The Midstates Consortium for Math and Science presents

Undergraduate Research Symposium

Physical Sciences, Mathematics and Computer Science

November 7-8, 2025
University of Chicago

Beloit College - Carthage College - Colorado College - Grinnell College
Gustavus Adolphus College - Hope College - Knox College
Lawrence University - Macalester College
St. Olaf College - University of Chicago
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Midstates Consortium for Math and Science
Undergraduate Research Symposium for Physical Sciences, Mathematics and Computer Science
University of Chicago

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Program Schedule for Friday, November 7		
1:00 – 5:00 pm	Registration at Hyatt Place South - University 5225 S Harper Ave, Chicago, IL 60615	Hyatt Place Lobby
5:30 pm	Shuttle to University of Chicago campus	Hyatt Place Lobby
6:00 – 6:10 pm	WELCOME Pamela Kittelson, Director Midstates Consortium for Math and Science Professor, Gustavus Adolphus College Scott Snyder, Professor Department of Chemistry University of Chicago	The Study University of Chicago 1227 E 60th Street Chicago, IL 60637
6:10 – 7:00 pm	KEYNOTE LECTURE ***The Origin of Life and the Nature of the First Cells*** Dr. Jack Szostak University Professor, Department of Chemistry University of Chicago	The Study University of Chicago
7:00 – 8:00 pm	Dinner	The Study University of Chicago
8:00 – 8:50 pm	JANET ANDERSON LECTURE ***Chasing Light, Cultivating Purpose: Undergraduate Research in Environmental Chemistry*** Dr. Amanda Nienow Professor, Department of Chemistry Gustavus Adolphus College	The Study University of Chicago
Following lecture	Group Picture and shuttle back to hotel	

	Program Schedule for Saturday, November 8 , 2025	
Starts at 7:00 am; avoid the 7:35 rush	Breakfast. Leave key cards at the desk. Bring luggage. There is a secure room at the meeting site.	Hyatt Place Hotel
7:50 - 8:15 am	Load buses and vans. Those with vans will drive to campus. Others will take the shuttle.	Eckhardt Research Center (ERC) 5640 S Ellis Ave.
8:30 - 9:00 am	Set-up for Poster Session 1 Ensure Oral Session I presentations are loaded	Posters in Eckhardt Research Center (ERC) Oral Sessions in Kersten
9:00 – 10:00 am	Session 1 Poster Presentations (n=20)	ERC
10:00 – 10:15 am	Remove posters. Go to Kersten for Oral Sessions	Coffee & tea in ERC
10:15 – 11:15 am	Session I Oral Presentations	
	Session I.A. Moderator: Dr. Ben Stucky	Kersten 101
	Session I.B. Moderator: Dr. Kristen Burson	Kersten 103
	Session I.C. Moderator: Dr. Paul Fischer	Kersten 105
	Session I.D. Moderator: Dr. Richard Mabbs	Kersten 309
11:15 am – 12:15 pm	Lunch in ERC. Graduate Panel for Students Faculty Social	ERC
12:15 – 12:30 pm	Set-up for Poster Session 2 Ensure Oral Session II presentations are loaded	ERC Oral Sessions in Kersten
12:30 – 1:30 pm	Session 2 Poster Presentations (n= 22)	
1:30 pm – 1:45 pm	Remove posters. Go to Kersten for Oral Session II	Coffee & tea in ERC
1:45 pm – 2:45 pm	Session II Oral Presentations	
	Session II.E. Moderator: Dr. Joseph Anderson	Kersten 101
	Session II.F. Moderator: Dr. Amanda Nienow	Kersten 103
	Session II.G. Moderator: Dr. Murphy Brasuel	Kersten 105
	Session II.H. Moderator: Dr. Scott Snyder	Kersten 309
2:45 pm – 3:00 pm	Set-up for Poster Session 3	Coffee & tea in ERC
3:00 pm – 4:00 pm	Session 3 Poster Presentations (n=22)	ERC
4:00 pm	Meeting Concludes Take boxed dinners. Depart. Complete online evaluations.	

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Keynote Address

The Origin of Life and the Nature of the First Cells

Dr. Jack W. Szostak
University Professor, Department of Chemistry
University of Chicago

Abstract: How did the first Protocells emerge from the chemistry and geology of the early Earth? Many questions must be addressed to trace the path from the synthesis of the chemical building blocks of biology to the emergence of primitive Life. For example, how could RNA copying and replication occur before the evolution of enzymes? How did the first protocell membranes grow and divide? And how could primitive cells accumulate and transmit useful genetic information? I will discuss recent exciting progress on these long-standing questions.

About: Jack W. Szostak, is the co-recipient of the 2009 Nobel Prize in Physiology or Medicine for research that he and Drs. Elizabeth Blackburn and Carol Greider did to describe the enzyme telomerase and the structure and function of telomeres. The protective telomeres on the ends of chromosomes and the enzyme, telomerase, which extends these caps, have roles in preventing senescence. Following an abiding curiosity in scientific processes, Dr. Szostak has pursued research interests in chemical biology, physical chemistry and biophysics. His expertise in biochemistry, and specifically in nucleic acids like DNA and RNA, is now being applied to understanding a fundamental question, how did life on this planet begin? At the University of Chicago, his research lab focuses on chemical and physical processes that facilitated the transition from a chemical world to the evolution of biological systems on early earth. In addition to his position as a University Professor at the University of Chicago, he is an investigator at the Howard Hughes Medical Institute and a member of the National Academy of Sciences and the American Philosophical Society, and a fellow of the Royal Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science. He received his B.Sc. from McGill University in Canada and then earned his Ph.D. at Cornell University. In addition to hundreds of publications with research collaborators, he is the co-author of *The Origins of Life* (2010) with David Deamer and the 2024 book, *Is Earth Exceptional: The Quest for Cosmic Life,* with astrophysicist Mario Livio.

2025 Janet Andersen Lecture

Chasing Light, Cultivating Purpose: Undergraduate Research in Environmental Chemistry

Dr. Amanda Nienow
Professor and Chair of Chemistry
Gustavus Adolphus College

ABSTRACT: Understanding the fate of agrochemicals in the environment is a challenge, one that my undergraduate research lab addresses by examining photodegradation of herbicides as a platform for discovery and student transformation. This talk will present a snapshot of the environmental fate of imazethapyr and dicamba, focusing on the phototransformation kinetics and product analysis of these two herbicides. Using advanced analytical techniques like HPLC and mass spectrometry, students determined the degradation rates and identified novel transformation products under various environmental conditions while gaining experiences that catalyzed their development into scientists and critical thinkers. Ultimately, this research demonstrates that the laboratory environment is an effective catalyst for cultivating purpose. The students who investigated the photodegradation pathways to understand reaction mechanisms and environmental fate gained the critical thinking, technical mastery, and professional maturity necessary to successfully launch careers in chemistry, medicine, environmental policy, and non-science careers such as financial planning.

ABOUT: Dr. Nienow was selected for the Janet Andersen Award because of her excellence in teaching and in mentoring undergraduate research collaborations. Dr. Nienow teaches a range of courses from first-year Principles of Chemistry to upper-level courses like Physical and Environmental Chemistry. She redesigned the physical chemistry curriculum to include application, scientific communication, and professional development, transforming the course from one that students dread to an experience they enjoy. Dr. Nienow's active research lab studies photodegradation of compounds, like the herbicide dicamba, in the environment. She has active collaborations in France and Minnesota, and undergraduates are co-authors on her publications. Amanda has earned numerous grants from the NSF-RUI, the Sherman-Fairchild Foundation, IUSE, among others. This funding supports her lab as well as undergraduate research across the Gustavus Science and Mathematics Division. Notably, she catalyzed the development of the summer Second Year Research Experience for Gustavus students. She supports and directs the summer student-faculty collaboration called the First Year Research Experience Program. Dr. Nienow's love of chemistry shines through in outreach programming she developed called 'Science on Saturday' and 'ChemistryNight,' which are one-day events for local K-12 students. At Gustavus, she is Director of Undergraduate Research and Co-Chair of the Chemistry Department.

About the Janet Andersen Award Lecture: Professor Janet Andersen was a beloved faculty member in the Hope College Mathematics Department and served as the Midstates Director for five years before her life ended tragically in an automobile accident in 2005. As a teacher and scholar, Janet was devoted to providing creative, high quality learning experiences for her students, and she always learned as she taught. As Consortium Director, she looked for ways to connect with and support 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. Each year, nominees from the Consortium are selected by the Executive Committee to present the Janet Andersen Lecture at the fall Undergraduate Research Symposia on a topic of his or her expertise.

November 8, 2025
Oral Session I

SESSION I.A: 10:15 - 11:15 am Kersten 101 Moderator: Dr. Ben Stucky			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.A.1	Ryan Pham and Alex Maule	Beloit College	Reducing the Pinning Problem to a variant of Boolean Satisfiability via Self-Overlapping Curves
I.A.2	Tamia Ware	Knox College	Flow in Game Design: A Transmedial Experience
I.A.3	Christine Lee and Julia Margie	University of Chicago	BallotBot: Can AI Help Voters Make Informed Decisions and Justify Them?
I.A.4	Evan Stoller	Grinnell College	Removing Likely Dust Events from PM2.5 Measurements in Kuwait

SESSION I.B: 10:15 – 11:15 am Kersten 103 Moderator: Dr. Kristen Burson			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.B.1	Trevor Harrison	Hope College	Effect of Energy-Dependent Proton Irradiation in Thin-Film YBaCuO Superconductor
I.B.2	Sarah Solomon	Macalester College	1,2,3 Triazole Synthesis of Metal Coordinating Biosensors
I.B.3	Ana Elias	University of Chicago	Resonator Design to Gain Optomechanical Control of an SnV Color Center in Diamond
I.B.4	Rick Yoon	University of Chicago	Developing a Systematic Framework for the Entanglement Renormalization of Fractal Spin Liquids

November 8, 2025
Oral Session I Continued

SESSION I.C: 10:15 – 11:15 am Kersten 105 Moderator: Dr. Paul Fischer			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.C.1	Bella Nimm	Macalester College	Effect of Shielding Polymers on the Activity of Asparaginase
I.C.2	Milo Sobel-Lewin	University of Chicago	Encapsulating Stretchable, Soft Electrochemical Sensors With Tough, Adhesive Hydrogels: A Path to Single Organ Sensing
I.C.3	Adithya Asokan and Subhan Ahmad	Knox College	Disease Detection from Chest X-ray Images Using Deep Learning
I.C.4	Gloria Kozak	Hope College	Frictional Behavior of Passive vs Reactive Nanoparticles in Hydrogels

SESSION I.D: 10:15 – 11:15 am Kersten 309 Moderator: Dr. Richard Mabbs			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
I.D.1	Michael Bolgov	University of Chicago	Multiple turnovers of RNA Modifications across Prebiotic Catalytic and Non-Enzymatic Pathways
I.D.2	Joyce Lin	Grinnell College	Exploring the Effects of Nanocage Size on Noble Gas Trapping Selectivity at Room Temperature
I.D.3	Charlie Fioriglio	Washington University	Using Prolate Spheroidal Coordinates to Describe Electron Detachment from a Diatomic
I.D.4	Yousef Abualatta	St. Olaf College	Investigation of the Interaction Between OGT and CARM1 Adaptor Protein

November 8, 2025

Oral Session II Schedule

SESSION II.E: 1:45 – 2:45 pm Kersten 101 Moderator: Dr. Joseph Anderson			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.E.1	Dawson Gaynor	Carthage College	Point Source Recovery Using Phase-Coherent Gravitational-Wave Sky Maps
II.E.2	Elisa Gao	University of Chicago	Analysis of 14 Years of X-ray Emission From SN 2011dh
II.E.3	Haohui Che	Washington University	Characterization of a Fine-grained 3D Projection Detector for High Energy Physics
II.E.4	Ashu Anand	Washington University	Developing Novel Non-Aqueous Magnetorheological Emulsions for Advanced Rheological Control in Modern Smart Fluids

SESSION II.F: 1:45 – 2:45 pm Kersten 103 Moderator: Dr. Amanda Nienow			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.F.1	Tanisha Dodla and Nadezhda Dominguez Salinas	Macalester College	A Topological Approach to Understanding the Development of Knowledge Networks
II.F.2	Lucas Peterson	Carthage College	Lower-Dimensional Coordinates for Neurons in Two-Layer Deep Neural Networks Under Gradient Flow
II.F.3	Yihao Ni	Hope College	Evaluating Machine Learning Strategies For The Reconstruction of Compton Scatter Tomographs
II.F.4	Stuart Bernath	Beloit College	Is Meta Learning an Effective Machine Learning Technique for the Detection of Heart Disease?

November 8, 2025
Oral Session II Continued

SESSION II.G: 1:45 – 2:45 pm Kersten 105 Moderator: Dr. Murphy Brasuel			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.G.1	Kush Banker	University of Chicago	Berry Phase Effects on Molecular Dynamics around Conical Intersections
II.G.2	Changmin Seo and Anastasia Ajkoviq	St. Olaf College	Ground State Estimation of Ising-Type Models Using Variational Quantum Algorithms
II.G.3	Siddhi Raut	University of Chicago	An Optimization of Precision Magnetic Field Mapping for Mu2e and Fringe Field Analysis
II.G.4	Ina Jaegy	Washington University	Using Single-Source Precursors to Synthesize Fe-Bi Quantum Material

SESSION II.H: 1:45 – 2:45 pm Kersten 309 Moderator: Dr. Scott Snyder			
Session #	**Presenter Name**	**Institution**	**Title of Presentation**
II.H.1	Dylan Costello	Beloit College	Dengue Fever and Meningitis, a Coinfection Model
II.H.2	Georgia Akins, Mara Pirone and Lucia Zuvela	Macalester College	The Ripple Effect: Impacts of Historical Redlining on Water Quality in the Twin Cities, MN
II.H.3	Regann Fishell	Grinnell College	Modeling Back-Trajectories of Rain Events in Jasper County, IA
II.H.4	Sam Strom and Marcus Cassell	St. Olaf College	Invariant Rings in Macaulay 2

November 8, 2025
Poster Session P1

9:00 – 10:00 a.m. W. Eckhardt Research Center Atrium (ERC)			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P1.01	Benke Grobler	Grinnell College	Synthesis and Biological Evaluation of Lugdunin Derivatives
P1.02	Nerlyn Velasquez-Ramos	Beloit College	Extraction of Salicylic Acid from Various Natural Sources
P1.03	Omar Gomez Rodriguez	Colorado College	Extraction of Insecticidal Phytochemicals in Silphium integrifolium and its Toxicological Effect on Fall Army Worms
P1.04	Eliana Wolf	Washington University	Interaction of Androgen Receptor and Wnt Signaling in Bladder Cancer
P1.05	Renée Nguyen	Beloit College	Computational Ar/Cl2 Plasmas Etching of Silicon Substrate
P1.06	Victor Huang	Washington University	Decoding Pore Loop Dynamics in Hsp104: Mutational and Computational Frameworks for Predictive Therapeutic Engineering
P1.07	Payton Gelande	Carthage College	NMR Analysis of Micelle Formation by a Phenylalanine-based Biosurfactant
P1.08	Megyn Fox and Trevor VanSkiver	Hope College	Moving Beyond Carbonyls in C-C Single Bond Activation
P1.09	Jared Loos, Laura Jaimes-Martinez and Katherine Sheldon	Carthage College	Optimization and Exploration of the Synthesis of 2-Pyridyl Substituted Carbazoles
P1.10	Cassidy Recker	Colorado College	Better Protein Representations via Better Amino Acid Representations
P1.11	Jaxon Jones	Gustavus Adolphus College	Leveraging LLMs to empower teacher's course designs: scalable AI-driven solutions for effective curriculum development
P1.12	Khanh Do	Grinnell College	Laying the Tracks: Developing a Digital Roller Coaster Game for Mathematical Visualization and Pedagogical Research
P1.13	Abdullah Yousafi	Beloit College	Tool-Augmented Agentic AI: A Survey on Composition, Selection and Integration
P1.14	Hugo Florentino-Avila	Colorado College	Grasshoppers? Also Good Jumpers

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Poster Session P1 Continued

P1.15	Gwen Sheley	University of Chicago	Accessing Potential Systematics in Cosmic Shear – tSZ Cross-Correlation Analyses
P1.16	Aidan Nicholas	University of Chicago	RFSoC Technology for Cosmic Observation
P1.17	Judd Brau	Grinnell College	Low Temperature Limits for p-adic log-Coulomb Gases
P1.18	Jonathan Ryan	Gustavus Adolphus College	From Io-Jupiter to Exomoons: Building the Infrastructure for Future Radio Analysis
P1.19	Jake Hams	Colorado College	U-Pb Geochronology of Rodingite Minerals Records Permian Supra-Subduction in Whakatū/Nelson, Aotearoa/New Zealand
P1.20	Nic Restivo	University of Chicago	Loess Provenance in Bosiljevski, Croatia Terra Rossa Formations Through SEM Based Mineralogical Analysis

November 8, 2025
Poster Session P2

12:30 – 1:30 p.m. W. Eckhardt Research Center Atrium (ERC)			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P2.01	Armita Aghamiri	Beloit College	Designing a Green Chemistry Lab: Removing Lead Chloride from the Analytical Chemistry Curriculum
P2.02	Rebecca Willner	Colorado College	Exploring Liquid Metal Electrode Identity Impact of ec-LLS Crystal Growth of Germanium
P2.03	Ariana LeBaron	Grinnell College	Structural Modification of an Asymmetric Thiosemicarbazide Metal Compound for CO2 Reduction
P2.04	Alex Juve	Beloit College	Column Chromatography to Separate Salicylic Acid from Willow Bark Extract in a General Chemistry Laboratory
P2.05	Brisa Garcia	Colorado College	Optimization of *Silphium integrifolium* Oil Extraction Techniques for Oil Characterization and Formulation of Moisturizer
P2.06	Paul Schroeder	Carthage College	Investigating Bidentate Stabilizer Binding to the V122I Transthyretin Variant with Molecular Dynamics Simulations
P2.07	Elissya Laze	Hope College	Varying the α-Substituent of Quinoline Hydrazones and BF2-Azo Dyes: Synthesis, Structure, and Spectroscopy
P2.08	Anders Herfindahl-Quint	St. Olaf College	Examination of Chemical Properties of N2P2 Ligand Complexes
P2.09	Haley Goetting	Colorado College	Hydroxyl Radical Generation and Amino Acid Oxidation by Cold Plasma Implicating Biomolecular Modification and Early Life Chemistry
P2.10	Lance Miller	Knox College	Synthesis and Characterization of Long-Chain Heteroleptic Liquid Crystals
P2.11	Sihan Tang	Grinnell College	Dye-labeled Gold Nanoparticles for Protease Detection
P2.12	Manya Lalwani	University of Chicago	The Role of Nuclear Laminal Rigidity in Compensatory Regeneration of the Mouse Incisor
P2.13	Dongting Li	Washington University	Design and Synthesis of Porous Organic Cages for Anion Sorption
P2.14	Bradyn Nordeen and Kendall Wiggins	Gustavus Adolphus College	Impacts of Warfare on Soil Erosion and Landscapes: a Baseline from Early Modern Period Strata

