigms.

#### Reference

[1] Sharma, Bhupendra, et al. "Large Berry curvature dipole and enhanced nonlinear Hall effects in monolayer W<sub>0.5</sub>Mo<sub>0.5</sub>Te<sub>2</sub>." *Physical Review B* 112.23 (2025): 235433.

### **Hashini Sithari**

*Chemistry*

#### “Controlled Synthesis and Characterization of Colloidally Stable Ternary Thiospinels”

Ternary thiospinels are promising candidates for various energy storage and generation applications, including supercapacitor anodes for lithium-ion batteries and catalysts for the hydrogen evolution reaction (HER) and oxygen reduction reaction (ORR). They exhibit better electrical conductivity, enhanced performance, and stability compared to their ternary oxide analogs.

However, achieving phase-pure synthesis of ternary thiospinels remains a significant challenge due to the presence of competing phases, such as binary sulfides, under similar synthetic conditions.

In this work, we demonstrate a low-temperature colloidal method for synthesizing highly complex, phase-pure ternary thiospinels, which offers a promising route to producing small, stable nanocrystals while avoiding the complicated, multistep procedures often required in complex sulfide synthesis. We present a one-step heat-up synthetic method to produce CoNi<sub>2</sub>S<sub>4</sub>, NiFe<sub>2</sub>S<sub>4</sub> and CoFe<sub>2</sub>S<sub>4</sub> thiospinel nanocrystals with tunable compositions and robust colloidal stability, utilizing a series of metal and thiourea precursors. We also address the challenge of incorporating Fe into spinel lattices to successfully synthesize Fe-containing thiospinels. The elemental distribution and targeted spinel framework of the nanocrystals are confirmed by structural and compositional analyses such as transmission electron microscopy (TEM), powder X-ray diffraction (PXRD), inductively coupled plasma (ICP) analysis, and X-ray photoelectron spectroscopy (XPS). This colloidal synthesis gives a simple route to high-quality ternary thiospinel nanocrystals, enabling systematic investigations of structure–property relationships and allowing their integration into catalytic applications.

### **Snehitha Srirangam**

*Chemical Engineering*

#### “Designing Inverse Metal-Oxide Interfaces for Selective Catalysis”

Heterogeneous catalysts play a crucial role in improving the efficiency of various industrial processes. Recently, tandem catalysts which couple multiple catalysts have been shown to dramatically improve the performance of complex alkane chemistries. Such catalysts can have different types of configurations with inverse oxide/metal configuration being an important subclass. However, the large-scale application of such catalysts is hindered by the lack of understanding of the atomic structure and function of these oxide-metal interfaces under operating conditions. While computational tools such as Density Functional Theory can reveal important insights regarding the reactivity, modeling the inverse oxide/metal interfaces is challenging due to the large phase space arising from multiple oxide configurations across compositions and geometries under operating conditions, hindering a physics-based search for optimal catalysts. In this study, we developed a computational workflow to accurately represent the active site structure of a tandem catalyst, Platinum-Indium oxide (Pt-InO<sub>x</sub>H<sub>y</sub>) used in the Oxidative Propane Dehydrogenation (ODHP) reaction for production of propylene, a key building block for plastics. Exploration of the chemical space of stable InO<sub>x</sub>H<sub>y</sub> phases on Pt revealed that the oxide preferentially occupies the under-coordinated Pt sites under low oxygen- and hydrogen-containing environments. The mechanistic pathway of ODHP on the catalyst revealed a dual-site mechanism which controls over-oxidation and improves catalyst stability. This framework can be extended to other metal-metal oxide systems to develop highly efficient next-generation catalysts for complex reactions such as methanol synthesis, with applications ranging from paints to fuel cells.

