The Midstates Consortium for Math and Science presents



Physical Sciences, Mathematics and Computer Science

November 6 - 7, 2026
Washington University in St. Louis

Beloit College - Carleton College - Carthage College - Colorado College
Grinnell College - Gustavus Adolphus College - Hope College
Knox College - Lawrence University - Luther College
Macalester College - St. Olaf College
University of Chicago - Washington University in St. Louis

Midstates Consortium for Math and Science
Undergraduate Research Symposium for Physical Sciences, Mathematics and Computer Science
Washington University in St. Louis

November 6-7, 2026 Program Schedule

Friday, November 6		
1:00 – 5:30 pm	Check-in at Clayton Plaza Hotel 7750 Carondelet Ave, Clayton, MO 63105 (314) 726-5400	Clayton Plaza Lobby
5:30 – 5:40 pm	WELCOME Richard Mabbs, Associate Professor Department of Chemistry Washington University in St. Louis Pamela Kittelson, Director Midstates Consortium for Math and Science Professor, Gustavus Adolphus College	Clayton Plaza Hotel Grand Ballroom
5:40 – 6:25 pm	KEYNOTE LECTURE *Living on Mars Time: Fourteen Years Exploring a Window into Ancient Earth* Scott VanBommel, Research Assistant Professor Earth and Planetary Sciences & McDonnell Center for the Space Sciences	Clayton Plaza Hotel Grand Ballroom
6:30 – 7:30 pm	Dinner Buffet	Clayton Plaza Hotel Grand Ballroom
7:45 – 8:30 pm	JANET ANDERSON LECTURE *Photoactivatable O-GlcNAc transferase library enables covalent chemical capture of protein interactors* Cassandra Joiner Associate Professor of Chemistry St. Olaf College	Clayton Plaza Hotel Grand Ballroom
	Group Picture	

WiFi Access: WUSTL-Guest-2.0

	Saturday, November 7	
Starts at 6:30 am	Breakfast at hotel: cold breakfast at 6:30 & hot at 7:00	Clayton Plaza Lobby
7:30 – 7:45 am	Load buses, Ubers & vans. Bring bags if leaving on Sat.	Clayton Plaza Lobby
	There is a secure room at the meeting.	Wrighton Kitchen - 3rd floor
8:00 – 8:15 am	Set-up for poster session 1	Wrighton Rettner Gallery
8:15 – 9:15 am	Session 1 Poster Presentations (n = 24-25)	Wrighton Rettner Gallery
9:15 – 9:30 am	Remove posters Check set-up for oral presentations	Coffee & Tea near Wrighton 300
9:30 – 10:45 am	Session I Oral Presentations	
	Session I.A: Moderator: Dr. Darsa Donelan	Wrighton 201
	Session I.B: Moderator: Dr. Richard Mabbs	Wrighton 250
	Session I.C: Moderator: Dr. Tom Stojsavljevic	Wrighton 301
10:45 am – 11:30 pm	Panel: Applying to and life in graduate school	Wrighton 300
11:30 - 12:15	Student lunch	Wrighton 400
11:30 - 12:15	Faculty social	Wrighton 250
12:15 – 12:30 pm	Set-up posters for Session 2	Wrighton Rettner Gallery
12:30 – 1:30 pm	Session 2 Poster Presentations	Wrighton Rettner Gallery
1:30 pm – 1:45 pm	Break. Remove posters. Check set-up for oral presentations	Coffee & Tea near Wrighton 300
1:45 pm – 2:45 pm	Session II Oral Presentations	
	Session II.E: Moderator: Dr. Scott Snyder	Wrighton 201
	Session II.F: Moderator: Dr. Joseph Anderson	Wrighton 250
	Session II.G: Moderator: Dr. Tom Clayton	Wrighton 301
2:45 pm – 3:00 pm	Break. Set-up for Poster Session 3	Coffee & Tea near Wrighton 300
3:00 pm – 4:00 pm	Session 3 Poster Presentations	Wrighton Rettner Gallery
4:00 pm - 4:15 pm	Remove posters. Meeting Concludes. Take boxed meals to go. Depart for drive, airport or hotel. Complete online evaluations. Thank you!	

Keynote Address

Living on Mars Time: Fourteen Years Exploring a Window into Ancient Earth

Dr. Scott VanBommel, Research Assistant Professor
Earth and Planetary Sciences & McDonnell Center for the Space Sciences



Abstract: Telecommuting across tens of millions of kilometers presents challenges unlike almost any other workplace on Earth. Since the first Mars rover touched down in 1997, NASA's exploration of the martian surface has evolved across four generations of increasingly sophisticated mobile robotic explorers. In this presentation we will trace the progression of past, active, and future missions that have brought planetary science to the cusp of milestones, generations in the making. Alongside the tactical rhythm of surface operations, the talk will examine how recent discoveries illuminate not only the geologic history of Mars but also provide a window into ancient Earth. We will also discuss the human side of exploring a new frontier, weaving through personal experiences spanning undergraduate and graduate studies, Antarctic meteorite recovery, and over 8,000 sols on the front lines of rover science, highlighting common threads across disciplines, career paths, and the worlds we study.

About: Dr. Scott VanBommel is a Research Assistant Professor at Washington University in the Department of Earth, Environmental, and Planetary Sciences and a fellow of the McDonnell Center for the Space Sciences. Dr. VanBommel completed his B.Sc. (Physics), M.Sc. (Physics), and Ph.D. (Physics) in Canada prior to joining Washington University in 2018. He was named to the Canadian Space Agency's astronaut shortlist in 2017 and was awarded the United States Antarctica Service Medal in 2018 for his contributions to a multi-month NASA expedition hunting for meteorites along the Transantarctic Mountains. Dr. VanBommel's research focuses on advancing the scientific capabilities of landed payloads, with a specific emphasis on past, present, and future X-ray spectrometers sent to the Moon and Mars. He has worked on every active NASA Mars rover since 2012, accumulating more than 8,000 sols of martian surface operations experience across three landing sites.

2026 Janet Andersen Award Lecture

Photoactivatable O-GlcNAc transferase library enables covalent chemical capture of protein interactors

Dr. Cassandra Joiner, Associate Professor of Chemistry
St. Olaf College



Abstract: The Joiner lab uses chemical tools and biochemical techniques to determine how protein-protein interactions control how the human O-linked beta-N-acetylglucosamine (O-GlcNAc) transferase (OGT) enzyme chooses which proteins (or substrates) to modify in our bodies. OGT is the sole enzyme responsible for the transfer of a single O-GlcNac sugar to serine and threonine residues of nuclear and cytoplasmic proteins involved in almost every cellular process. This sugar modification is essential for cellular growth and development and misregulation of protein O-GlcNAc levels has been implicated in metabolic diseases, cancers, and neurodegenerative diseases. The broad disease activity makes OGT an attractive therapeutic target, however the substrate diversity makes pan inhibition as a therapeutic strategy unfeasible. Rather, a substrate-specific approach to targeting is more advantageous, but how OGT chooses its substates is poorly understood. We have developed a library of OGT constructs containing a UV-active unnatural amino acid at different locations along OGT's noncatalytic domain to covalently capture and map OGT's interaction network to determine how non-substrate interactions control how OGT chooses its protein targets.

About Dr. Joiner: Dr. Joiner is a protein biochemist who has integrated real-world research questions into her courses and has developed methods to spur creativity in both intro and upper-level chemistry laboratories. She has mentored over 37 students in research that focuses on the mechanisms of adaptor protein engagement related to glycosylation. Dr. Joiner also contributes to CourseSource, serves on the Education Committee for the Protein Society, and builds a lively STEM community at St. Olaf.

About the Janet Andersen Award Lecture: Professor Janet Andersen was a beloved faculty member of the Hope College Mathematics Department and served as the Midstates Consortium Director before her life ended tragically in an automobile accident. As a teacher and scholar, Janet designed creative, high quality learning experiences. As Consortium Director, she looked for ways to connect with and support science faculty, both new and experienced. To honor Janet's work in her teaching, research and service, the Janet Andersen Lecture Award was established in 2008.

ORAL SESSION I.A: 9:30 - 10:45 a.m. Room: Wrighton 201 Moderator: Dr. Darsa Donelan			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.A.1	Braedon Larsen	Carthage College	Geometric Feature Finding for 3D Bubble Localization in Acoustic Microgravity Phase-Separation
I.A.2	Juliana Alvarez and Owen Bonnett	Carthage College	Suborbital Payload Design for Acoustic Phase Separation in Microgravity Conditions
I.A.3	Noah Gehler	Gustavus Adolphus College	From Jupiter-Io to Exomoons: Engineering and Modeling Approaches for Future Radio Analysis
I.A.4	Dar Evan	Gustavus Adolphus College	Simulations of Radio Galaxies
I.A.5	Sofya Fadeeva, Boden Komorech and Ayesha Rana	University of Chicago	Constraints on Long-Term Variability in Young Stellar Objects

ORAL SESSION I.B: 9:30 - 10:45 a.m. Room: Wrighton 250 Moderator: Dr. Richard Mabbs			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.B.1	Bethany Bao	Washington University in St. Louis	Rare Earth Element Release during Simulated Weathering of Mine Tailings from an Iron Oxide-Apatite Deposit
I.B.2	Benjamin Murr	Luther College	Measurements of D0 --> Ks0 pi+ pi- pi0 Intermediate State Branching Fractions Using Data from the Belle II Experiment
I.B.3	Karl Lyu	Washington University in St. Louis	Lattice Relaxation Drives Re-Entrant Interlayer Decoupling in Twisted CrSBr Bilayers
I.B.4	Ina Jaegy	Washington University in St. Louis	Rapid Thermal Annealing to Improve Crystal Quality in GeSn for Optoelectronic Applications
I.B.5	Brookelyn Velmont	Carthage College	Evaluation of ResNet50 Segmentation Performance with Presence of Necrosis within Pleural Mesothelioma Tumors on CT Scans

WiFi Access: WUSTL-Guest-2.0

SESSION I.C: 9:30 - 10:45 a.m. Room: Wrighton 301 Moderator: Dr. Tom Stojsavljevic			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.C.1	Shan Ghimire and Linh Nguyen	Luther College	Statistical Relationships Are Not Learning Relationships in Multi-Task Learning: An Empirical Study
I.C.2	Julia Raphael	Washington University in St. Louis	Validation of a Computer Vision Motion Capture System for Clinical Outcome Measures in Young Adults
I.C.3	Jack Farah	Washington University in St. Louis	Irreducibility of the Intersection of Matrix Schubert Varieties of the Longest Grassmannian Permutations
I.C.4	Jeffrey Yu	Macalester College	Image and Kernel Persistence on Temporal Knowledge Networks
I.C.5	Uliana Hauk	University of Chicago	Searching for Population III-Dominated Galaxies Using JWST Photometry and Machine Learning

WiFi Access: WUSTL-Guest-2.0

Oral Session II Schedule

SESSION II.D: 1:45 - 2:45 p.m. Room: Wrighton 201 Moderator: Dr. Scott Snyder			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.D.1	Mansoor Johnson	University of Chicago	Non-Enzymatic RNA Strand Separation via Complement Fragmentation
II.D.2	Mihail Palmov	Grinnell College	Studies on Advanced LiFSI Localized High Concentration Electrolytes with Variable Temperature Diffusion NMR
II.D.3	Xuannan Liu	Washington University in St. Louis	Exploring Chiral Side Chain Crowding on Semicarbazone Macrocycles
II.D.4	Alyssa Zhang	Washington University in St. Louis	Removal of Iodine and Iodide in Hot Water Using Porous Organic Polymer

SESSION II.E: 1:45 - 2:45 p.m. Room: Wrighton 250 Moderator: Dr. Joseph Anderson			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.E.1	Sabina Stalbekova	Knox College	Can AI-Rewritten Banking Phishing Messages Change Detector Decisions?
II.E.2	Thereza Cristina Pedrazini de Castilho	University of Chicago	Synthesis and Evaluation of Machine-Learning-Generated Analogs of Imatinib
II.E.3	Mohsin Asad	Knox College	Gemini, Gemini, Unlock My Phone: AI-Generated Presentation Attacks and Template Drift on Android Face Unlock
II.E.4	Kamlesh Kumar	Knox College	Can You Be Me? A Game-Based Approach to Behavioral User Authentication

SESSION II.F: 1:45 - 2:45 p.m. Room: Wrighton 301 Moderator: Dr. Tom Clayton			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.F.1	Altynai Ruslanova	Knox College	Computational Modeling of Disease Spread
II.F.2	Tess Agoglia	Washington University in St. Louis	Optimizing Reverse Micelles for Structural Studies of Amyloid-β Oligomers
II.F.3	Yuhua Miao	Washington University in St. Louis	Nanoclusters: Accessing Solvent-Incompatible Mixed-Shell Compositions in Minutes

Poster Session P1

8:15 - 9:15 a.m. Room: Rettner Gallery			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P1.01	Michel Heinrich	Luther College	Post-Fabrication Surface Modification of PDMS-co-PVMS Microspheres via Thiol-ene Click Chemistry
P1.02	Danny Phan	Washington University in St. Louis	Investigating the role of the CdrA lectin subdomain in *Pseudomonas aeruginosa* biofilm formation
P1.03	Ramses Ponce	Grinnell College	MTHFR Thr59Ala, Gln219Ala, and Tyr275Ala Mutant Analysis via HDX and LC-MS
P1.04	Henry Batson	Colorado College	Impact of o-Phenylenediamine Degradation on Molecularly Imprinted Polymer Based PFAS Sensor Performance
P1.05	Eeshaan Malladi	Washington University in St. Louis	Computational Genomics and Clinical Evidence Curation in Precision Oncology
P1.06	Marc Duebener	Grinnell College	Variable-Temperature PFG-NMR Analysis of Ion Transport in Localized High-Concentration Lithium-Ion Electrolytes
P1.07	Ellie Repinski	Beloit College	Mathematical Modelling of Human African Trypanosomiasis
P1.08	Benjamin Schweit	Beloit College	Actuarial Applications of Epidemiological Models: Chagas Disease
P1.09	Zixi Yu	Washington University in St. Louis	Multi-Tissue Landscape of NUMTs and Mitochondrial DNA Variation in Humans
P1.10	Katrina Brinkmann	Macalester College	Exploring the Use of Speech Pattern Analysis in Differentiating Neurological Disorders
P1.11	Dipsha Budhathoki	Knox College	Multimodal Deep Fusion for Antarctic Sea Ice Classification
P1.12	Abigail Gardner	Carleton College	The Origins of Neutron-Capture Elements in a Cosmological Simulation
P1.13	Oscar Peterson	Gustavus Adolphus College	From Jupiter-Io to Exomoons: Engineering and Modeling Approaches for Future Radio Analysis
P1.14	Ben Lagerhausen and Ella Stugelmeyer	Carthage College	Integration of MUD as a Standardized Testing Payload for NASA's Universal Payload Interface Challenge
P1.15	Elliott Lewis	Macalester College	Persistent or Bursting: Star Formation in NGC 3109
P1.16	Carson Bridigum	St. Olaf College	Curvotaxis of Thin Floating Films: Wrinkles as a Driver for a Dynamical Transition
P1.17	Abby Clasemann	Gustavus Adolphus College	Perfect State Transfer in Cycle Graphs

P1.18	Mauricio Vega	Carthage College	Designing, Prototyping, and Educational Applications for Injection Molding
P1.19	Evie Doran	Colorado College	Investigation of Template Removal Process for Molecularly Imprinted Polymer for PFAS Sensor Use
P1.20	Michelle Laferriere	Colorado College	EQCM as a Tool for Mechanistic Study of PFAS Binding in Molecularly Imprinted Polymer-based Sensors
P1.21	Kacy Tran	Knox College	Crop-Label Alignment: Auditing Crop-Dependent Auto-Labels in Remote-Sensing Segmentation
P1.22	Maya Holland	Grinnell College	Auditing Potential Bias in AI Through College Admissions
P1.23	Maria Zhang	Grinnell College	College Course Registration System Modeling
P1.24	Samara Melisbek	Knox College	Data Driven Career Guidance System for High School Students in Kyrgyzstan

Poster Session P2

12:30 - 1:30 p.m. Room: Rettner Gallery			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P2.01	Drew Fargo	Grinnell College	An approach to PKA Completeness through Iteration Theories
P2.02	Joseph Merrigan	Gustavus Adolphus College	Deciphering Cell-State Dynamics Using Applied Topology and Optimal Transport
P2.03	Lincoln Bosh	Hope College	Proton Irradiation Effects on Superconducting Tc and Residual Resistivity ρ0 in Single-Crystal Bi2Sr2CaCu2O8+δ
P2.04	Doga Eker	University of Chicago	Stellar Yields of Rapidly Rotating Pop III Stars for the High Redshift Universe
P2.05	Kyle Thompson	Carleton College	Coherently coupled quantum oscillators for predicting and characterizing chaotic maps
P2.06	Anna Imdieke	Gustavus Adolphus College	A Python Application Framework for an AI AssistiveDevice
P2.07	Rebecca Moran	Carleton College	Modeling Access Patterns for a Shared GPU
P2.08	Daniel Lee	Grinnell College	Smoothing Synchronized Power Swings in HPC Clusters Using Software: Measurement, Prediction, and Grid Simulation
P2.09	Julian Mitchell	Washington University in St. Louis	Patterns and Drivers of Human-Snake Conflict in Honduras
P2.10	Sadé Brooks-Robinson	St. Olaf College	Modeling Competition Outcomes Between Species in Shared Habitats
P2.11	Eeman Naveed	Knox College	How Player Choices Affect Game Length and Winning Probability in Snakes and Ladders
P2.12	Batsambuu Batbold	Macalester College	Beyond the Persistence Diagram: Visualizing Representative Cycles and Knowledge Gaps in Concept Networks
P2.13	Annie Do	Knox College	How Much Renewable Energy Will We ALL Need in 2050
P2.14	Santosh Pant	Knox College	Auditing GeoFM Evaluation for Field-Extent Segmentation: Label Proxies, Baselines, and When Frozen Features Match Fine-Tuning
P2.15	SarahPearl Anderson	Grinnell College	Optimizing LSPR Biosensors on Substrates
P2.16	Liv Panos	Colorado College	Is your room making you think less clearly? The Impact of CO_2 on Cognition and Stress Biomarkers
P2.17	Ian Morgan	Carleton College	Written in Light: Determining Stellar Population Classification for Red Clump Stars Using Low-resolution Spectra

P2.18	Sudhi Adusumilli	Macalester College	Comparing the Shielding Effects of Poly(ethylene glycol) and Polysarcosine Polymers on Esterase
P2.19	Brooke Kreeger	Grinnell College	Structural Analysis of *E. coli* MTHFR Y275F Mutant Using HDX and LC-MS
P2.20	Douglas Leung	Colorado College	Developmental Synthesis of Fluorinated Amodiaquine Analogs
P2.21	Gus Krueger and David Pittman	Luther College	Development of Methods for Dye Loading and Release from PDMS Microspheres
P2.22	Amari Herndon-Goodman	Washington University in St. Louis	Methanol-Modified Carbonate Mineralogy in Ammonia-Rich Ocean World Analogs
P2.23	Mayank Raghuvanshi	Knox College	Repeatability and Precision Testing of Half Meter Class Telescope Filter Wheels
P2.24	Faith Mitchell	Hope College	Effects of Proton Irradiation on the Properties of TBCC Thin-film Superconductors

Poster Session P3

3:00 - 4:00 p.m. Room: Rettner Gallery			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P3.01	Anya Troyer	Grinnell College	Duality of Orthogonal Polynomials with Rational Weights
P3.02	Minh Le	Luther College	Synthetic Data Generation via Factorized Feature–Target Synthesis
P3.03	Ronak Jha	Knox College	Mechanistic Consistency Is Not Correctness: A Transferable Circuit That Computes the Wrong Causal Answer
P3.04	Marcos Arnold and Ja'Toria Johnson	Colorado College	An Accessible Design Thinking Process to Support Students with Intellectual and Developmental Disabilities in Independent Making
~~P3.05~~	~~Araf Israk~~	~~Beloit College~~	~~An Interactive Engine for Reidemeister Simplification of Plane Loops~~
P3.06	Tioluwani Olubunmi	Knox College	Testing Complex Chemical Reaction Networks: A Metamorphic and Probabilistic Evaluation Framework for ChemTest
P3.07	Finn Rowles	Grinnell College	Modeling Uncertainty and Outcomes in Grinnell College Registration Processes
P3.08	Filip Maleev	Colorado College	Properties of Wild Colored Graphs
P3.09	Jinwoo Chun	University of Chicago	Heterogeneous Landscape of Neutrophil Dynamics in Zebrafish
P3.10	Natalie Booth	University of Chicago	Direct Measurement of Turbulence in Early-Type Galaxies
P3.11	Emrah Omerovic	Washington University in St. Louis	Quantum Trajectories and Wave Packet Dynamics in Open Quantum Systems
P3.12	Jennifer Hong	Washington University in St. Louis	Beyond the Encapsulation of Amyloid-Beta 40: Is Extraction the Key to the Alzheimer's Toxicity Problem?
P3.13	Alexis Mendoza	Grinnell College	Using FRET microscopy to study microtubule dynamics
P3.14	Joy Kim	Washington University in St. Louis	Investigating the Alteration of Condensate Morphology and Toxicity of MATR3 Isoforms in Yeast
P3.15	Nima J. Sherpa	Knox College	Physics-Informed Neural Networks (PINNs) for Ice Shelf Viscosity Inference Under Sparse Observations
P3.16	Mara Neace	Grinnell College	Meteorological Analysis of Grinnell College's Conard Environmental Research Area Weather Station Data

P3.17	Owen McCredie	Luther College	End-to-End Machine Learning Water Quality Prediction at lowa Monitoring Stations
P3.18	Seth Vizel	Carleton College	Clustering Non-Isomorphic Clonal Trees by Shape
P3.19	Richard Cuzydlo	Hope College	Controlling Perovskite Crystal Growth through a Single Additive to Achieve Enhanced Brightness Luminescence
P3.20	Luis Rios	Colorado College	Optimization Of Chemical Pretreatments Of Tooth Enamel For Forensic Analysis Using Thermogravimetric Analysis (TGA)
P3.21	Sydney Fuller	St. Olaf College	Investigating the Synthesis, Characterization, and Reactivity of N2P2 Cobalt (I) Complexes
P3.22	Gavin Hoelzel	St. Olaf College	Methyl Substituted N2P2 Complex Synthesis and Characterization with a Nickel Center

Abstracts for all Sessions
Physical Sciences, Mathematics and Computer Science
MCMS Undergraduate Research Symposium Washington University in St. Louis
November 7, 2026

All abstracts (poster and oral) are listed alphabetically by presenter last name.