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Poster Session P2 Continued

P2.15	Sasha Renton	Colorado College	Analysis of Ozone and its Precursors in Baltimore and the Northern Chesapeake Bay
P2.16	Dipsha Budhathoki	Knox College	Strategic Decision-Making in a Probabilistic Board Game: Ludo
P2.17	Brookelyn Velmont	Carthage College	Development of a Deep Learning Model for Differentiation Between Epithelioid and Sarcomatoid Pleural Mesothelioma
P2.18	Emily Lackershire and Kevin Tang	Grinnell College	How Edit Simpliciality Impacts Dynamics on Hypergraphs
P2.19	Husain Master	Washington University	Linear Recurrence Relations over Finite Fields: Constructive Linear Algebra Approach to Solution Space and Periodicity
P2.20	Meera Dasgupta	University of Chicago	Evaluating Deep Learning and Decision Tree Models for EMAG2v3 Global Magnetic Anomaly Predictions
P2.21	Elliott Lewis	Macalester College	Charting High Mass Stars in a Nearby Dwarf Galaxy
P2.22	Maya Atassi	University of Chicago	Detector Bias Stability Across Elevation Changes in the Simons Observatory Small Aperture Telescope

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Poster Session P3

3:00 p.m. – 4:00 p.m. W. Eckhardt Research Center Atrium (ERC)			
Poster #	**Presenter Name**	**Institution**	**Title of Presentation**
P3.01	Miranda Vizoso-Marino	Gustavus Adolphus College	Stromatolite Interpretation in Ancient Marine Environments: Ordovician Carbonates of Minnesota and Wisconsin
P3.02	Michael Li	Grinnell College	Event-Scale Relationships Between Mercury Wet Deposition, PM2.5, and Other Wet Deposition Pollutants in Central Iowa
P3.03	Nima J. Sherpa	Knox College	Assessing Glacial Lake Outburst Flood Risks Using Remote Sensing and Machine Learning in the Himalayas
P3.04	Youdahe Asfaw	Gustavus Adolphus College	Creating a User Interface to Aid People with Visual Disabilities
P3.05	Momina Amjad	Beloit College	Redesigning High-Temperature Magnetic Diagnostics for the Mirror Fusion Experiment WHAM
P3.06	Ashton Miller	St. Olaf College	Synthesis and Characterization of Cobalt and Copper Complexes
P3.07	Selam Zerabruk	Grinnell College	Synthesis and Characterization of Nickel and Copper Bound Bis(thiosemicarbazide) Compounds with Amine Functionalized Secondary Coordination Spheres
P3.08	Karl Lyu	Washington University	Ab Initio Description of High-Symmetry Polycyclic Aromatic Hydrocarbons and Their Anion Resonance States
P3.09	Blake Drinka	Carthage College	Investigating the Self-Assembly of Amino-Acid Based Surfactants with Electrical Conductivity Experiments
P3.10	Samantha Anderson	Gustavus Adolphus College	Exosome Mediated Decay of mRNA in *Saccharomyces cerevisiae*
P3.11	Ari Frisch	Beloit College	Development of Salicylic Acid Extraction From Willow Bark For General Chemistry Class
P3.12	Gabriela Carranza-Torres	Beloit College	Analysis of Natural Product Extracts from Willow Bark and More

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Poster Session P3 Continued

P3.13	Jordan Bopp	Carthage College	Characterization of Lyman-Alpha Absorption for Calibrating DIII-D's LLAMA Diagnostic
P3.14	Spencer Hughes	Hope College	Rutherford Backscattering Spectroscopy to Correct Faraday Cup Measurements at Varied Beam Energies
P3.15	Iman Khan	Beloit College	Analyzing Quintessence Models with Reference to 2025 DESI Data
P3.16	Alexander DeRosa	University of Chicago	Modeling Quantum Experiments as Non-Nashian Games
P3.17	Gabe Klinepeter and Teagan Steineke	Carthage College	Validating an Ullage Detection Technique for Liquid Propellant Tanks in Microgravity
P3.18	Owen Bonnett and Juliana Alvarez	Carthage College	Microgravity Ullage Formation and Trapping Using Phased Array Acoustic Excitation
P3.19	Meilin Song	University of Chicago	Dynamics of Immiscible Drop Impact in a Volume-of-Fluid Simulation
P3.20	Audrey Hooper	Washington University	Binary Surface Phase Diagrams with Nested Sampling and Lattice Models
P3.21	Joyce Gill and Khanh Do	Grinnell College	College Navigator: An Interactive R Shiny Platform for Transparent and Evidence-Based Decision-Making
P3.22	Tanvi Rao	University of Chicago	QuTiP-Based Modelling of Cavity-Controlled Molecular Formation

Abstracts for all Sessions
Physical Sciences, Mathematics and Computer Science
MCMS Undergraduate Research Symposium, University of Chicago
November 8, 2025

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

Presenter(s): Abualatta, Yousef
School: St. Olaf College
Session: I.D.4
Title: Investigation of the Interaction Between OGT and CARM1 Adaptor Protein
Co-Author(s): Abby Towel, Huy Huynh, Peter Leach, Tiarra Glogowski, Dr. Cassandra Joiner
Advisor(s): Cassandra M Joiner

Abstract: O-linked beta-N-acetylglucosamine (O-GlcNAc) transferase (OGT) is the only human enzyme that transfers the O-GlcNAc sugar from UDP-GlcNAc to nuclear and cytoplasmic proteins. OGT can O-GlcNAcylate over one thousand substrates that participate in almost every cellular process, and misregulation of O-GlcNAc levels can lead to a variety of diseases. Despite its large scope of substrates, how OGT chooses its many targets is poorly understood. It has recently been proposed that adaptor proteins drive selection by interacting with the tetratricopeptide repeat (TPR) domain of OGT to direct the enzyme to subsets of substrates. Recently, CARM1 (Coactivator Associated Arginine Methyltransferase 1) was shown to interact with OGT's TPR domain. To map the binding sites of CARM1 along OGT's TPR domain, we used an OGT protein library where we incorporated the photoactivatable unnatural amino acid, p-benzoyl-L-phenylalanine (Bpa), at 26 locations along the solvent-exposed surface of the TPR domain. Previous data from our lab found a higher molecular weight OGT-CARM1 complex at TPRs 10-13 (V346, M372, T409, H422) that we propose to be a heterotrimeric complex containing a single CARM1 protein bound to the OGT homodimer. However, the molecular mechanism of this interaction is unclear. Here, we use site-directed mutagenesis and photocrosslinking experiments to determine whether OGT dimerization is driving the interaction with CARM1 at TPRs 10-13.

Presenter(s): Aghamiri, Armita
School: Beloit College
Session: P2.01
Title: Designing a Green Chemistry Lab: Removing Lead Chloride from the Analytical Chemistry Curriculum
Co-Author(s): Corbin Livingston
Advisor(s): Corbin Livingston

Abstract: Analytical chemistry laboratories frequently use lead salts to teach solubility and gravimetric analysis, but the toxicity and disposal challenges of lead raise serious health and environmental concerns. This study addresses this issue by evaluating a safer and more sustainable replacement for lead chloride in a common ion and precipitation experiment. Building on an established procedure, we redesigned the experiment using calcium sulfate and assessed its ability to illustrate equilibrium concepts, solubility product determination, and gravimetric techniques. Calcium sulfate proved to be a non-toxic, cost-effective substitute that maintains the core educational goals of the original experiment. Student results showed that the substitution provides reproducible and quantifiable data while eliminating hazardous waste. The redesigned experiment supports green chemistry education by enhancing laboratory safety, reducing disposal costs, and modeling sustainable practices that can be readily adopted in

undergraduate curriculum.

Presenter(s): Ahmad, Subhan and Vaithinathan Asokan, Adithya
School: Knox College
Session: I.C.3
Title: Disease Detection from Chest X-ray Images Using Deep Learning
Co-Author(s): Adithya Asokan
Advisor(s): Ole Forseberg

Abstract: This project aims to create a machine learning model that can detect diseases like pneumonia, tuberculosis, and COVID-19 using chest X-ray images. Detecting these diseases early is crucial because it allows for faster treatment and better patient outcomes, especially in areas with limited access to medical professionals. I will work with Subhan Ahmad and use convolutional neural networks(CNNs). The first step is to train a model to predict accurately whether a chest x-ray is healthy. Data from NIH ChestX-ray14 and the COVID-19 Radiography Database will be used for model development and testing. Evaluating model performance will be through accuracy, precision, recall, and AUC scores, and Grad-CAM techniques will also be used to make model predictions more interpretable to human users. Geospatial analysis will also be done to see any regional trends in disease occurrences and to check if healthcare is available in rural and urban areas. Through this research, I aim to contribute to the growing field of AI-assisted healthcare diagnostics while gaining practical skills in medical image analysis, data exploration, and geospatial mapping.

Presenter(s): Ajkoviq, Anastasia and Seo, Changmin
School: St. Olaf College
Session: II.G.2
Title: Ground State Estimation of Ising-Type Models Using Variational Quantum Algorithms
Co-Author(s): Prabal Adhikari, Changmin Seo, John Carlson Yunga, Ray Reyes
Advisor(s): Prabal Adhikari

Abstract: In this research, we implemented the VQE algorithm on the 1D Ising model with a transverse magnetic field. We used the 1D-Ising model to test our accuracy of our VQE algorithm. In order to construct the variational ansatz, we explored the symmetries of the Hamiltonian, where we found in addition to the standard spin-flip symmetry, a spatial symmetry, which keeps the quantum state invariant under a particular set of exchanges of quantum spins. Using the exponentiated spin flip operator and the spatial symmetry, we constructed the ansatz for our VQE algorithm. Using the ansatz, we were able to estimate the ground state energy with high precision and determined the ground state with fidelities of 0.99.

Presenter(s): Akins, Georgia, Pirone, Mara and Zuvela, Lucia
School: Macalester College
Session: II.H.2
Title: The Ripple Effect: Impacts of Historical Redlining on Water Quality in the Twin Cities, MN
Co-Author(s): Mara Pirone, Lucia Zuvela, Anika Bratt
Advisor(s): Anika Bratt

Abstract: Redlining was a racist, discriminatory practice developed by the Home Owners Loan Corporation (HOLC) in the mid-1930s that assigned grades to residential neighborhoods based on their perceived “mortgage security”. Neighborhoods were graded A (“best”), B (“still desirable”), C (“definitely declining”), or D (“hazardous”). While this policy stopped in the mid-1950s, numerous studies have connected redlining to disparities in infrastructure funding, temperature, air quality, and green space between neighborhoods. There is, however, limited research exploring the connections between surface water quality and redlining. This study investigated these relationships in Saint Paul and Minneapolis, MN. It was hypothesized that water bodies in neighborhoods with lower HOLC grades (C/D) would exhibit characteristics of lower water quality than their higher-graded counterparts (A/B). Over the course of two summers, 28 small lakes and ponds were sampled for various water quality metrics, including: temperature, nutrients, heavy metals, and algae. Two lakes were terrestrially sampled to explore differences in the cooling effect of water bodies on the surrounding areas, and were also surveyed to understand human use and value. Long-term data from the Minnesota Pollution Control Agency (MPCA) was used to assess historical changes in water quality across the sampled sites and other large water bodies. Limited study results warrant continued data analysis and further investigation of redlining and water quality.

Presenter(s): Alvarez, Juliana and Bonnett, Owen
School: Carthage College
Session: P3.18
Title: Microgravity Ullage Formation and Trapping Using Phased Array Acoustic Excitation
Co-Author(s): Owen Bonnett, Semaje Farmer, Skylar Farr, Braedon Larson, Kevin Crosby
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): Amjad, Momina
School: Beloit College
Session: P3.05
Title: Redesigning High-Temperature Magnetic Diagnostics for the Mirror Fusion Experiment WHAM
Co-Author(s): Douglass Endrizzi
Advisor(s): Britt Scharringhausen

Abstract: The Wisconsin HTS Axisymmetric Mirror (WHAM) experiment at the University of Wisconsin–Madison is a magnetic mirror device designed to study the physics and engineering of plasma confinement and heating physics relevant to future mirror-based fusion reactors. To enable high-precision magnetic measurements in this environment, this presents the redesign of the WHAM flux loop diagnostic system for compatibility with high-temperature operation with the upcoming titanium gettering. The new design replaces polymer-based insulations with alternative solutions of ceramic isolation housed in

stainless steel tubing or use of mineral insulated (MI) cable to withstand reactor-relevant conditions. Mechanical supports were re-engineered to suppress vibrations, significantly improving signal quality. Flux loop placement was optimized to reduce neutral beam ion scrape-off while maintaining sensitivity to fast-ion confinement. The engineering strategies, failures, and test results validating this diagnostic platform for future high temperature mirror machines will be presented.

Presenter(s): Anand, Ashu
School: Washington University in St. Louis
Session: II.E.4
Title: Developing Novel Non-Aqueous Magnetorheological Emulsions for Advanced Rheological Control in Modern Smart Fluids
Co-Author(s): Emmanual Johnson, Amanda Koh
Advisor(s): Amanda Koh

Abstract: Magnetorheological fluids (MRFs) are smart fluids notable for rapid, controllable viscosity changes under a magnetic field. Upon magnetization, MRFs undergo a liquid-to-semi-solid transition driven by the alignment of ferromagnetic particles to the magnetic field direction, forming chain-like networks that restrict fluid motion. This tunable behavior makes MRFs ideal for adaptive energy-damping applications, including prosthetics and seismic protection systems. Recent studies in the Koh Laboratory at the University of Alabama demonstrate that integrating emulsions into aqueous MRF systems, termed magnetorheological emulsions (MREms), significantly enhances energy-damping capacity compared to state-of-the-art MRFs. However, aqueous systems face challenges, including instability and limited durability. The study presented here aims to (1) engineer a stable, non-aqueous emulsion system to formulate non-aqueous MREms and (2) benchmark their performance against modern MRFs. An emulsion system was achieved using polydimethylsiloxane (PDMS) emulsified in glycerol and stabilized with a fumed silica Pickering emulsifier. By systematically manipulating key parameters—iron concentration, emulsion droplet size, magnetized soak duration, and magnetic field strength—this study reveals that MREms exposed to prolonged magnetization and elevated fields exhibit enhanced viscosity control. These results present non-aqueous MREms as a superior alternative to traditional MRFs, pioneering a new class of superior smart materials with transformative potential for energy-damping applications.

Presenter(s): Anderson, Samantha
School: Gustavus Adolphus College
Session: P3.10
Title: Exosome Mediated Decay of mRNA in *Saccharomyces cerevisiae*
Co-Author(s):
Advisor(s): Jeff Dahlseid

Abstract: The structure and functions of a cell are dictated by information contained within the biological molecule DNA. To utilize the information contained within DNA, the cell synthesizes a molecule of messenger RNA (or mRNA). mRNA is used to inform the construction of protein. The amount of protein can be regulated through the degradation of the mRNA that encodes it. My research focuses on mRNA degradation in *Saccharomyces cerevisiae*, specifically through the pathway of Exosome Mediated Decay. The exosome is a multiprotein complex found within the cell that degrades mRNA through a pathway distinct from the default pathway. The mRNA for an unknown regulator of the CTF13 gene is predicted to be one of the targets of Exosome Mediated Decay. The purpose of this research is to identify this mRNA and determine the features that are responsible for its recognition by the exosome. I am using a genetics-focused approach in my research to achieve this goal. Several different potential candidates have

been identified and sequenced and I am now evaluating them to determine the effect that they have on the expression of the CTF13 gene, as well as the effect that exosome has on their own expression.

Presenter(s): Asfaw, Youdahe
School: Gustavus Adolphus College
Session: P3.04
Title: Creating a User Interface to Aid People with Visual Disabilities
Co-Author(s):
Advisor(s): Guarionex Salivia, Flint Million

Abstract: This project aims to create a user interface (UI) designed specifically for individuals who are blind, have physical disabilities, or face other barriers to completing forms. The proposed UI will support multimodal interactions, incorporating features such as voice commands and tactile feedback to enable users to complete both paper and electronic forms. It will include prompts to guide users through the process and mechanisms for receiving their input, addressing the limitations of existing systems and ensuring accessibility for a wider range of users.

Presenter(s): Atassi, Maya
School: University of Chicago
Session: P2.22
Title: Detector Bias Stability Across Elevation Changes in the Simons Observatory Small Aperture Telescope
Co-Author(s): Katie Harrington
Advisor(s): Katie Harrington

Abstract: The Simons Observatory (SO) will measure the cosmic microwave background (CMB) with high precision using thousands of transition-edge sensor (TES) detectors. A primary goal of the SO Small Aperture Telescopes (SATs) is to measure large-scale CMB polarization and search for primordial gravitational waves from inflation. To succeed, the detectors must be voltage-biased onto transition, but atmospheric loading—set by telescope elevation and precipitable water vapor (PWV)—shifts the optimal bias point. Currently, SO re-biases detectors every four hours or after elevation changes, but future scan strategies will require more frequent elevation shifts, motivating a study of detector stability without constant re-biasing. We analyzed calibration data from the SATp1 telescope (March–May 2025), examining detector bias voltage (v_bias) versus atmospheric loading, modeled as PWV/sin(elevation). Most bias groups follow the expected trend of decreasing v_bias with increasing loading, though some show anomalous behavior likely due to faulty or dark detectors. To isolate elevation-driven effects, we fit linear trends at 48° and 60° and extracted v_bias at PWV ≈ 1 mm. Instead of controlling loading directly, we used PWV variation to simulate the loading change caused by an elevation shift. Fractional resistance (r_frac) histograms then served as a proxy for detector bias accuracy. Preliminary results indicate that many bias lines remain stable across moderate elevation changes, while others degrade. These findings suggest that re-biasing may not always be required, informing future scan strategies and improving detector yield for SO's search for inflationary B-modes.

Presenter(s): Banker, Kush
School: University of Chicago
Session: II.G.1
Title: Berry Phase Effects on Molecular Dynamics around Conical Intersections
Co-Author(s): Indranil Ghosh, Greg Engel
Advisor(s): Greg Engel

Abstract: The adiabatic approximation is where one separates the total wavefunction of a molecule into a product of nuclear and electronic wave functions. Using the nuclear positions as parameters to the electronic Hamiltonian, we can define Adiabatic Potential Energy Surfaces (APES), where electronic energy levels vary with nuclear coordinates. Conical intersections (CI) are symmetry-protected degeneracies in these surfaces as a function of nuclear coordinates where two surfaces intersect linearly, so they are real space analogues of Dirac cones. For nuclear wave packets evolving on the APES, a Berry phase of pi exists for any closed path that encircles a CI. Lifting this degeneracy changes the topology of the energetic landscape which introduces a new force called the Berry force near where the CI existed. This phenomenon has so far been explored in crystalline materials in the k-space (momentum space), while its consequences in photochemical reactions in molecules remain unexplored. I will present my model that uses a semiclassical method known as fewest switches surface hopping (FSSH) to simulate dynamics in the presence of a CI, with and without Berry force, showing that the addition of Berry force in calculations shows changes in dynamics around a conical intersection.

Presenter(s): Bernath, Stuart
School: Beloit College
Session: II.F.4
Title: Is Meta Learning an Effective Machine Learning Technique for the Detection of Heart Disease?
Co-Author(s):
Advisor(s): Eyad Haj Said

Abstract: This study explores how Convolution Neural Network, Recurrent Neural Network, and Deep Neural Network meta learning contributes to accuracy and privacy in csv datasets for detecting heart disease and/or heart attack. Three data sets are used, the famous UCI heart disease dataset which includes four different hospitals, Doppala and Bhattacharyya's Cardiovascular Disease dataset, and a much larger Behavioral Risk Factor Surveillance System dataset. A global model was made from edges, or each different hospital, and in the case of the larger dataset, the data was separated with an even number of target 0s and 1s into four separate datasets. Then this global model was either kept plain, or ran through the three different meta learning algorithms mentioned above with 12 Machine Learning classifiers tested. Accuracies were recorded in the results section, and an attempt to find the meta learning type that maintains accuracy of the non-meta learning models was explored. This was the DNN meta learning. DNN meta learning has similar accuracy to non-meta learning, unlike CNN and RNN meta learning, and meta learning is shown to maintain patient privacy unlike the non-meta learning model, making DNN meta learning the best model for maintaining HIPAA standards with decent accuracy.