**Colin Steiner**

*Materials Science*

“Determining Refractive Index of Materials Through Terahertz Frequency-Domain Spectroscopy and the Fresnel Equations”

THz spectroscopy can be split into two main approaches: Time-Domain (THz TDS) uses sub-picosecond in duration bursts of electromagnetic waves, and Frequency-Domain (THz FDS) uses a continuous-wave source and, traditionally, sweeps frequency. THz TDS allows for broadband frequency information but requires ultrafast pulsing laser setups, THz FDS is a comparatively simpler setup, but much of the complexity is due to methods such as photomixing, frequency sweeps, and complex data analysis techniques to get some of the same material properties as a THz TDS setup. Due to the characterizable properties of light at material interfaces at a given angle, sample rotation can offer additional methods for deriving material properties with THz FDS. Samples were rotated within a THz FDS setup, the resulting intensities were normalized and fit with the Fresnel equations, as the unknown material’s refractive index is the only unknown variable the value that results in the best fit can be assumed to be the refractive index of the unknown material. This work shows a method of deriving refractive indexes with THz FDS that is inexpensive and simple.

**Sayan Swar**

*Electrical Engineering*

“Interpretable Spectral Representations of Planetary Signals in Vector Spaces (Spec2VEC)”

The application of Machine Learning (ML) to planetary science is often bottlenecked by a scarcity of labeled data and the complexity of non-stationary seismo-acoustic signals. While deep learning offers powerful feature extraction, it requires massive datasets that are rarely available for phenomena like Martian quakes or deep-ocean volcanism.

Consequently, researchers rely on “hand-engineered” features from Time-Frequency Representations (TFRs), but these are often impoverished (simple statistics) and brittle (highly sensitive to subjective TFR hyperparameters). To resolve this, we introduce Spec2VEC, a framework that constructs interpretable spectral representations in vector space. Analogous to generating embeddings in natural language processing, Spec2VEC projects raw, subjective TFRs into a high-dimensional, discriminative feature space. We achieve this by treating the TFR not just as a probability distribution, but as a textured image. Our framework systematically extracts a feature vector using two novel pathways: (1) a Textural path that uses Hilbert space-filling curves to map 2D spectral patterns into 1D sequences for information-theoretic analysis (e.g., Entropy, Complexity); and (2) a Spatial path that uses a novel probabilistic segmentation (PDFSI) to quantify the energy concentration, connectivity, and coherence of signal components. We validate this vector space on a comprehensive benchmark of synthetic geophysical signals, demonstrating that it creates a distinct separation between signal classes where traditional metrics fail. Finally, we demonstrate its utility for label-scarce discovery through the unsupervised clustering of hydroacoustic signals from the 2021 Fukutoku-Oka-no-Ba eruption. The results show that Spec2VEC generates a robust, interpretable feature space that enables the automated discovery of complex planetary processes, independent of the underlying TFR choice.

**Eliya Tazreena Tashbib**

*Chemical Engineering*

“PRDM16 is required for normal nasal septal cartilage and bone development in mice”

Nasal septum deviation is among the most common congenital craniofacial disorders, affecting ~2.2 million individuals in the United States and 20% of newborns globally. Despite its prevalence, treatment options are limited and rely almost entirely on invasive surgery, which often provides only partial or temporary relief. This research aims to understand why nasal septal deviation occurs by studying a gene regulator called PRDM16, which controls nasal cartilage and bone development in mice and humans. Using an osteochondral lineage-specific, conditional knockout mouse model (Col2a1Cre; Prdm16flox/flox, cKO), we have identified female and male cKO mice exhibit shortened nasal septal cartilage and severely deviated nasal septum. Additionally, loss of PRDM16 also has sex-dependent effects on nasal bone parameters. Single-cell RNA-seq showed that loss of PRDM16 drives chondrocytes toward hypertrophy and enhances osteogenesis, potentially leading to nasal septal deviation in cKO mice. Using state-of-the-art spatial transcriptomics further identified that Mgp<sup>+</sup> chondrocytes in nasal cartilage and Fibrotic cells within the nasal bone are both located near the deviation site, suggesting that altered cell-cell interactions between these two cell populations are responsible for the septal deviation. Gene regulatory network analysis showed that loss of PRDM16 upregulates Tgfβ2 and Ccn2, activating fibrosis and osteogenesis signaling pathways. In contrast, WT mice maintain homeostasis by downregulating Ccn2. Overall, our results demonstrate that loss of PRDM16 disrupts communication between Fibrotic and Mgp<sup>+</sup> population, mediated by Tgfβ2 and Ccn2, leading to septal deviation in cKO mice. These findings provide a foundation for developing novel therapeutic strategies for correcting nasal septal deformities.