Presenter(s): Adusumilli, Sudhi
School: Macalester College
Session: P2.18
Title: Comparing the Shielding Effects of Poly(ethylene glycol) and Polysarcosine Polymers on Esterase
Co-Author(s): Isabella Nimm, Madeleine Ruddy, Leah S. Witus
Advisor(s): Leah Witus

Abstract: Poly(ethylene glycol) (PEG) is a widely used, FDA approved shielding polymer for many protein therapeutics, which often serves to prolong the proteins' circulation time in the bloodstream. However, an increase in allergic reactions towards PEG have been observed. In order to combat this, alternative shielding polymers have been garnering attention, including polysarcosine (Psar), for their hypothesized ability to function similarly to PEG. To study how Psar compares to PEG, each polymer was conjugated to esterase, a model enzyme. After polymer attachment, enzymatic activity assays were performed to assess the catalytic activity of esterase when conjugated to either polymer. Through these experiments, a frame of comparison of the efficacy between PEG and Psar is being established, where Psar and PEG appear to similarly impact enzymatic function.

Presenter(s): Agoglia, Tess
School: Washington University in St. Louis
Session: II.F.2
Title: Optimizing Reverse Micelles for Structural Studies of Amyloid-β Oligomers
Co-Author(s): Huanran Sun, Johnny Yang, Jennifer Hong
Advisor(s): Yusuke Okuno

Abstract: My research addresses the need to understand the early molecular events underlying Alzheimer's disease. While amyloid-beta (Aβ) plaques have long been associated with the disease, clinical efforts to remove them have had minimal impact on progression. Increasing evidence suggests that an intermediate species, between an Aβ monomer and a mature plaque, may instead be responsible. These oligomers are difficult to study because they aggregate rapidly in aqueous solution and Aβ is intrinsically disordered.This project aims to isolate and structurally characterize Aβ dimers, the earliest discrete step in aggregation beyond the monomer. Because structure is directly associated with function, characterizing these dimers could provide critical insight into early aggregation pathways implicated in Alzheimer's disease.To do so, we use reverse micelles: nanoscale aqueous droplets stabilized by surfactants in a nonpolar solvent. These confine Aβ within size-controlled environments that promote dimer formation while restricting larger fibrillar assemblies. This summer, I investigated how formulation variables, including water loading (W_0), surfactant concentration (CO520), oil phase, and hexanol concentration, affect reverse micelle size and stability. Optimizing these variables reduced average micelle diameter by 53%, from approximately 47 nm to 22 nm, while maintaining homogeneous formulations, efficient Aβ encapsulation, and native-like Aβ conformation. These findings establish a foundation for future NMR studies characterizing early Aβ oligomers.

Presenter(s): Alvarez, Juliana
School: Carthage College
Session: I.A.2
Title: Suborbital Payload Design for Acoustic Phase Separation in Microgravity Conditions
Co-Author(s): Kevin Crosby, Owen Bonnett, Gabe Klinepeter, Braedon Larsen, Justin Wheeler, Walker Brown
Advisor(s): Kevin Crosby

Abstract: Long-term, sustainable space exploration requires reliable in-space refueling, but the absence of gravity complicates propellant transfer. During propellant transfer, excess pressurant gas must be vented to maintain proper tank pressure. In microgravity, however, liquid propellant adheres to the tank walls, leaving a central ullage gas bubble whose uncontrolled position makes targeted venting unreliable. To address this challenge, the Microgravity Ullage Trapping (MUT) experiment seeks to form and trap ullage bubbles at designated vent ports using acoustic excitation. MUT is a companion project to Carthage College's Microgravity Ullage Detection (MUD) experiment and builds on recent advances in acoustic manipulation of gas bubbles. MUT uses ultrasonic transducers to grow micron-scale bubbles from dissolved pressurant gases and steer them via acoustic pressure gradients. The experiment exploits both primary and secondary Bjerknes forces to achieve bubble migration and coalescence. We have demonstrated proof of concept in ground-based testing with a single transducer, confirming bubble growth and translation under controlled conditions. Based on these results, we are developing a suborbital payload featuring a phased array of transducers to enable group manipulation of ullage bubbles. By precisely nucleating and steering bubbles toward the vent port, this approach facilitates reliable, targeted ullage venting during microgravity propellant transfer.

Presenter(s): Anderson, SarahPearl
School: Grinnell College
Session: P2.15
Title: Optimizing LSPR Biosensors on Substrates
Co-Author(s): Daniel Lee, Keisuke Hasegawa
Advisor(s): Keisuke Hasegawa

Abstract: Localized surface plasmon resonance (LSPR) biosensors have emerged as a promising alternative to conventional virus detectors because they are quick, easy to administer, and cost-effective. LSPR occurs when the electric field of a light wave incident on a noble metal nanoparticle (NP) excites its free electrons to collectively oscillate at a resonant wavelength. In biosensing, target molecules bind to an NP, shifting the refractive index within nanometers of the sensor. This causes the resonant wavelength to change in response. As a performance metric, we define sensitivity as the change in resonant wavelength divided by the change in local refractive index. LSPR biosensors can float in suspension or be placed on a flat substrate, where NP orientation can be controlled. We aimed to predict the sensitivity of various NP shapes (nanorods, nanodisks, nanocylinders, nanotriangles) on substrates using NANOBEM, an open-source Maxwell's equation solver designed for simulating nanophotonics. To generalize the sensitivity of any NP shape on substrate, we proposed a partial, embedded sphere model and derived an effective refractive index equation based on energy density. We are continuing to optimize its parameters and look to extend the model to more realistic multi-layer sensors.

Presenter(s): Arnold, Marcos
School: Colorado College
Session: P3.04
Title: An Accessible Design Thinking Process to Support Students with Intellectual and Developmental

Disabilities in Independent Making
Co-Author(s): Ja'Toria Johnson, Varsha Koushik, Lauren Milne
Advisor(s): Varsha Koushik
Abstract: Design thinking, the ability to ideate and create a design, can be a challenging yet rewarding process, and even more beneficial for creating assistive devices for individuals with intellectual and developmental disabilities (IDD). Nevertheless, current maker tools such as 3D printers, electronic toolkits, and the overall design process are inaccessible and not beginner-friendly for people with disabilities. To address this concern, our research focuses on making the process of design thinking more accessible to individuals with IDD. To explore accessible alternatives, we followed a user-centered approach, designing for the user needs through brainstorming, market research, understanding user needs, sketching, and prototyping. This involved participating in a challenge posted by the Maker's Making Change, a forum for designing and creating custom assistive devices based on real user needs, to scaffold an accessible process for individuals with IDD. We developed helpful guides and supported the research team in conducting a Do-It-Yourself design workshop with students and teachers to explore need-specific scaffolding strategies for the design thinking process. Overall, a human-centered, scaffolded, accessible design process can support autonomy in creation for designers of all abilities.

Presenter(s): Asad, Mohsin
School: Knox College
Session: II.E.3
Title: Gemini, Gemini, Unlock My Phone: AI-Generated Presentation Attacks and Template Drift on Android Face Unlock
Co-Author(s):
Advisor(s): David Bunde

Abstract: A phone recognizes your face, learns from every successful unlock, and is meant to protect your most personal data. But what if that learning can be turned against it? This study investigates whether consumer AI tools can bypass Android face-unlock systems without specialized equipment. We tested three Android phones the Vivo Y21, Samsung Galaxy A56, and Samsung Galaxy S25 Ultra, using AI-generated facial images, partial-face inputs, mirror reflections, and repeated presentation attempts. The results revealed a clear security gradient: entry-level devices were highly vulnerable, while the flagship device showed stronger but incomplete resistance. More concerningly, AI-generated images that looked visibly different from the enrolled user could still unlock the devices. Our most important finding was evidence of template drift: after repeated successful spoofing attempts, images that initially failed began to unlock the phones. Resetting facial enrollment restored much of the devices' resistance, suggesting that adaptive face-template learning may gradually expand what the system accepts as a match. The project highlights a growing concern: as AI makes realistic image generation easier, 2D face unlock may provide convenience but not reliable security. We recommend stronger liveness detection, drift monitoring, and clearer warnings for users relying on facial recognition to protect sensitive data.

Presenter(s): Bao, Han
School: Washington University in St. Louis
Session: I.B.1
Title: Rare Earth Element Release during Simulated Weathering of Mine Tailings from an Iron Oxide-Apatite Deposit
Co-Author(s): Emily G. Wright, Jeffrey G. Catalano
Advisor(s): Jeffrey G. Catalano

Abstract: Rare earth elements (REEs) are critical elements due to their commercially limited sources and

wide usage in technologies such as magnets and catalysts. Mine wastes can serve as economic sources for REEs, avoiding high excavation costs. Since the extractability of REEs depends on their mineral hosts, understanding how weathering affects the fate of REEs in the environment is important. Mine tailings at the Pea Ridge iron oxide-apatite deposit contain elevated concentrations of REEs. While two chemically resistant REE phosphate minerals, monazite [(Ce,La,Nd,Th)PO4] and xenotime (YPO4), occur in the tailings, a major REE host is apatite [Ca5(PO4)3(OH,F,Cl)], a less resistant calcium phosphate mineral. Aging samples from unvegetated and vegetated surficial deposits as well as from the base of the tailings in a series of air-equilibrated fluids reveals that different ligand-sample pairings have distinct effects on leaching REEs. Citrate induces substantial initial REEs dissolution followed by their reprecipitation or adsorption. Heavy REEs (Tb-Lu, Y) are preferentially leached over light REEs (La-Gd), likely due to a larger fraction of the heavy REEs being hosted in the less resistant apatite. Organic ligands may therefore be important agents in weathering REEs in iron oxide-apatite mine tailings, forming phases with greater mobility or extractability.

Presenter(s): Batbold, Batsambuu
School: Macalester College
Session: P2.12
Title: Beyond the Persistence Diagram: Visualizing Representative Cycles and Knowledge Gaps in Concept Networks
Co-Author(s): Nadezhda Dominguez Salinas, Rachel Xu, Jeffrey Yu, Gavin Engelstad, Frances McConnell, Lori Ziegelmeier, Russell Funk
Advisor(s): Lori Ziegelmeier

Abstract: Understanding how science evolves often involves finding "knowledge gaps"—areas where related ideas have not yet been studied together. We model scientific literature as a network where nodes are concepts and links connect concepts that appear in the same paper abstract. Using topological data analysis (TDA), these knowledge gaps appear as "holes" (or 1-cycles) in the network. However, standard TDA summaries only record when a hole opens and closes, hiding the actual concepts and papers behind it. We built TDA Cycle Explorer, an interactive web tool that lets researchers visually inspect these knowledge gaps. Users can select any hole to see its boundary concepts, identify the papers that connect them, and watch an interactive timeline showing how later research eventually fills the gap. To keep the network readable, the application uses graph layout algorithms to turn messy edge collections into clean 2D circles and 3D surfaces. By connecting topological methods with intuitive visual tools, our platform makes it easy to explore concrete case studies of how scientific discoveries occur.

Presenter(s): Batson, Henry
School: Colorado College
Session: P1.04
Title: Impact of o-Phenylenediamine Degradation on Molecularly Imprinted Polymer Based PFAS Sensor Performance
Co-Author(s): Michelle Laferriere, Evie Doran, Eli Fahrenkrug
Advisor(s): Eli Fahrenkrug

Abstract: Per- and polyfluoroalkyl substances (PFAS) are a large class of persistent environmental contaminants that are commonly found in water and are associated with a range of health concerns. Molecularly imprinted polymers (MIPs) are promising materials for PFAS detection. MIPs can be used to create target-specific binding sites for PFAS sensing. o-Phenylenediamine (o-PD) is a monomer used to form the MIP film and create these binding sites. In this study, the effect of o-PD degradation on the fabrication and PFAS sensing performance of MIP sensors was investigated. UV-Vis spectroscopy was

used to monitor changes in o-PD associated with aging and degradation. MIP sensors were fabricated through electropolymerization using o-PD with different aging conditions, and the resulting cyclic voltammetry data were examined for changes in the polymerization process. Following fabrication, differential pulse voltammetry (DPV) was used to evaluate the sensor response to varying PFAS concentrations. The electropolymerization and DPV responses showed similar behavior across the tested o-PD conditions, despite the UV-Vis data indicating that degradation had occurred. This work provides insight into the relationship between o-PD stability and the performance of MIP-based PFAS sensors, with implications for sensor reproducibility and storage.

Presenter(s): Bonnett, Owen
School: Carthage College
Session: I.A.2
Title: Suborbital Payload Design for Acoustic Phase Separation in Microgravity Conditions
Co-Author(s):
Advisor(s): Kevin Crosby

Abstract: Long-term, sustainable space exploration requires reliable in-space refueling, but the absence of gravity complicates propellant transfer. During propellant transfer, excess pressurant gas must be vented to maintain proper tank pressure. In microgravity, however, liquid propellant adheres to the tank walls, leaving a central ullage gas bubble whose uncontrolled position makes targeted venting unreliable. To address this challenge, the Microgravity Ullage Trapping (MUT) experiment seeks to form and trap ullage bubbles at designated vent ports using acoustic excitation. MUT is a companion project to Carthage College's Microgravity Ullage Detection (MUD) experiment and builds on recent advances in acoustic manipulation of gas bubbles. MUT uses ultrasonic transducers to grow micron-scale bubbles from dissolved pressurant gases and steer them via acoustic pressure gradients. The experiment exploits both primary and secondary Bjerknes forces to achieve bubble migration and coalescence. We have demonstrated proof of concept in ground-based testing with a single transducer, confirming bubble growth and translation under controlled conditions. Based on these results, we are developing a suborbital payload featuring a phased array of transducers to enable group manipulation of ullage bubbles. By precisely nucleating and steering bubbles toward the vent port, this approach facilitates reliable, targeted ullage venting during microgravity propellant transfer.

Presenter(s): Booth, Natalie
School: University of Chicago
Session: P3.10
Title: Direct Measurement of Turbulence in Early-Type Galaxies
Co-Author(s): Yuanyuan Su, Ryan Eskansy, Valeria Olivares, Yuan Li, Marie-Lou Gendron-Marsolais
Advisor(s): Yuanyuan Su

Abstract: Modern multi-wavelength surveys have revealed the multiphase nature of the interstellar medium in early-type galaxies (ETGs). Measuring the turbulence of this multiphase gas is key to understanding the energy budget and baryon cycle in ETGs. In this work, we present a systematic study of rotation-subtracted velocity structure functions (VSFs) of the warm ionized gas in ETGs observed with the Multi Unit Spectroscopic Explorer (MUSE) on the Very Large Telescope (VLT). Galaxies in our sampleare divided into three categories: brightest cluster galaxies (BCGs) with filamentary warm gas, non-BCG ETGs with filamentary warm gas, and non-BCG ETGs with disky warm gas. Non-BCG ETGs with filamentary warm gas have VSF slopes clustered around 1/3, consistent with the expectation for classical (Kolmogorov) turbulence, whereas both disky sources and BCGs show steeper VSF slopes. The steep VSF in disky sources may be due to an incomplete subtraction of the ordered rotation from the velocity map.

For sources with filamentary warm gas, we find a positive correlation between their VSF slopes and stellar masses. The deep gravitational potential well of BCGs may have suppressed the radial gas motion and modified the shape of the VSF. The large-scale motion in galaxy clusters (e.g., sloshing) may have also caused the motion to deviate from classical turbulence.

Presenter(s): Bosh, Lincoln
School: Hope College
Session: P2.03
Title: Proton Irradiation Effects on Superconducting Tc and Residual Resistivity ρ0 in Single-Crystal Bi2Sr2CaCu2O8+δ
Co-Author(s): Faith Mitchell, Kyuil Cho
Advisor(s): Kyuil Cho

Abstract: The superconducting and normal-state properties of Bi2Sr2CaCu2O8+δ single-crystals were studied by performing 2.0 MeV proton irradiations with a total fluence of 4.00 × 1017 p/cm2, resulting in high Tc suppression as well as an increase in normal-state resistivity ρ. The change in residual resistivity Δρ0 was calculated from Δρ(150K), which in turn was used to calculate g, the dimensionless scattering rate at each fluence level. The relationship between tc and g in our study was compared with generalized d-wave Abrikosov–Gor'kov theory along with other previous experiments which used different irradiation techniques, and it was determined that proton irradiation fails to approximate AG theory as well as electron irradiation, but it is still much closer to the theoretical relationship than heavy-ion irradiation. This is likely due to electron irradiation's tendency to create point defects, while protons and especially heavy ions are more likely to create cluster or cascading defects.

Presenter(s): Bridigum, Carson
School: St. Olaf College
Session: P1.16
Title: Curvotaxis of Thin Floating Films: Wrinkles as a Driver for a Dynamical Transition
Co-Author(s): Atlas Conger, Joseph Paulsen
Advisor(s): Joseph Paulsen

Abstract: Many objects from microparticles to insects can climb curved liquid menisci using the distortions they create in the liquid interface around them. In our project we observe patterns of wrinkling in thin floating films as they are propelled along a curved liquid interface. We investigate how the wrinkling pattern varies with film thickness. Previously theorized behavior was explored in the regime far from the meniscus edge, the research we undertook suggests a new behavioral regime on the curved edge of the meniscus. The dynamical transition between these regimes was captured in photography and video. We illustrate our production process as well as our imaging setup. These findings can be useful for sensing curvatures in situ or delivering cargo to precise locations.