Presenter(s): Bolgov, Michael
School: University of Chicago
Session: I.D.1
Title: Multiple turnovers of RNA Modifications across Prebiotic Catalytic and Non-Enzymatic Pathways
Co-Author(s): Aman Agrawal, Jack Szostak, Matthew Tirrell
Advisor(s): Aman Agrawal

Abstract: How life on Earth began is one of the biggest mysteries, and the answer may help humanity search for life on other planets. Ribonucleic acid (RNA) is central to this mystery, as it could store genetic information and act as a protein enzyme to catalyze reactions on early Earth. Research in this field seeks mechanisms for RNA self-replication under prebiotic conditions. In one mechanism, a template RNA strand is copied by adding complementary, chemically activated nucleotides to a growing primer strand, similar to polymerase chain reaction but without enzymes. Multiple primer extensions require strand separation (denaturation), which remains a challenge. One option is formamide, a solvent likely abundant on early Earth, which denatures RNA duplexes. Thus, we explore reducing RNA degradation and using formamide for duplexed-RNA denaturation to enable repeated primer extensions. Furthermore, a common post-transcriptional reaction conserved from the prebiotic world is RNA methylation, where a methyltransferase enzyme adds a methyl to an RNA nucleotide, modifying RNA structure, function, and gene expression. Completing multiple methylation reactions with one ribozyme requires separating ribozymes from target RNA, which remains unsolved. This project will explore using formamide and heating cycles to complete multiple turnovers of RNA methylation reactions, further elucidating the evolution of RNA methylation, essential to many modern RNA functions.

Presenter(s): Bonnett, Owen and Alvarez, Juliana
School: Carthage College
Session: P3.18
Title: Microgravity Ullage Formation and Trapping Using Phased Array Acoustic Excitation
Co-Author(s): Owen Bonnett, Semaje Farmer, Skylar Farr, Braedon Larson, Kevin Crosby
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): Bopp, Jordan
School: Carthage College
Session: P3.13
Title: Characterization of Lyman-Alpha Absorption for Calibrating DIII-D's LLAMA Diagnostic
Co-Author(s): Laszlo Horvath, Raul Gerrú
Advisor(s): Laszlo Horvath

Abstract: We present experimental studies of the effects of environmental parameters on the calibration of DIII-D's Lyman-α neutral hydrogen density diagnostic, LLAMA. Lyman-α (121.6nm) light is readily absorbed by air, therefore the Krypton calibration source (123.6nm) that mimics Lyman-α plasma edge emissions is housed in a dedicated vacuum chamber. During calibration, unexpected Lyman-α absorption in the chamber results in ~25% variation in the intensity measurement of the calibration source. Vacuum causes a coating of unknown composition to form on the magnesium fluoride entrance window of the Krypton source, which is avoided by taking measurements in atmospheric argon pressure. However, impurities (namely oxygen) accompany venting, and the chamber walls outgas trapped moisture. Minimizing the concentration of these impurities, and thus their associated absorption, is key to

maintaining a consistent calibration environment. We find that this environment requires a vacuum pressure of at least 10^{-4} torr in both the chamber and vent lines prior to argon venting. Environmental consistency yields higher precision calibration, and thus improved neutral density measurements with LLAMA.

Presenter(s): Brau, Judd
School: Grinnell College
Session: P1.17
Title: Low Temperature Limits for p-adic log-Coulomb Gases
Co-Author(s): Ian Clawson
Advisor(s): Joe Webster

Abstract: This project extends results on log-Coulomb gases done in recent years and creates new tools to aid the investigation of the model. In past results, it was found that the canonical partition function for an N particle log-Coulomb gas in p-adic space can be expressed as a sum over all 'phylogenetic trees' with N labeled leaves. Using a computational approach to calculate and analyze the behavior of the canonical partition over this discrete sum for small N values, we formed, then later proved our main result: an explicit expression for the low temperature limit of the system of N charged particles dependent only on the maximum and minimum charges of the system as well as the number of those charges, and importantly not dependent on N at all.

Presenter(s): Budhathoki, Dipsha
School: Knox College
Session: P2.16
Title: Strategic Decision-Making in a Probabilistic Board Game: Ludo
Co-Author(s):
Advisor(s): David Bunde

Abstract: This project looks at how people and computer agents make decisions in Ludo (a board game similar to Sorry), where both luck and strategy play a role. I built a Java simulation of the game and made different computer-controlled players, each with their own style: aggressive (going for captures), defensive (playing it safe), greedy (trying to move forward quickly while still avoiding risks), and a simple dummy version that just made random moves. After running a lot of simulated games, I compared how the strategies did against each other. The greedy mode came out on top most of the time because it mixed parts of aggressive and defensive play. It could adapt better to what was happening on the board, while the other styles often got stuck being too cautious or too reckless. I also played around with small rule changes, like adjusting how captures work or changing movement conditions, and that really shifted which strategies worked best. Even tiny changes to the rules ended up creating new patterns of play. Even though this project is based on a board game, it connects to bigger ideas about decision-making when there’s uncertainty. It ties into research in AI, probability, and game design, and it shows how something as simple as Ludo can still be used to understand really complex behavior.

Presenter(s): Carranza-Torres, Gabriela
School: Beloit College
Session: P3.12
Title: Analysis of Natural Product Extracts from Willow Bark and More
Co-Author(s): Nerlyn Velasquez Ramos, Ari Frisch, Alexandria Juve, Corbin Livingston
Advisor(s): Corbin Livingston

Abstract: Salicylic acid is found in a majority of plants. A simple extraction method was used to extract salicylic acid from various natural sources. Thin-layer chromatography (TLC) was then used to qualitatively determine which extracts contain salicylic acid. This work is part of a larger project working to incorporate the indigenous science in the general chemistry lab. Using a simple technique, such as TLC, allows introductory students to engage with this important work in the instruction lab space.

Presenter(s): Cassell, Marcus and Strom, Sumner
School: St. Olaf College
Session: II.H.4
Title: Invariant Rings in Macaulay 2
Co-Author(s): Sumner Strom, Sasha Arasha, Gordon Novak, Francesca Gandini
Advisor(s): Francesca Gandini

Abstract: Macaulay2 (M2) is a Computer Algebra System utilized in several fields of mathematics for computations involving commutative rings. Our primary research goal is to develop an algorithm for calculating the invariants of finite group actions on skew commutative polynomials. We first studied the field of invariant theory to form a basis for exploring degree bounds for skew commutative invariants. We will then apply this research to develop the respective algorithm in M2 for the InvariantRings 3.0 package. Particularly for finite groups, there are known degree bounds for invariant skew polynomials in the exterior algebra, which inevitably results in termination of our computational recipe. The algorithm has a planned release for the October 2025 release of M2.

Presenter(s): Che, Haohui
School: Washington University in St. Louis
Session: II.E.3
Title: Characterization of a Fine-grained 3D Projection Detector for High Energy Physics
Co-Author(s): Guang Yang
Advisor(s): Richard Loomis

Abstract: The Super Fine-Grained Detector (SFGD) is a fully active, 3-D scintillator tracker built from $1 \times 1 \times 1$ cm^3 optically isolated cubes, each threaded by three wavelength-shifting fibers and read out with multi-pixel photon counters (MPPCs). This project aims to establish an absolute calibration between MPPC analogue-to-digital counter (ADC) counts and deposited particle energy for the 1,728-channel SFGD prototype operated at Brookhaven National Laboratory (BNL). Event selection and reconstruction algorithms are written to collect cosmic-muon events with the data acquisition (DAQ) system. Collected events are used to: (i) improve the data analysis pipeline, (ii) correct for fiber attenuation and channel response, and (iii) fit the minimum-ionizing muon energy deposition (2 MeV/cm) to derive per-channel ADC-to-MeV conversion constants. Additional tests are conducted on other particles such as electrons and gamma rays, for multi-particle characterization. Muon decay events are filtered from ordinary muon passes with selection algorithms and used as sanity checks for the calibration map. Currently the detector and analysis pipeline are operational at BNL and have collected 350,000+ cosmic muon events with 322 muon decay events. Energy spectrums of muon decay electrons and γ-ray emission from Americium–beryllium match expected spectrums from simulations and past data.

Presenter(s): Costello, Dylan
School: Beloit College
Session: II.H.1
Title: Dengue Fever and Meningitis, a Coinfection Model
Co-Author(s):

Advisor(s): Thomas Stojsavljevic

Abstract: Meningitis and dengue fever are diseases that appear in similar geographies and have been shown to infect simultaneously. There currently exist no coinfection models of these two diseases. In this paper, a compartmental model of the coinfection between bacterial meningitis and dengue fever is developed and analyzed. The basic reproduction number is determined along with the equilibrium states. The stability conditions for the disease-free equilibrium are determined. Simulations are performed using MATLAB's ode15s and the endemic equilibria corresponding to bacterial meningitis and dengue fever are displayed. Our simulations demonstrate that even when dengue or meningitis is endemic, the other disease will be able to be epidemic and coinfection occurs at low rates, consistent with existing medical literature.

Presenter(s): Dasgupta, Meera
School: University of Chicago
Session: P2.20
Title: Evaluating Deep Learning and Decision Tree Models for EMAG2v3 Global Magnetic Anomaly Predictions
Co-Author(s): Manoj Nair, Richard Saltus
Advisor(s): Manoj Nair

Abstract: Magnetic anomaly maps have traditionally been constructed using satellite data, and marine and airborne trackline data, among other kinds of observational sources. EMAG2v3 (Earth Magnetic Anomaly Grid, 2-arc-minute resolution-version 3) is a global magnetic anomaly grid that represents the spatial distribution and intensity of crustal magnetic anomalies, those which are primarily associated with variations in local geologic structures. As magnetic anomaly maps are being increasingly considered as a reference for alternative positioning and navigation, particularly in environments where GPS access is limited, the demand for high-resolution, up-to-date magnetic anomaly maps has grown substantially. Given that acquiring observational data can be both time and resource-intensive, in this paper, we explore the use of machine learning techniques to predict magnetic anomalies based on a set of geospatial predictor grids, including, but not limited to, sediment thickness, magnetic field model MF7 data, and curie point depth. Through the application of regression-based models and novel implementation of U-NET, a convolutional neural network (CNN) approach traditionally used in image segmentation tasks, we present a comparative analysis of machine learning models for predicting continuous spatial data values in comparison with the ground truth EMAG2v3 dataset.

Presenter(s): DeRosa, Alexander
School: University of Chicago
Session: P3.16
Title: Modeling Quantum Experiments as Non-Nashian Games
Co-Author(s):
Advisor(s): Ghislain Fourny

Abstract: We consider two mathematical frameworks for modeling quantum experiments as games played between the universe and an experimenter: causal contextuality scenarios and alternating spacetime games. The former is rooted in sheaf theory and previous work that sought to describe quantum contextuality in terms of the non-existence of global sections over certain presheaves. The latter is rooted in non-Nashian game theory and its ability to clarify certain conceptual issues in quantum mechanics. This framework has the advantage of being expressed in terms of games in extensive form, a topic for which much literature already exists. The goal of our project is to show that the non-Nashian game-theoretic approach subsumes the sheaf-theoretic approach. In particular, we aim to construct a

category of scenarios and a category of games and show that, under suitable assumptions, there is a categorical equivalence between the two. The case where each possible measurement has a "unique causal bridge," or unique set of measurements that can precede it, was solved by Ghislain Fourny, and our current efforts focus on the case where this assumption is removed, resulting in more interesting possibilities for experiments.

Presenter(s): Do, Khanh Phuong
School: Grinnell College
Session: P1.12
Title: Laying the Tracks: Developing a Digital Roller Coaster Game for Mathematical Visualization and Pedagogical Research
Co-Author(s): Minh Nguyen, Dieu-Anh Trinh, Linh-Chuc Vu, Yueran Qi
Advisor(s): Shonda Kuiper

Abstract: Undergraduate students often struggle to understand abstract mathematical concepts such as slope, continuity, and differentiability when taught primarily through symbolic manipulation and textbook examples. Game-based learning environments offer a promising pedagogical framework by situating mathematical reasoning in interactive, real-world contexts. This project reports on the development of a digital Roller Coaster Game, implemented in Unity using C-sharp and designed as an extension of prior calculus coaster projects. The game requires students to construct tracks defined by algebraic and piecewise functions while adhering to mathematical constraints, with performance quantified by a scoring mechanism based on vertical displacement. In addition to gameplay, the system records data on equations, scores, and design strategies, which are visualized through R Shiny dashboards. These tools allow students to compare approaches, reflect on the mathematical properties of their designs, and develop strategies for improvement, thereby reinforcing calculus concepts through experimentation and analysis. Preliminary use suggests that the scoring system and visualization features are both engaging and effective in encouraging applied reasoning. Although systematic evaluation of learning outcomes is ongoing, this work establishes a foundation for future research on the efficacy of interactive visualization tools in enhancing mathematics education.

Presenter(s): Dodla, Tanisha and Dominguez Salinas, Nadezhda
School: Macalester College
Session: II.F.1
Title: A Topological Approach to Understanding the Development of Knowledge Networks
Co-Author(s): Nadezhda Dominguez Salinas, Gavin Engelstad, Floyd Liu, Tam Nguyen, Frances McConnell, Lori Ziegelmeier, Russell Funk
Advisor(s): Lori Ziegelmeier

Abstract: Understanding how science evolves is key to anticipating the discoveries of tomorrow. We examine scientific development through a knowledge-network framework, where nodes represent scientific concepts and edges link concepts that co-occur in the abstract of a scientific paper. Using topological data analysis (TDA), we investigate how the shape of these knowledge networks changes over time. By considering topological information as a vectorization known as a persistence image, we conduct downstream analysis using machine learning algorithms to inform our understanding of scientific development within and among fields. Our results show that scientific fields do not evolve uniformly; yet, a field-level continuum emerges across disciplines. Moreover, we find that subfields within broad academic areas do not generally develop similarly. These patterns underscore the power of topological methods and reveal new insights into the dynamic evolution of scientific knowledge.

Presenter(s): Dominguez Salinas, Nadezhda and Dodla, Tanisha
School: Macalester College
Session: II.F.1
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Co-Author(s): Tanisha Dodla, Gavin Engelstead, Frances McConnell, Floyd Liu, Tam Nguyen, Lori Ziegelmeier, Russell Funk
Advisor(s): Lori Ziegelmeier

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Presenter(s): Drinka, Blake
School: Carthage College
Session: P3.09
Title: Investigating the Self-Assembly of Amino-Acid Based Surfactants with Electrical Conductivity Experiments
Co-Author(s): Kevin Morris, Fereshteh Billiot, and Eugene Billiot
Advisor(s): Kevin Morris

Abstract: Amino acid-based surfactants are naturally sourced, environmentally friendly alternatives to the petroleum-based surfactants found in many detergents, cosmetics, and other consumer goods. In this project electrical conductivity was used to investigate the physical properties of the amino acid-based surfactants undecylalanine phenylalanineate and undecylenyl L-leucinate. Changes in the surfactants' critical micelle concentrations (CMC) brought about by organic counterions (L-arginine, Agmatine, 1,3-diaminopropane, and 1,6-diaminohexane) binding to the micelles were investigated. Conductivity experiments were also done as a function of solution pH and CMC values were used to calculate the free energies of micellization for each surfactant-counterion mixture. For all mixtures investigated the surfactant CMC values were lower at low pH where the counterions had a positive charge. This behavior was attributed to a templating effect where counterions bound to the negative surfactant monomers and facilitated micelle formation. The free energy calculations showed that micelle formation was more thermodynamically favorable at lower pH where the counterions were charged.

Presenter(s): Elias, Ana
School: University of Chicago
Session: I.B.3
Title: Resonator Design to Gain Optomechanical Control of an SnV Color Center in Diamond
Co-Author(s): Judas Strayer, Tanvi Deshmukh, Alexander High
Advisor(s): Alexander High

Abstract: Quantum transducers enable entanglement between superconducting qubits that could be used for long range interactions between remote superconducting systems. Our project aims to

entangle a superconducting qubit with an SnV solid state qubit in diamond. To have efficient quantum state transfer during entanglement, we aim to optomechanically control SnVs with a SAW phonon resonator and a bullseye photonic resonator. SAW waves can be driven at a large range of frequencies, making them a suitable quantum bus between qubits. The photonic resonator will increase spin-photon coupling of the SnV by enhancing the collected photons emitted in the ZPL (Zero Phonon Line) and will allow us to optically extract information from the color center's spin state. By using a new technique for transferring diamond membranes onto various substrates, we will integrate our color centers with an alumina, lithium niobate and silicon dioxide material stack. We are adapting this membrane transfer process for alumina and potentially a larger range of substrate material stacks. We fabricated the SAW resonators and the bullseye resonators separately on practice membranes to perfect the nanofabrication process before interleaving the resonators. We are going to take preliminary performance measurements of our SnV systems using an AttoDry cryostat.

Presenter(s): Fioriglio, Charles
School: Washington University in St. Louis
Session: I.D.3
Title: Using Prolate Spheroidal Coordinates to Describe Electron Detachment from a Diatomic
Co-Author(s): Richard Mabbs
Advisor(s): Richard Mabbs

Abstract: Current models for photodetachment often ignore any interaction between the ejected electron and the neutral molecule, approximating the continuum as a plane wave. Photodetachment is the process of removing an electron into the continuum from an anion via a photon. Since the continuum wavefunctions are affected by electron-molecule interactions, neglecting these interactions can lead to errors in the interpretation of photodetachment data, including misidentification of electronic structure and/or temporary anion states. We present a two-center treatment of the continuum electron derived in prolate spheroidal coordinates, which naturally incorporates the bond length and field of the neutral in photodetachment from a diatomic. We solve the Schrödinger equation for the continuum electron wavefunctions in prolate spheroidal coordinates and use them to calculate total and differential cross sections for detachment from a diatomic with and without a dipole, testing our results against less physical models (e.g. the non-interacting and point dipole approximations) and experimental results (CN^- and $O2^-$ photodetachment) to verify the accuracy of our method.

Presenter(s): Fishell, Regann
School: Grinnell College
Session: II.H.3
Title: Modeling Back-Trajectories of Rain Events in Jasper County, IA
Co-Author(s): Evan Couzo
Advisor(s): Evan Couzo

Abstract: Shifts in rain patterns can be indications of larger climate events, such as larger shifts in storm tracks and general climate warming. Using precipitation data, indicated as rain events, we can model shifts present over long periods of time. This project uses NOAA's HYSPLIT model to model 10 years of rain event data from Newton, IA to look for potential shifts in this span. While small, there is indication of a shift in the general direction of rain events from 2021-2023 from the SSW direction to the SSE direction. While this could be the start of a larger shift in the future, it could also be explained by El Niño or La Niña climate patterns or simply the current selection of data used. This project also uses modeling to create a dataset of potential polluters in rain events that happened during summer 2025. This dataset was

utilized by another student to look for correlations between pollutions in rainwater and rain event trajectories.