**Aldo Tecse Castillo**

*Biomedical Engineering*

“Non-contact optical coherence elastography enables decoupling of corneal mechanical properties from intraocular pressure”

Optical Coherence Tomography (OCT) is widely used clinically to assess ocular geometry, yet many corneal diseases and interventions—such as keratoconus, corneal cross-linking, and LASIK—are fundamentally biomechanical. Current approaches to measure corneal elasticity are confounded by intraocular pressure (IOP), making it difficult to isolate intrinsic tissue properties. We hypothesize that separating symmetric (S0) and antisymmetric (A0) Lamb-wave modes generated by non-contact optical coherence elastography (OCE) enables IOP-independent assessment of corneal mechanics. Experiments were performed on intact porcine eyes (N=5) within 24 hours post-mortem. IOP was controlled from 5 to 60 mmHg via saline infusion into the anterior chamber. A custom OCE system combined phase-sensitive swept-source OCT with a confocal air-coupled ultrasonic transducer to deliver non-contact mechanical excitation at the corneal apex. Surface waves at 4 kHz were captured synchronously, and S0 and A0 modes were isolated in the spatial–frequency domain. Mode-specific wave speeds were estimated and fit as functions of IOP.

S0 wave speeds were significantly higher than A0 across all IOPs ( $p \ll 0.01$ ) and exhibited a substantially greater IOP dependence ( $1.02 \pm 0.07$  vs.  $0.13 \pm 0.01$  m/s/mmHg;  $p \ll 0.01$ ). These results suggest that S0 reflects IOP-sensitive tensile behavior dominated by collagen, while A0 is more sensitive to the non-fibrillar extracellular matrix. Thus, decoupled S0 and A0 measurements enable intrinsic corneal elasticity assessment, with potential applications in diagnosis and treatment monitoring.

**Baotong Tian**

*Electrical Engineering*

“Conan: A Chunkwise Online Network for Zero-Shot Adaptive Voice Conversion”

Zero-shot online voice conversion (VC) holds significant promise for real-time communications and entertainment. However, current VC models struggle to preserve semantic fidelity under real-time constraints, deliver natural sounding conversions, and adapt effectively to unseen speaker characteristics. To address these challenges, we introduce Conan, a chunkwise online zero-shot voice conversion model that preserves the content of the source while matching the speaker representation of reference speech. Conan comprises three core components: 1) a Stream Content Extractor that leverages Emformer for low-latency streaming content encoding; 2) an Adaptive Style Encoder that extracts fine-grained stylistic features from reference speech for enhanced style adaptation; 3) a Causal Shuffle Vocoder that implements a fully causal HiFiGAN using a pixel-shuffle mechanism. Experimental evaluations demonstrate that Conan outperforms baseline models in subjective and objective metrics.

**Shivanshi Tiwari**

*Physics*

### “A Framework for Verifying Robustness in Neutrino Modeling”

We are working on tuning the GENIE Monte Carlo generator to external data to improve neutrino interaction predictions. Specifically, we use different experiment datasets (e.g. T2K or MicroBooNE) to replicate tuning procedures within GENIE. With the help of NUISANCE, we tune the interaction model to match cross section measurements and assess how well each tuned prediction agrees with the data. We also evaluate the robustness of the AR23 alternative neutrino interaction model implemented in the GENIE Monte Carlo framework. Our work describes a framework to generate data driven mock data and experimental tunings instead of following ad hoc methods.