Presenter(s): Brinkmann, Katrina
School: Macalester College
Session: P1.10
Title: Exploring the Use of Speech Pattern Analysis in Differentiating Neurological Disorders
Co-Author(s): Patricia Bloom
Advisor(s): Patricia Bloom

Abstract: Changes in speech are some of the earliest manifestations of neurological disorders. Speech analysis is a quick, non-invasive way to screen patients for these conditions. Previous studies have

demonstrated the capability of statistical algorithms to discern people with Parkinson's Disease (PD) from healthy controls, ataxia from controls, and HE (a complication of severe liver disease) from controls. However, studies have yet to compare the speech patterns between these disorders. This research focuses on identifying unique speech signatures of these three neurological disorders (PD, ataxia, HE) with the goal of accurately distinguishing between each condition.

Presenter(s): Brooks-Robinson, Sadé
School: St. Olaf College
Session: P2.10
Title: Modeling Competition Outcomes Between Species in Shared Habitats
Co-Author(s): Adam Rickman, Erin Ellefsen
Advisor(s): Erin Ellefsen

Abstract: How species move through their environment can have an important influence on their ability to survive and compete for resources. In this project, we developed a mathematical model using systems of differential equations to investigate how different movement strategies affect competition between two species living in a shared habitat. Our model considers both movement based on population density (p-Laplacian exponents) and movement in response to the presence of another species (cross diffusion) in a two-patch environment. We used mathematical analysis and computer simulations to determine when different species populations remain stable or become unstable under varying environmental and movement conditions. We identified four key results describing how movement, population growth, and resource availability can impact competitive success, all highlighted in the theorem we derived through this project. Previous work found that faster movement does not always provide a competitive advantage. Our results build upon this finding by identifying the conditions under which movement strategies, diffusion rates, and species interactions influence the stability of competitive outcomes between two species. These findings demonstrate the importance of considering complex movement behaviors when studying species survival and provide a strong foundation for exploring competition and coexistence in interconnected habitats.

Presenter(s): Budhathoki, Dipsha
School: Knox College
Session: P1.11
Title: Multimodal Deep Fusion for Antarctic Sea Ice Classification
Co-Author(s): Santosh Pant, Kacy Tran, Arito Nakamichi
Advisor(s): Jurdana Masuma Iqrah

Abstract: Sea ice in Antarctica is melting faster as the planet warms, and tracking it matters for climate science, weather forecasting, and safe shipping. Satellites are the only practical way to watch such a huge, remote area, but each satellite has blind spots. Sentinel-2 takes detailed color photos of the surface, but clouds and darkness block its view. ICESat-2 shoots laser pulses that measure surface height even in the dark, but it only sees a thin line along its path with no picture of the surroundings. We built a deep learning system that uses both. One network (a U-Net) reads the photos, and another (a Bi-LSTM) reads the laser height data. We compared three ways of combining them: merging the learned features inside the network, averaging the two networks' final answers, and a hybrid of both. The goal is to label every pixel as thick ice, thin ice, or open water. We tested on a region the models had never seen. Every combined approach beat either satellite alone. Merging features inside the network worked best on thin ice, the hardest class, correctly identifying 92% of it, while thick ice and open water reached about 96%.

Presenter(s): Chun, Jinwoo
School: University of Chicago
Session: P3.09
Title: Heterogeneous Landscape of Neutrophil Dynamics in Zebrafish
Co-Author(s):
Advisor(s): Elizabeth Jerison

Abstract: Previous work from our group has shown surprisingly heterogeneous transcriptional immune responses in tissues to uniform stimuli. To investigate how this heterogeneity contributes to systemic immune function, we subjected larval zebrafish to a spatially uniform inflammatory stimulus and systematically tracked neutrophil dynamics across the entire organism using high speed whole volume light-field microscopy. Quantitative trajectory analysis suggests that neutrophil trajectory in the speed-turning angle phase space is confined to a 1D manifold. Furthermore, spatial mapping of both speed and turning radius uncovered distinct, localized hotspots of neutrophil behavior rather than a uniform body-wide response. These behavioral hotspots suggest that local microenvironmental factors establish distinct signaling domains, driving heterogeneous neutrophil dynamics despite homogeneous global input. To test this hypothesis we plan to integrate live cell tracking with comprehensive genetic measurement via spatial transcriptomics to map how heterogeneous transcriptional signaling gives rise to neutrophil behavioral "hot spots."

Presenter(s): Clasemann, Abigail
School: Gustavus Adolphus College
Session: P1.17
Title: Perfect State Transfer in Cycle Graphs
Co-Author(s): Gillian Lyons, Preston Vo
Advisor(s): Maksym Derevyagin

Abstract: In an interacting chain of particles, which we call a spin chain, perfect state transfer (PST) occurs if there is a complete transfer of a quantum state at some time from one end of the spin chain to the other -- an important concept in the field of quantum information theory. A 1D system with nearest neighbor interactions in the spin chain is represented using a weighted adjacency matrix H, which is tridiagonal. PST occurs from the first site to the Nth site at time t with respect to some real constant ϕ if the following equation holds:

$$e^{itH}\vec{e}_1 = e^{i\phi}\vec{e}_N,$$

where $\vec{e}_1$ and $\vec{e}_N$ are standard basis vectors. In 2010, Kay gave a spectral characterization of the class of such matrices H that achieve PST. In the paper published in 2020 by Derevyagin, Dunne, Mograby, and Teplyaev, an algorithm that lifts a 1D spin chain onto various graphs was proposed. In particular, a Hamiltonian on a $(2n - 2)$-particle cycle with PST going from the left-most to the right-most particle can be generated from an n-particle spin chain with PST. The resulting Hamiltonian is a weighted adjacency matrix of a cycle, which is not tridiagonal. This algorithm raises the natural question whether there is a one-to-one correspondence between 1D chains and cycles with PST. In our work, we construct examples of Hamiltonians that realize PST on a cycle that cannot be obtained using the algorithm, showing that the set of all Hamiltonians with PST on cycles is larger than the set of all Hamiltonians with PST on 1D chains. Moreover, we prove partial results for the characterization of Hamiltonians that realize PST on cycles.

Presenter(s): Cuzydlo, Richard
School: Hope College
Session: P3.19

Title: Controlling Perovskite Crystal Growth through a Single Additive to Achieve Enhanced Brightness Luminescence
Co-Author(s):
Advisor(s): Kestor Ighodalo

Abstract: Solution-processed metal halide perovskites (MHPs) have attracted considerable attention for light-emitting diode (LED) applications due to their high color purity, tunable emission wavelengths, and high color gamut. Although MHPs are highly tolerant of defects, defects in solution-processed perovskite LEDs (PeLEDs) still lead to severe nonradiative recombination and poor luminescence. Here, a design of a single-additive system for the passivation of the halide defects in the CsPbI3 perovskites is presented. We incorporated 5-Phenethylammonium Iodide (PEAI) at different volumes into the CsPbI3 perovskite solution. Our results indicate that the amino group (NH3+) and iodide (I−) ions in PEAI inhibit the formation of iodide vacancies (Iv), thereby passivating surface defects in the perovskite. This process facilitates controlled crystal growth, enhances structural uniformity, reduces grain size, and decreases surface roughness compared to the control, as evidenced by our SEM and AFM images, resulting in a distinct bright red luminescence.

Presenter(s): Do, Annie
School: Knox College
Session: P2.13
Title: How Much Renewable Energy Will We ALL Need in 2050
Co-Author(s): Peter Schwartzman
Advisor(s): Peter Schwartzman

Abstract: There is increasing concern about energy consumption and its implications for sustainable development. Even though fossil fuels provide energy for human development and well-being, many people still suffer from energy poverty. At the same time, fossil fuels have been a major contributor to carbon dioxide emissions. Here, we estimate the energy required for all people to achieve decent living standards by 2050 under a transition to renewable energy (RE). Our model projects per capita energy use (PCE) and population for 239 nations and territories from 2025 to 2050 at five year intervals. For countries below the minimum energy threshold (MET), PCE increases toward the MET by 2050, while for countries above the MET, PCE decreases by up to 30 percent by 2050. We observed an achievable 9.1% and 10.7% increase in energy consumption for the 2.2 kW/p and 3.5 kW/p thresholds, respectively. Our analysis suggests that a global transition to RE is not only feasible but also supports a more equitable distribution of energy by enabling populations below the threshold to achieve decent living standards while reducing energy consumption among countries above the threshold.

Presenter(s): Doran, Evie
School: Colorado College
Session: P1.19
Title: Investigation of Template Removal Process for Molecularly Imprinted Polymer for PFAS Sensor Use
Co-Author(s): Eli Fahrenkrug, Michelle Laferriere, Henry Batson
Advisor(s): Eli Fahrenkrug

Abstract: Per- and polyfluoroalkyl substances (PFAS) are a wide ranging species that were identified as carcinogenic contaminants, especially in water sources, in recent years after being used extensively industrially since the 1940s to resist water, heat, and grease. Testing of these substances is exorbitantly expensive and requires highly specialized equipment and professionals. Molecularly Imprinted Polymers

(MIPs) can be used to develop a far cheaper and more accessible alternative sensor. o-Phenylenediamene (o-PD) is a polymerizable molecule that can be used to form a MIP. o-PD and PFOS (perfluorooctane sulfonate) can form a polymer, with the PFOS molecules subsequently being removed to form a MIP, which can then be tested using differential pulse voltammetry (DPV) to analyze the sensor response. In this study, the MIP-based sensors were formed through electropolymerization and template removal on an EQCM (Electrochemical Quartz Crystal Microbalance). By holding the electropolymerization step constant, adjusting template removal parameters can be used to understand the resulting film mass and sensor performance. Knowing the impact of these various parameters can lead to the design of a more accurate and consistent PFAS sensor.

Presenter(s): Duebener, Marc
School: Grinnell College
Session: P1.06
Title: Variable-Temperature PFG-NMR Analysis of Ion Transport in Localized High-Concentration Lithium-Ion Electrolytes
Co-Author(s):
Advisor(s): Leslie J. Lyons

Abstract: Variable-temperature pulse field gradient nuclear magnetic resonance (PFG-NMR) spectroscopy was used to investigate ion transport in localized high-concentration electrolytes (LHCEs) and related solvent blends for lithium-ion battery applications. Self-diffusion coefficients of ^{1}H, ^{7}Li, and ^{19}F nuclei were measured from 253 to 333 K and used to calculate transport numbers, ionicity, and Stokes radii. Diffusion coefficients increased with temperature and followed Vogel-Tammann-Fulcher (VTF) behavior for all electrolyte formulations. The 1:1 LHCE exhibited higher diffusion coefficients and greater ionicity than the 3:7 LHCE while maintaining similar transport numbers, indicating reduced ion association without altering the dominant transport mechanism. Solvent blends displayed higher diffusion coefficients than the LHCEs, highlighting the influence of electrolyte composition on molecular mobility. These results provide insight into the relationship between solvation structure, ion transport, and electrolyte composition, contributing to the rational design of safer, higher-performance lithium-based battery electrolytes.

Presenter(s): Eker, Doga
School: University of Chicago
Session: P2.04
Title: Stellar Yields of Rapidly Rotating Pop III Stars for the High Redshift Universe
Co-Author(s): Devesh Nandal, Konstantinos Topalakis, Vasilisa Sergienko, Doga Eker, Efe K. Celep, Danielle A. Berg, Daniel J. Whalen, Sophie Tsiatsiou, and Raphael Hirschi
Advisor(s): Devesh Nandal

Abstract: JWST has revealed surprisingly rapid nitrogen enrichment in high redshift galaxies, renewing the need for stellar yields that follow metal free stars beyond the main sequence and across their final fates. We present stellar evolution models of rapidly rotating Pop~III stars from $5 \leq M_{ini}/M_{\odot} \leq 200$ and $\upsilon_{ini}/\upsilon_{crit}=0.7$, evolved with the Geneva stellar evolution code to the end of core O-burning. We compute ejecta yields for selected isotopes from H through Zn with a fate-dependent remnant prescription spanning core collapse (CC), the pulsational pair-instability (PPISN), and complete pair-instability (PISN) disruption. Rotation produces primary CNO material by mixing newly synthesized C and O into H-burning layers, and CNO burning produces nitrogen. The abundance signature, however, is set by which reservoir escapes. Models that leave compact remnants can reach log(N/O)= -0.49 while remaining poor in Si/S/Ar/Ca-rich material. PI SN models eject the largest nitrogen masses, $M_N=1.8$ -- $2.5\ M_{\odot}$, but also release 57 -- 65 $M_{\odot}$ of oxygen, driving log(N/O) down to -1.44 to -1.29, so high nitrogen yields do not

imply high N/O ratios. This trend persists after initial mass function (IMF) weighting, since a more top-heavy population adds oxygen and deep-alpha material from PI SN ejecta faster than it builds a nitrogen dominated mixture. Our grid provides a new prompt-enrichment yield set for rapidly rotating Pop~III stars and a baseline for interpreting nitrogen-rich systems such as GN-z11, CEERS-1019, and GS~3073.

Presenter(s): Evan, Dar
School: Gustavus Adolphus College
Session: I.A.4
Title: Simulations of Radio Galaxies
Co-Author(s): Chris Nolting
Advisor(s): Chris Nolting

Abstract: Galaxy clusters are the largest gravitationally bound structures in the universe, reaching masses up to 10^{15} times that of the Sun. Much of their baryonic matter exists as a hot plasma called the intracluster medium (ICM). Radio galaxies within clusters launch powerful jets of plasma and relativistic particles that interact with the ICM, influencing their resulting morphology. Most radio galaxies are classified as either center-brightened (FR I) or edge-brightened (FR II). However, Hybrid Morphology Radio Sources (HyMoRS) exhibit FR I and FR II characteristics on opposite sides of the same galaxy. Their origin remains uncertain, with possible explanations including environmental differences and viewing-angle effects. We use large-scale, three-dimensional magnetohydrodynamic (MHD) simulations to model radio jets propagating through cluster environments. The simulations track density, pressure, velocity, magnetic fields, gravity, and cosmic-ray electrons, allowing us to generate synthetic radio observations from different viewing angles. Here, we introduce an isothermal density-pressure gradient across the simulated ICM, creating different environments on opposite sides of the radio galaxy. The resulting jet asymmetry demonstrates that variations in the surrounding ICM can significantly influence radio morphology, supporting environmental asymmetry as a possible mechanism for producing HyMoRS.

Presenter(s): Fadeeva, Sofya
School: University of Chicago
Session: I.A.5
Title: Constraints on Long-Term Variability in Young Stellar Objects
Co-Author(s): Leah Grossman, Ethan Jick, Gianna Kennelly, Boden Komorech, Richard G. Kron, Zach Montbach, Mansha Nigam, Madeline Prible, Ayesha Rana, Jared St. Jean, Michelle Somogyi, Snehil Kumar Vidyarthy
Advisor(s): Richard G. Kron

Abstract: We report measurements of the apparent brightness of FU Orionis-type stars (FUors) from the early 20th century, obtained by digitizing photographic glass plate negatives from the Yerkes Observatory Glass Plate Collection. Young stellar objects (YSOs) are surrounded by disks of material that eventually coalesce into the central star and surrounding planetary system. YSOs exhibit changes in optical brightness associated with changes in the rate of material falling from these disks onto the star. FUors are an extreme example, with outbursts that can increase their apparent brightness by more than 4 magnitudes and remain bright for decades. Using the Outbursting Young Variable Stars Catalog (OYCAT), we identify known FUors covered by the Yerkes Observatory plates and measure their brightness at these early epochs. We also investigate other YSO categories in OYCAT, including FUor-like and EX Lupi-type, for changes in brightness over extended periods. We calibrate these early measurements at blue wavelengths and combine them with observations from more recent astronomical surveys to extend their light curves to more than a century. These archival observations provide a long-term baseline for studying variability in young stellar

objects and allow us to place constraints on their photometric behavior.

Presenter(s): Farah, Jack
School: Washington University in St. Louis
Session: I.C.3
Title: Irreducibility of the Intersection of Matrix Schubert Varieties of the Longest Grassmannian Permutations
Co-Author(s): Martha Precup
Advisor(s): Martha Precup

Abstract: A permutation v in the Symmetric Group of size n is a bijection of the set {1,2,...,n} onto itself. Given a fixed permutation, we can define an algebraic object called a matrix Schubert variety of such a permutation, which gives a set of matrices which meet certain rank conditions in relation to the associated permutation matrix of v. By fixing two permutations, v and w, and intersecting their corresponding matrix Schubert varieties, we can determine whether the intersection can be represented as the union of multiple matrix Schubert varieties (reducible), or if it equals another matrix Schubert variety (irreducible). We can study such properties using Bruhat order, a partial order on the Symmetric Group. Let us fix a permutation, w, in the Symmetric Group of size n as [n,1,2,...,n-1]. Then, we prove that for any other permutation v, the intersection of the matrix Schubert varieties of w and v always equals another matrix Schubert variety for a permutation u, meaning it is irreducible. We give an explicit formula for the permutation u in terms of the permutations v and w using a function called the Downward Demazure Product.

Presenter(s): Fargo, Andrew
School: Grinnell College
Session: P2.01
Title: An approach to PKA Completeness through Iteration Theories
Co-Author(s): Sam Hopkins, Shawn Ong
Advisor(s): Shawn Ong

Abstract: Our research extends a previous project about a model of computation incorporating both probability and nondeterminism. Over the past 3 decades, several attempts endeavored to incorporate the two in a single model of computation. Recent work has suggested the viability of angelic nondeterminism, modeled using multisets, as an approach that admits a viable distributive law with probability, and thus allows for a fully compositional model of automata. This model is called Probabilistic Kleene Algebra with Angelic Nondeterminism, abbreviated PKA. We have both a Kleene theorem for automata and their expressions and a decision procedure for semantic equivalence, but we do not have a complete set of axioms for such expressions. To this end, we connected PKAs to the field of universal algebra through constructs called "iteration theories." While we have not proven completeness with this theory, iteration theories are surprisingly capable at describing our model. We highlight this capability with a negative result concerning matrix representations which is true for standard Kleene Algebras.

Presenter(s): Fuller, Sydney
School: St. Olaf College
Session: P3.21
Title: Investigating the Synthesis, Characterization, and Reactivity of N2P2 Cobalt (I) Complexes
Co-Author(s):
Advisor(s): Elodie E. Marlier

Abstract: Second and third row transition metals are highly effective catalysts, however, they are

expensive and environmentally harmful. First row transition metals are sustainable alternatives due to their abundance and affordability. In an effort to study first row transition metals across multiple oxidation states, a hybrid monoanionic, tetradentate N2P2 ligand with a β-diketiminate backbone and phosphine pendant arms was synthesized. Its hybrid nature provides both hard and soft electron donors allowing for versatility when bonding to late first row transition metals. With the aim of studying cobalt complexes, the ligand was metallated with cobalt(II) iodide before being reduced to Co(I). The Co(II) and Co(I) complexes have been characterized via UV-vis spectroscopy, NMR spectroscopy, and mass spectrometry. Reactivity of the Co(I) complex is under investigation.