Presenter(s): Florentino-Avila, Hugo
School: Colorado College
Session: P1.14
Title: Grasshoppers? Also good jumpers
Co-Author(s):
Advisor(s): Kristine Lang

Abstract: Textbook problems are an important part of engaging with the material that is presented in a class or independently, and they are the main way that teachers and professors test their students' understanding of the material. The problem must be reasonably solvable within what has been taught in the class or present in the textbook. Our assignment then is to write problems that test the students' ability to use what they have learned and apply them while making sure the assignments are within their range of abilities. The textbook that we have written problems for is on biophysics, aimed at undergraduate first years with limited physics knowledge. By reviewing research articles and existing data, cross referencing, double-checking, and working out details, we have designed practice problems in real world contexts that can be solved using the knowledge provided by this textbook. By writing these problems, we hope to not only test the students' ability to solve problems but also make introductory physics less abstract and more useful in applications. In this poster, I will focus on the writing process of a problem involving desert locust jumping and usability in this textbook.

Presenter(s): Fox, Megyn and VanSkiver, Trevor
School: Hope College
Session: P1.08
Title: Moving Beyond Carbonyls in C-C Single Bond Activation
Co-Author(s): Trevor VanSkiver, Jeffery Johnson
Advisor(s): Jeffery Johnson

Abstract: Selective transition-metal-catalyzed C-C bond activation is a promising method for reducing the time and cost of synthesizing complex organic molecules. Previous work has succeeded in rhodium-catalyzed decarbonylation to form new C-C bonds from pyridyl ketone starting materials, in which a ketone carbonyl is selectively spliced. Although this reaction exhibits high yields, the necessity of using a pyridyl ketone as a substrate limits the range of molecules that can be synthesized. The goal of this project is to move beyond the ketone in the classic decarbonylation reaction to increase the scope and application of C-C single bond activation. This will be attempted by synthesizing ketone alternatives and subjecting them to a variety of reaction conditions with rhodium catalysts to test if they behave similarly to carbonyls in the decarbonylation reaction.

Presenter(s): Frisch, Ari
School: Beloit College
Session: P3.11
Title: Development of Salicylic Acid Extraction From Willow Bark For General Chemistry Class
Co-Author(s): Alexandria Juve, Nerlyn Jafia Ramos, Gabriela Carranza-Torres, Corbin Livingston
Advisor(s): Corbin Livingston

Abstract: Salicylic acid is an analgesic that is used in aspirin synthesis. Current extraction experiments are done in organic chemistry classes. A new procedure was developed to use a more

simple set up that would be friendly to students in general chemistry classes. This introduces students to natural product extraction earlier in the curriculum. This work is part of a larger project working to incorporate the indigenous science in the general chemistry lab.

Presenter(s): Gao, Elisa
School: University of Chicago
Session: II.E.2
Title: Analysis of 14 Years of X-ray Emission From SN 2011dh
Co-Author(s): Vikram V. Dwarkadas
Advisor(s): Vikram Dwarkadas

Abstract: Ejecta from core-collapse supernovae (CCSNe) interact with the circumstellar medium created by the progenitor star, producing X-ray emission. Type IIb SNe are those that have a small amount of H present in the spectrum initially. The prototype Type IIb SNe was SN 1993J, which was extremely well studied due to its proximity. Few other IIb SNe have received the same detailed treatment. Type IIb SN 2011dh had been previously studied in X-rays up to 500 days after explosion. In this paper we extend the X-ray light curve of SN 2011dh to 5100 days, analysing all available Chandra and XMM-Newton data, along with newly released Swift observations. We also include past Swift observations analysed by other authors in the literature. The new extended X-ray light curve over 5100 days traces almost 21,000 years of stellar mass-loss preceding the star's explosion. The X-ray luminosity has been decreasing at a steady rate for the past 14 years. We also infer the rate at which the progenitor was losing mass, which is consistent with previous estimates. Our analysis of the X-ray emission suggests that it is dominated by an adiabatic reverse shock.

Presenter(s): Garcia, Brisa
School: Colorado College
Session: P2.05
Title: Optimization of *Silphium integrifolium* Oil Extraction Techniques for Oil Characterization and Formulation of Moisturizer
Co-Author(s): Murphy Brasuel, David Van Tassel, and Betsy Trana
Advisor(s): Murphy Brasuel

Abstract: In an era of increasing need and desire for something innovative in the cosmetics industry, support is crucial from green agricultural practices. *Silphium integrifolium* (Rosinweed) is a perennial flower native to the Midwest region of the United States with exceptional properties for medicinal and cosmetic production. Rosinweed Oil contains squalene and may contain phytoene which can protect the skin and hydrate it. These properties, along with its green agricultural production, make it a great candidate for environmentally conscious cosmetic production. The goal of this study was to use Super critical CO2 extracted Rosinweed (*Silphium integrifolium*) oil to produce moisturizer that complies with standards in the cosmetic industry. The comparative compositional analysis of *Silphium integrifolium* oil with sunflower oil and olive oil via GC-MS demonstrates that s. integrifolium is a feasible alternative to other popular oil seed crops. Rosinweed oil-based moisturizer formulation was compared to moisturizers formulated with olive oil and sunflower oil as well as commercially available moisturizers. The potential of rosinweed oil as an alternative oil for cosmetic production and moisturizer formulation is proven as the resultant product met industry standards in pH, acid value, stability, and iodine values.

Presenter(s): Gaynor, Dawson
School: Carthage College

Session: II.E.1
Title: Point Source Recovery Using Phase-Coherent Gravitational-Wave Sky Maps
Co-Author(s):
Advisor(s): Gosia Curyło, Eric Thrane, Paul Lasky

Abstract: Pulsar timing arrays probe the nanohertz stochastic gravitational wave background. Supermassive black hole binaries in their inspiral period are thought to be a major element of this background. If this is the case, some sources should be resolvable as point sources within the background. Sky maps are used to attempt to resolve point sources within the background. This report discusses and compares two different mapping methods, the current standard: power maps, and suggests a new method, phase-coherent maps. Power maps are unable to utilize all the information that pulsar timing array analysis can provide and inherently lose signal information within their processes. Phase-coherent maps, on the other hand, utilize more information, including phase, polarization, and power, from the gravitational wave signal to create their maps. Simulations using one and two point sources suggested that phase-coherent maps were as good as power maps in identifying a single source and provided better point source resolution than the current standard power maps in the two-source simulation.

Presenter(s): Gelande, Payton
School: Carthage College
Session: P1.07
Title: NMR Analysis of Micelle Formation by a Phenylalanine-based Biosurfactant
Co-Author(s): Blake Drinka, Kevin Morris, Fereshteh Billiot, Eugene Billiot
Advisor(s): Kevin Morris

Abstract: Bio-based surfactants are green alternatives to the molecules used in many commercial products such as soaps, detergents, and cosmetics. These bio-based surfactants are naturally sourced, biodegradable, biocompatible, and do not use petroleum in their synthesis. In this project, NMR spectroscopy was used to study the physical properties of a bio-based surfactant with a dipeptide alanine-phenylalanine headgroup. The effects of counterion and pH on the critical micelle concentration (CMC), micelle radius, and free energy of counterion binding were investigated. Due to the dipeptide alanine-phenylalanine surfactant containing a nonpolar hydrocarbon tail as well as a nonpolar phenylalanine headgroup, it was found that the surfactant molecule adopted a folded conformation in solution. Critical micelle concentration measurements in solutions with the cationic counterions L-Homoarginine and Agmatine showed the counterions facilitated surfactant aggregation through a templating effect that lowered the CMC. The radii of the micelles were also larger at low pH when the counterions were bound to the micelle surface. Micelle radii decreased at high pH when the counterions dissociated from the micelles. Finally, the free energies of counterion binding to the micelles was found to vary linearly with cation charge.

Presenter(s): Gill, Joyce
School: Grinnell College
Session: P3.21
Title: College Navigator: An Interactive R Shiny Platform for Transparent and Evidence-Based Decision-Making
Co-Author(s): Khanh Do, William Rebelsky
Advisor(s): William Rebelsky

Abstract: The U.S. college application process is often characterized by fragmented information

sources, ambiguous ranking methodologies, and tools that prioritize institutional prestige over student-institution fit. Such conditions complicate students' ability to evaluate institutions holistically and increase reliance on external heuristics rather than data-driven criteria. We present College Navigator, an interactive R Shiny application that leverages the U.S. Department of Education's College Scorecard dataset to support more transparent and evidence-based decision-making in the college application process. The system aggregates data from more than 6,600 institutions and 3,300 variables into a unified platform with three key features: (1) a College Finder feature that allows users to filter institutions based on self-defined parameters; (2) a College Comparison tool that enables side-by-side evaluation of two colleges across financial, academic, and graduation outcome metrics; (3) a Composition Dashboard that visualizes gender and racial distributions to provide a comprehensive look on student body profiles. By consolidating disparate data into a single, user-friendly interface, College Navigator reduces cognitive overload, improves interpretability, and reframes the application process around systematic evaluation rather than externally imposed rankings. This work demonstrates the potential of data-driven tools to enhance the decision-making process in higher education.

Presenter(s): Goetting, Haley
School: Colorado College
Session: P2.09
Title: Hydroxyl radical generation and amino acid oxidation by cold plasma implicating biomolecular modification and early life chemistry
Co-Author(s): Neena Grover, Adam Light
Advisor(s): Neena Grover, Adam Light

Abstract: Cold atmospheric pressure plasma (CAP) is increasingly explored for biomedical applications, yet aqueous-phase chemistry underlying plasma–biomolecule interactions remains poorly understood. Hydroxyl radicals (•OH) are a direct product of plasma–water interactions and chemically aggressive toward biomolecules, making them both a sensitive probe of plasma jet energetics and a key driver of biomolecule oxidation and degradation. We present progress toward characterizing oxidation pathways of nine amino acids, supporting a mechanistic framework for understanding plasma–biomolecule interactions in aqueous systems and contributing to research for applications in plasma medicine, protein modification, and radical aqueous chemistry. A combined method of chemical dosimetry and mass spectrometry elucidates hydroxyl radical (•OH) generation and amino acid oxidation during helium CAP treatment of aqueous solutions under inert conditions. Terephthalic acid (TA) served as a selective fluorescent probe, allowing detection of •OH generation rates via 2-hydroxyterephthalic acid (HTA) formation across varying treatment times in phosphate buffer at neutral pH. HTA fluorescence enabled estimation of •OH generation rate below the micromolar range (~10^{-7} M/s), with pseudo-first order kinetics. Complementary LC-MS analysis characterized chemical modifications of amino acids treated under identical plasma conditions with and without TA present, providing insight into competing radical pathways and establishing groundwork for understanding plasma-biomolecular chemistry.

Presenter(s): Gomez Rodriguez, Omar
School: Colorado College
Session: P1.03
Title: Extraction of Insecticidal Phytochemicals in *Silphium integrifolium* and its Toxicological Effect on Fall Army Worms
Co-Author(s): Betsy Trana, David Van Tassel, Murphy Brasuel
Advisor(s): Murphy Brasuel

Abstract: *Silphium integrifolium*, a North American perennial with traditional medicinal use, has gained interest for its insecticidal properties. In collaboration with The Land Institute (Salina, Kansas), this study aimed to identify bioactive compounds—such as α-pinene, D-limonene, germacrene D, neophytadiene, and phytol—and optimize supercritical CO_2 extraction parameters. Due to limited plant material, white sage (*Salvia apiana*), another insecticidal species, was used for extraction trials. Pressures ranging from 1500 to 4000 PSI were tested, with GC-MS analysis indicating optimal extraction of small bioactive molecules at 1500–1950 PSI. In aged *S. integrifolium* samples, germacrene D, neophytadiene, and phytol were present but reduced, likely from volatilization. Results confirm supercritical CO_2 as a non-degradative method for extracting insecticidal compounds from both plants. Cold ethanol extraction produced similar compounds. Extracts, along with controls, were tested against *Spodoptera frugiperda* (fall armyworm). Bioassays showed extracts were competitive with neem oil through day six but ultimately less effective at disrupting the pest's full life cycle. These findings highlight *S. integrifolium's* potential as a natural insecticide and demonstrate the value of CO_2 extraction for preserving bioactive compounds.

Presenter(s): Grobler, Benke
School: Grinnell College
Session: P1.01
Title: Synthesis and Biological Evaluation of Lugdunin Derivatives
Co-Author(s):
Advisor(s): Erick Leggans

Abstract: Lugdunin, a natural product, demonstrates potent antibiotic activity against a wide range of Gram-positive bacteria. Notably, it is the first antibiotic discovered from the human commensal bacterium *Staphylococcus lugdunensis* and exhibits a minimal resistance development, making it a promising candidate for future antibiotics. To enable its total synthesis, we developed two complementary strategies to construct the linear peptide precursor, each featuring distinct C-terminal functionalities. These synthetic routes are designed to facilitate late-stage macrocyclization through thiazoline formation, a novel approach to cyclization of the linear peptide chain.

Presenter(s): Hams, Jacob
School: Colorado College
Session: P1.19
Title: U-Pb Geochronology of Rodingite Minerals Records Permian Supra-Subduction in Whakatū/Nelson, Aotearoa/New Zealand
Co-Author(s): Michelle Gevedon, Claudiu Nistor, Jamie D. Barnes1, Lisa Danielle Stockli, Daniel Stockli
Advisor(s): Michelle Gevedon

Abstract: The timing and geochemical composition of rocks called rodingites, collected from the Dun Mountain Ophiolite (DMO) in the Whakatū/Nelson region of Aotearoa/New Zealand, may provide insight into the the changing Gondwana-Panthalassa supercontinental margin and into widespread hydrothermal alteration processes of the ocean crust. Oceanic crust is generally inaccessible for study, however, ophiolites (i.e. ocean crust that has been emplaced on land) allows for study of processes that form and change the seafloor. The DMO and related Patuki and Croisilles tectonic mélanges are hypothesized to record a Permian (300-250 Ma) intraoceanic near-continent supra-subduction zone. The DMO and mélange units are established to be the same age, but little is known about their spatial

relationship. If these geologic units were altered by the same types of fluids, at the same time, then a spatial-temporal relationship can be established. This project focuses on rodingite minerals garnet and titanite to establish 1) the timing of their formation during ocean crust alteration as revealed by in-situ U-Pb geochronology and 2) the conditions of their formation via geochemical compositions. Our data adds to the known DMO tectonic framework by establishing a relationship between the Patuki and Croisilles mélanges and the DMO.

Presenter(s): Harrison, Trevor
School: Hope College
Session: I.B.1
Title: Effect of Energy-Dependent Proton Irradiation in Thin-Film YBaCuO Superconductor
Co-Author(s): Joshua Kim, Katharina Cook, Hope Weeda, Joseph Fogt, Nolan Miles, Kyuil Cho
Advisor(s): Kyuil Cho

Abstract: The superconducting properties of YBaCuO thin-films were investigated by conducting 1.7 MeV proton irradiations. The experimental procedure was similar to the previous study (0.6 MeV proton irradiation). We compared the effectiveness of Tc suppression by varying the proton energy from 0.6 to 1.7 MeV and found that in general both protons of 1.7 MeV and 0.6 MeV were effective in suppressing the Tc of YBCO. For heavily irradiated cases (more than 80% Tc suppression), however, 1.7 MeV protons were more effective in suppressing Tc than 0.6 MeV protons. This can be understood by the fact that in thin-film samples, higher energy protons tend to produce less clustered point-defects while lower energy protons tend to create agglomeration of point-defects. This result increases our understanding of cuprate materials for use in electronic systems such as fusion reactors and space telecommunications high-frequency filters.

Presenter(s): Herfindahl-Quint, Anders
School: St. Olaf College
Session: P2.08
Title: Examination of Chemical Properties of N2P2 Ligand Complexes
Co-Author(s): Elodie Marlier
Advisor(s): Elodie Marlier

Abstract: Catalysts are commonly made from late second and third row transition metals, which are often more expensive and toxic. Therefore, efforts are being made to shift towards more sustainable options such as late first row transition metals, as they are both more abundant and cheaper. Due to the instability of such metals in their reactive +1 oxidation state, a ligand must be employed to make them catalytically viable. Previous work focused on the synthesis of three variations of a nitrogen donating β-diketiminate structure with phosphorus substituted phenyl linkers, or N2P2 ligand, allowing for hard and soft electron donation. These ligands are able to be metalated with first row transition metals such as cobalt. Co(II) ligand complexes have been made and reduced to a Co(I) ligand complex. Characterization on the Co(I) complex was done using UV-vis, 1H NMR, and 31P NMR spectroscopy. Future work includes the continuing characterization, recrystallization, and exploration into the reactivity of the reduced Co(I) ligand complexes.

Presenter(s): Hooper, Audrey
School: Washington University in St. Louis
Session: P3.20
Title: Binary Surface Phase Diagrams with Nested Sampling and Lattice Models
Co-Author(s): Robert Wexler, Ray Yang

Advisor(s): Ray Yang

Abstract: Starting in January 2025, I have been working with the Wexler Group to study the phase transitions of adsorbates on surfaces using computational modeling. My project expands on Ray Yang's work studying nested sampling simulations of surface adsorption by implementing a second atomic component that condenses onto the surface. My system is a binary set of adsorbates, identified as atoms A and B, with atoms B having twice the interaction strength as atoms A. Focusing on 16 atoms condensing onto a 4x4 (100) surface structure, I have varied the ratio of A atoms to B atoms and observed the transitions of the adsorbates from a disordered to an ordered state. Using a 2-dimensional lattice model and an exact enumeration method to determine the energies of different configurations, I have determined ground state structures, entropically favored states, and heat capacity peaks that correlate to ordering phase transitions. More recently, I have been analyzing the same system using a continuous nested sampling model, implementing mixed step and swap Monte Carlo moves to determine the ground state energies and heat capacity graphs. Overall, my research has shown strong agreement between the models, and I am continuing to further analyze nested sampling simulations and eventually build a grand canonical ensemble of the system.

Presenter(s): Huang, Victor
School: Washington University in St. Louis
Session: P1.06
Title: Decoding Pore Loop Dynamics in Hsp104: Mutational and Computational Frameworks for Predictive Therapeutic Engineering
Co-Author(s): Meredith Jackrel; Madalyn Bochantine; Karlie Miller; April Lopez; Joshuan J. Alicea Salast
Advisor(s): Meredith Jackrel

Abstract: Protein misfolding and aggregation are central features of several neurodegenerative disorders, including Parkinson's and ALS. Although absent from metazoans, the yeast AAA+ protein Hsp104 is capable of disaggregating amyloid and amorphous aggregates, making it an attractive scaffold for therapeutic engineering. While the conserved primary pore loops (PL1 and PL2) are known to engage substrate and translocation, less is known about the contributions of the secondary pore loop (SPL) in NBD1 and the substrate specificity of SPL/PL1/PL2 mutants in potentiated Hsp104 backgrounds. To address these gaps, we introduced SPL variants via site-directed mutagenesis and assayed them in Saccharomyces cerevisiae, which implicated the SPL as a charge-sensitive mechanical lever coupling NBD1 ATP hydrolysis to substrate translocation. In parallel, PL1/PL2/SPL combinatorial mutations will be assayed against toxic substrates (ASYN/FUS/TDP) to assess whether potentiated Hsp104s can be strategically designed to minimize off-target effects. Alongside these efforts, we will apply principal component analysis (PCA)–a numerical pattern-extraction technique not yet used in Hsp104 studies–to computationally analyze recently collected deep mutational scanning datasets. Using systematically refined MDS dimension-reduction algorithms, PCA can reveal latent structure–function relationships masked in phenotypic assays, helping us construct predictive frameworks for engineering Hsp104s with therapeutic potential.