**Yun-Cheng Dylan Wang**

*Philosophy*

### “Some Religious Beliefs Are Delusional but That’s OK”

This paper argues that some religious beliefs are delusional but not pathological. Philosophers and psychologists resist the idea that religious beliefs are delusional on the grounds that they don’t seem to be pathological – many have led healthy lives on account of their religious beliefs. Major existing approaches have tried to distinguish faith from delusion by appealing to differences in their social dynamics, etiological profiles, or display of agency. I will argue that none of these approaches satisfactorily distinguish the two and that current etiological models of delusion do seem to support the idea that religious beliefs are culturally acquired delusions.

But even if religious beliefs are delusions, I show that we can resist the Freudian inference that religious beliefs are therefore pathological by adopting the ecological model of mental pathology advocated by neurodiversity theorists. On this model, whether or not a mental trait is pathological depends not on its intrinsic features but on its relationships with its social environment. If the mental trait in question can in actual or foreseeable social contexts contribute to the mutual thriving of the individuals with the trait and their community, then it is not to be considered inherently pathological. Since religious beliefs do contribute to the thriving of religious communities and the persons within, they are non-pathological delusions. Adopting this view not only allows a possible recognition of the epistemic risk of religious belief without over-pathologizing, but also gestures at the potential de-pathologization of delusions given that non-pathological cases of delusion do exist.

**Jin Hyeok Yoon**

*Chemistry*

### “Copper Pyridonate Mediated Chan-Evans-Lam Coupling”

Transition metal catalyzed C–N bond formation has been a cornerstone of pharmaceutical and natural product synthesis. Unlike many palladium mediated reactions, the Chan-Evans-Lam (CEL) coupling uses copper salts, providing a simple, mild, and economical approach to achieve this goal. Despite its advantages, the current approach using copper salts requires extensive re-optimization across various substrates, making it difficult to elucidate reaction mechanisms due to challenging intermediate isolation and condition-dependent behavior.

We hypothesize that a ligand-based copper catalyst in the CEL coupling will provide mechanistic insight and offer a generalized approach to reliable C–N coupling. As a model ligand, pyridonate ligands were chosen due to their versatile steric and electronic tunability through modification of the co-ligand and the bite angle. Additionally, our X-ray diffraction (XRD) analysis of single crystals obtained from the reaction of a pyridonate copper complex with 4-

trifluorophenyl boroxine showed a secondary coordination sphere Lewis acid-base interaction between the pyridonate oxygen and the boron atom.

Herein, we aim to examine the mechanism of the CEL coupling mediated by copper-pyridonate catalysts. Initial screening of ligands showed that the reaction with copper pyrazole pyridonate resulted in a substantial enhancement over a ligand-free condition. With this information in hand, this poster will cover progress toward understanding the mechanism of CEL coupling using the pyridonate-derived copper catalyst.

**Irem Zengin**

*Electrical Engineering*

“A Remote Power Analysis Attack on Mobile Shared-memory Devices”

Power side-channel attacks exploit the correlation between power consumption and system activity. Modern accelerator-rich platforms integrate CPUs and GPUs that share DRAM. Although operating systems enforce privilege boundaries that limit direct inter-process communication, shared DRAM introduces an indirect interaction surface.

In this study, coordinated workloads on the CPU and GPU induce controlled DRAM contention. Memory-intensive activity increases bandwidth usage and DRAM power consumption, generating measurable interference observable across processing units. By modulating memory activity on one processing unit and observing the resulting variations in DRAM power telemetry, shared-resource contention produces observable cross-domain effects.

Experimental results demonstrate that shared-memory contention combined with software-accessible power measurements enables a covert communication channel when access to power telemetry is available. These findings highlight the security risks introduced by shared physical resources and exposed power-monitoring interfaces in heterogeneous systems.