Presenter(s): Gardner, Abigail
School: Carleton College
Session: P1.12
Title: The Origins of Neutron-Capture Elements in a Cosmological Simulation
Co-Author(s): Andreia Carrillo
Advisor(s): Andreia Carrillo

Abstract: Through the use of the magnetohydrodynamical cosmological simulation Auriga, the formation history of a Milky Way-like galaxy can be characterized at specific points in time. Throughout galaxy formation, accretion events significantly altered the internal structures of the galaxy and its subsequent chemical evolution. Looking at neutron capture elements provides insight into galactic chemical evolution specifically with regards to the origins of heavy elements. In this work, we investigate different models of the rapid neutron capture element europium (Eu) within the Auriga simulation, specifically in a Gaia-Enceladus/Sausage-like dwarf galaxy. [Eu/Fe] trends for this galaxy were analyzed from 12 Eu synthesis models. At infall, the subhalo of interest exhibited a positive trend in the [Eu/Fe] versus galactocentric radius plane for 10 of the 12 Eu synthesis models explored, while only two showed negative gradient trends. Similar trends persist in the phase-mixed subhalo at present day, however these trends are shallower. In contrast, observational studies show a negative Eu abundance trend contradicting the majority of the models explored in this research. Differentiating between in situ and accreted stellar populations and comparing their associated chemical evolution will aid in disentangling the tension in the radial gradient trends seen in the observations.

Presenter(s): Gehler, Noah
School: Gustavus Adolphus College
Session: I.A.3
Title: From Jupiter-Io to Exomoons: Engineering and Modeling Approaches for Future Radio Analysis
Co-Author(s): Oscar Peterson, Jonathan Ryan, Darsa Donelan
Advisor(s): Darsa Donelan

Abstract: The interaction between Jupiter's magnetic field and the plasma torus of its moon Io produces radio emissions detectable on Earth with a small radio telescope. Scientists theorize that similar interactions outside the solar system could emit signals leading to the confirmation of an exomoon. This project models the Jupiter-Io interaction while comparing it with collected data at an on-campus quad-dipole square array. Past research carried out by Rosario-Franco failed to detect an exomoon using radio astronomy. A potential cause of this error lies in the theoretical calculations used by Noyola et al., which made many numerical assumptions and required high similarity to the Jupiter-Io system for optimal results. To reconcile this discrepancy, a major goal of the project is the construction of a large database of collected and simulated Jupiter-Io information, serving as a framework for a potential algorithm that could identify exomoon emissions and differentiate them from background noise.

Presenter(s): Ghimire, Shan
School: Luther College
Session: I.C.1
Title: Statistical Relationships Are Not Learning Relationships in Multi-Task Learning: An Empirical Study
Co-Author(s): Linh Nguyen
Advisor(s): Thuy Do

Abstract: Multi-task learning (MTL) relies on the assumption that related tasks can benefit from shared representations. In practice, task selection is often guided by statistical measures such as target correlation. We argue that statistical relationships and learning relationships are fundamentally different concepts. To investigate this distinction, we analyze several task pairs derived from real-world Earth observation and climate datasets, specifically the ERA5 and SMOPS using a Pareto multi-task learning framework. By comparing target correlations with the behavior of Pareto fronts under varying task preferences, we observe that strongly correlated targets do not necessarily exhibit strong learning interactions, while weakly correlated targets can significantly influence one another during training. These results suggest that target correlation alone is insufficient for characterizing task compatibility in MTL.

Presenter(s): Hauk, Uliana
School: University of Chicago
Session: I.C.5
Title: Searching for Population III-Dominated Galaxies Using JWST Photometry and Machine Learning
Co-Author(s):
Advisor(s): Harley Katz

Abstract: The first generation of metal-free stars, Population III (Pop III), played a fundamental role in the early Universe by initiating chemical enrichment and contributing to cosmic reionization. Because individual Pop III stars are difficult to detect, galaxies whose integrated light contains a significant Pop III contribution are more promising observational targets. Such systems are expected to exhibit distinctive spectral signatures, including strong hydrogen recombination emission, a pronounced Balmer jump, and a relatively flat UV continuum.
We develop a machine-learning framework to identify Pop III-dominated systems in large James Webb Space Telescope (JWST) photometric surveys. Using synthetic photometry derived from cosmological simulations, we construct three features tracing the UV continuum slope, Balmer jump, and H-alpha emission, and train support vector machine classifiers to distinguish between Pop III and metal-enriched populations over the redshift range 4.0-6.7. The classifiers achieve greater than 99.8% accuracy on held-out simulated data. We then apply them to the JWST UNCOVER and GLIMPSE surveys. The models identify a small number of candidates, but further examination reveals no convincing Pop III detections. Our results demonstrate that combining physically informed diagnostics with machine learning provides an efficient method for narrowing large galaxy samples to rare candidates for follow-up observations.

Presenter(s): Heinrich, Michel
School: Luther College
Session: P1.01
Title: Post-Fabrication Surface Modification of PDMS-co-PVMS Microspheres via Thiol-ene Click Chemistry
Co-Author(s): Matthew Binsfeld, Jen Baldwin
Advisor(s): Jen Baldwin

Abstract: Microsphere absorption and release of small molecules make them interesting for applications requiring targeted releases. Silicone microspheres are of interest, yet their hydrophobicity limits the effective use in polar environments. Post-fabrication surface modification of these spheres allows the surface properties to be changed, enabling the tailoring of microspheres for desired applications. The radical initiated thiol-ene click reaction provides a metal free and selective surface modification. To demonstrate the versatility of the method, silicone microspheres were functionalized with propanethiol, L-cysteine and 7-mercapto-4-methylcoumarin. SEM imaging demonstrated that all samples remained spheres of similar size. The spheres with propanethiol were analyzed using 1H-NMR while the spheres with 7-mercapto-4-methylcoumarin were analyzed by fluorescence. The spheres with cysteine were found to have different solvent compatibility and provided the spheres with surface molecules of biochemical interest. This method of post-synthesis surface modification offers an approach to design silicone microspheres for the specific application or target.

Presenter(s): Herndon-Goodman, Amari
School: Washington University in St. Louis
Session: P2.22
Title: Methanol-Modified Carbonate Mineralogy in Ammonia-Rich Ocean World Analogs
Co-Author(s):
Advisor(s): Jeffrey G. Catalano

Abstract: Many icy moons, including Titan, Enceladus, and Ganymede, show geochemical evidence of ammonia-rich subsurface oceans. Ammonia lowers water's freezing point while altering ocean pH and buffering capacity. Plume reconstructions from Enceladus identify an alkaline, ammonia-rich ocean, conditions well suited to carbonate formation. Carbonate mineralogy helps constrain long-term carbon sequestration and pH buffering, both important for habitability. Icy moon oceans may also contain alcohols such as methanol, potentially introduced through hydrothermal processes, yet no terrestrial analog captures the combined effects of ammonia and alcohol content on carbonate formation, leaving these systems poorly understood. To investigate this, Ca-Mg-Na-NH4-HCO3-Cl-SiO2 analog solutions were prepared across a series of methanol mixtures, with ammonium, sodium, and bicarbonate concentrations systematically varied at pH 8–9. Precipitated solids were analyzed by powder X-ray diffraction. At low methanol and solute concentrations, aragonite and calcite dominated, with nesquehonite appearing only at pH 9. Increasing methanol shifted precipitation toward calcite and nesquehonite, prominent at pH 8.5–9, while dolomite emerged as a major phase at the highest methanol and solute concentrations under low-to-moderate pH. These results show methanol-associated solvent effects promote Mg-rich carbonate formation in ways pH alone cannot predict, suggesting carbonate mineralogy on methanol-bearing icy worlds may differ substantially from terrestrial analogs.

Presenter(s): Hoelzel, Gavin
School: St. Olaf College
Session: P2.22
Title: Methyl Substituted N2P2 Complex Synthesis and Characterization with a Nickel Center
Co-Author(s):
Advisor(s): Elodie Marlier

Abstract: While catalysts commonly utilize late second and third row transition metals due to their high reactivity, these metals are often costly and unsustainable. In light of this, first row transition metals have been investigated as alternatives due to their higher availability and lower cost. In order to explore the reactivity of first row transition metals, a monoanionic tetradentate N2P2 ligand has been synthesized and metallated with late first row transition metals. The ligand consists of a beta-diketiminate backbone

attached to phenyl linkers appended to phosphine arms. These characteristics maximize its electron donating capabilities due to the mixture of hard and soft donors. Different substituents have been introduced on the phenyl linkers to probe the metal's binding modes and solubility. The methyl substituted ligands have been metallated using nickel (II) iodide and bis(1,5-cyclooctadiene) Ni(0) to achieve differing oxidation states in the final complex. Both complexes were characterized using UV-vis spectroscopy, NMR spectroscopy, and mass spectrometry in order to determine their molecular geometry and chemical properties.

Presenter(s): Holland, Maya
School: Grinnell College
Session: P1.22
Title: Auditing Potential Bias in AI Through College Admissions
Co-Author(s): Aidan Michaelson, Owen Block
Advisor(s): Nicole Eikmeier

Abstract: In 2025, 84% of high schoolers used generative artificial intelligence to complete schoolwork, and by 2026, at least five major universities used algorithms to help with college admissions. This study aimed to determine whether algorithms such as GPT-OSS or Claude Haiku 4.5 discriminated against students by race in a college admissions setting and was evaluated in two contexts. The first is a student querying the algorithm about their chances of admission to both a liberal arts college and a university. The second is a college admissions board tasked with admitting a class year. The variables of interest were both explicit (race) and implicit (extracurricular involvement and location). We also used variables for GPA, SAT, income, the number of AP classes taken, and their average AP score. Results show that Claude Haiku 4.5 does take race and, at times, other demographic factors into account when considering college admissions; however, it does so unreliably and irresponsibly. While GPA and SAT scores are the primary factors that determine a student's likelihood of being marked as accepted, other factors such as race and extracurricular activities also play a role.

Presenter(s): Hong, Jennifer
School: Washington University in St. Louis
Session: P3.12
Title: Beyond the Encapsulation of Amyloid-Beta 40: Is Extraction the Key to the Alzheimer's Toxicity Problem?
Co-Author(s):
Advisor(s): Yusuke Okuno

Abstract: Alzheimer's disease (AD) is an irreversible neurodegenerative brain disorder. AD is linked to the accumulation of toxic amyloid-beta (Aβ) aggregates that misfold into oligomers. Oligomers stack into insoluble fibrils, which group together to form large brain plaques. Low molecular weight oligomers are highly toxic in AD; this research focuses on the dimer stage instead of Aβ plaques. It is unknown which structure, size, or orientation are toxic. They are challenging to study due to their rapid aggregation in bulk solution and intrinsically disordered nature. This study aims to extract Aβ while possessing an advantage over existing studies as it incorporates reverse micelles (RM) which trap Aβ to predefined size distributions. This high-interest topic has many impactful applications, such as allowing biologists to observe effects in the nervous system. This study has managed to encapsulate 25uM Aβ 40 with 100% efficiency. After encapsulation, the preliminary results include the successful extraction N15 Aβ 40 at Day 0. This method includes the RM method, stripping the buffer, and exposing the aqueous layer containing back extracted Aβ peptide which was let to settle. The extraction was confirmed via NMR. The goal now is to extract Aβ reproducibly over numerous days of aggregation.

Presenter(s): Imdieke, Anna
School: Gustavus Adolphus College
Session: P2.06
Title: A Python Application Framework for an AI Assistive Device
Co-Author(s): Kaylie Fox, Guarionex Salivia, Flint Million
Advisor(s): Guarionex Salivia

Abstract: Users who are blind or visually impaired increasingly rely on AI-powered assistive devices, but existing systems share three structural limitations: dependence on cloud services that impose connectivity requirements, privacy exposure, and potentially inaccessible recurring costs; a closed, fixed set of functions with no extension model; and voice-only interaction with no deterministic fallback when speech recognition fails. This project addresses these gaps by developing an application framework powered by an on-board AI accelerator, hosted on a Raspberry Pi device, designed specifically as a voice-first assistive device for these individuals. The device runs all functions and the AI agent locally and offline. All code, hardware plans, and 3D-printable files will be released as an open-sourced project. Device functionality is implemented as small, self-contained Python applications reachable through both natural voice commands and physical buttons, enabling extensibility for future developers. Representative apps built on this framework will include an audio/text note-taker, a document scanner/analyzer using the onboard camera, a voice-driven calendar, and an orientation walk-through of device capabilities. We present the framework's architecture, a usability test with participants who are blind or visually impaired, and plans to evaluate voice routing accuracy and end-to-end response latency comparing local and cloud inference.

~~**Presenter(s):** Israk, Araf~~
~~**School:** Beloit College~~
~~**Session:** P3.05~~
~~**Title:** An Interactive Engine for Reidemeister Simplification of Plane Loops~~
~~**Co-Author(s):** Ben Stucky, Christopher-Lloyd Simon~~
~~**Advisor(s):** Ben Stucky~~

~~**Abstract:** A generic closed curve in the plane, a plane loop, or a knot shadow with over/under information forgotten, can always be reduced to a minimal-crossing form by a sequence of Reidemeister moves that never increases the crossing count (Hass–Scott; de Graaf–Schrijver). We present an interactive engine that lets a user perform and watch this simplification in real time. Existing combinatorial knot programs either forbid Reidemeister moves or force a full redraw after each, and standard drawing algorithms (circle packing, Tutte embeddings) suffer "exponential smallness," making large diagrams undrawable. Instead we maintain one persistent geometric model and deform it continuously. Each loop is laid out with Tamassia's bend-minimized orthogonal grid algorithm, which guarantees a lower bound on every face's area and a natural home for a region pin, then realized as a "bead necklace": a chain of equal-radius hard disks that relax under springs and self-avoidance, so no strand can thread another. Clicking a face classifies it by the number of bordering crossings, one, two, or three, selecting R1, R2, or R3, and animates the move smoothly; the diagram itself is encoded exactly by a vertex permutation. The tool is open source, with future work on multiple components, other surfaces, and the unpinning game.~~

Presenter(s): Jaegy, Ina
School: Washington University in St. Louis
Session: I.B.4
Title: Rapid Thermal Annealing to Improve Crystal Quality in GeSn for Optoelectronic Applications
Co-Author(s): Yuta Goto, Ryo Matsumura Naoki Fukata

Advisor(s): Naoki Fukata and Ryo Matsumura

Abstract: GeSn is a promising material for silicon photonics due to its CMOS-compatibility and direct bandgap when the Sn content is greater than 8%. However, non-equilibrium growth methods, such as molecular beam epitaxy (MBE), are required to suppress Sn segregation caused by the low solubility of Sn in Ge (<1%). The low growth temperatures used in MBE both reduce crystal quality and introduce compressive strain due to the lattice mismatch, the latter which increases the material's bandgap at the Γ point. Rapid thermal annealing (RTA) following growth of GeSn films containing up to 7% Sn content have demonstrated increased strain relaxation and crystal quality with minimal Sn segregation. This work examines the application of RTA to films with greater Sn content (10%), which are ideal for applications as mid-wave IR photodetectors. I will discuss the growth of the films and the subsequent RTA process; characterization with Raman spectroscopy, X-ray diffraction/reciprocal space mapping, and photoluminescence spectroscopy to study the degree of strain relaxation; fabrication of photodetectors using photolithography; and testing of their photoelectric performance measured through current-voltage curves.

Presenter(s): Jha, Ronak
School: Knox College
Session: P3.03
Title: Mechanistic Consistency Is Not Correctness: A Transferable Circuit That Computes the Wrong Causal Answer
Co-Author(s):
Advisor(s):

Abstract: Does reinforcement learning (RL) post-training teach language models to reason causally, or merely to correlate more convincingly? We investigate this question by RL-post-training GPT-2 small on a synthetic causal-DAG benchmark spanning four graph topologies and all three levels of Pearl's causal hierarchy (Pearl, 2009), with results replicated on Pythia- 410M. Activation patching reveals a striking result: a single attention head, together with a handful of MLP layers, forms a sparse circuit that transfers across all four topologies with 90–98% fidelity and outperforms every one of 25 random-circuit baselines. By every standard mechanistic-interpretability check, this circuit looks like genuine, general-purpose causal reasoning. It is not. On the one topology that actually requires distinguishing intervention from correlation—confounded structures—both models substitute the associational answer P(Y | X) for the interventional answer P(Y | do(X)) with 0% accuracy, and this failure reproduces to the decimal across two independently trained, architecturally distinct models (an identical 50.0%/50.0% directional split, p = 0.540, in both). We then attempt to close this gap three separate ways—post-hoc ablation, inference-time do-calculus prompting, and training-time rationale injection—and each fails for a distinct, precisely diagnosed reason. The result is a circuit that is simultaneously real, general, validated, and wrong: mechanistic consistency that carries no guarantee of behavioral correctness. This dissociation has direct consequences for interpretability practice, where circuit discovery, transfer, and baseline validation are often treated as evidence that a model's computation is understood, when in fact they establish only that it is consistent.

Presenter(s): Johnson, Ja'Toria
School: Colorado College
Session: P3.04
Title: An Accessible Design Thinking Process to Support Students with Intellectual and Developmental Disabilities in Independent Making
Co-Author(s): Marcos Arnold, Varsha Koushik, Lauren Milne

Advisor(s): Varsha Koushik

Abstract: Design thinking, the ability to ideate and create a design, can be a challenging yet rewarding process, and even more beneficial for creating assistive devices for individuals with intellectual and developmental disabilities (IDD). Nevertheless, current maker tools such as 3D printers, electronic toolkits, and the overall design process are inaccessible and not beginner-friendly for people with disabilities. To address this concern, our research focuses on making the process of design thinking more accessible to individuals with IDD. To explore accessible alternatives, we followed a user-centered approach, designing for the user needs through brainstorming, market research, understanding user needs, sketching, and prototyping. This involved participating in a challenge posted by the Maker's Making Change, a forum for designing and creating custom assistive devices based on real user needs, to scaffold an accessible process for individuals with IDD. We developed helpful guides and supported the research team in conducting a Do-It-Yourself design workshop with students and teachers to explore need-specific scaffolding strategies for the design thinking process. Overall, a human-centered, scaffolded, accessible design process can support autonomy in creation for designers of all abilities.

Presenter(s): Johnson, Mansoor
School: University of Chicago
Session: II.D.1
Title: Non-Enzymatic RNA Strand Separation via Complement Fragmentation
Co-Author(s): Aman Agrawal, Jack Szostak
Advisor(s): Jack Szostak

Abstract: The RNA World hypothesis, a leading theory for the origins of life, posits that RNA served as both genetic material and as a catalyst for biological processes before the emergence of proteins. While several mechanisms for non-enzymatic RNA replication, among the most important of these processes, have been proposed in recent years, the question remains how the strands of an RNA duplex can be separated to enable further rounds of replication. Recent work has introduced the concept of a virtual circular genome (VCG), in which short oligonucleotides collectively encode a longer template sequence without requiring a continuous complementary strand. In such systems, replication produces fragmented rather than full-length strands, reducing duplex stability and potentially facilitating strand dissociation. In this study, we use a ribozyme activity assay as a gauge for strand separation and show that such fragmented complementary strands can be displaced using denaturing agents and temperature elevation, restoring ribozyme cleavage activity and providing a proof-of-concept for non-enzymatic RNA replication in a VCG system. Strand separation was achieved across varying thermal, stoichiometric, and assembly conditions, suggesting these strand separation dynamics are robust across different prebiotic conditions.

Presenter(s): Kim, Joy
School: Washington University in St. Louis
Session: P3.14
Title: Investigating the Alteration of Condensate Morphology and Toxicity of MATR3 Isoforms in Yeast
Co-Author(s):
Advisor(s): Meredith Jackrel

Abstract: Matrin-3 (MATR3) is an intrinsically disordered, RNA-binding protein associated with neurodegenerative diseases, most prominently amyotrophic lateral sclerosis (ALS). In diseased neurons, MATR3 pathology is marked by nuclear overabundance, cytoplasmic mislocalization, and cytoplasmic inclusions that may arise from phase-separated condensates. In yeast, MATR3 is toxic and forms nuclear puncta, reminiscent of condensate morphology. Prior research has linked domain deletions of MATR3 to

impaired condensate morphology and toxicity rescue. Here, I investigate the naturally occurring, N-terminally truncated Isoform 2 (Iso2) and isoform 3 (Iso3) of MATR3 in a MATR3 yeast model. Additionally, I investigated strategic truncations of these isoforms to identify the specific region contributing to isoform 2, but not isoform 3 toxicity in yeast. Since MATR3 isoforms disrupt the arrangement of folded and disordered domains that drive microphase separation, different truncations were expected to alter toxicity and condensate morphology in an established yeast model of MATR3 proteinopathy. To test this, I use yeast toxicity assays, validate protein expression by western blot analysis, and characterize condensate morphology by fluorescence microscopy.