Presenter(s): Hughes, Spencer
School: Hope College
Session: P3.14
Title: Rutherford Backscattering Spectroscopy to Correct Faraday Cup Measurements at Varied Beam Energies
Co-Author(s): Paul DeYoung, Andrew Bunnell, Joshua Kim

Advisor(s): Paul DeYoung

Abstract: A Faraday cup is a conductive cup that measures the current of an incident beam of charged particles. Faraday cups are frequently used in particle accelerator-based studies where the beam intensity must be measured. A previous study determined the systematic error in Faraday cup measurements for a 3.4 MeV proton beam using Rutherford scattering at large angles. Our study builds upon this previous work to include six different beam energies ranging from 3.0 MeV to 0.6 MeV and two different incident masses (H and He). The energy of back-scattered ions from a copper target was measured by a silicon surface barrier detector. The number of incident beam particles was determined by fitting this energy spectrum with SIMNRA. This value was compared to the Faraday cup measurement to give a correction factor for each distinct beam setting. These correction factors allow cup readings to be corrected, reducing the systematic error in fluence and cross-section measurements.

Presenter(s): Jaegy, Ina
School: Washington University in St. Louis
Session: II.G.4
Title: Using Single-Source Precursors to Synthesize Fe-Bi Quantum Material
Co-Author(s): Jayna Wallinger, Kelly M. Powderly
Advisor(s): Kelly M. Powderly

Abstract: Quantum materials are a growing field of research for their applications in ultrafast computing and precise medical imaging. Density Functional Theory calculations propose binary intermetallics in metal-bismuth systems as potential synthetic targets, as they are predicted to host exciting properties such as superconductivity and magnetism. Unfortunately, many of these compounds are inherently metastable and have not been stabilized at ambient pressure since the high temperatures used in traditional solid-state synthesis favor more thermodynamically stable products. Therefore, to synthesize these intermetallics, we employ atomically mixed single-source precursors already containing metal-bismuth bonds and additional stabilizing molecular ligands, then perform thermolysis, adding just enough thermal energy to kick off the molecular ligands to produce a metastable intermetallic phase. In this presentation, I will discuss my synthesis of a molecular cluster precursor containing iron, bismuth, and organic carbonyl groups; utilization of in situ thermal analysis to probe the loss of the organic ligands; determination of the average elemental composition of the resultant solid phase(s); and study of the formation of intermetallic compounds with increasing temperature using in situ X-ray diffraction. Future work includes performing temperature-dependent magnetization and resistivity measurements to reveal potential exotic magnetic or electronic behavior present in a new Fe-Bi intermetallic phase.

Presenter(s): Jaimes-Martinez, Laura, Loos, Jared and Sheldon, Katherine
School: Carthage College
Session: P1.09
Title: Optimization and Exploration of the Synthesis of 2-Pyridyl Substituted Carbazoles
Co-Author(s): Jared Loos, Katherine Sheldon, Alec N Brown
Advisor(s): Alec N Brown

Abstract: The development of a greener and less expensive methodology towards 1,8-disubstituted dipyridyl carbazoles and non-symmetrical 1,8-disubstituded carbazoles with potential use in ion/molecular sensing and catalysis was explored leveraging Miyaura borylation and Suzuki cross coupling with 2-halo pyridines. The development of a gram-scale synthesis of 1,8-dibromo-3,6-bis(1,1-dimethylethyl)-9H carbazole and 1-bromo-3,6-bis(1,1-dimethylethyl)-9H carbazole allowed for the synthesis of 1-Bpin-3,6-bis(1,1-dimethylethyl)-9H carbazole and

1,2-bis(Bpin)-3,6-bis(1,1-dimethylethyl)-9H carbazole using Miyaura borylation. A new 1,8-ditrifluoromethylpyridyl-3,6-bis(1,1-dimethylethyl)-9H carbazole was synthesized using a Suzuki cross-coupling reaction demonstrating the utility of the borylated precursor.

Presenter(s): Jones, Jaxon
School: Gustavus Adolphus College
Session: P1.11
Title: Leveraging LLMs to empower teacher's course designs: scalable AI-driven solutions for effective curriculum development
Co-Author(s):
Advisor(s): Louis Lei Yu

Abstract: This study introduces an application that integrates Large Language Models (LLMs) into educational technology to support teachers in curriculum design and instructional improvement. While LLMs demonstrate significant potential, they also present notable challenges within educational contexts, specifically: 1) sensitivity to the clarity and precision of prompts, and 2) a tendency to produce lengthy, unstructured content that can overwhelm educators and hinder practical usability. To address these challenges, our application utilizes the TELeR (Turn, Expression, Level of Details, Role) taxonomy, systematically structuring teachers' queries into precise, detailed instructions to enhance the quality of LLM-generated outputs. Additionally, to improve usability, the application analyzes outputs and reorganizes lengthy responses into clearly categorized, concise, and user-friendly formats. A core component of the application is an integrated LLM-enhanced chatbot, which offers educators a streamlined and intuitive interface for effective interaction with the LLM. Beyond immediate instructional support, the application also facilitates broader educational objectives, such as analyzing student performance data and generating actionable insights to enable personalized instructional strategies.

Presenter(s): Juve, Alexandria
School: Beloit College
Session: P2.04
Title: Column Chromatography to Separate Salicylic Acid from Willow Bark Extract in a General Chemistry Laboratory
Co-Author(s): Nerlyn Velasquez-Ramos, Ari Frisch, Gabriela Carranza-Torres, Corbin Livingston
Advisor(s): Corbin Livingston

Abstract: Some current laboratory procedures for the extraction and analysis of salicylic acid from natural sources, like willow bark, are designed for organic chemistry courses using appropriate techniques. This topic is one that allows a connection between biology and chemistry, and examines a cultural connection to ancient medicine that would be beneficial in an introductory chemistry lab. As a result, a procedure was developed to introduce the natural product extraction into a general chemistry curriculum with some modified techniques, including the addition of a column chromatography step for purification of the resulting sample.

Presenter(s): Khan, Iman
School: Beloit College
Session: P3.15
Title: Analyzing Quintessence Models with Reference to 2025 DESI Data
Co-Author(s): Husam Adam, Mark Hertzberg, Daniel Jiménez-Aguilar
Advisor(s): Mark Hertzberg

Abstract: We examine the data from the 2025 Dark Energy Spectroscopic Instrument (DESI) to understand the possible implication that dark energy density is evolving. We consider quintessence models with different potential energies, classified with hilltop, monomial, and decaying potential functions. We find that some quintessence models fit the DESI data better compared to the cosmological constant, but the statistical evidence is not significant. We further consider non-minimally coupled quintessence models, where the scalar field is coupled with gravity. This gives models that fit the DESI data well and provide significant improvement over the cosmological constant. However, these models are constrained by tests of gravity as they predict a fifth force and an evolving effective gravitational field strength.

Presenter(s): Klinepeter, Gabe and Steineke, Teagan
School: Carthage College
Session: P3.17
Title: Validating an Ullage Detection Technique for Liquid Propellant Tanks in Microgravity
Co-Author(s): Teagan Steineke, Justin Wheeler, Kevin Crosby
Advisor(s): Kevin Crosby

Abstract: The Microgravity Ullage Detection (MUD) experiment is part of the effort to address gas venting during in-space refueling operations, done by developing technologies to locate the ullage within a propellant tank. The primary technical objectives of the MUD payload are to demonstrate that, under gravity, a liquid-vapor interface can be detected non-invasively using external acoustic patch sensors mounted on the tank, and that, under microgravity, changes in the thickness of the adhered liquid layer can be measured during a tank drain using these external acoustic sensors. Ullage detection is accomplished by exploiting the fact that the sensor output is sensitive to the local stiffness and damping of the tank wall. By calculating the Root Mean Square of the sensor at a given location, liquid presence and interface velocity at the location of the sensor can be inferred, thus identifying the location and geometry of the ullage. Under gravity, the location of the fluid interface has been determined with a resolution of $< 1\%$ for settled liquids. The success of this experiment influenced the development of three identical payloads for NASA's Universal Payload Interface Challenge, where teams will test their interfaces on copies of MUD in an effort to improve compatibility.

Presenter(s): Kozak, Gloria
School: Hope College
Session: I.C.4
Title: Frictional Behavior of Passive vs Reactive Nanoparticles in Hydrogels
Co-Author(s): Meagan B. Elinski
Advisor(s): Meagan B. Elinski

Abstract: Nanomedicine treatments include nanocomposite hydrogels to repair damaged cartilage and nanoparticles for targeted drug delivery. However, it is important to understand how different nanoparticle/drug combinations impact friction and how it feels to patients as the body moves. Therefore, to gain insight into sliding, we used polyacrylamide hydrogels as a model for cartilage. We then used a wide variety of nanoparticle capping ligands, simulating different drugs. Passive ligands compare hydrogen bonding, molecular weight, and molecular shape via: citric acid, polyacrylic acid (PAA), polyvinylpyrrolidone (PVP), and cetyltrimethylammonium bromide (CTAB). Polymer ligands (PVP, PAA) used in nanocomposites exhibited an increase in friction over time, likely due to charge buildup. Another promising field is click-chemistry, using azides as a photo-reactive ligand. Preliminary work suggests potential differences in friction in an unreacted vs reacted state. Further work towards understanding the underlying sliding mechanisms will help discern how different drugs may impact

movement in the joint and how it feels to the patient.

Presenter(s): Lackershire, Emily and Tang, Kevin
School: Grinnell College
Session: P2.18
Title: How Edit Simpliciality Impacts Dynamics on Hypergraphs
Co-Author(s): Annie Li, Engtieng Ourn, Kevin Tang, Nicole Eikmeier
Advisor(s): Nicole Eikmeier

Abstract: Dynamics on hypergraphs can be useful for many things, for example, tracking the spread of a pandemic. If one person has been infected, we can model the spread throughout groups, and track how many people are going to be infected, or how to stop the spread. As a result, we can identify high-risk areas in events of diseases and provide a numeric representation of how likely someone is to be infected based on their relative placement in a group. In our work, we investigate dynamics on hypergraphs through their edit simpliciality (ES). As ES is a measure of how close the given graph is to a simplicial complex, we seek to understand its impact on dynamic processes on hypergraphs. In order to study the impact ES has on dynamics on hypergraphs, we created a model that will generate synthetic data with a controlled ES. Our experiments focus on two objectives. We first confirmed that our model accurately represents real-world data. We verified this by comparing simulations of the SIR model. Afterward, we generated data with varying ES values to analyze how differing ES affects dynamic processes.

Presenter(s): Lalwani, Manya
School: University of Chicago
Session: P2.12
Title: The Role of Nuclear Laminal Rigidity in Compensatory Regeneration of the Mouse Incisor
Co-Author(s): Christian R. Suarez, Leah Ye, Abinaya Thooyamani, Jimmy K. Hu
Advisor(s): Jimmy K. Hu

Abstract: The mouse incisor grows continually due to stem cells in the epithelial and mesenchymal tissue of the incisor. The epithelial stem cells differentiate into transit-amplifying cells (TACs), which become pre-ameloblasts and enamel-secreting ameloblasts. These populations exhibit distinct nuclear rigidity levels and cell behavior. This study investigates the role of nuclear lamins (A/C, B1, B2) in nuclear shape and cellular function. Epithelial knockout of all three isoforms resulted in pre-ameloblasts with shortened nuclei and altered nuclear spatial organization. ScRNA-seq of epithelial cells from control and knockout mice yielded 11 cell clusters. Gene-set enrichment of the clusters revealed upregulation of genes related to nuclear and cellular integrity. Cell trajectory analysis showed forking of the triple-knockout differentiation pathway at a relatively TAC-like cluster compared to the same control cluster. These findings help explain the triple-knockout phenotype and associate lamin loss with cellular plasticity, supporting a role for nuclear rigidity in regulating cell differentiation.

Presenter(s): Laze, Elissya
School: Hope College
Session: P2.07
Title: Varying the α-Substituent of Quinoline Hydrazones and BF2-Azo Dyes: Synthesis, Structure, and Spectroscopy
Co-Author(s): Keaton Mulshine, J. Henry Westphal, Jason G. Gillmore
Advisor(s): Jason G. Gillmore

Abstract: Azo dyes are photoresponsive chromophores that undergo reversible trans–cis

photoisomerization when exposed to light, producing significant changes in geometry and electronic distribution, absorbing in the UV-green region of the spectrum. Aprahamian's BF2-azo dyes push their absorbance into the orange through near-IR. Our group has been working to study effects of substituents on the quinoline moiety of Aprahamian's dyes, but have been limited by a cyano substituent essential to Aprahamian's route. We've devised a route without the problematic nitrile, but find that the "Y" substituent at that α-position has an effect on whether the dyes cyclize to the 5-membered BF2 azo or the 6-membered BF2-hydrazone. This work investigates how varying Y impacts the formation of desired five- versus undesired six-membered rings. In this poster we report our synthetic efforts to date varying Y and studying the hydrazones and azo dyes obtained. Synthesis, purification, computational modeling, UV-vis, NMR spectroscopy, and X-ray crystallography results will be reported, along with our envisioned next steps.

Presenter(s): LeBaron, Ariana
School: Grinnell College
Session: P2.03
Title: Structural Modification of an Asymmetric Thiosemicarbazide Metal Compound for CO2 Reductions
Co-Author(s): Maisha Kamunde-Devonish
Advisor(s): Maisha Kamunde-Devonish

Abstract: As atmospheric levels of carbon dioxide (CO2) increase, it is becoming increasingly important to find a way to take it out of the atmosphere. Current methods involve carbon capture and storage, which requires money and space. Recently, chemists have been developing an alternative in which CO2 is reduced to profitable products such as methanol and formic acid with the use of a bis(thiosemicarbazide) metal catalyst. Most catalysts must be exposed to an atmosphere of CO2 to work, but a zinc compound containing a pyridine heterocycle has twice been reported to be capable of CO2 reduction when exposed to atmospheric levels of CO2. Here, a modification regarding both the metal and heterocycle within the compound is presented. While all three new metal compounds showed an interaction with CO2, the Ni(BthMe3) compound showed the greatest potential for reducing CO2.

Presenter(s): Lee, Christine and Margie, Julia
School: University of Chicago
Session: I.A.3
Title: BallotBot: Can AI Help Voters Make Informed Decisions and Justify Them?
Co-Author(s): Chenhao Tan, Julia Mendelsohn, Lexing Xie, Karen Zhou, Mourad Heddaya, Christine Lee, Julia Margie
Advisor(s): Chenhao Tan

Abstract: Ballot measures—direct democracy initiatives often first encountered by voters in the booth—are frequently written in dense, technical, sometimes obscure language that hinders comprehension and increases abstention rates. Prior research has shown that ballot text complexity can reliably predict real-world voting outcomes, disproportionately affecting young, low-income, minority women, the very populations already less likely to possess high political knowledge. This study investigates whether modern large language model (LLM)-based tools can support democratic participation by improving voters' comprehension and confidence when evaluating ballot measures. We empirically compare three information delivery modes: a static LLM-generated summary, a traditional civic information source (Ballotpedia), and an interactive retrieval-augmented generation (RAG) chatbot. Participants were randomly assigned to one of these conditions and asked to read a real ballot measure, vote, rate their confidence and understanding, and answer both multiple-choice and open-ended comprehension questions. These measures were designed to assess factual understanding and depth of reasoning. In a pilot study (N=30), we observed strong comprehension in the Ballotpedia condition, providing initial support for the effectiveness of established civic information sources. This research contributes to emerging work on how AI tools can enhance voter comprehension and decision-making, with implications for equitable access to political information and the design of future civic technologies.

Presenter(s): Lewis, Elliott
School: Macalester College
Session: P2.21
Title: Charting High Mass Stars in a Nearby Dwarf Galaxy
Co-Author(s): Ralf Kotulla, Caedan Miller, John S. Gallagher III
Advisor(s): John S. Gallagher III

Abstract: We present a catalog of high-mass stars in the nearby, low-metallicity dwarf galaxy NGC 3109. Individual massive stars are resolved in multi-filter HST images that we used for photometric observations. We estimated stellar masses by fitting spectral energy distributions and focused on stars identified as post-main-sequence objects, for which mass determinations are more reliable. This catalog provides a basis for examining the evolution of high-mass stars in low-metallicity environments and offers insight into the formation of X-ray binary systems and the evolutionary pathways of massive stars in galaxies analogous to those of the early universe.

Presenter(s): Li, Dongting
School: Washington University in St. Louis
Session: P2.13
Title: Design and Synthesis of Porous Organic Cages for Anion Sorption
Co-Author(s): Evan C. Schultheis, Fangzhou Li, Chenfeng Ke
Advisor(s): Chenfeng Ke

Abstract: Porous organic cages (POCs) have become a new candidate for investigating molecular recognition and gas separation in the past decade due to their porous nature, which allows gas and liquid to easily access their voids (Yang et al., 2023). Our previous project synthesized a tripodal cage with high affinity to perchlorate ion via the unconventional Csp3-H···O hydrogen bonds. We are currently exploring other cage structures and properties. During this period of working with cage molecules, I expanded my knowledge of synthetic techniques. In the lab, I ran electrophilic aromatic substitution reaction and attached protecting groups to synthesize the intermediates of cage molecules, purified the product via flash column chromatography, and attempted to optimize conditions for the cage cyclization step. I have also gotten hands-on experience working on different synthetic tools, such as using a Schlenk line to run N2-protected reactions and carrying out organic solvent removal with a vacuum solvent evaporator and rotary evaporator. For the tripodal cage, our current projects have modified its structure by removing the carbonyl groups to test the effect of the unconventional hydrogen bond interaction and increase guest sorption. For each step of synthesizing this new structure, the intermediate and the product were characterized using 1H-NMR spectroscopy.

Presenter(s): Li, Michael
School: Grinnell College
Session: P3.02
Title: Event-Scale Relationships Between Mercury Wet Deposition, $PM_{2.5}$, and Other Wet Deposition Pollutants in Central Iowa
Co-Author(s): Regann Fishell, Andrew Graham, Evan Couzo

Advisor(s): Evan Couzo

Abstract: Mercury is a potent neurotoxin whose wet deposition varies significantly across the Midwestern United States. Central Iowa lacks a dedicated mercury deposition monitor, limiting exposure assessment. We evaluated whether event-scale $PM_{2.5}$ concentrations can serve as a proxy for mercury content in rainfall. In the summer of 2025 at the Conard Environmental Research Area, precipitation samples were collected from unique rainfall events and analyzed for mercury and major ions (sulfate, nitrate, ammonium, and total nitrogen). For each event, $PM_{2.5}$ concentration data from a nearby sensor prior to rainfall were collected. Correlation analysis showed that mercury content in rain was positively correlated with $PM_{2.5}$ concentrations; this provides preliminary evidence that $PM_{2.5}$ concentrations can serve as an event-scale proxy of mercury wet deposition and outlines a methodology that can be implemented with commercially available instruments, applicable in contexts where direct monitoring is absent. In addition, correlation analysis of other pollutants revealed that precipitation amount exerted a dilution effect on dissolved pollutant components (i.e., anticorrelation), but this effect was weakly associated with mercury. Source apportionment indicated that pollutants likely originated from different sources and exhibit different atmospheric chemical behaviors and reaction processes, explaining the correlation patterns.