Presenter(s): Komorech, Boden
School: University of Chicago
Session: I.A.5
Title: Constraints on Long-Term Variability in Young Stellar Objects
Co-Author(s): Sofya Fadeeva, Leah Grossman, Ethan Jick, Gianna Kennelly, Richard G. Kron, Zach Montbach, Mansha Nigam, Madeline Prible, Ayesha Rana, Jared St. Jean, Michelle Somogyi, Snehil Kumar Vidyarthy
Advisor(s): Richard G. Kron

Abstract: We report measurements of the apparent brightness of FU Orionis-type stars (FUors) from the early 20th century, obtained by digitizing photographic glass plate negatives from the Yerkes Observatory Glass Plate Collection. Young stellar objects (YSOs) are surrounded by disks of material that eventually coalesce into the central star and surrounding planetary system. YSOs exhibit changes in optical brightness associated with changes in the rate of material falling from these disks onto the star. FUors are an extreme example, with outbursts that can increase their apparent brightness by more than 4 magnitudes and remain bright for decades. Using the Outbursting Young Variable Stars Catalog (OYCAT), we identify known FUors covered by the Yerkes Observatory plates and measure their brightness at these early epochs. We also investigate other YSO categories in OYCAT, including FUor-like and EX Lupi-type, for changes in brightness over extended periods. We calibrate these early measurements at blue wavelengths and combine them with observations from more recent astronomical surveys to extend their light curves to more than a century. These archival observations provide a long-term baseline for studying variability in young stellar objects and allow us to place constraints on their photometric behavior.

Presenter(s): Kreeger, Brooke
School: Grinnell College
Session: P2.19
Title: Structural Analysis of E. Coli MTHFR Y275F Mutant Using HDX and LC-MS
Co-Author(s):
Advisor(s): Elaine Marzluff

Abstract: Methylenetetrahydrofolate reductase (MTHFR) is a flavoprotein that catalyzes the reduction of 5,10-methylenetetrahydrofolate (CH2-H4folate) into 5-methyltetrahydrofolate (CH3-H4folate). CH3-H4folate is then used as the methyl donor for synthesis of the essential amino acid methionine from homocysteine. In this study, we performed a structural analysis of the E. Coli MTHFR mutant Y275F. Following previous research indicating significant structural disruption by the Y275A mutant, the Y275F mutant was selected to investigate the role of the hydrogen bonding from the hydroxyl group and π-stacking from the aromatic ring of the original tyrosine residue. To investigate the structural impact of the Y275F mutant, we measured differences in hydrogen-deuterium exchange (HDX) using a liquid chromatography-mass spectrometry system (LC-MS). Measuring HDX provided quantifiable mass differences over time as a convenient basis for structural analysis. One specific peptide, peptide 28-37,

exhibited an increase in deuterium uptake of both Y275A and Y275F mutants, indicating that the hydroxyl group of Tyr275 could be involved in hydrogen bonding that stabilizes this peptide. Additionally, certain marginal but noteworthy deuteration differences provided evidence regarding the role of hydrogen bonding in supporting the inner barrel core of MTHFR and the role of aromatic stabilization in maintaining the overall structure and folding of MTHFR.

Presenter(s): Krueger, Augustine
School: Luther College
Session: P2.21
Title: Development of Methods for Dye Loading and Release from PDMS Microspheres
Co-Author(s): David Pittman
Advisor(s): Jen Baldwin

Abstract: Polydimethylsiloxane (PDMS) microspheres are useful for a variety of applications, many of which involve adding functional molecules to the matrix. In this project, methods for dye loading and release from PDMS microspheres are investigated. Crystal violet, congo red, and methylene blue were loaded into microspheres using two approaches: incorporation during microsphere synthesis or post-synthesis loading of microspheres. Dye release was monitored by collecting solution aliquots over time and measuring fluorescence intensity. Preliminary results showed an initial burst for both loading methods, while microspheres loaded during synthesis showed evidence of additional sustained release. However, the amount of dye released was much higher for the post-synthesis loaded microspheres. These results suggest that the loading method influences the loading capacity and dye release behavior. Ongoing work is focused on developing methods to quantify total dye loading capacity and further testing of dye release.

Presenter(s): Kumar, Kamlesh
School: Knox College
Session: II.E.4
Title: Can You Be Me? A Game-Based Approach to Behavioral User Authentication
Co-Author(s):
Advisor(s): David Bunde

Abstract: Knowledge-based authentication is vulnerable to compromise and induces high cognitive load, while biometrics cannot be revoked once they are compromised. To address this, we introduce a gamified aim-trainer that captures mouse kinematics and cognitive delay as a revocable behavioral biometric. It utilizes a 28-dimensional feature vector, capturing cursor velocity, acceleration, curvature, and cognitive processing delay (the delay difference between pressing a series of known vs. unknown on a numpad). The game uses weighted Mahalanobis distance with the weights derived from a Random Forest algorithm. This system achieved a 0% FRR (False Rejection Rate) and a 0% FAR (False Acceptance Rate) against active impersonations from six unique users across 60 authentication events. The key findings from the data collection across six users showed that the cog_variance is the top feature at an influence of 22.84%, showing that cognitive hesitation outperforms motor speed metrics.

Presenter(s): Laferriere, Michelle
School: Colorado College
Session: P1.20
Title: EQCM as a Tool for Mechanistic Study of PFAS Binding in Molecularly Imprinted Polymer-based Sensors
Co-Author(s): Evie Doran, Henry Batson, Eli Fahrenkrug

Advisor(s): Eli Fahrenkrug

Abstract: Per- and polyfluoroalkyl substances (PFAS) in drinking water are linked to adverse health effects and remain exceptionally difficult and expensive to detect. Electrochemical sensors incorporating molecularly imprinted polymers (MIPs) can convert PFAS concentrations into electrical signals, providing real-time analysis of PFAS contaminants. However, fabrication variability remains a barrier to sensor reproducibility. We developed a method to resolve condition-dependent differences through in-situ correlation of synthesis parameters with MIP properties. An electrochemical quartz crystal microbalance (EQCM) simultaneously measures current and nanogram-level mass changes at an electrode surface. This enables real-time monitoring of molecular-level mass changes during the fabrication and operation of MIP sensors. The aim of this study was to develop and apply a rigorous EQCM method to connect synthesis parameters to polymer growth, mass, and film properties. We found that film mass increased with monomer concentration and decreased with scan rate, demonstrating that EQCM can provide insight into structural and mass differences during MIP electropolymerization. This work also shows that electropolymerization conditions can tune the quantity, structure, and properties of the deposited polymer, providing a possible explanation for observed changes in sensor performance. Initial results demonstrating the effects of scan rate and monomer concentration on polymer properties will be presented.

Presenter(s): Lagerhausen, Benjamin
School: Carthage College
Session: P1.14
Title: Integration of MUD as a Standardized Testing Payload for NASA's Universal Payload Interface Challenge
Co-Author(s): Nathaniel Cabrera, Maximilian Dan, Cecilia Degenhard, Evelyn Gotschewski, Maya Griffin, Henry Martin, Leena Maryanski, Karl Sanchez, Ella Stugelmeyer, Sofia Worley
Advisor(s): Kevin M. Crosby

Abstract: In commercial spaceflight, providers each impose various kinds of payload lockers, weight limits, and power interfaces. This forces researchers to redesign payloads for each new flight opportunity, raising costs and slowing down experiment development. To lower this barrier of entry, NASA held a Universal Payload Interface Challenge (UPIC) in 2023, selecting three winning interface designs: Aegis's EPIIC, Ecoatoms's ANIMA, and UCLA's SDPI. To test these designs, Carthage was chosen as a standard testing payload for each winner because of the sizeable power draw and complex payload architecture. Three identical payloads of Microgravity Ullage Detection (MUD), a vibration based sensor system for detecting the liquid-vapor interface in microgravity, were built, one for each winner. Each integration will be assessed across various criteria such as mounting capability, power delivery, or ease of installation. By maintaining an identical test payload across all three integrations, interface specific performance differences can be isolated and directly compared. The resulting comparison is intended to aid future standardization efforts of commercial payload interfaces to improve the overall lead time and entry cost of commercial spaceflight.

Presenter(s): Larsen, Braedon
School: Carthage College
Session: I.A.1
Title: Geometric Feature Finding for 3D Bubble Localization in Acoustic Microgravity Phase-Separation
Co-Author(s):
Advisor(s): Kevin M. Crosby

Abstract: Microgravity Ullage Trapping Technology (MUTT) investigates the feasibility of acoustic phase separation for microgravity refueling operations. The system is a suborbital payload equipped with 12 ultrasonic transducers that nucleate, migrate, and trap bubbles from dissolved pressurant gas within a fuel simulant. MUTT's success depends on accurately knowing the 3D regions within the tank where bubbles exist and where trapping occurs. This is assessed by analyzing optical video from a variable number of calibrated camera perspectives. The analysis proceeds in three stages: first, intensity-based feature-finding identifies probable bubbles in each camera's video from their refracted-light signature; second, features are compared across cameras using the system's known geometry to identify correspondences and assign each candidate a probability of representing a real bubble; third, candidate bubble positions are corrected for refraction across the fluid, tank wall, and lens interfaces.

Presenter(s): Le, Minh
School: Luther College
Session: P3.02
Title: Synthetic Data Generation via Factorized Feature–Target Synthesis
Co-Author(s): Thuy Do
Advisor(s): Thuy Do

Abstract: In supervised machine learning, a dataset consists of predictor variables and a target variable. Existing synthetic data generation methods, such as CTGAN and TVAE, typically generate predictors and targets jointly, effectively treating the target as another feature. However, the dependency between predictors and the target is central to supervised learning. We propose factorized feature–target synthesis (FFTS), which explicitly preserves this predictor-target dependency during synthetic data generation. FFTS decouples predictor generation from target generation. First, a generative model (e.g. CTGAN, TVAE) synthesizes the predictor features. Next, a separate supervised model (e.g. Random Forest or Deep Neural Network) trained on the original data assigns target values conditioned on those synthetic features. To evaluate synthetic data quality, a downstream deep neural network is trained exclusively on the generated synthetic data and tested on real observations. Across four benchmark datasets (Adult, Covertype, MNIST12, and MNIST28), FFTS increases the mean downstream macro-F1 score by 0.1176. This represents an 18.49% relative improvement over pooled CTGAN and TVAE baselines. Additionally, a mixed-effects analysis confirms no statistical benefit from including target variables during initial generator training (adjusted $p = 0.9991$). These results demonstrate that explicitly factorizing predictor–target dependencies significantly improves synthetic data quality for supervised machine learning tasks.

Presenter(s): Lee, Daniel
School: Grinnell College
Session: P2.08
Title: Smoothing Synchronized Power Swings in HPC Clusters Using Software: Measurement, Prediction, and Grid Simulation
Co-Author(s): Emily Doyle, Alexander Johnson
Advisor(s): Erin Carrick

Abstract: Modern high-performance computing (HPC) clusters run highly parallel jobs across thousands of nodes. AI training involves iterative compute and communication between nodes, creating massive, synchronized power fluctuations that can bottleneck long-term performance by damaging server hardware and grid infrastructure. We asked whether software alone can smooth power swings to meet National Security Agency (NSA) compute standards. To monitor server health and flag risks, we built a real-time dashboard reporting measurements from various telemetry sources. We developed three mechanisms that schedule secondary jobs before a large job finishes to smooth the power drop. After creating simulation

benchmarks and evaluation criteria at both the node and grid level, we found that reactive power smoothers provide no measurable benefit, as the power signal offers little warning of sudden drops. CPU utilization thresholds detected rapid swings better than fine-tuned logistic regression and random-forest models. The NSA adopted our evaluation framework and approach to ramp and maintain high baseline power, reducing simulated grid-facing load volatility by 68.8 percent in exchange for a premium in energy cost. NSA executives later shared our dashboard, built using Intel's Running Average Power Limit (RAPL), with internal teams and partner processor vendor AMD to develop faster, more accurate power-sampling hardware.

Presenter(s): Leung, Chung
School: Colorado College
Session: P2.20
Title: Developmental Synthesis of Fluorinated Amodiaquine Analogs
Co-Author(s):
Advisor(s): Habiba Vaghoo

Abstract: This study places a focus on the synthesis of fluorinated amodiaquine analogs, through developing a procedure that begins with ortho-para nitrobenzene starting materials. The methodology encompasses a multi-step synthesis process that includes the reduction of nitrobenzene, succeeded by a nucleophilic substitution reaction (SNAr). Furthermore, a multicomponent reaction was employed for the Mannich sidechain addition reaction. Samples were subjected to purification and subsequent assessment of purity through column chromatography, nuclear magnetic resonance (NMR) spectroscopy, and liquid chromatography-mass spectrometry (LC-MS). Microwave-Assisted Organic Synthesis (MAOS) was employed to optimize product formation while minimizing reagent consumption. A product exhibiting 98% purity was successfully synthesized and is slated for rigorous testing to evaluate its antimalarial properties. The study identified that steric hindrance, and specific sidechains present in the starting materials pose significant challenges to the success of the general procedure. Although the proposed synthetic routes necessitate further optimization, they have demonstrated success with particular starting materials and hold promise for the development of alternative malaria treatments.

Presenter(s): Lewis, Elliott
School: Macalester College
Session: P1.15
Title: Persistent or Bursting: Star Formation in NGC 3109
Co-Author(s): John Gallagher, Ralf Kotulla, Lida Oskinova, Margaritis Chatzis, Caedan Miller
Advisor(s): Jay Gallagher

Abstract: NGC 3109 is a local low-metallicity dwarf galaxy. Because it is a similar galaxy to galaxies predicted to exist in the early universe, NGC 3109 provides a rare opportunity to characterize stellar populations in young galaxies. By counting B type stars and using an assumed initial mass function, we calculate the star formation rate of the galaxy and compare it to other measures of star formation rate. NGC 3109 has a low proportion of stars in clusters and the clusters that are present appear to be diffuse, which could explain the low x-ray flux of the galaxy because stars are not formed very close to each other, inhibiting binary formation.

Presenter(s): Liu, Xuannan
School: Washington University in St. Louis
Session: II.D.3
Title: Exploring Chiral Side Chain Crowding on Semicarbazone Macrocycles

Co-Author(s):
Advisor(s): Chenfeng Ke

Abstract: Side-chain crowding has recently emerged as an effective strategy for controlling the conformation and supramolecular assembly of semicarbazone-based macrocycles into hydrogen-bonded organic framework. Increasing the steric demand of achiral alkyl substituents can distort the planar framework and generate wrinkled or wavy architectures, which limit the interlayer sliding and structure stability without using a precurved monomer. In this project, we extend this concept by investigating how side-chain chirality influences the crowding effect and potential chiral selectivity of semicarbazone-based macrocycles. A new triangular macrocycle bearing chiral alkoxy side chains was designed and synthesized, while retaining the self-complementary hydrogen-bonding motifs responsible for intermolecular assembly. Single crystals suitable for X-ray diffraction were obtained, providing a molecular-level view of how chiral side chains are accommodated within the crowded environment surrounding the macrocycle. The macrocycles were packed in a hexagonal planar sheets with a wrinkled curvature which is similar to our previous result. The voids were continuous 1D channels and were likely to bind acetone, epoxide, as well as chiral aliphatic alcohol substrates.

Presenter(s): Lyu, Karl
School: Washington University in St. Louis
Session: I.B.3
Title: Lattice Relaxation Drives Re-Entrant Interlayer Decoupling in Twisted CrSBr Bilayers
Co-Author(s): Yiyang Lai, Xilong Xu, Shaffique Adam
Advisor(s): Shaffique Adam

Abstract: Adding an interlayer twist to the van der Waals antiferromagnet CrSBr produces a moiré structure which exhibits magnetic properties with no analogue in the aligned bilayer. Though lattice relaxation is widely invoked as a driver of moiré magnetism, its consequences for the magnetic response have not been corroborated. We model twisted bilayer (tBL) CrSBr at 1.8 K with atomistic spin dynamics following the Landau-Lifshitz-Gilbert formalism. Exchange coupling and magnetic anisotropy are determined from first-principles energies. Lattice relaxation is introduced through a scaling factor λ that interpolates from the rigid model ($\lambda = 0$) through the relaxed cell ($\lambda = 1$) to an over-relaxed limit. We find that relaxation qualitatively reshapes the magnetic response of tBL CrSBr. At 1.5°, with an applied field along the easy *b* axis, the rigid model yields a square hysteresis loop in which both layers undergo a spin flip at 0.315 T. In contrast, the relaxed cell yields a pinched loop, where the layers decouple and switch separately, at 0.018 and 0.308 T, creating an antialigned window in between. Sweeping across λ opens this window near $\lambda = 0.7$ and closes it again above 1.4. This re-entrant behavior correlates with the fraction of antiferromagnetic (AFM) moiré domains. We map critical field against λ at several twist angles and identify a critical angle below which the relaxation-driven window survives. The antialigned window and its width are directly accessible to tunneling magnetoresistance and magneto-optical techniques, giving lattice relaxation a measurable magnetic signature that rigid moiré models miss entirely.

Presenter(s): Maleev, Filip
School: Colorado College
Session: P3.08
Title: Properties of Wild Colored Graphs
Co-Author(s): Cory Scott, Rebecca Garcia, Katherine Rodbell, Yuji Zhang
Advisor(s): Rebecca Garcia

Abstract: An edge colored graph assigns each edge a color, for example, to represent different modes of

travel through a network; such as bus lanes, bike lanes, and sidewalks. In order for a graph of this kind to be fully spanning, each color must have a spanning tree. Our research explores how making an edge "wild," essentially having it count for all colors, impact minimum spanning trees, and what characteristics graphs of a certain wild number have. We thus build this paper around the wild number of a graph. We develop an algorithm in Python for computing a minimum wild edge set and examine when such a set has a unique solution. We give a complete characterization of when the wild number of a two-colored wheel graph is 0 or 1, and give partial characterizations for larger graphs. We also introduce the idea of partial wild edges and prove several bounds relating total partial wildness to the wild number itself. Finally, we establish deletion-contraction relationships for the wild number, and end with some questions left on topics to further explore.

Presenter(s): Malladi, Eeshaan Varshith
School: Washington University in St. Louis
Session: P1.05
Title: Computational Genomics and Clinical Evidence Curation in Precision Oncology
Co-Author(s): Mariam Khanfar, Peter S. Goedegebuure, Tammi Vickery, John Olson, Arpad M. Danos, Malachi Griffith, Obi L. Griffith
Advisor(s): Malachi Griffith

Abstract: Interpreting molecular data and published evidence is essential to precision oncology. We pursued two complementary projects: exploratory transcriptomic analysis of benign parathyroid disease and structured curation of cancer variant evidence. For the parathyroid project, we developed a reproducible workflow importing kallisto transcript abundances through tximport into DESeq2 using Ensembl transcript-to-gene mapping. Nineteen samples remained after excluding one sample with unresolved patient identity. Filtering retained 21,001 genes. Principal component analysis showed no clear separation between adenoma and uninvolved glands in the first two components, and glands from the same patient did not cluster uniformly. These exploratory findings motivate paired analyses and integration with genomic and copy-number data. For the curation project, we evaluated published KRAS A146P evidence in colorectal cancer and submitted seven Evidence Items to the Clinical Interpretation of Variants in Cancer (CIViC) knowledgebase: three addressing oncogenicity and four addressing resistance to cetuximab or panitumumab. Evidence statements preserved the scope of broader RAS subgroups when studies did not isolate A146P. Together, these projects establish a reproducible foundation for molecular investigation and organize variant evidence for clinical interpretation. Future work includes formal differential-expression testing and editor-guided refinement of CIViC submissions.

Presenter(s): McCredie, Owen
School: Luther College
Session: P3.17
Title: End-to-End Machine Learning Water Quality Prediction at Iowa Monitoring Stations
Co-Author(s):
Advisor(s): Thuy Do

Abstract: This project builds an end-to-end machine learning pipeline to predict water quality conditions at Iowa EPA monitoring stations. Water quality measurements are integrated with climate, streamflow, soil, land-use, and agricultural nutrient-loading data into a unified 315-column modeling table spanning 48,251 station-day observations across 1,345 stations (2015-2025). Four model families-linear regression, random forest, gradient boosting, and neural network-are trained per target across thirteen water quality indicators, including dissolved oxygen, nitrate, E. coli, turbidity, and a composite water quality Index. Models are evaluated using a station-grouped train/test split to prevent spatial leakage, benchmarked against a

no-feature persistence baseline, with target transforms (e.g., log-scale) selected via cross-validated bake-offs rather than fixed conventions. Random forest size is capped to keep the full model suite deployable within limited hosting memory. Results are served through an interactive Dash dashboard that maps predictions statewide by target, model, and date, with a comparison table of held-out performance metrics. The project demonstrates rigorous evaluation practices, including grouped splits, persistence baselines, measured transform selection. However, it remains a research prototype: known gaps include seasonal weather staleness in dashboard predictions, non-extrapolating forecasts, and predictions at station types absent from training, documented for future work.

Presenter(s): Melisbek kyzy, Samara
School: Knox College
Session: P1.24
Title: Data Driven Career Guidance System for High School Students in Kyrgyzstan
Co-Author(s):
Advisor(s): Ole Forsberg

Abstract: Choosing a career can be challenging for high school students, especially when access to career guidance and reliable information about university majors and professions is limited. This project examines how data science can be used to better understand the career interests, educational goals, and decision-making patterns of high school students in Kyrgyzstan.
Survey data were collected from students and analyzed using Python to identify patterns in career interests, preferred fields of study, educational goals, and factors that influence future choices. The analysis is designed to show what information students may be missing and what kinds of support could help them make more informed decisions.
Based on these findings, the next stage of the project is to develop a data-driven career guidance system for students in Kyrgyzstan. The system will help students explore career options, university majors, useful skills, and educational opportunities based on their interests and needs. This research demonstrates how data science can be applied to a practical educational problem and used to improve access to career guidance.

Presenter(s): Mendoza, Alexis
School: Grinnell College
Session: P3.13
Title: Using FRET microscopy to study microtubule dynamics
Co-Author(s): Zaiye Wang
Advisor(s): Keisuke Hasegawa

Abstract: Förster resonance energy transfer (FRET) microscopy detects molecular interactions at nanometer distances despite the diffraction-limited resolution of conventional light microscopy. It describes the non-radiative transfer of energy between fluorophores separated by <10 nm. FRET generates measurable signals when labeled tubulin assembles into microtubules, as fluorophores are brought within the Förster radius (R0), allowing FRET to report changes in molecular interactions. We are developing a live-cell FRET assay for microtubule dynamics using HaloTag-based labeling with JFX fluorophores and measuring FRET signals to characterize growing and shrinking microtubule ends. First, we generate and validate HaloTag-α-tubulin expression constructs by molecular cloning. We also calculate R0 between different fluorophore pairs to optimize FRET signals. Next, we express these constructs in Drosophila cells and simultaneously measure microtubule dynamics and FRET signals to correlate growth and shrinkage with nanoscale changes in molecular interactions at microtubule ends. This approach complements static cryo-electron tomography by providing live-cell measurements of dynamic nanoscale changes and offers a

practical comparison of FRET modalities for future studies of microtubule regulation.

Presenter(s): Merrigan, Joseph
School: Gustavus Adolphus College
Session: P2.02
Title: Deciphering Cell-State Dynamics Using Applied Topology and Optimal Transport
Co-Author(s): Thomas Cancino, Madelyn McInnis, Isaac Wachsman, Avery Paulsen, Zixuan Cang
Advisor(s): Zixuan Cang

Abstract: Förster resonance energy transfer (FRET) microscopy detects molecular interactions at nanometer distances despite the diffraction-limited resolution of conventional light microscopy. It describes the non-radiative transfer of energy between fluorophores separated by <10 nm. FRET generates measurable signals when labeled tubulin assembles into microtubules, as fluorophores are brought within the Förster radius (R0), allowing FRET to report changes in molecular interactions. We are developing a live-cell FRET assay for microtubule dynamics using HaloTag-based labeling with JFX fluorophores and measuring FRET signals to characterize growing and shrinking microtubule ends. First, we generate and validate HaloTag-α-tubulin expression constructs by molecular cloning. We also calculate R0 between different fluorophore pairs to optimize FRET signals. Next, we express these constructs in Drosophila cells and simultaneously measure microtubule dynamics and FRET signals to correlate growth and shrinkage with nanoscale changes in molecular interactions at microtubule ends. This approach complements static cryo-electron tomography by providing live-cell measurements of dynamic nanoscale changes and offers a practical comparison of FRET modalities for future studies of microtubule regulation.

Presenter(s): Miao, Lavender (Yuhua)
School: Washington University in St. Louis
Session: II.F.3
Title: Mechanochemical Ligand Exchange on Au25 Nanoclusters: Accessing Solvent-Incompatible Mixed-Shell Compositions in Minutes
Co-Author(s): Kelly Marie Powderly
Advisor(s): Kelly Marie Powderly

Abstract: The surface chemistry of thiolate-protected gold nanoclusters governs their functional properties, yet solution-phase ligand exchange typically requires hours to days and is limited to solvent-compatible ligand combinations. Here, mechanochemical grinding is demonstrated as a rapid alternative for ligand exchange on Au25 nanoclusters, surveyed across six incoming thiols spanning aromatic, aliphatic, and crystalline solid chemical classes and characterized by high-resolution ESI-MS, solid-state 19F MAS NMR, and diffuse reflectance UV–vis spectroscopy. Exchange completes within 30 seconds to 2 minutes, more than an order of magnitude faster than solution stirring under matched conditions. Liquid-assisted grinding further enables co-functionalization of 2-naphthalenethiol and 11-mercaptoundecanoic acid on a single Au25 nanocluster, a solvent-incompatible ligand pair not previously accessible by solution-phase exchange, producing a mixed shell bearing both hydrophobic aromatic and polar carboxylate-terminated groups. Mixed ligand shells of this type are well established on larger gold nanoparticles for applications in nanomedicine and interfacial science, yet remain largely unexplored in the atomically precise cluster regime. These results establish mechanochemical grinding as a practical complement to solution-phase methods for post-synthetic surface engineering of atomically precise nanoclusters.

Presenter(s): Mitchell, Faith
School: Hope College

Session: P2.24
Title: Effects of Proton Irradiation on the Properties of TBCCO Thin-film Superconductors
Co-Author(s): Lincoln Bosh, Jeonghyun Rhee, Kyuil Cho
Advisor(s): Kyuil Cho

Abstract: We studied the effect of 0.6MeV and 1.7Mev proton irradiation on two thin film superconductors, A and B. Sample A (5.69E-7 m thick) received a total fluence of 6.98 p/cm^2 while sample B(5.95E-7m) received a fluence of 3.17E17 p/cm^2. The critical temperature (Tc) was suppressed from 101.38K(A) and 101.84K(B) towards 0K as normal state resistivity increased. The ratio between Tc suppression and resistivity increase will be used to get insight on the cooper pairing mechanism in high-Tc superconductors.

Presenter(s): Mitchell, Julian
School: Washington University in St. Louis
Session: P2.09
Title: Patterns and Drivers of Human-Snake Conflict in Honduras
Co-Author(s): Tasman Ezra, Jonathan Losos
Advisor(s): Tasman Ezra

Abstract: Honduras hosts 17 species of venomous snakes, and anecdotal reports suggest snakebite and envenoming incidents are rising, particularly involving medically significant species like *Bothrops asper*. Deforestation and land-use change, especially at middle and high elevations, are altering habitat availability, while climate change is expected to further shift species distributions. Understanding how these pressures will reshape snake ranges is critical for anticipating and mitigating future human-snake conflict, yet no comprehensive predictive framework currently exists for Honduras. We hypothesized that climatic and land-use changes are driving an increase in human-snake conflict across the country. We built species distribution models (SDMs) for Honduran venomous snakes using Maximum Entropy machine learning, trained on occurrence records and climatic, elevational, and land-cover predictors, comparing climate-only models to climate-plus-land-cover models. Present-day and future (2040, 2070, 2100) conflict-risk maps combined each species' SDM with projected human population density and distance to healthcare facilities under future climate scenarios. Both climatic and land-cover variables meaningfully influenced predicted distributions, with land-use effects varying systematically with elevation. Risk maps show conflict hotspots shifting over time, with highland western Honduras emerging as the area of greatest projected risk for conflict with *B. asper* through 2100, informing where to prioritize antivenom and healthcare resources.

Presenter(s): Moran, Rebecca
School: Carleton College
Session: P2.07
Title: Modeling Access Patterns for a Shared GPU
Co-Author(s): Theodore L. Demetriades, Tanya Amert
Advisor(s): Tanya Amert

Abstract: Mutually exclusive access to a shared resource is often managed using a locking protocol. In the context of real-time systems, such protocols are evaluated on the basis of priority-inversion blocking (pi-blocking), in which a high-priority task is delayed by a lower-priority task, e.g., due to the lower-priority task accessing a shared resource. These evaluations typically rely only on the worst-case duration of shared-resource accesses. However, recent work showed that it may be beneficial to group multiple accesses to a shared resource to enable deadlines to be met despite the potential for increasing

pi-blocking. Grouping accesses necessitates modeling not just the durations of shared-resource accesses, but also their distributions within the execution of a task. Unfortunately, the evaluations in prior work made overly simplified assumptions about the distributions of such shared-resource accesses. In this paper, an empirical study is detailed and a series of parameters are presented to model the patterns of graphics processing unit (GPU) accesses among several GPU-using applications. The final result is a deeper understanding of GPU-using applications for use in real-time systems, including empirically derived worst-case access times that can be used for computing pi-blocking terms in existing schedulability analyses.

Presenter(s): Morgan, Ian
School: Carleton College
Session: P2.17
Title: Written in Light: Determining Stellar Population Classification for Red Clump Stars Using Low-resolution Spectra
Co-Author(s): Andreia Carrillo
Advisor(s): Andreia Carrillo

Abstract: We set out to examine the kinematics and chemistry of a sample of Red Clump stars from the Lucey et al. 2020 photometric catalog, chosen at >10 kpc to be at the interface of the thick disk and halo, and followed up with VIRUS-W spectra observed in the optical range at R~3000. We aim to classify the stars into the disk and halo first kinematically and then to examine how elemental abundances may be different in the kinematically selected populations. This process revealed the importance of strong continuum normalization tools, in this case RASSINE, the necessity of strong, deep lines, the use of grid instead of line-by-line analysis, and using the MOOG code in iSpec presents the best abundances for our low metallicity, low-resolution stars. These aforementioned qualities necessitate careful consideration of the stellar parameters. To this effect, we have derived stellar parameters from the spectra through several mean, none satisfactory. Additional avenues for stellar parameter determination such as the method from Escala et al's 2019 paper are being pursued. Once reasonable stellar parameter accuracy is achieved, benchmark star testing—at low-resolution and low-metallicity—has demonstrated the chemical abundances of the sample stars can be obtained with well below 10% error.

Presenter(s): Murr, Benjamin
School: Luther College
Session: I.B.2
Title: Measurements of D0 --> Ks0 pi+ pi- pi0 Intermediate State Branching Fractions Using Data from the Belle II Experiment
Co-Author(s):
Advisor(s): Todd Pedlar

Abstract: This presentation presents new studies of the charm meson decay D0 → Ks π+ π- π0 using data and Monte Carlo simulations from the Belle II experiment which is conducted at KEK in Japan. Among possible intermediate states that contribute to the production of this final state, are D0 → Ks η and D0 → Ks ω where η and ω decay to π+ π- π0. We found branching fractions for these decays of Γ (1.08 ± 0.08) × 10^-3 and Γ (9.09 ± 0.36) × 10^-3 respectively, both of which are in agreement with measurements last made in the 1990s. These studies provide a framework for further analysis of additional intermediate states which contribute to the D0 → Ks π+ π- π0 decay process.

Presenter(s): Naveed, Eeman
School: Knox College

Session: P2.11
Title: How Player Choices Affect Game Length and Winning Probability in Snakes and Ladders
Co-Author(s):
Advisor(s): David Bunde

Abstract: Snakes and Ladders is a simple board game that can be studied using probability, simulation, and mathematical modeling. This project investigated how different rule variations affect the expected number of turns required to complete the game. Python programs were developed to analyze multiple versions of the game using Monte Carlo simulation, dynamic programming, and matrix methods. Simulations of 10,000 games from each starting position were compared with exact mathematical solutions to verify the models. Starting from square zero, the exact expected game length was 33.3333 turns without ladders, 23.4828 turns with ladders, 25.9428 turns with the six-rule, and 55.9545 turns with snakes and ladders. The simulation results closely matched these exact values. After completing the mathematical analysis, the project was extended into an interactive game using the Godot game engine. The implementation included two-token gameplay, hazards, shields, and multiple levels. Gameplay testing showed that these additional mechanics could substantially increase game length while still allowing games to be completed. Overall, the project demonstrates how simulation, mathematical modeling, and interactive game development can be combined to analyze and extend a familiar board game.

Presenter(s): Neace, Mara
School: Grinnell College
Session: P3.16
Title: Meteorological Analysis of Grinnell College's Conard Environmental Research Area Weather Station Data
Co-Author(s): Rei Kozaki, Evan Couzo
Advisor(s): Evan Couzo

Abstract: Shifting climate patterns have made local weather station access imperative for ensuring timely and accurate environmental data. The Conard Environmental Research Area (CERA) weather station was installed near Grinnell, Iowa in summer 2025 and has been collecting continuous data since November 2025. This study presents the first comprehensive analysis of this weather station data. Our data, ranging from November 2025 to July 2026, was compared to six nearby weather stations in the Iowa Environmental Mesonet ASOS/AWOS Network to determine if CERA data aligned with others in the region. Ensuring our data is regionally consistent helps identify site error and improve the CERA station's reliability. Our comparisons show that the CERA weather station produces similar results to the comparison stations. We also uncovered malfunction in our rain gauge and 10-meter METSENS500 sensor, highlighting where data was inaccurately reported. We then used CERA data to estimate real-time wet-bulb temperature, which can improve the safety of CERA staff and visitors. Altogether, these results suggest the weather station data is suitable for future use in research and classroom settings. This will allow students to gain experience working with and understanding meteorological and climatological data, diversifying opportunities available to students at Grinnell College.

Presenter(s): Nguyen, Khanh Linh
School: Luther College
Session: I.C.1
Title: Statistical Relationships Are Not Learning Relationships in Multi-Task Learning: An Empirical Study
Co-Author(s): Shan Ghimire
Advisor(s): Thuy Do

Abstract: Multi-task learning (MTL) relies on the assumption that related tasks can benefit from shared representations. In practice, task selection is often guided by statistical measures such as target correlation. We argue that statistical relationships and learning relationships are fundamentally different concepts. To investigate this distinction, we analyze several task pairs derived from real-world Earth observation and climate datasets, specifically the ERA5 and SMOPS using a Pareto multi-task learning framework. By comparing target correlations with the behavior of Pareto fronts under varying task preferences, we observe that strongly correlated targets do not necessarily exhibit strong learning interactions, while weakly correlated targets can significantly influence one another during training. These results suggest that target correlation alone is insufficient for characterizing task compatibility in MTL.

Presenter(s): Olubunmi, Tioluwani
School: Knox College
Session: P3.06
Title: Testing Complex Chemical Reaction Networks: A Metamorphic and Probabilistic Evaluation Framework for ChemTest
Co-Author(s):
Advisor(s): Michael Gerten

Abstract: Chemical reaction networks are programs written in the language of chemistry, and because they run in random order they are difficult to test reliably. ChemTest is a framework that tests such programs using four kinds of oracles: functional, invariant, metamorphic, and probabilistic. This project extended ChemTest and evaluated how well those oracles hold up as the networks grow more complex. We studied three subject networks, Approximate Majority and two different Hailstone implementations, and seeded 22 faults across them, where each fault is a deliberately altered copy of a program used to measure whether an oracle catches the mistake. We added automated invariant generation, which derives conservation laws directly from each model rather than by hand, and a rate-based scoring rule for the probabilistic oracles. The automatically generated invariants caught all 22 faults. Rate-based scoring nearly doubled fault detection on the probabilistic subject, from 15 to 29, by keeping naturally flaky but informative tests in play. Most notably, metamorphic testing performed well on one Hailstone program and poorly on the other, showing that no single oracle type is universally reliable. The results indicate that a diverse test suite anchored on automatically generated invariants is the most robust strategy.

Presenter(s): Omerovic, Emrah
School: Washington University in St. Louis
Session: P3.11
Title: Quantum Trajectories and Wave Packet Dynamics in Open Quantum Systems
Co-Author(s): Renato Feres
Advisor(s): Renato Feres

Abstract: We created a quantum framework for repeated collision systems generated by energy conserving scattering. A system interacts with independent particles from a thermal environment. After each interaction, we focused on the system alone, which produces a quantum channel. We showed that a product Gibbs state remains invariant under the full dynamics whenever the Gibbs factors are normalizable. For scattering systems with continuous spectrum, however, a normal Gibbs density may not exist. In this setting, we used an invariant Gibbs KMS weight and showed that its restriction to energy observables gives a stationary probability measure. The quantum channel preserved the algebra of energy observables and induced a classical Markov kernel determined by the scattering amplitudes. Its invariant law agreed with the equilibrium energy law of the corresponding classical two mass model. We then studied the quantum

problem of deriving a quantum Markov semigroup whose restriction to energy reproduces the classical diffusion limit.

Presenter(s): Palmov, Mihail
School: Grinnell College
Session: II.D.2
Title: Studies on Advanced LiFSI Localized High Concentration Electrolytes with Variable Temperature Diffusion NMR
Co-Author(s): Leslie J. Lyons
Advisor(s): Leslie J. Lyons

Abstract: Localized high concentration electrolytes (LHCEs) have shown great promise in improving battery longevity, cycling efficiency, and safety by combining the beneficial solvation structure of high concentration electrolytes (HCEs) with the ionic conductivity of lower concentration systems. In the interest of better understanding these novel electrolytes, diffusion in samples containing lithium bis(fluorosulfonyl)imide (LiFSI) in dimethyl carbonate (DMC) – fluorinated diluent blends, provided by Orbia Fluor & Energy Materials, was measured using Pulsed-Field Gradient (PFG) NMR over a temperature range from 253 K to 333 K for the coordinating solvent and fluorinated diluent (proton), cation (7-Li), and anion (19-F). These samples were then compared to a standard 1.0 M lithium hexafluorophosphate in EC/EMC/DEC electrolyte, a 4.2 M LiFSI/DMC HCE, and the well-known 1.5 M LiFSI/DMC/TTE LHCE. Higher transport numbers and lower ionicity are found in the LHCE regime, compared to the standard electrolyte. The addition of a non-coordinating diluent is shown to greatly increase diffusion rates compared to those in the HCE regime, while minimally changing the solvation environment. An adjusted Stokes-Einstein formula is used to find the hydrodynamic radii of the diffusing ion species, confirming larger solvated structures exist in the LHCE regime.