Presenter(s): Lin, Joyce
School: Grinnell College
Session: I.D.2
Title: Exploring the Effects of Nanocage Size on Noble Gas Trapping Selectivity at Room Temperature
Co-Author(s): Alexandria Roy, Kristen Burson, Jorge Anibal Boscoboinik
Advisor(s): Kristen Burson

Abstract: Purified noble gases are a valuable natural resource with uses ranging from medical applications to detection of nuclear byproducts. The industry standard for noble gas isolation, cryogenic distillation, is expensive and energy-intensive, creating interest in alternative methods of isolation. Noble gas mitigation challenges, such as radon abatement, require room-temperature approaches that are both selective for particular noble gases and exhibit long gas retention times. Previous work trapped the larger noble gases xenon, krypton, and argon (modeling predicts radon will also trap) via confinement using hexagonal silicate cages on a metal substrate. This summer, we used smaller cubic cages on a ruthenium substrate to selectively capture argon. We showed that cages selective for a particular noble gas retain that gas for more than a week, confirmed by the presence of characteristic xenon and argon peaks in the x-ray photoelectron spectroscopy data. While the hexagonal cages are selective for the larger noble gases, the cubic cages show selectivity for smaller noble gases by retaining xenon for less than 24 hours, compared to argon, which was retained for more than a week. This work can be used in different applications including nuclear energy development and production of medical isotopes.

Presenter(s): Loos, Jared, Jaimes-Martinez, Laura and Sheldon, Katherine
School: Carthage College
Session: P1.09
Title: Optimization and Exploration of the Synthesis of 2-Pyridyl Substituted Carbazoles
Co-Author(s): Alex N Brown, Katherine Sheldon, Laura Jaimes-Martinez
Advisor(s): Alec N Brown

Abstract: The development of a greener and less expensive methodology towards 1,8-disubstituted dipyridyl carbazoles and non-symmetrical 1,8-disubstituded carbazoles with potential use in ion/molecular sensing and catalysis was explored leveraging Miyaura borylation and Suzuki cross coupling with 2-halo pyridines. The development of a gram-scale synthesis of 1,8-dibromo-3,6-bis(1,1-dimethylethyl)-9H carbazole and 1-bromo-3,6-bis(1,1-dimethylethyl)-9H carbazole allowed for the synthesis of 1-Bpin-3,6-bis(1,1-dimethylethyl)-9H carbazole and 1,2-bis(Bpin)-3,6-bis(1,1-dimethylethyl)-9H carbazole using Miyaura borylation. A new 1,8-ditrifluoromethylpyridyl-3,6-bis(1,1-dimethylethyl)-9H carbazole was synthesized using a Suzuki cross-coupling reaction demonstrating the utility of the borylated precursor.

Presenter(s): Lyu, Karl
School: Washington University in St. Louis
Session: P3.08
Title: Ab Initio Description of High-Symmetry Polycyclic Aromatic Hydrocarbons and Their Anion Resonance States
Co-Author(s): Richard Mabbs
Advisor(s): Richard Mabbs

Abstract: High-symmetry polycyclic aromatic hydrocarbons (PAHs) exhibit geometrically elegant frameworks that generate intricate networks of π-bonding molecular orbitals (MOs), and this alone is a point of interest. Beyond their theoretical appeal, PAHs occur prevalently in vital energy sources including coal and petroleum, but also present severe health hazards as carcinogens and mutagens. This two-sidedness makes PAHs important in both research and regulation. Despite this, the current characterization of their temporary anion states, or resonances, remains limited, particularly for larger species. Because resonances are critical in transition states of chemical reactions, a deeper understanding of their electronic structure is needed. We employ post-Hartree-Fock coupled-cluster methods and correlation-consistent basis sets to determine the minimal-energy geometries of PAH anions and characterize their energetics. We further apply the stabilization method to identify potential anion resonance states. Our results show that the MO theory provides broadly accurate orbital structures and bonding patterns, while Jahn-Teller distortions are common and often govern the localization of the added electron. Finally, we present precise structural descriptions of the molecular orbitals accessed by temporary anions and resolve a long-standing debate regarding the stability of the triphenylene anion.

Presenter(s): Margie, Julia and Lee, Christine
School: University of Chicago
Session: I.A.3
Title: BallotBot: Can AI Help Voters Make Informed Decisions and Justify Them?
Co-Author(s): Karen Zhou, Mourad Heddaya, Christine Lee, Julia Mendelsohn, Chenhao Tan, Lexing Xie
Advisor(s): Chenhao Tan

Abstract: Ballot measures—direct democracy initiatives often first encountered by voters in the booth—are frequently written in dense, technical, sometimes obscure language that hinders comprehension and increases abstention rates. Prior research has shown that ballot text complexity can reliably predict real-world voting outcomes, disproportionately affecting young, low-income, minority women, the very populations already less likely to possess high political knowledge. This study investigates whether modern large language model (LLM)-based tools can support democratic participation by improving voters' comprehension and confidence when evaluating ballot measures. We empirically compare three information delivery modes: a static LLM-generated summary, a traditional civic information source (Ballotpedia), and an interactive retrieval-augmented generation (RAG) chatbot. Participants were randomly assigned to one of these conditions and asked to read a real ballot measure, vote, rate their confidence and understanding, and answer both multiple-choice and open-ended

comprehension questions. These measures were designed to assess factual understanding and depth of reasoning. In a pilot study (N=30), we observed strong comprehension in the Ballotpedia condition, providing initial support for the effectiveness of established civic information sources. This research contributes to emerging work on how AI tools can enhance voter comprehension and decision-making, with implications for equitable access to political information and the design of future civic technologies.

Presenter(s): Master, Husain
School: Washington University in St. Louis
Session: P2.19
Title: Linear Recurrence Relations over Finite Fields: Constructive Linear Algebra Approach to Solution Space and Periodicity
Co-Author(s):
Advisor(s): Karl Schaefer

Abstract: We consider sequences formed by homogeneous linear recurrence relations with constant coefficients, generalizing familiar examples such as the Fibonacci sequences (1,1,2,3,5,..) which satisfies Fn = Fn-1 + Fn-2. We first establish a vector space structure on the set of sequences determined by a fixed recursion relation and give a constructive proof of a known result: the closed-form description of the basis of this vector space as a Jordan Basis of the companion matrix. We then show that all linear recurrence sequences over finite fields are periodic, which motivates our investigation into computing the period. Our approach analyses the action of powers of the companion matrix on true and generalized eigenvectors separately. Finally, we combine these results to give an explicit description of the period.

Presenter(s): Maule, Alex and Pham, Ryan
School: Beloit College
Session: I.A.1
Title: Reducing the Pinning Problem to a variant of Boolean Satisfiability via Self-Overlapping Curves
Co-Author(s): Ryan Pham
Advisor(s): Ben Stucky

Abstract: This project contributes to an ongoing program to make the pinning problem computationally tractable through a novel implementation approach. In "The Pinning Ideal of a Multiloop" (Simon & Stucky), the authors proposed a theoretical strategy to reduce instances of the pinning problem to a variant of Boolean satisfiability, with the goal of enabling solver-based methods for computing efficient pinning strategies. As a concrete step toward this objective, we present a comprehensive Python implementation of the algorithm by Shor and Van Wyk for detecting and decomposing self-overlapping curves in the plane. Our system employs a multi-layered architecture that begins with permutation representations of multiloops, where vertices, edges, faces, and strands are encoded using half-edge data structures. The core algorithm utilizes the Whitney index calculation to determine curve orientation and employs a dynamic programming approach to systematically detect self-overlapping configurations. The implementation successfully processes multiloops with varying complexities, generating corresponding geometric visualizations using a circle packing algorithm by Collins and Stephenson, and identifying critical self-overlapping regions that compute the Mobidisc Conjunctive Normal Form with a complexity of O(n^5).

Presenter(s): Miller, Ashton
School: St. Olaf College
Session: P3.06
Title: Synthesis and Characterization of Cobalt and Copper Complexes

Co-Author(s):
Advisor(s): Elodie Marlier

Abstract: Many industries rely on catalysts to improve manufacturing efficiency, with the most commonly used catalysts often containing a second or third-row transition metal. However, these metals are generally less sustainable and more expensive than their first row counterparts. To study low-oxidation-state first-row transition metals, a new family of N2P2 ligands was synthesized. The nitrogen-donating β-diketiminate structure was appended with phosphorus-substituted phenyl linkers, creating a tetradentate binding environment that allows for both hard and soft electron donation. These ligands were metalated with first-row transition metals such as cobalt(II) or copper(I). Additionally, the cobalt(II) was reduced to its +1 oxidation state. The synthesis and characterization of both complexes will be discussed, as well as the reactivity of the cobalt(I) complex.

Presenter(s): Miller, Lance
School: Knox College
Session: P2.10
Title: Synthesis and Characterization of Long-Chain Heteroleptic Liquid Crystals
Co-Author(s):
Advisor(s): Thomas Clayton

Abstract: This research has produced a variety of copper carboxylate liquid crystals. Homoleptic species of Cu2(Octanoate)4 and Cu2(Hexadecanoate)4 were produced from cupric acetate and fatty acid. Variations were made to these liquid crystals via substitution reactions to produce heteroleptic species including Cu2(Octanoate)3Hexadecanoate, Cu2(Hexanoate)3Hexadecanoate, and Cu2(Hexanoate)3Oleate. Mixtures of homoleptic species mirroring the stoichiometry of the heteroleptic dimers were also produced and compared with the heteroleptic species. Infrared spectroscopy (IR) was utilized to determine if the correct product was synthesized by assessing the relative sharpness of peaks and confirming the presence of double bond character for species with unsaturated ligands. Differential Scanning Calorimetry (DSC) was used to determine melting temperature and enthalpy. Polarized Optical Microscopy (POM) was used to determine if the species were liquid crystalline.

Presenter(s): Nguyen, Anh (Renée)
School: Beloit College
Session: P1.05
Title: Computational Ar/Cl2 Plasmas Etching of Silicon Substrate
Co-Author(s): Maryam Khaji, Mark J. Kushner
Advisor(s): Mark J. Kushner

Abstract: Plasmas, which are ionized gases, play a crucial role in the fabrication of microelectronic devices. Plasma-assisted etching is a highly precise and accurate technique commonly employed for nanometer-scale patterning. In this process, positively charged ions are accelerated toward the wafer surface within a plasma reactor. In this study, the Hybrid Plasma Equipment Model (HPEM) was utilized to computationally investigate the etching of silicon wafers in an inductively coupled plasma (ICP) reactor. Specifically, we examined the impact of applying continuous-wave radio-frequency (RF) bias to the substrate. To track the evolution of the feature profiles, the Monte Carlo Feature Profile Model (MCFPM) was employed. The ICP reactor used in the simulation is cylindrically symmetric, with a height of 15.7 cm and a radius of 27.3 cm. The wafer has a diameter of 30 cm. A gas mixture consisting of 99% argon and 1% chlorine is introduced into the chamber at a flow rate of 600 sccm. The results indicate that

increasing the continuous-wave (CW) RF bias voltage leads to higher etch rates and improved feature characteristics. Future work will focus on analyzing feature profile evolution under pulsed bias power conditions.

Presenter(s): Ni, Yihao
School: Hope College
Session: II.F.3
Title: Evaluating Machine Learning Strategies For The Reconstruction of Compton Scatter Tomographs
Co-Author(s): Karsten Wiegerink., Jeffery Martin
Advisor(s): Jeffery Martin

Abstract: Compton Scatter Tomography (CST) is a non-invasive imaging technique that reconstructs tomographic images of electron density in materials using Compton-scattered gamma rays. While convolutional neural networks (CNNs) have shown promise in computed tomography (CT), the nonlinear integration paths inherent in CST make reconstruction more challenging than in conventional CT. CST offers advantages such as reduced radiation dose and enhanced sensitivity to low-Z materials; however, its indirect measurement geometry introduces unique reconstruction difficulties. In this work, we develop and evaluate a data-driven reconstruction framework for CST. We first construct a forward model by mapping detector–energy measurements into polar coordinates following Norton's scattering circle formulation. We then investigate deep learning–based reconstruction approaches, including a configurable CNN and a hybrid CNN–U-Net within a Deep Image Prior (DIP) framework, and explore the effect of incorporating additional regularization into the DIP method.
Presenter(s): Nicholas, Aidan
School: University of Chicago
Session: P1.16
Title: RFSoC Technology for Cosmic Observation
Co-Author(s):
Advisor(s): Abigail Vieregg

Abstract: The recent proliferation and increase in availability of all-in-one FPGA packages coming out of the private sector has allowed for streamlined and improved implementation of firmware triggers on-chip for cosmological and astronomical observations. In particular this allows us to perform complex triggering techniques such as phased array triggering for implementation on the Cosmic Ray Lunar Sounder.

Presenter(s): Nimm, Isabella
School: Macalester College
Session: I.C.1
Title: Effect of Shielding Polymers on the Activity of Asparaginase
Co-Author(s): Leah S. Witus
Advisor(s): Leah S. Witus

Abstract: Therapeutic proteins are used to treat a wide variety of diseases, and are often conjugated to shielding polymers to help protect the protein and prolong its circulation. Historically, poly(ethylene-glycol) (PEG) has been used as the main shielding polymer, but anti-PEG antibodies, which can lead to severe immune responses, have been observed in some patients. Therefore, there is a need to find alternative biocompatible shielding polymers for therapeutic applications. Our research group is examining the shielding polymer polysarcosine (PSar) - a polypeptoid with a repeating unit of an endogenous amino acid. There is an established interest in the scientific community regarding the

evaluation of PSar as an alternative to PEG. Towards this endeavor, we sought to examine the effect of PSar on enzymes, an important class of therapeutic proteins. Asparaginase (ASNase) is used clinically in its PEGylated form as the first-line treatment for leukemia. We conjugated PSar to ASNase, then investigated how the catalytic activity compares to that of PEG conjugates. Preliminary Michaelis Menton kinetic values have been obtained from an enzymatic assay. Future experiments will be used to compare the rates of proteolytic digestion. These data will help evaluate the viability of PSar as an alternative shielding polymer to PEG.

Presenter(s): Nordeen, Bradyn and Wiggins, Kendall
School: Gustavus Adolphus College
Session: P2.14
Title: Impacts of Warfare on Soil Erosion and Landscapes: a Baseline from Early Modern Period Strata
Co-Author(s): Kendall Wiggins, Erik L. Gulbranson, Kathleen Rodrigues, Kaisa Whittaker, Willy Tegel, Marta Dominguez-Delmás
Advisor(s): Erik L. Gulbranson

Abstract: Our understanding of anthropogenic soil erosion centers on facets of the built world. However, the effect of warfare on soil erosion is largely underexplored with potentially significant consequences for the environment and contemporary geopolitics. A significant knowledge gap exists on a baseline for war-induced soil erosion that hampers our ability to fully contextualize the environmental impact of historical conflicts. This project seeks to address scaling factors for this environmental disturbance. This project focuses on the early modern period in northeastern France and western Germany, as this region witnessed persistent warfare over several centuries. A chronostratigraphic framework is presented with four new precise luminescence ages. Stratigraphy is studied along river basins in the Rhine River watershed, indicating basin-wide erosional events in the early modern period. However, paleolandscape equilibrium displays stratigraphic variation across these basins. This indicates localized landscape impacts from the anthropogenic and/or natural processes generating these erosional episodes. Moreover, dendrochronologic analysis indicates that warfare impacts on the land surface scaled dramatically from the early modern period to the 20th century. Ongoing work seeks to elucidate the provenance of colluvial material to refine estimates of soil erosion through time and space.

Presenter(s): Peterson, Lucas
School: Carthage College
Session: II.F.2
Title: Lower-Dimensional Coordinates for Neurons in Two-Layer Deep Neural Networks Under Gradient Flow
Co-Author(s):
Advisor(s): Diana Thomson

Abstract: We study numerical relationships in the weights of deep neural networks (DNN) with rectified linear unit (ReLU) activation functions trained under gradient descent. Gradient descent can be generalized by a continuous gradient flow, under which the DNN's weights are conserved such that they can be mapped to points on a hyperbolic hyperplane. For DNNs with a one-dimensional output and N-dimensional input, there are N+1 directions of motion; however, when we consider a simplified DNN that is trained on only a single point, all N+1 directions become parallel. This ensures that the incoming weight and bias stay bounded to a hyperplane, which then intersects the hyperbolic hyperplane derived by the symmetry of ReLU. We derive a mapping from any point on this curve formed by this intersection to the weights of the neural network, allowing for all the weights related to a single neuron to be described by only a single coordinate. We then confirm these results computationally, showing that given a small learning rate, weights associated with a given neuron stay bounded on a hyperbola.

Presenter(s): Pham, Ryan
School: Beloit College
Session: I.A.1
Title: Reducing the Pinning Problem to a variant of Boolean Satisfiability via Self-Overlapping Curves
Co-Author(s): Alex Maule
Advisor(s): Ben Stucky

Abstract: This project contributes to an ongoing program to make the pinning problem computationally tractable through a novel implementation approach. In "The Pinning Ideal of a Multiloop" (Simon & Stucky), the authors proposed a theoretical strategy to reduce instances of the pinning problem to a variant of Boolean satisfiability, with the goal of enabling solver-based methods for computing efficient pinning strategies. As a concrete step toward this objective, we present a comprehensive Python implementation of the algorithm by Shor and Van Wyk for detecting and decomposing self-overlapping curves in the plane. Our system employs a multi-layered architecture that begins with permutation representations of multiloops, where vertices, edges, faces, and strands are encoded using half-edge data structures. The core algorithm utilizes the Whitney index calculation to determine curve orientation and employs a dynamic programming approach to systematically detect self-overlapping configurations. The implementation successfully processes multiloops with varying complexities, generating corresponding geometric visualizations using a circle packing algorithm by Collins and Stephenson, and identifying critical self-overlapping regions that compute the Mobidisc Conjunctive Normal Form with a complexity of O(n^5).

Presenter(s): Pirone, Mara, Akins, Georgia and Zuvela, Lucia
School: Macalester College
Session: II.H.2
Title: The Ripple Effect: Impacts of Historical Redlining on Water Quality in the Twin Cities, MN
Co-Author(s): Georgia Akins, Lucia Zuvela, Anika Bratt
Advisor(s): Anika Bratt

Abstract: Redlining was a racist, discriminatory practice developed by the Home Owners Loan Corporation (HOLC) in the mid-1930s that assigned grades to residential neighborhoods based on their perceived “mortgage security”. Neighborhoods were graded A (“best”), B (“still desirable”), C (“definitely declining”), or D (“hazardous”). While this policy stopped in the mid-1950s, numerous studies have connected redlining to disparities in infrastructure funding, temperature, air quality, and green space between neighborhoods. There is, however, limited research exploring the connections between surface water quality and redlining. This study investigated these relationships in Saint Paul and Minneapolis, MN. It was hypothesized that water bodies in neighborhoods with lower HOLC grades (C/D) would exhibit characteristics of lower water quality than their higher-graded counterparts (A/B). Over the course of two summers, 28 small lakes and ponds were sampled for various water quality metrics, including: temperature, nutrients, heavy metals, and algae. Two lakes were terrestrially sampled to explore differences in the cooling effect of water bodies on the surrounding areas, and were also surveyed to understand human use and value. Long-term data from the Minnesota Pollution Control Agency (MPCA) was used to assess historical changes in water quality across the sampled sites and other large water bodies. Limited study results warrant continued data analysis and further investigation of redlining and water quality.