Presenter(s): Panos, Liv
School: Colorado College
Session: P2.16
Title: Is your room making you think less clearly? The Impact of CO2 on Cognition and Stress Biomarkers
Co-Author(s): Chenxin Xiang, Ashanty Garcia, Allyson Pena
Advisor(s): Sally Meyer

Abstract: Elevated indoor carbon dioxide levels are recognized to be associated with physiological dysfunction and cognitive difficulties, including impaired attention and reduced decision-making capacity. These effects raise concerns about the potential impact on college students' academic outcomes and long-term health issues. This study investigated how short-term exposure to indoor CO_2 concentrations from 500 to more than 3000 ppm affects cognitive performance and salivary stress biomarkers, particularly α-amylase, in young adults. Twenty-two participants completed two overnight sessions under controlled CO_2 conditions. After each exposure, saliva was collected for ELISA analysis of α-amylase, followed by a cognitive test battery assessing attention and short-term memory paired with EEG analysis. It was found that elevated CO_2 from a closed window significantly reduced active focus and mental alertness. However, it did not cause a consistent increase in mental decision-making workload. Cognitive test results were analyzed in R to show that the participants have shorter reaction time and higher correction rate in tasks when the concentration level of CO_2 is lower. On average, participants that slept in the window closed environment displayed 2.474 more ng/mL of salivary α-amylase indicating acute stress and activations of the sympathetic nervous system.

Presenter(s): Pant, Santosh
School: Knox College
Session: P2.14
Title: Auditing GeoFM Evaluation for Field-Extent Segmentation: Label Proxies, Baselines, and When Frozen Features Match Fine-Tuning
Co-Author(s):
Advisor(s): David Bunde

Abstract: Geospatial foundation-model (GeoFM) benchmarks for agricultural field-extent segmentation often rely on cropland land-cover proxies and compare against per-pixel spectral baselines. We measure how these choices affect conclusions using identical single-date Sentinel-2 pixels from six countries. Replacing polygon-derived field labels with ESA WorldCover cropland raises random-forest AUROC from 0.55-0.82 to 0.79-0.96, making the task more spectrally separable. On the actual field-extent labels, a U-Net trained from scratch reaches 0.89-0.98 AUROC and has a higher point estimate than a Prithvi frozen linear probe in five of six regions. We then compare a frozen backbone and full fine-tuning using the same decoder for Prithvi and TerraMind, with ten matched seeds. Under an equivalence test with a 0.02 AUROC margin, 9 of 12 region-by-model comparisons are equivalent. Kenya, where positives cover roughly 0.1 percent of pixels, is the common failure case, and full fine-tuning does better there for both models. Cross-region transfer is less favorable to frozen models: the U-Net leads the full 30-transfer matrix on AUROC and average precision. For Prithvi, a frozen decoder trains about 110 times fewer parameters than full fine-tuning. These results argue for auditing labels and baselines before interpreting GeoFM rankings.

Presenter(s): Pedrazini de Castilho, Thereza Cristina
School: University of Chicago
Session: II.E.2
Title: Synthesis and Evaluation of Machine-Learning-Generated Analogs of Imatinib
Co-Author(s): Penda Diop, Olabisi Aishat Bello, María Román, Scott A. Snyder, Aaron Esser Kahn
Advisor(s): Scott A. Snyder

Abstract: Current vaccine adjuvants mainly act through upstream pattern-recognition receptors (PRRs), which can often produce unpredictable immune responses. This research aims to develop small-molecule immunomodulators that act downstream to enable more precise control of immune reactivity. Based on prior screening data, our group synthesized 20 novel Bafetinib analogs targeting Lyn and Abl kinases, varying the non-aromatic amine ring, a structurally underexplored region of the molecule. Identifying structural modifications that improve target binding, however, requires exploration of a largely uncharted chemical space. Conventional medicinal chemistry approaches to systematically sample this space are slow and resource-intensive, motivating the use of machine-learning-guided methods to prioritize modifications likely to improve immunomodulatory activity. My research focused on synthesizing four novel Bafetinib analogs prioritized by GenaLOG, a machine-learning-guided generative genetic algorithm designed to selectively explore chemical space and propose structural modifications of lead compounds. Experimental target-binding data from synthesized compounds are essential for evaluating the model's predictions and guiding its exploration of chemical space. The analogs were characterized and evaluated based on their binding affinities for Lyn and Abl kinases, providing experimental data to assess the effects of the proposed structural modifications on target binding. This work contributes to the experimental validation of GenaLOG while expanding the chemical space of Bafetinib analogs available for future model development.

Presenter(s): Peterson, Oscar
School: Gustavus Adolphus College

Session: P1.13
Title: From Jupiter-Io to Exomoons: Engineering and Modeling Approaches for Future Radio Analysis
Co-Author(s): Jonathan Ryan, Noah Gehler, Darsa Donelan
Advisor(s): Darsa Donelan

Abstract: The interaction between Jupiter's magnetic field and the plasma torus of its moon Io produces radio emissions detectable on Earth with a small radio telescope. Scientists theorize that similar interactions outside the solar system could emit signals leading to the confirmation of an exomoon. This project models the Jupiter-Io interaction while comparing it with collected data at an on-campus quad-dipole square array. Past research carried out by Rosario-Franco failed to detect an exomoon using radio astronomy. A potential cause of this error lies in the theoretical calculations used by Noyola et al., which made many numerical assumptions and required high similarity to the Jupiter-Io system for optimal results. To reconcile this discrepancy, a major goal of the project is the construction of a large database of collected and simulated Jupiter-Io information, serving as a framework for a potential algorithm that could identify exomoon emissions and differentiate them from background noise.

Presenter(s): Phan, Danny
School: Washington University in St. Louis
Session: P1.02
Title: Investigating the role of the CdrA lectin subdomain in *Pseudomonas aeruginosa* biofilm formation
Co-Author(s):
Advisor(s): Courtney Reichhardt

Abstract: Biofilms are biopolymer-rich extracellular matrices produced by bacteria that aid in surface adhesion and protect against the host immune system. Biofilm bacteria often utilize fibrillar adhesin proteins to facilitate surface adhesion and interactions with the biofilm matrix, making them an attractive target for anti-biofilm therapeutics. CdrA is a fibrillar adhesin produced by *Pseudomonas aeruginosa* and plays a key role in biofilm formation by interacting with the biofilm exopolysaccharide Psl. However, the mechanism of the CdrA-Psl interaction is unknown. We identified a subdomain of CdrA with homology to bacterial lectins. To investigate the importance of this subdomain on CdrA-dependent biofilm formation, we quantified the adherent biomass of a *P. aeruginosa* strain containing mutations within the lectin subdomain binding pocket under static conditions. We observed that mutations in the lectin subdomain do not affect static biofilm formation under the tested conditions. Future experiments will test these mutations under more dynamic conditions using flow cell confocal microscopy, which better replicates conditions experienced by *P. aeruginosa* within the human body. Further investigation of the lectin subdomain will provide a better understanding of how CdrA interacts with Psl to inform the development of anti-biofilm therapeutics.

Presenter(s): Pittman, David
School: Luther College
Session: P2.21
Title: Development of Methods for Dye Loading and Release from PDMS Microspheres
Co-Author(s): Augustine Krueger
Advisor(s): Jennifer Baldwin

Abstract: Polydimethylsiloxane (PDMS) microspheres are useful for a variety of applications, many of which involve adding functional molecules to the matrix. In this project, methods for dye loading and release from PDMS microspheres are investigated. Crystal violet, congo red, and methylene blue were loaded into microspheres using two approaches: incorporation during microsphere synthesis or

post-synthesis loading of microspheres. Dye release was monitored by collecting solution aliquots over time and measuring fluorescence intensity. Preliminary results showed an initial burst for both loading methods, while microspheres loaded during synthesis showed evidence of additional sustained release. However, the amount of dye released was much higher for the post-synthesis loaded microspheres. These results suggest that the loading method influences the loading capacity and dye release behavior. Ongoing work is focused on developing methods to quantify total dye loading capacity and further testing of dye release.

Presenter(s): Ponce, Ramses
School: Grinnell College
Session: P1.03
Title: MTHFR Thr59Ala, Gln219Ala, and Tyr275Ala Mutant Analysis via HDX and LC-MS
Co-Author(s):
Advisor(s): Elaine Marzluff

Abstract: Methylenetetrahydrofolate Reductase (MTHFR) is a catalytic flavoprotein for the reduction of 5,10-methylenetetrahydrofolate. The product of this reaction, CH3-CH4Folate, is used in the methylation of homocysteine to form methionine. In this study, we attempted to characterize conformational changes of three mutants of E. coli MTHFR, T59A, Q219A, and Y275A. These mutants are of interest as the residues are located in proximity to the catalytic domain of MTHFR and are suspected to play a role in the catalysis. Characterization was completed via liquid chromatography-tandem mass spectrometry (LC-MS) using hydrogen-deuterium exchange (HDX) to compare changes in deuterium uptake with those of wild-type E. coli MTHFR. Results show similar levels of deuterium uptake in T59A and Y275A mutants. Thus, these mutants share similar conformational changes. Q219A showed uptake unlike the aforementioned mutants thus has a distinct folding behavior. Global HDX analysis of all mutants supported the results of peptide analysis.

Presenter(s): Raghuvanshi, Mayank
School: Knox College
Session: P2.23
Title: Repeatability and Precision Testing of Half Meter Class Telescope Filter Wheels
Co-Author(s): Seong Kyung Jung, Thomas R. Moses, J. Alex Fluegel
Advisor(s): Thomas R. Moses

Abstract: Astronomical instrumentation demands high precision and repeatability. This study evaluates the repeatability, positional error, and long-duration drift of multiple filter wheels across more than 40,000 trials, incorporating weighted filters to simulate custom grism housings.
Testing revealed that the ZWO 7x2 achieved the highest performance (dr = 4.01 ± 1.86), outperforming the Apogee 50-9R (dr = 123.80 ± 122.58) and the FLI CFW3-12 (3,230 errors and 404 outliers).

Presenter(s): Rana, Ayesha
School: University of Chicago
Session: I.A.5
Title: Constraints on Long-Term Variability in Young Stellar Objects
Co-Author(s): Sofya Fadeeva, Leah Grossman, Ethan Jick, Gianna Kennelly, Boden Komorech, Richard G. Kron, Zach Montbach, Mansha Nigam, Madeline Prible, Ayesha Rana, Jared St. Jean, Michelle Somogyi, and Snehil Kumar Vidyarthy
Advisor(s): Richard Kron

Abstract: We report measurements of the apparent brightness of FU Orionis-type stars (FUors) from the early 20th century, obtained by digitizing photographic glass plate negatives from the Yerkes Observatory Glass Plate Collection. Young stellar objects (YSOs) are surrounded by disks of material that eventually coalesce into the central star and surrounding planetary system. YSOs exhibit changes in optical brightness associated with changes in the rate of material falling from these disks onto the star. FUors are an extreme example, with outbursts that can increase their apparent brightness by more than 4 magnitudes and remain bright for decades. Using the Outbursting Young Variable Stars Catalog (OYCAT), we identify known FUors covered by the Yerkes Observatory plates and measure their brightness at these early epochs. We also investigate other YSO categories in OYCAT, including FUor-like and EX Lupi-type, for changes in brightness over extended periods. We calibrate these early measurements at blue wavelengths and combine them with observations from more recent astronomical surveys to extend their light curves to more than a century. These archival observations provide a long-term baseline for studying variability in young stellar objects and allow us to place constraints on their photometric behavior.

Presenter(s): Raphael, Julia
School: Washington University in St. Louis
Session: I.C.2
Title: Validation of a Computer Vision Motion Capture System for Clinical Outcome Measures in Young Adults
Co-Author(s): Bokkyu Kim
Advisor(s): Bokkyu Kim

Abstract: Background: Markerless motion capture systems provide an alternative to traditional motion capture for physical therapy assessments. This study evaluated the reliability of a computer-vision-based markerless motion capture system by comparing its measurements with manual assessments. Methods: Twenty-five healthy young adults completed the five times sit-to-stand test (5XSTS), timed up and go (TUG), and Figure-8 walking test (F8WT). Two human raters recorded stopwatch measurements of these tests while a computer-vision system measured them. Interrater reliability between human raters and agreement between manual and computer-vision measurements were evaluated using intraclass correlation coefficients (ICC [2,1]) and Bland–Altman analyses. Results: Manual measurements demonstrated excellent interrater reliability for all outcome measures (ICC = 0.93–0.98). Computer-vision showed excellent agreement with manual measurement for the 5XSTS (ICC = 0.97 for both trials), moderate for the TUG (ICC = 0.55–0.64), and ranged from poor to good for the F8WT (ICC = 0.79 and 0.40). Bland–Altman analysis demonstrated minimal bias between human raters and greater variability for the TUG and F8WT. Conclusions: The computer-vision motion capture system demonstrated strong agreement with manual clinical assessment for the 5XSTS test. Additional refinement of the software is needed to improve its performance assessing other mobility tasks.

Presenter(s): Repinski, Ellie
School: Beloit College
Session: P1.07
Title: Mathematical Modelling of Human African Trypanosomiasis
Co-Author(s):
Advisor(s): Thomas Stojsavljevic

Abstract: Human African trypanosomiasis (HAT), also known as African sleeping sickness, is a Neglected Tropical Disease (NTD) primarily found in Sub-Saharan Africa. This work develops a compartmental model of HAT that incorporates human, vector, and zoonotic components. Infection is modeled by a two channel system wherein vectors can simultaneously infect both human and zoonotic compartments. The

zoonotic compartment also serves as a reservoir for the disease in the environment. The basic reproductive number and the equilibrium states of the model are found, as well as local stability conditions for both equilibrium. We simulate the model numerically to show the conditions under which the stability of each equilibrium state is achieved.

Presenter(s): Rios, Luis
School: Colorado College
Session: P3.20
Title: Optimization Of Chemical Pretreatments Of Tooth Enamel For Forensic Analysis Using Thermogravimetric Analysis (TGA)
Co-Author(s): Nate Bower, Murphy Brasuel
Advisor(s): Nate Bower, Murphy Brasuel

Abstract: Scientists have used Attenuated-Total-Reflectance Fourier-Transform-Infra-Red (ATR-FTIR) to determine how effective specific treatments are for cleaning teeth samples. Although this technique can determine how successful the procedure unfolds, the overlapping of organic and inorganic material presents an issue in determining the efficacy of debris removal. In this project, Thermogravimetric Analysis (TGA) is used as an alternative to better understand the effectiveness of cleaning treatments with these practices. Using TGA clarifies and quantifies the materials removed from tooth samples (i.e. water, volatile, organic, carbonate content). The applications of TGA spread from forensic analysis, archaeological studies, and isotopic mapping, providing more contextualization through quantifying the removal of material. The treatments used consisted of Ultrasonication, Hydrogen Peroxide, Hydrazine, Ethanol, Bleach, Acetate Buffer (pH 4.8), and Acetic Acid. These treatments were found in literature deemed of interest to the project. A multitude of combinations were performed on collected enamel samples to examine the impact of the treatments. Out of the treatments tested in the project, bleach was determined to yield the best results in removing organic material. Investigations surrounding its concentration should be investigated to establish a consensus on the best percentage of bleach to uphold the integrity of teeth samples without compromising its structure.

Presenter(s): Rowles, Finn
School: Grinnell College
Session: P3.07
Title: Modeling Uncertainty and Outcomes in Grinnell College Registration Processes
Co-Author(s): Jonathan Wells, Brigid Leahy, Jiayi Zhang
Advisor(s): Jonathan Wells

Abstract: This project investigates first-year course registration at Grinnell College using five years of Yellow Card registration data. During the summer, we analyzed students' course requests and allocation outcomes across courses, departments, registration rounds, and years. We developed measures of registration satisfaction, used unsupervised clustering to identify patterns in students' course-request profiles, and applied supervised machine-learning methods to examine relationships between first-semester requests and later academic directions, including declared majors. Through these analyses, we were able to identify patterns in how students requested and received courses and how those patterns differed across groups and years. Now, we shift from primarily descriptive and predictive questions toward statistical modeling of the relationship among submitted choices, received allocations, and later academic trajectories. We are exploring ways to preserve the categorical structure of submitted choices rather than imposing numerical interpretations of preference or satisfaction. Current work focuses on how realized academic access varies conditional on students' stated preferences on their Yellow Card and whether allocation (particularly access to gateway courses and curricular pathways) provides additional information

about each student's later academic direction. More broadly, we want to understand how constrained course-allocation systems translate stated choices into academic opportunities and subsequent outcomes.

Presenter(s): Ruslanova, Altynai
School: Knox College
Session: II.F.1
Title: Computational Modeling of Disease Spread
Co-Author(s):
Advisor(s): Matthew Jones-Rhoades

Abstract: The rapid spread of infectious diseases across regions has become increasingly influenced by human mobility between cities. Modern transportation networks allow individuals to move frequently between communities, accelerating the transmission of pathogens. The COVID-19 pandemic demonstrated how intercity travel can transform local outbreaks into widespread regional epidemics. Mathematical epidemiology provides tools to study these dynamics and to predict how disease spreads under different mobility conditions. This project will use the SIR epidemiological model to simulate the spread of infectious disease between two to three connected cities under varying levels of travel. Three primary scenarios will be analyzed: a baseline scenario with minimal travel between cities, a moderate mobility scenario and a high mobility scenario. Computational simulations will be performed to observe how infection curves, peak infection levels and epidemic duration change as mobility increases. The goal of this project is to evaluate how travel intensity affects epidemic dynamics between connected populations. By combining mathematical modeling with real demographic data, the study aims to demonstrate how simple models can provide insights into disease spread in interconnected communities. The results may contribute to improved understanding of how mobility restrictions, travel policies, or regional coordination could influence epidemic outcomes.

Presenter(s): Schweit, Benjamin
School: Beloit College
Session: P1.08
Title: Actuarial Applications of Epidemiological Models: Chagas Disease
Co-Author(s):
Advisor(s): Thomas Stojsavljevic

Abstract: Chagas disease (American trypanosomiasis) is a neglected tropical disease (NTD) that affects an estimated 8 million people worldwide and is endemic throughout Latin America, South America, and parts of the southern United States. Although the disease can often be cured when detected and treated during the acute phase, many individuals develop chronic infection. Up to one third of people with chronic infection develop cardiac disease, while one in ten develop digestive, neurological, or mixed alterations which may require specific treatment. In this work, we develop a multilayer model capturing both the epidemiological dynamics of Chagas disease as well as the actuarial consequences of chronic infection and long term disability in children. The model incorporates disease progression, treatment pathways, and associated insurance costs and benefits to investigate the interplay between disease dynamics and the financial risks associated with chronic Chagas disease.

Presenter(s): Sherpa, Nima J.
School: Knox College
Session: P3.15
Title: Physics-Informed Neural Networks (PINNs) for Ice Shelf Viscosity Inference Under Sparse Observations
Co-Author(s): Emma Liu, Meghana Ranganathan

Advisor(s): Emma Liu, Meghana Ranganathan

Abstract: Ice viscosity affects how fast ice deforms, making it essential for modeling ice flow, but it cannot be measured directly. It can instead be inferred from surface velocity and ice thickness. We do this with a physics-informed neural network (PINN). These observations are often sparse and uneven, and it is not known how much this limits the accuracy of the inferred viscosity. We combine a Shallow Shelf Approximation flow model with the PINN to infer viscosity on ice shelves. We modify it so the network sees observations at only N locations, fixed before training, and place those N points using six sampling strategies that differ in how they distribute points. We apply this to two synthetic ice shelves with known ground-truth viscosity. Viscosity is mostly recovered from observation points covering under 1% of the domain on both shelves. Beyond this, spatial distribution governs accuracy more than the number of points. At equal N, strategies that spread points across the domain outperform those that concentrate them. These results give an initial guideline for observation number and placement in viscosity inversion.