Presenter(s): Rao, Tanvi
School: University of Chicago
Session: P3.22
Title: QuTiP-Based Modelling of Cavity-Controlled Molecular Formation
Co-Author(s):
Advisor(s): Zoe Yan

Abstract: Cavity quantum electrodynamics (cQED) utilizes unique properties of a cavity to amplify quantum phenomena, and has been theorized to be a powerful tool for controlling molecular formation in ultracold systems. Particularly, theoretical work has shown that ultracold ground-state molecules can be constructed via photoassociation and spontaneous emission processes when coupled to an optical cavity of high cooperativity. To further investigate the mechanism, I developed a software simulation of the dynamics of a cavity system using the open source QuTiP Python package. This framework models the Hamiltonian and incorporates dissipative processes via the master equation, calculating the state population evolutions. By introducing realistic experimental parameters for the cavity, the simulation can act as a powerful tool to predict how cavity parameters can be tuned to maximize molecular yield within the strong-coupling regime.

Presenter(s): Raut, Siddhi
School: University of Chicago
Session: II.G.3
Title: An Optimization of Precision Magnetic Field Mapping for Mu2e and Fringe Field Analysis
Co-Author(s): Andrew Nilsson, Simon Corrodi, Lei Xia, and Peter Winter
Advisor(s): Dr. Peter Winter

Abstract: We conducted the mapping of the fringe magnetic field surrounding a 4T superconducting magnet for potential applications at the Paul Scherrer Institute (PSI). This mapping effort utilizes the Galil motion controller in conjunction with a software program called EMMA and a laser tracking system to create a detailed 3D profile of the field. Accurate characterization of the fringe field is crucial for understanding its potential impact on nearby equipment and future experimental setups. This work draws on the Mu2e experiment, which seeks to detect the rare conversion of a muon into an electron, indicating the presence of new particles or forces beyond the Standard Model. For Mu2e, extremely precise magnetic field measurements of up to 10^-4 accuracy are needed within the detector solenoid to guide particles and for momentum reconstruction. As part of our contribution to Mu2e, we replaced the original LabVIEW control layer in the Field Mapping System (FMS) with a Python script to simplify operating the system. Even though our Python improvement focuses on the field mapping in Mu2e, it also allows us to apply the magnetic field measurements in other contexts, such as the 4T fringe field project, of which we present an analysis here.

Presenter(s): Recker, Cassidy
School: Colorado College
Session: P1.10
Title: Better Protein Representations via Better Amino Acid Representations
Co-Author(s): Andrew Peng
Advisor(s): Cory Scott

Abstract: Machine learning models struggle with understanding three-dimensional (3D) geometry, particularly in dynamic, deformable structures like proteins. In this work, we introduce a novel approach to improving protein representations by using Signed Distance Functions (SDFs). SDFs are functions that return the distance to the surface of a given shape and are widely used to represent deformable or articulatable shapes. We construct a dataset of pose-parameterized SDFs for each of the 20 standard amino acids using position normalized structural data extracted from the Protein Data Bank. Using this dataset, we train a dedicated neural network model to determine articulated SDF architectures for each amino acid. Based on our neural network outputs, we are able to recreate 3D mesh models of amino acids. Our models achieve low reconstruction error across amino acid types, demonstrating their capacity to capture complex, deformable 3D geometry. We release both our amino acid SDF dataset and the trained model weights as resources for the community. This work paves the way for improved downstream protein modeling tasks by enabling more accurate geometric representations at the amino acid level.

Presenter(s): Renton, Sasha
School: Colorado College
Session: P2.15
Title: Analysis of ozone and its precursors in Baltimore and the Northern Chesapeake Bay
Co-Author(s): Xinrong Ren, Winston Luke, Russ Dickerson, Steve Brown
Advisor(s): Allison Lawman

Abstract: Baltimore and the northern Chesapeake Bay region frequently do not meet the EPA's National Ambient Air Quality Standards for ozone (O3), posing health risks like impaired respiratory and cardiovascular functions. In the troposphere, O3 is produced through photochemical reactions involving nitrogen oxides (NOx) and volatile organic compounds (VOCs). One metric for evaluating O3 formation is the ozone production efficiency (OPE), defined as the number of Ox (O3 + NO2) molecules produced per molecule of NOx oxidized. OPE provides information regarding NOx dependence of O3 formation and an estimate of its background level. OPE as well as other related metrics were used to evaluate air quality in the study regions. Data were collected in 2019, 2020, 2022 and 2025 by aircraft as part of the RAMMPP and AiRMAPS/BAQMS campaigns and analyzed using ArcMap and MATLAB. It was expected that these systems would be NOx saturated due to the prevalence of emissions from transportation in cities. Sillman 1995 presented OPE as the most reliable metric, which suggests VOC sensitivity in these regions. Identifying the O3 production regime indicates that reducing those emissions would be more effective at reducing O3 levels and improving public health and safety.

Presenter(s): Restivo, Nicolas
School: University of Chicago
Session: P1.20
Title: Loess provenance in Bosiljevski, Croatia Terra Rossa Formations through SEM Based Mineralogical Analysis
Co-Author(s): Justin Wheeler, Jordan Wheeler, Sikiel Graves, Owen Bonnett
Advisor(s): Michael Soreghan

Abstract: Terra Rossa soils are a distinctive feature of Mediterranean karst terrains, marked by reddish coloration and clayey-silty textures overlying carbonate bedrock. Considered polygenetic relict soils, they preserve a stratigraphic record of partial depositions and periods of growth unique to karst environments. The Istrian Peninsula of Croatia hosts extensive Terra Rossa profiles, where loess deposition and local bedrock weathering reflect climatic and environmental changes over the Quaternary. This project investigates the provenance of sediments contributing to loess and paleosol development in Bosiljevski, Karlovac County. Five identified soil horizons and underlying bedrock were sampled in situ. Epoxy mounts of these samples will be analyzed via FIB-SEM, using EDS and BSE to determine mineral modes and clay-silt abundance. These results will be compared with other Istrian sites and integrated with complementary analyses conducted with collaborators at the University of Zagreb. By constraining

sediment sources and depositional pathways, this research advances understanding of Mediterranean pedogenesis under changing climates. The findings will aid efforts to reconstruct Quaternary landscape evolution, assess climatic controls on karst soil development, and provide comparative data for global Terra Rossa systems. This work ultimately supports broader goals in paleoclimate reconstruction and interpretation of glacial–interglacial dynamics.

Presenter(s): Ryan, Jonathan
School: Gustavus Adolphus College
Session: P1.18
Title: From Io-Jupiter to Exomoons: Building the Infrastructure for Future Radio Analysis
Co-Author(s): Erin Coleman, Darsa Donelan
Advisor(s): Darsa Donelan

Abstract: Magnetic interactions between Jupiter and its moon Io emit radio waves which can be observed on Earth using small antennae. Gustavus Adolphus College has a square array radio antenna that is capable of receiving signals from these "radio storms". This poster will discuss the coding and design process of building a microcomputer capable of remotely operating the Gustavus radio antenna and analyzing the data received from the antenna. It will also detail the process of integrating a prototype noise temperature calibrator into the antenna, enabling the conversion of radio data into quantitative measurements. Particular focus will be placed on the software operation, coding process, and problem-solving that were necessary during the design phase for the microcomputer. The data collection techniques and what form the data takes will also be showcased. Finally, the poster will also discuss future applications for the data collected, including its potential use in the discovery of exomoons.

Presenter(s): Schroeder, Paul
School: Carthage College
Session: P2.06
Title: Investigating Bidentate Stabilizer Binding to the V122I Transthyretin Variant with Molecular Dynamics Simulations
Co-Author(s): Kevin Morris, Matthew George Jr., and Yayin Fang
Advisor(s): Kevin Morris

Abstract: Transthyretin (TTR) is a protein tetramer synthesized in the liver. Its primary function is the transport of thyroid hormones through the body. A V122I point mutation destabilizes the protein complex and prompts the tetramer to dissociate into monomers. Over time, the monomers can misfold and aggregate into plaques around the heart causing a disease known as Familial Amyloid Cardiomyopathy (FAC). Current treatments for FAC are obtrusive, so less invasive pharmaceutical drug therapies are needed. This study used molecular dynamics simulations to investigate the binding of the ligand molecule Mds84 and four of its derivatives to the V122I mutant protein. This ligand has been shown to stabilize the TTR protein and inhibit its aggregation and plaque formation. Hydrogen bonding interactions between the ligands and the protein were studied and free energies of binding were calculated for each ligand molecule. Most ligands experienced hydrogen-bonding and electrostatic interactions with Lys-15 residues. London dispersion interactions with Leu-17 and Leu-110 residues were also observed. The insights obtained from the molecular dynamics simulations will be used to design new TTR stabilizing ligands.

Presenter(s): Seo, Changmin and Ajkoviq, Anastasia
School: St. Olaf College
Session: II.G.2
Title: Ground State Estimation of Ising-Type Models Using Variational Quantum Algorithms

Co-Author(s): John Carlson-Yunga, Anastasia Ajkoviq, Ray Reyes, Prabal Adhikari
Advisor(s): Prabal Adhikari

Abstract: In this research, we implemented the VQE algorithm on the 1D Ising model with a transverse magnetic field. We used the 1D-Ising model to test our accuracy of our VQE algorithm. In order to construct the variational ansatz, we explored the symmetries of the Hamiltonian, where we found in addition to the standard spin-flip symmetry, a spatial symmetry, which keeps the quantum state invariant under a particular set of exchanges of quantum spins. Using the exponentiated spin flip operator and the spatial symmetry, we constructed the ansatz for our VQE algorithm. Using the ansatz, we were able to estimate the ground state energy with high precision and determined the ground state with fidelities of 0.99.

Presenter(s): Sheldon, Katherine, Jaimes-Martinez, Laura and Loos, Jared
School: Carthage College
Session: P1.09
Title: Optimization and Exploration of the Synthesis of 2-Pyridyl Substituted Carbazoles
Co-Author(s): Jared Loos, Laura Jaimes-Martinez, Alec N Brown
Advisor(s): Alec N Brown

Abstract: The development of a greener and less expensive methodology towards 1,8-disubstituted dipyridyl carbazoles and non-symmetrical 1,8-disubstituded carbazoles with potential use in ion/molecular sensing and catalysis was explored leveraging Miyaura borylation and Suzuki cross coupling with 2-halo pyridines. The development of a gram-scale synthesis of 1,8-dibromo-3,6-bis(1,1-dimethylethyl)-9H carbazole and 1-bromo-3,6-bis(1,1-dimethylethyl)-9H carbazole allowed for the synthesis of 1-Bpin-3,6-bis(1,1-dimethylethyl)-9H carbazole and 1,2-bis(Bpin)-3,6-bis(1,1-dimethylethyl)-9H carbazole using Miyaura borylation. A new 1,8-ditrifluoromethylpyridyl-3,6-bis(1,1-dimethylethyl)-9H carbazole was synthesized using a Suzuki cross-coupling reaction demonstrating the utility of the borylated precursor.

Presenter(s): Sheley, Gwendolyn
School: University of Chicago
Session: P1.15
Title: Accessing Potential Systematics in Cosmic Shear – tSZ Cross-Correlation Analyses
Co-Author(s): Chun-Hao To, Chihway Chang
Advisor(s): Chihway Chang

Abstract: Gravitational lensing describes the effect that gravity has on light passing through or nearby objects with mass. While strong lensing is easy to spot, weak lensing is only observable statistically. Baryonic feedback, i.e. feedback from the processes of massive particles, if not accounted for, can reduce the statistical power of weak lensing analyses by ⅓. However, these effects are difficult to model, and it is unknown how and to what extent different processes affect observables. One way to constrain baryonic feedback is by cross-correlating thermal Sunyaev–Zeldovich (tSZ) signal with lensing shear. The tSZ effect is a small spectral distortion of the cosmic microwave background (CMB) because of inverse-Compton scattering of CMB photons with electrons1. In this talk, I will show my progress on building models for these cross-correlations. I will show key systematics that can affect the interpretation of the signal and its impact on cosmological constraints. This talk will conclude by discussing possible additions/alterations to the model to mitigate the problem.

Presenter(s): Sherpa, Nima

School: Knox College
Session: P3.03
Title: Assessing Glacial Lake Outburst Flood Risks Using Remote Sensing and Machine Learning in the Himalayas
Co-Author(s):
Advisor(s): Andrew Leahy

Abstract: Glacial Lake Outburst Floods (GLOFs) are an escalating hazard in the Himalayas, where climate-driven glacier retreat is rapidly expanding high-altitude lakes. These sudden floods can devastate downstream communities, infrastructure, and ecosystems. This study develops a scalable framework for forecasting GLOF susceptibility using remote sensing and machine learning. Multi-temporal satellite imagery and terrain data were used to map glacial lakes, monitor their expansion, and extract features such as area, elevation, expansion rate, and proximity to glaciers. To address sparse and incomplete records, features were derived directly from satellite imagery and merged with global glacial lake inventories, while missing data and class imbalance were handled with imputation and resampling strategies to ensure robust model performance. Validation showed that automated NDWI-derived lake areas correlated well with documented inventories ($r = 0.67$), and expansion statistics revealed a steady increase in lake growth across the region. Supervised machine learning models trained on historical GLOF events distinguished hazardous lakes from stable ones and generated probabilistic susceptibility maps highlighting areas of elevated risk. By integrating Earth observation with data-driven modeling, this research advances understanding of GLOF hazards and provides an automated framework for large-scale monitoring, early warning, and climate adaptation in vulnerable Himalayan landscapes.

Presenter(s): Sobel-Lewin, Milo
School: University of Chicago
Session: I.C.2
Title: Encapsulating Stretchable, Soft Electrochemical Sensors With Tough, Adhesive Hydrogels: A Path to Single Organ Sensing
Co-Author(s): Sean Sutyak, Sihong Wang
Advisor(s): Sihong Wang

Abstract: Rigid electrochemical aptamer-based biosensors (EABs) can reversibly, precisely, and continuously monitor the concentration of biological signaling molecules close to the skin, but are unable to monitor individual organs due to the mechanical mismatch between the surface of smooth, hard, rigid EABs and that of wrinkled, soft, elastic organs. A seamless device-organ interface is critical to enable direct coupling of device measurements to analyte concentrations within an organ, but impossible with such a mechanical mismatch. We propose a fully stretchable EAB implant with a tough, adhesive, hydrogel encapsulation that enables an intimate, robust implant-tissue interface while minimizing tissue damage. In vitro FRAP experiments will show that the hydrogel minimally inhibits transport of analytes from tissue to device receptors while tensile testing of bulk hydrogels will validate toughness and successful synthesis. In order to validate hydrogel performance in vitro, electrochemical impedance spectroscopy will be performed on an encapsulated mock device adhered to pork tissue. Single organ sensing could have ground-breaking basic research and clinical applications, for example in investigating signaling pathways in brain-body circuits or relating the repeated short term release of proteins with progression of chronic disease.

Presenter(s): Solomon, Sarah
School: Macalester College
Session: I.B.2

Title: 1,2,3 Triazole Synthesis of Metal Coordinating Biosensors
Co-Author(s): Babs Nkomo, Hazel Waters, Ronald Brisbois
Advisor(s): Ronald Brisbois

Abstract: The 1,2,3-triazole scaffold is an important pharmacophore and a versatile, increasingly leveraged, substructure in biochemical, materials, polymer, and metal-coordinating applications. Continuing advances in 1,2,3-triazole construction foster further creative use by non-catalyzed or metal-catalyzed azide/alkyne cycloaddition. Previously, we have optimized a protocol for reacting bis(trimethylsilyl)butadiyne with azides to form 5-trimethylsilylethynyl-4-trimethylsilyl-1,2,3-triazoles in good to excellent yield. We continued this precedent with the successful synthesis of triazoles with pyridine and t-butyl benzene scaffolds, containing good pockets for potential metal coordination. We performed selective desilylation processes to deprotect our alkyne group. Utilizing the alkyne moiety, we attempted a Sonagashira cross-coupling to attach 9-bromoantracene and 9,10-dibromoantracene to our molecule, creating a fluorescent triazole, with varying success. In addition, we performed NAS reactions on our azide triazole precursor to create an analogous fluorescent triazole, exploring their potential for metal coordination.

Presenter(s): Song, Meilin
School: University of Chicago
Session: P3.19
Title: Dynamics of Immiscible Drop Impact in a Volume-of-Fluid Simulation
Co-Author(s):
Advisor(s): Marie-Jean Thoraval

Abstract: A numerical study of immiscible drop impact on a liquid pool was conducted with two-dimensional volume-of-fluid simulations in Basilisk. The Fr-We parameter space was explored for the case of a water drop with low surface tension falling into a deep pool of oil, and regimes of bubble encapsulation were identified and compared to existing literature on miscible liquid impact. Surface tension was found to dominate the dynamics of droplet spreading and contraction as compared to gravity. Cavity expansion dynamics and velocity profiles revealed significant qualitative differences from the case of miscible liquids. The evolution of the drop was largely separate from that of the cavity, and the drop dynamics determined bubble entrapment. A comparison was made to the spreading and contraction of a water drop on a solid hydrophobic surface for a limited range of Weber numbers. The results suggest that the timescales of immiscible drop impact are well-described by those of liquid-on-solid impact for some but not all stages of the process.

Presenter(s): Steineke, Teagan and Klinepeter, Gabe
School: Carthage College
Session: P3.17
Title: Validating an Ullage Detection Technique for Liquid Propellant Tanks in Microgravity
Co-Author(s): Gabe Klinepeter, Justin Wheeler, Kevin Crosby
Advisor(s): Kevin Crosby

Abstract: The Microgravity Ullage Detection (MUD) experiment is part of the effort to address gas venting during in-space refueling operations, done by developing technologies to locate the ullage within a propellant tank. The primary technical objectives of the MUD payload are to demonstrate that, under gravity, a liquid-vapor interface can be detected non-invasively using external acoustic patch sensors mounted on the tank, and that, under microgravity, changes in the thickness of the adhered liquid layer can be measured during a tank drain using these external acoustic sensors. Ullage detection is accomplished

by exploiting the fact that the sensor output is sensitive to the local stiffness and damping of the tank wall. By calculating the Root Mean Square of the sensor at a given location, liquid presence and interface velocity at the location of the sensor can be inferred, thus identifying the location and geometry of the ullage. Under gravity, the location of the fluid interface has been determined with a resolution of < 1% for settled liquids. The success of this experiment influenced the development of three identical payloads for NASA's Universal Payload Interface Challenge, where teams will test their interfaces on copies of MUD in an effort to improve compatibility.

Presenter(s): Stoller, Evan
School: Grinnell College
Session: I.A.4
Title: Removing Likely Dust Events from PM2.5 Measurements in Kuwait
Co-Author(s): Evan Couzo
Advisor(s): Evan Couzo

Abstract: PM2.5 causes millions of premature deaths every year due to lung inflammation, lung tissue damage, and even cardiovascular diseases (Albahar et al, 2022; Ritchie, 2024). Kuwait has some of the most polluted air in the world, usually exceeding the WHO guidelines by at least five times the guideline amount (IQAir, 2024). A trouble Kuwait as well as many other countries with desert environments face in measuring this air pollution is its intense and frequent dust storms. With dust storm influence, an accurate representation of anthropogenic pollution cannot be formed. Because dust particles generally tend to be coarse and large, similar to most PM10, a ratio of PM10:PM2.5 ratios were used as a proxy for the attempt of screening dust storms in Kuwait. Using geolocation data through ArcGIS as well comparative analyses through PM10:PM2.5 ratios, there was no substantial difference based on location within wind corridors nor was there a consistent positive contribution of dust events towards PM2.5. Thus, PM10:PM2.5 ratios as a proxy for dust events in Kuwait needs reevaluation. Nonetheless, certain stations show particularly interesting distributions that suggest they are extremely high polluting or susceptible to dust storms.

Presenter(s): Strom, Sumner and Cassell, Marcus
School: St. Olaf College
Session: II.H.4
Title: Invariant Rings in Macaulay 2
Co-Author(s): Francesca Gandini, Gordon Novak, Sasha Arasha, Marcus Cassell
Advisor(s): Marcus Cassell

Abstract: Macaulay2 (M2) is a Computer Algebra System utilized in several fields of mathematics for computations involving commutative rings. Our primary research goal is to develop an algorithm for calculating the invariants of finite group actions on skew commutative polynomials. We first studied the field of invariant theory to form a basis for exploring degree bounds for skew commutative invariants. We will then apply this research to develop the respective algorithm in M2 for the InvariantRings 3.0 package. Particularly for finite groups, there are known degree bounds for invariant skew polynomials in the exterior algebra, which inevitably results in termination of our computational recipe. The algorithm has a planned release for the October 2025 release of M2.

Presenter(s): Tang, Kevin and Lackershire, Emily
School: Grinnell College
Session: P2.18
Title: How Edit Simpliciality Impacts Dynamics on Hypergraphs

Co-Author(s): Annie Li, Engtieng Ourn, Kevin Tang, Nicole Eikmeier
Advisor(s): Nicole Eikmeier

Abstract: Dynamics on hypergraphs can be useful for many things, for example, tracking the spread of a pandemic. If one person has been infected, we can model the spread throughout groups, and track how many people are going to be infected, or how to stop the spread. As a result, we can identify high-risk areas in events of diseases and provide a numeric representation of how likely someone is to be infected based on their relative placement in a group. In our work, we investigate dynamics on hypergraphs through their edit simpliciality (ES). As ES is a measure of how close the given graph is to a simplicial complex, we seek to understand its impact on dynamic processes on hypergraphs. In order to study the impact ES has on dynamics on hypergraphs, we created a model that will generate synthetic data with a controlled ES. Our experiments focus on two objectives. We first confirmed that our model accurately represents real-world data. We verified this by comparing simulations of the SIR model. Afterward, we generated data with varying ES values to analyze how differing ES affects dynamic processes.

Presenter(s): Tang, Sihan
School: Grinnell College
Session: P2.11
Title: Dye-labeled gold nanoparticles for protease detection
Co-Author(s): Corasi Ortiz
Advisor(s): Corasi Ortiz

Abstract: Proteases are important contributors in key cellular activities and abnormal protease activity is found to be closely related to cancer and other diseases. Herein, we report the development of prolyl endopeptidase activity sensor based on dye-labeled gold nanoparticles. They are composed of gold nanoparticle functionalized with a peptide sequence labeled with 5-carboxyfluorescein, 5-FAM. Proteolysis of peptide bond releases 5-FAM-labeled peptide segments into the solution, which is subsequently measured via fluorescence spectroscopy and surface-enhanced Raman spectroscopy (SERS). We have successfully detected strong fluorescence signal, evidence of proteolysis via fluorescence spectroscopy. Moreover, we have successful detected SERS signal from free dye and dye labeled peptide. Nevertheless, no strong SERS signal was detected after proteolysis. The developed sensors provide a promising approach for protease activity detection.

Presenter(s): Vaithinathan Asokan, Adithya and Ahmad, Subhan
School: Knox College
Session: I.C.3
Title: Disease Detection from Chest X-ray Images Using Deep Learning
Co-Author(s): Adithya Asokan
Advisor(s): Ole Forseberg

Abstract: This project aims to create a machine learning model that can detect diseases like pneumonia, tuberculosis, and COVID-19 using chest X-ray images. Detecting these diseases early is crucial because it allows for faster treatment and better patient outcomes, especially in areas with limited access to medical professionals. I will work with Subhan Ahmad and use convolutional neural networks(CNNs). The first step is to train a model to predict accurately whether a chest x-ray is healthy. Data from NIH ChestX-ray14 and the COVID-19 Radiography Database will be used for model development and testing. Evaluating model performance will be through accuracy, precision, recall, and AUC scores, and Grad-CAM techniques will also be used to make model predictions more interpretable to human users. Geospatial analysis will also be done to see any regional trends in disease occurrences and to check if

healthcare is available in rural and urban areas. Through this research, I aim to contribute to the growing field of AI-assisted healthcare diagnostics while gaining practical skills in medical image analysis, data exploration, and geospatial mapping.

Presenter(s): VanSkiver, Trevor and Fox, Megyn
School: Hope College
Session: P1.08
Title: Moving Beyond Carbonyls in C-C Single Bond Activation
Co-Author(s): Trevor VanSkiver, Jeffery Johnson
Advisor(s): Jeffery Johnson

Abstract: Selective transition-metal-catalyzed C-C bond activation is a promising method for reducing the time and cost of synthesizing complex organic molecules. Previous work has succeeded in rhodium-catalyzed decarbonylation to form new C-C bonds from pyridyl ketone starting materials, in which a ketone carbonyl is selectively spliced. Although this reaction exhibits high yields, the necessity of using a pyridyl ketone as a substrate limits the range of molecules that can be synthesized. The goal of this project is to move beyond the ketone in the classic decarbonylation reaction to increase the scope and application of C-C single bond activation. This will be attempted by synthesizing ketone alternatives and subjecting them to a variety of reaction conditions with rhodium catalysts to test if they behave similarly to carbonyls in the decarbonylation reaction.

Presenter(s): Velasquez-Ramos, Nerlyn
School: Beloit College
Session: P1.02
Title: Extraction of Salicylic Acid from Various Natural Source
Co-Author(s): Ari Frisch, Alexandria Juve, Gabriela Carranza-Torres, Corbin Livingston
Advisor(s): Corbin Livingston

Abstract: Salicylic Acid is a phenolic compound with medicinal use as a precursor of acetylsalicylic acid (aspirin). This project investigates the extraction and qualitative analysis of salicylic acid from a variety of botanical sources, with the goal of broadening understanding of plant-based natural products. This work also focuses on providing an expanded background on salicylic acid extraction sources for general chemistry students at Beloit College.

Presenter(s): Velmont, Brookelyn
School: Carthage College
Session: P2.17
Title: Development of a Deep Learning Model for Differentiation Between Epithelioid and Sarcomatoid Pleural Mesothelioma
Co-Author(s): Christopher Valdes, Owen Mitchell, Feng Li, Hedy Kindler, Christopher Straus, Samuel Armato III
Advisor(s): Samuel Armato III

Abstract: This study aims to explore whether a conditional generative adversarial network (cGAN) can non-invasively distinguish between epithelioid and sarcomatoid pleural mesothelioma (PM) using computed tomography (CT) imaging data. We trained a cGAN model on CT scans from 20 epithelioid patients. The slice with the largest tumor cross-section was selected as the "Primary" input, and the superior adjacent slice was selected as the "Secondary" input. Data augmentation included mirrored and tilted versions to improve generalizability. The generator was trained on both inputs and tasked with reconstructing the Secondary input. The discriminator evaluated the output realism. The trained generator was then tested on 5 epithelioid and 5 sarcomatoid images. L2 loss values were calculated to assess reconstruction accuracy between the synthetic output and the real inputs and outputs. We hypothesized that non-epithelioid scans would yield a higher L2 Loss. Loss values were higher in epithelioid cases compared to sarcomatoid cases. The model achieved an area under the curve (AUC) of 0.92, and a p value of p=0.032 from the Wilcoxon Rank Sum Test. Our findings indicate that cGANs trained on single-subtype datasets may reveal subtype differences through loss-based analysis, creating a potential step toward non-invasive mesothelioma classification. Further validation with larger, more diverse datasets, including biphasic cases, is warranted.

Presenter(s): Vizoso-Marino, Miranda
School: Gustavus Adolphus College
Session: P3.01
Title: Stromatolite Interpretation in Ancient Marine Environments: Ordovician Carbonates of Minnesota and Wisconsin
Co-Author(s): Julie Bartley
Advisor(s): Julie Bartley

Abstract: Stromatolites are organo-sedimentary structures whose morphology reflects the environment that formed them. This environment-shape connection makes them useful markers of environmental change in ancient marine systems. Around 500 million years ago, stromatolites built small reefs on a shallow carbonate platform that covered much of the upper Midwest. The Ordovician-aged Prairie du Chien Group (PDC) in Minnesota and Wisconsin records interactions between stromatolites, clastics, and chemical sediment in this basin. We conducted fieldwork in eastern Minnesota and western Wisconsin and drafted stratigraphic columns for 11 localities that preserved the boundary between the lower and upper formations of the PDC. Comparisons of stratigraphic columns revealed consistent relationships between stromatolites, stratigraphic position and lithology, indicating that stromatolites initiated in this basin during sea level rise. We also observed a close connection between sea level change and stromatolite form as the stromatolites developed. Past studies proposed stromatolite development during sea level fall and did not note systematic relationships between morphology and sea level change. Our work suggests that stromatolites are useful, along with other lines of evidence in interpreting sea level change even 500 million years in the past, allowing us a glimpse of marine environmental change through stromatolite morphology and stratigraphic relationships.

Presenter(s): Ware, Tamia
School: Knox College
Session: I.A.2
Title: MFlow in Game Design: A Transmedial Experience
Co-Author(s):
Advisor(s): Jaime Spacco

Abstract: Despite our technologically-focused society, research has shown that the rise of digital games has not forced analog games to cease existing. This suggests that there may be factors in analog games that may not be transferable to the digital versions. Literature shows other tools currently exist for solely digital games or analog games, but none that can measure both effectively and accurately. The Games Experience Questionnaire (GEQ) is a commonly used user experience (UX) tool while playing a digital game. This project seeks to answer the following questions: Which factors of flow (simply defined as an in-the zone state) are affected the most when converting a board game into digital format and vice versa? What changes could be made (in terms of elements of flow) to make them equally or more enjoyable?

This mixed-methods study intends to investigate these questions by having participants play analog and digital versions of UNO and Tetris and later complete a modified version of the GEQ. The goal of this project is to give insight for game developers into how they could conserve the essence of the original version of a game when translating it into another format to provide consistent or improved enjoyment.

Presenter(s): Wiggins, Kendall and Nordeen, Bradyn
School: Gustavus Adolphus College
Session: P2.14
Title: Impacts of Warfare on Soil Erosion and Landscapes: a Baseline from Early Modern Period Strata
Co-Author(s): Bradyn Nordeen, Erik L. Gulbranson, Kathleen Rodrigues, Kaisa Whittaker, Willy Tegel, Marta Dominguez-Delmás
Advisor(s): Erik L. Gulbranson

Abstract: Our understanding of anthropogenic soil erosion centers on facets of the built world. However, the effect of warfare on soil erosion is largely underexplored with potentially significant consequences for the environment and contemporary geopolitics. A significant knowledge gap exists on a baseline for war-induced soil erosion that hampers our ability to fully contextualize the environmental impact of historical conflicts. This project seeks to address scaling factors for this environmental disturbance. This project focuses on the early modern period in northeastern France and western Germany, as this region witnessed persistent warfare over several centuries. A chronostratigraphic framework is presented with four new precise luminescence ages. Stratigraphy is studied along river basins in the Rhine River watershed, indicating basin-wide erosional events in the early modern period. However, paleolandscape equilibrium displays stratigraphic variation across these basins. This indicates localized landscape impacts from the anthropogenic and/or natural processes generating these erosional episodes. Moreover, dendrochronologic analysis indicates that warfare impacts on the land surface scaled dramatically from the early modern period to the 20th century. Ongoing work seeks to elucidate the provenance of colluvial material to refine estimates of soil erosion through time and space.

Presenter(s): Willner, Rebecca
School: Colorado College
Session: P2.02
Title: Exploring liquid metal electrode identity impact of ec-LLS crystal growth of germanium
Co-Author(s): Sophia Bograd, Eli Fahrenkrug
Advisor(s): Eli Fahrenkrug

Abstract: Electrochemical liquid-liquid-solid (ec-LLS) crystal growth is a novel low-temperature method for the synthesis of covalent Group IV and III-V semiconductor materials. The process starts with the electrochemical reduction of fully oxidized aqueous precursors like GeO2 at the surface of a low-melting-temperature liquid metal like gallium (Ga). The reduced Ge0 dissolves into the Ga(l) electrode until reaching supersaturation, which triggers the continuous extrusion of Ge crystals from the electrode surface. The target of this work was twofold: (1) engineer an electrochemical cell that provides high-fidelity electrical contact to the liquid metal electrode over the duration of the experiment; (2) evaluate the impact of the liquid metal identity (e.g. alloy composition) on the crystal structure and morphology of the resulting semiconductor products. This presentation will highlight practical challenges and solutions in designing and fabricating electrochemical cells for systematic ec-LLS studies across varied liquid-metal alloy compositions. It will then present structural, morphological, and compositional characterization of Ge crystals synthesized by ec-LLS using three low-melting alloys: pure Ga (Ga100), EGaIn (Ga75In25), and Galinstan (Ga68In22Sn10). Finally, proof-of-concept experiments will be

described for an alternative ec-LLS growth mode, in which a thin liquid-metal film on the surface of an n-Si(111) wafer serves as the electrode.

Presenter(s): Wolf, Eliana
School: Washington University in St. Louis
Session: P1.04
Title: Interaction of Androgen Receptor and Wnt Signaling in Bladder Cancer
Co-Author(s): Yan Yin, Liang Ma
Advisor(s): Liang Ma

Abstract: Bladder urothelial carcinoma (UC) occurs about three times more often in men than in women. In our previous study, ectopic activation of β-catenin signaling in mouse urothelium caused UC predominantly in males and coincided with androgen receptor (AR) signaling activation, suggesting cooperation between the AR and WNT/β-catenin in UC tumorigenesis. Next, we used split DamID to map where AR co-occupies chromatin with the coactivator p300 in juvenile urothelium. We engineered a transgenic mouse model in which AR and p300 were fused to complementary fragments of DNA adenine methyltransferase (Dam) that reconstitute activity only when both proteins bind nearby, depositing methylation marks at those loci. Sequencing identified 7,275 target genes, 5,816 exhibiting stronger binding affinities in males (>1.3-fold). Cross-referencing the Cancer Genome Atlas database revealed that 669 of these genes are also frequently mutated in UC. When compared to gene expression data from β–catenin–activated urothelium, 72 candidate genes were identified. Of these, 51 were tested in UC cells using siRNA. Knockdown of seven genes, including BCL9, reduced cancer cell growth. These findings support a reinforcing AR–Wnt/β-catenin circuit in male bladders that may explain the higher incidence of UC in men, nominating potential therapeutic targets for UC.

Presenter(s): Yousafi, Abdullah
School: Beloit College
Session: P1.13
Title: Tool-Augmented Agentic AI: A Survey on Composition, Selection and Integration
Co-Author(s): Mehmet Dik, Nabiha Fatima
Advisor(s): Ben Stucky

Abstract: Agentic AI systems augmented by tool use constitute a transformative leap in the evolution of artificial intelligence, enabling autonomous, multi-step reasoning and dynamic interaction capabilities with external resources. By autonomously invoking a wide array of external tools, from APIs to simulators, they are able to overcome inherent limitations to singular large language models and AI agents such as static knowledge and limited execution capabilities. This survey delves into the rapidly expanding body of research in tool-augmentated Agentic AI. We examine foundational concepts, architectural designs, methodological trends in tool composition, selection, and integration, current challenges and future research directions in this field. We outline current and emerging applications including research assistance, business automation and domain-specific deployments, and review principal limitations impacting this field. By synthesizing empirical findings and theoretical frameworks, this work provides a definitive reference and guide for researchers, practitioners and policymakers and offers a unifying taxonomy and actionable guidance for navigating this complex landscape and achieving robust, safe, and scalable deployment of tool-augmented agentic AI.

Presenter(s): Yoon, Rick
School: University of Chicago
Session: I.B.1

Title: Developing a Systematic Framework for the Entanglement Renormalization of Fractal Spin Liquids
Co-Author(s):
Advisor(s): Wilbur Shirley

Abstract: Quantum systems composed of many interacting particles can exhibit emergent phenomena that defy properties of their individual constituents. When these interactions occur through quantum entanglement, they can give rise to exotic quantum phases of matter with remarkable properties. One such phase is fracton order, a recently discovered class of quantum matter that differs sharply from conventional topological order. Specifically, they host quasiparticle excitations with constrained mobility. Some can move only along lower-dimensional submanifolds; others are completely immobile. These highly unusual behaviors make fracton phases both conceptually rich and potentially useful for robust quantum information storage. Despite growing interest, fracton order remains poorly understood. A hallmark of these systems is their bifurcating entanglement renormalization group (RG) flows, where the system effectively splits into multiple copies under coarse-graining, contrasting with the stable RG flows typical of other quantum phases. Here, we systematically study the entanglement renormalization of a class of (fracton) fractal spin liquids known as three-dimensional lineon codes. Our goal is to identify entanglement entropic signatures that characterize their distinct renormalization behavior. To this end, we compute key properties such as ground state degeneracy as a function of system size, providing insight into the structure and scaling of fracton entanglement

Presenter(s): Zerabruk, Selam
School: Grinnell College
Session: P3.07
Title: Synthesis and Characterization of Nickel and Copper Bound Bis(thiosemicarbazide) Compounds with Amine Functionalized Secondary Coordination Spheres
Co-Author(s): Maisha Kamunde-Devonish
Advisor(s): Maisha Kamunde-Devonish

Abstract: The development of synthetic catalysts capable of the electrochemical and photochemical reduction of CO_2 into a value-added species remains a challenge in inorganic chemistry. In this study, four nickel and copper compounds, each incorporating primary or secondary coordination spheres, were synthesized in moderate to high yields and characterized with NMR, IR, and UV-vis spectroscopy. Two of the compounds were treated with iodomethane to create a fixed charge in the secondary coordination sphere. The bis(thiosemicarbazide) compounds were further investigated through cyclic voltammetry experiments to evaluate how the differing ligand frameworks impact a compound's ability to interact with and reduce CO2. All metal compounds exhibited CO_2 interactions and reduction abilities, however, the nickel BTSC compound with a charged secondary coordination sphere showed the greatest potential for CO_2 reduction.

Presenter(s): Zuvela, Lucia, Akins, Georgia and Pirone, Mara
School: Macalester College
Session: II.H.2
Title: The Ripple Effect: Impacts of Historical Redlining on Water Quality in the Twin Cities, MN
Co-Author(s): Georgia Akins, Lucia Zuvela, Anika Bratt
Advisor(s): Anika Bratt

Abstract: Redlining was a racist, discriminatory practice developed by the Home Owners Loan Corporation (HOLC) in the mid-1930s that assigned grades to residential neighborhoods based on their perceived "mortgage security". Neighborhoods were graded A ("best"), B ("still desirable"), C

(“definitely declining”), or D (“hazardous”). While this policy stopped in the mid-1950s, numerous studies have connected redlining to disparities in infrastructure funding, temperature, air quality, and green space between neighborhoods. There is, however, limited research exploring the connections between surface water quality and redlining. This study investigated these relationships in Saint Paul and Minneapolis, MN. It was hypothesized that water bodies in neighborhoods with lower HOLC grades (C/D) would exhibit characteristics of lower water quality than their higher-graded counterparts (A/B). Over the course of two summers, 28 small lakes and ponds were sampled for various water quality metrics, including: temperature, nutrients, heavy metals, and algae. Two lakes were terrestrially sampled to explore differences in the cooling effect of water bodies on the surrounding areas, and were also surveyed to understand human use and value. Long-term data from the Minnesota Pollution Control Agency (MPCA) was used to assess historical changes in water quality across the sampled sites and other large water bodies. Limited study results warrant continued data analysis and further investigation of redlining and water quality.

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