Presenter(s): Stalbekova, Sabina
School: Knox College
Session: II.E.1
Title: Can AI-Rewritten Banking Phishing Messages Change Detector Decisions?
Co-Author(s):
Advisor(s): Shengting Cao

Abstract: Phishing remains a serious cybersecurity problem and recent threat reports show that artificial intelligence is making social engineering messages easier to create and more realistic. This is especially important in banking, where attackers can imitate trusted institutions and use familiar language about accounts, payments, fraud or security. My project studies whether AI rewritten banking phishing messages can change the behavior of current text based phishing detectors even when the malicious meaning stays the same. I created a banking focused message dataset and compared original phishing messages with neutral AI rewritten versions. I tested these message pairs using two traditional detection models based on TF IDF, Logistic Regression and Random Forest. Overall, the detectors remained strong after rewriting, but some individual messages showed noticeable changes in phishing probability and some crossed the detection threshold. I also found that legitimate banking messages can sometimes receive high phishing scores because they use language similar to phishing messages. This project shows that strong overall detector performance does not always mean that every individual decision is stable. Understanding these changes can help identify where current text based phishing detectors are more sensitive and guide the development of more robust detection methods.

Presenter(s): Stugelmeyer, Ella
School: Carthage College
Session: P1.14
Title: Integration of MUD as a Standardized Testing Payload for NASA's Universal Payload Interface Challenge
Co-Author(s): Nathaniel Cabrera, Maximilian Dan, Cecilia Degenhard, Evelyn Gotschewski, Maya Griffin, Ben Lagerhausen, Henry Martin, Leena Maryanski, Karl Sanchez, Sofia Worley
Advisor(s): Kevin Crosby

Abstract: In commercial spaceflight, providers each impose various kinds of payload lockers, weight limits, and power interfaces. This forces researchers to redesign payloads for each new flight opportunity, raising costs and slowing down experiment development. To lower this barrier of entry, NASA held a Universal Payload Interface Challenge (UPIC) in 2023, selecting three winning interface designs: Aegis's

EPIIC, Ecoatoms's ANIMA, and UCLA's SDPI. To test these designs, Carthage was chosen as a standard testing payload for each winner because of the sizeable power draw and complex payload architecture. Three identical payloads of Microgravity Ullage Detection (MUD), a vibration based sensor system for detecting the liquid-vapor interface in microgravity, were built, one for each winner. Each integration will be assessed across various criteria such as mounting capability, power delivery, or ease of installation. By maintaining an identical test payload across all three integrations, interface specific performance differences can be isolated and directly compared. The resulting comparison is intended to aid future standardization efforts of commercial payload interfaces to improve the overall lead time and entry cost of commercial spaceflight.

Presenter(s): Thompson, Kyle
School: Carleton College
Session: P2.05
Title: Coherently coupled quantum oscillators for predicting and characterizing chaotic maps
Co-Author(s): Efe Celep, Arjendu Pattanayak
Advisor(s): Arjendu Pattanayak

Abstract: Quantum reservoir computing uses the dynamics of a quantum system as a computational resource for machine learning and information processing. A time-dependent input is encoded into a quantum system, and measurements of the resulting dynamics provide observables that are used to construct a feature space for a trained linear readout. In this work, we investigate coherently coupled quantum oscillators as a reservoir for predicting chaotic maps. We use off-diagonal elements of the quantum density matrix as observables, providing access to coherence between quantum states as part of the reservoir feature space. We apply this approach to discrete-time chaotic maps, providing a different prediction task from the continuous trajectory prediction typically considered with this system. This change in application allows the computational properties of the coupled-oscillator reservoir to be examined in the context of discrete chaotic dynamics while also investigating the information provided by coherence-based observables. We evaluate the ability of the reservoir to reproduce the evolution of chaotic maps from input sequences and examine how the resulting quantum features support prediction. More broadly, this work explores how coherently coupled quantum systems can be used as computational resources for machine learning and how different quantum observables influence their ability to represent complex dynamical systems.

Presenter(s): Tran, Kacy
School: Knox College
Session: P1.21
Title: Crop-Label Alignment: Auditing Crop-Dependent Auto-Labels in Remote-Sensing Segmentation
Co-Author(s): Jurdana Masuma Iqrah, David Bunde, Chau Tran, Santosh Pant, Dipsha Budhathoki, Arito Nakamichi
Advisor(s): Jurdana Masuma Iqrah, David Bunde

Abstract: Some segmentation pipelines fit context dependent label rules inside each crop. Overlapping crops can assign different labels to one pixel, so patch wise scoring can reward models for following crop specific labels rather than the scene. We introduce crop label alignment, κ, distinct from Cohen kappa. On pixels whose crop specific labels disagree, κ measures whether predictions follow the label in the crop being read more often than labels from other covering crops. Any fixed crop invariant predictor has κ equal to zero algebraically, avoiding simulated null models. Attributing a nonzero value to training labels still requires a matched control. We calibrate the diagnostic on Sen1Floods11 by moving from its event threshold to crop fitted thresholds. On the disagreement set, 24.71 percent of pixels, the end to end contrast

is 0.2613. Averaged over seeds, five levels are ordered in every held out event. Surveys show crop adaptive SAR rules create disagreement on 12 to 18 percent of covered pixels, while fixed and scene fitted variants create none. On imagery, per crop color labeling gives 37.04 percent disagreement, while scene context gives zero. On a sea ice benchmark, per patch labels yield κ of 0.1518 versus 0.0097 for matched scene labels.

Presenter(s): Troyer, Anya
School: Grinnell College
Session: P3.01
Title: Duality of Orthogonal Polynomials with Rational Weights
Co-Author(s): Judd Brau
Advisor(s): Ahmad Barhoumi

Abstract: Given a rational function w(z), we consider the space of polynomials with degree at most n under the bilinear form given by a contour integral on γ of f(z)g(z)w(z) for two polynomials f and g, where γ is a smooth curve encircling the zeros and poles of w(z). A dual bilinear form is given by the replacement of w(z) with 1/w(z) . For each bilinear form, conditional on the non-vanishing of certain determinants, one can define two families of orthogonal polynomials {Pn} and {Qn} respectively. Motivated by appearances of this duality in random tiling models, we prove two different formulas for Qn. The first is an explicit description of the coefficients in terms of super-symmetric skew Schur functions (Schur functions in two sets of variables). In this formula, the duality can be thought of as a swap in these sets of variables. The second formula expresses a particular Qn(z) as the polynomial part (terms with positive powers) of the Laurent expansion of Pn(z)w(z) at infinity.

Presenter(s): Vega, Mauricio
School: Carthage College
Session: P1.18
Title: Designing, Prototyping, and Educational Applications for Injection Molding
Co-Author(s): Jessica Lavorata
Advisor(s): Jessica Lavorata

Abstract: This project explores the integration of thermoplastic injection molding into engineering makerspaces using 3D-printed plastic molds as a cost-effective, rapid alternative to traditional steel and aluminum molds. Standard metal tooling requires substantial lead times and high fabrication costs. By leveraging in-house filament 3D printers, custom molds can be produced in days to enable low-budget, rapid prototyping for student projects and educational outreach. Mold designs were modeled in SolidWorks, evaluated using Plastics Flow simulations, and fabricated using temperature-resistant materials including Onyx (Nylon), ABS, PETG, and PLA. To evaluate mold durability and part quality, testing evaluated performance benchmarks targeting 8–10 injection runs using polypropylene, an average part weight of ~24 grams, minimal flash (~0 mm), and run times around 3.65 seconds. The experimental trial tested various mold formulations and surface coatings, including heat-resistant epoxy and standard mold release. The best results were achieved using ABS-HH and PLA-Epoxy combinations, which produced complete, well-formed parts despite minor flashing. Primary failure modes of the molds stemmed from continuous exposure to molten plastic causing thermal deformation which resulted in gaps that caused flash or incomplete fills. Ultimately, this research demonstrates that 3D-printed molds offer a practical solution for hands-on engineering education, while future work will evaluate alternative non-stick surface coatings and resin-based SLA printing to refine surface finish and structural integrity.

Presenter(s): Velmont, Brookelyn

School: Carthage College
Session: I.B.5
Title: Evaluation of ResNet50 Segmentation Performance with Presence of Necrosis within Pleural Mesothelioma Tumors on CT Scans
Co-Author(s): Christopher Valdes, Samuel Fulton, Owen Mitchell, Feng Li, Hedy Kindler, Christopher Straus, Samuel Armato
Advisor(s): Samuel Armato

Abstract: Purpose: This study evaluated the segmentation performance of a deep learning model of pleural mesothelioma tumors on computed tomography (CT) scans, with particular emphasis on the impact of necrosis on segmentation accuracy. Methods: A deep learning segmentation model based on a ResNet50 encoder architecture was trained using 2,125 CT section images demonstrating pleural mesothelioma and their manual tumor segmentations. The test set, consisting of 5 CT sections with necrosis and 5 sections without necrosis, was evaluated by the trained model at every epoch of training. Model performance was evaluated using the Dice similarity coefficient (DSC) by comparing predicted tumor masks with radiologist-generated reference segmentations. Segmentation performance was compared between tumors with and without necrosis. Results: Across all epochs of training, necrosis images yielded an average DSC of 0.83 (95% CI: [0.81, 0.85]). Non-necrosis images yielded an average DSC of 0.86 (95% CI: [0.84, 0.87]). Welch's t-test yielded a p-value of p=1.06∗10^(−9). Conclusion: Necrosis is a prominent confounding variable for pleural mesothelioma solid tumor segmentation on CT scans.

Presenter(s): Vizel, Seth
School: Carleton College
Session: P3.18
Title: Clustering Non-Isomorphic Clonal Trees by Shape
Co-Author(s): Kezia Sharnoff
Advisor(s): Layla Oesper

Abstract: Clonal Trees are a type of ancestral tree which map how mutations within tumors evolve over time. Inference of clonal trees from sequenced data may be helpful in the creation of targeted cancer treatments. We were interested in categorizing the shapes of clonal trees since different forms of cancer follow alternate patterns of evolution. For small numbers of mutations, it is trivial to enumerate the entire space of clonal trees. However, as the number of mutations increase, the space quickly grows beyond computational feasibility. We therefore modified an algorithm to enumerate all uniquely shaped trees and devised a method to measure the distribution of tree shapes on the full space via this smaller set. We concluded that the shapes of all clonal trees are unevenly distributed in the space, and therefore the set does not represent all potential evolutionary patterns equally.

Presenter(s): Yu, Jeffrey
School: Macalester College
Session: I.C.4
Title: Image and Kernel Persistence on Temporal Knowledge Networks
Co-Author(s): Russell Funk, Jonathan Mousley, Himanshu Yadav, Lori Ziegelmeier
Advisor(s): Lori Ziegelmeier
Abstract: We present a computational framework using image and kernel persistence to compare temporal knowledge networks constructed from research grants and publications. In these networks, nodes represent scientific concepts, edges record the first year in which two concepts co-occur, and filtered clique complexes encode how higher-order relationships develop over time. We study maps from Grant and Paper networks into their Union across 154 fields. Image persistence identifies one-dimensional cycles that

remain after information from the other source is added, while kernel persistence detects cycles eliminated by this inclusion. We implement these computations in Oineus using mapping-cylinder reductions and validate the framework in both Grant-to-Union and Paper-to-Union directions. Preliminary computations show that adding information from the other source can preserve some persistent cycles while eliminating others, revealing structural differences between proposed and published scientific relationships. We also compare the Union construction with a layered representation. Our analysis shows that the layered construction contains no mixed triangles, making the induced map on first homology injective and preventing it from detecting nontrivial kernel classes. These results demonstrate that the choice of comparison space fundamentally shapes the topological features detected and provide a scalable framework for studying how scientific knowledge develops across grants and publications.

Presenter(s): Yu, Zixi
School: Washington University in St. Louis
Session: P1.09
Title: Multi-Tissue Landscape of NUMTs and Mitochondrial DNA Variation in Humans
Co-Author(s): Zefan Li, Nahyun Kong, Brandt Bessell, Emma Casey, Hang Su, Christina Zakarian, Sheng Chih Jin
Advisor(s): Sheng Chih Jin

Abstract: Mitochondrial DNA (mtDNA) is linked to tissue-specific mosaicism and age-related remodeling, but the mechanisms remain unclear. Its high copy number, elevated mutation rate, and maternal inheritance produce heteroplasmy and nuclear mitochondrial DNA insertion (NUMT)-related mosaicism that standard approaches struggle to resolve. Using deep multi-platform sequencing from the Somatic Mosaicism across Human Tissues (SMaHT) consortium, we systematically characterized NUMTs and mtDNA variation across human tissues. Benchmarking against a high-confidence truth set showed accurate detection of somatic NUMTs at variant allele frequencies as low as 0.25%. Applying this workflow to 19 tissues from 25 SMaHT production donors, we built a high-confidence catalog of germline and somatic NUMTs, identifying an average of 8.6 non-reference germline NUMTs per donor and six high-confidence somatic NUMTs, indicating ongoing integration of mtDNA into the nuclear genome. One donor carried a homoplasmic pathogenic mtDNA variant associated with Leber hereditary optic neuropathy across tissues, and disease-associated variants appeared in 21 of the remaining 24 donors, generally at low heteroplasmy. These results reveal tissue-specific and age-related patterns of mitochondrial gene variation and provide a multi-tissue framework for studying mitochondrial genome maintenance and mosaicism.

Presenter(s): Zhang, Alyssa
School: Washington University in St. Louis
Session: II.D.4
Title: Removal of Iodine and Iodide in Hot Water Using Porous Organic Polymer
Co-Author(s):
Advisor(s): Chenfeng Ke

Abstract: Iodine (I2) and iodide (I-) have been used as biocides in water purification systems. However, consumption of elevated iodine concentrations can cause various health disorders. Potable water dispenser (PWD) systems have been used to purify water with I2 by passing it through an activated carbon/ion exchange (ACTEX) cartridge, reducing the total iodine content to a safe level (<0.2 ppm). ACTEX cartridges are currently limited to room temperature and exhibit decreased performance at higher temperatures. In this project, we synthesized a new iodine removing motif (WU-POP-1) that has a high density of N-rich melamine units and ionic imidazolium moieties. The primary objective is to investigate the I2 and I- absorption capabilities of this motif under dynamic and static conditions at various

temperatures. WU-POP-1 was synthesized through a photoinitiated free-radical polymerization of a melamine-based crosslinker with an imidazolium-containing monomer– product purity confirmed through 1H NMR spectroscopy. Static and dynamic I2/I- uptake capabilities of WU-POP-1 were tested using a diluted iodine/potassium iodide (I2/KI) aqueous solution (5 ppm), and residual I2/I- concentrations were determined by leuco crystal violet method. This work demonstrates the potential of WU-POP-1 as a high-temperature iodine-removing material and a potential alternative to ACTEX cartridges.

Presenter(s): Zhang, Jiayi
School: Grinnell College
Session: P1.23
Title: College Course Registration System Modeling
Co-Author(s): Brigid Leahy, Finn Rowles
Advisor(s): Jonathan Wells

Abstract: This project investigates first-year course registration at Grinnell College using five years of Yellow Card registration data. During the summer, we analyzed students' course requests and allocation outcomes across courses, departments, registration rounds, and years. We developed measures of registration satisfaction, used unsupervised clustering to identify patterns in students' course-request profiles, and applied supervised machine-learning methods to examine relationships between first-semester requests and later academic directions, including declared majors. Through these analyses, we were able to identify patterns in how students requested and received courses and how those patterns differed across groups and years. Now I shift from primarily descriptive and predictive questions toward statistical modeling of the relationship among submitted choices, received allocations, and later academic trajectories. I am exploring ways to preserve the categorical structure of submitted choices rather than imposing numerical interpretations of preference or satisfaction. Current work focuses on how realized academic access varies conditional on students' stated preferences on their Yellow Card and whether allocation (particularly access to gateway courses and curricular pathways) provides additional information about each student's later academic direction. More broadly, we want to understand how constrained course-allocation systems translate stated choices into academic opportunities and subsequent outcomes.

All Students Presenting at
MCMS Undergraduate Research Symposium,
Washington University in St. Louis
Physical Sciences, Math and Computer Science
November 6-7, 2026

Beloit College: Araf Israk, Ellie Repinski, Benjamin Schweit

Carleton College: Abigail Gardner, Rebecca Moran, Ian Morgan, Kyle Thompson, Seth Vizel

Carthage College: Juliana Alvarez, Owen Bonnett, Ben Lagerhausen, Braedon Larsen, Ella Stugelmeyer, Mauricio Vega, Brookelyn Velmont

Colorado College: Marcos Arnold, Henry Batson, Evie Doran, Ja'Toria Johnson, Michelle Laferriere, Douglas Leung, Filip Maleev, Liv Panos, Luis Rios

Grinnell College: SarahPearl Anderson, Marc Duebener, Drew Fargo, Maya Holland, Brooke Kreeger Emily Lackershire, Daniel Lee, Alexis Mendoza, Mara Neace, Mihail Palmov, Ramses Ponce, Finn Rowles, Evan Stoller, Anya Troyer, Maria Zhang

Gustavus Adolphus College: Abby Clasemann, Dar Evan, Noah Gehler, Anna Imdieke, Joseph Merrigan, Oscar Peterson

Hope College: Lincoln Bosh, Richard Cuzydlo, Faith Mitchell

Knox College: Mohsin Asad, Dipsha Budhathoki, Annie Do, Ronak Jha, Kamlesh Kumar, Samara Melisbek, Eeman Naveed, Tioluwani Olubunmi,Santosh Pant, Mayank Raghuvanshi, Altynai Ruslanova, Nima J. Sherpa, Sabina Stalbekova, Kacy Tran

Luther College: Shan Ghimire, Michel Heinrich, Gus Krueger, Minh Le, Owen McCredie, Benjamin Murr, Linh Nguyen, David Pittman

Macalester College: Sudhi Adusumilli, Batsambuu Batbold, Katrina Brinkmann, Elliott Lewis, Jeffrey Yu

St Olaf College: Carson Bridigum, Sadé Brooks-Robinson, Sydney Fuller, Gavin Hoelzel

University of Chicago: Natalie Booth, Jinwoo Chun, Doga Eker, Sofya Fadeeva, Uliana Hauk, Mansoor Johnson, Boden Komorech, Thereza Cristina Pedrazini de Castilho, Ayesha Rana

Washington University in St. Louis: Tess Agoglia, Bethany Bao, Jack Farah, Amari Herndon-Goodman, Jennifer Hong, Ina Jaegy, Joy Kim, Teddy Liu, Karl Lyu, Eeshaan Malladi, Lavender Miao, Julian Mitchell, Emrah Omerovic, Danny Phan, Julia Raphael, Jack Yu, Alyssa Zhang

Participating Faculty at
MCMS Undergraduate Research Symposium,
Washington University in St. Louis
Physical Sciences, Math and Computer Science
November 6-7, 2026

Tanya Amert, Assistant Professor, Computer Science Department, Carleton College

Joseph Anderson, Assistant Professor, Department of Physics and Astronomy, Carthage College

Jen Baldwin, Assistant Professor, Department of Chemistry, Luther College

Andrew Beveridge, Professor, Department of Chemistry, Macalester College

Murphy Brasuel, Professor, Department of Chemistry, Colorado College

Kyuil Cho, Assistant Professor, Department of Physics, Hope College

Tom Clayton, Professor, Department of Chemistry, Knox College

Darsa Donelan, Senior Continuing Instructor, Department of Physics, Gustavus Adolphus College

Cassandra Joiner, Associate Professor, Department of Chemistry, St. Olaf College

Andrew Leahy, Chair and Rothwell C. Stephens Distinguished Service Professor, Department of Mathematics, Knox College

Leslie Lyons, Professor, Department of Chemistry, Grinnell College

Richard Mabbs, Associate Professor and Director of Undergraduate Studies in Chemistry, Department of Chemistry, Washington University in St. Louis

Kim Mandery, Computer Scientist in Residence, Department of Mathematics, Statistics, and Computer Science, St. Olaf College

Scott Snyder, Master of the Physical Sciences Collegiate Division and Deputy Dean of the College and the Division of the Physical Sciences, Department of Chemistry, University of Chicago

Tom Stojsavljevic, Assistant Professor, Department of Mathematics and Computer Science and Co-Department Chair of Data Science and Data Analytics, Beloit College