Irene Piscopo Rodgers ’59 Summer Science Institute Research Symposium 2025

Wednesday, July 23rd
Chandler Ballroom, Cedric Rucker University Center
University of Mary Washington

The University of Mary Washington Irene Piscopo Rodgers ’59 Summer Science Institute is a program that offers UMW science majors an opportunity to participate in a summer-long, research project supervised by a faculty member. At the end of this 10-week program, students present the results of their research through poster and oral presentations at our annual symposium. This year, 30 students in 7 STEM disciplines conducted research on campus, as well as field research from Florida, to West Virginia, to the Chesapeake Bay, and one team traveled to Norway for the first part of the summer for lab work there. Judges will select the top two poster and oral presentations, and awarded scholarships from the John C. and Jerri Barden Perkins ’61 Student Research Endowment.

Irene Piscopo Rodgers ’59 Summer Science Institute
Research Symposium 2025

Schedule of Events

CONTINENTAL BREAKFAST.....8:30

OPENING COMMENTS 8:55

ORAL PRESENTATION SESSION I 9:00 – 10:00

9:00 Ashton Crawford
Splitting the Bill: An Extension of the Dining Cryptographers Problem
Faculty Advisor: Dr. Randall Helmstutler

9:15 Sophie Jenson
The Universe Sings: An Investigation of Gravitational Wave Cosmology
Faculty Advisor: Dr. Desmond Villalba

9:30 Ashlynn Peszko
Optimizing Japanese Rice Fish (Oryzias latipes) Pituitary Organ Culture
Faculty Advisor: Dr. Dianne Baker

9:45 Jillian Pabalan
Improved Synthesis of Indazole-Based Sulfonamides for Use in Treating Mycobacterium tuberculosis
Faculty Advisor: Dr. E. Davis Oldham

POSTER PRESENTATION SESSION I 10:00 – 11:00

Autumn Pembleton
The Role of Aggressive Vibrations in Male Combat of Red Milkweed Beetles
Faculty Advisor: Dr. Lauren Cirino

Mohammed Ali Hassan
Call for back up: Cisplatin induced an immunogenic cell death to delay tumor onset in a preclinical model of triple negative breast cancer
Faculty Advisor: Dr. Laura Sipe

Nora McMullen
Celebrities of the Microbial World: What Does it Take to Be a Model Organism?
Faculty Advisor: Dr. Theresa Grana

Chessa Lowery
Effect of Size-Dependent Predation on Eastern Oysters (Crassostrea virginica): a Field Experiment

Faculty Advisor: Dr. Bradley Lamphere

Kassi Williams
Machine Learning for Block Preconditioners
Faculty Advisor: Dr. Evan Coleman

Franco Trujillo
Developing a Method to Analyze the Effect of Proton Pump Inhibitors on Cancer Cells
Faculty Advisor: Dr. Randall Reif

ORAL PRESENTATION SESSION II **11:00 – 11:45**

11:00 Marina Klein
Investigation of Trinitrotoluene (TNT) Degradation in Simulated River Conditions using Design of Experiments
Faculty Advisor: Dr. Sarah Smith

11:15 Lillian Burbulis
Investigating Methodologies for Triggering an Immune Response in Leaf-footed Bugs
Faculty Advisor: Dr. Lauren Cirino

11:30 Edmund Garcia
Modeling Intermediate-scale Outflow Dynamics of Eta Carinae
Faculty Advisor: Dr. Matthew Fleenor

11:45 BREAK

LUNCH BREAK **12:00 – 1:00**

(on your own, Top of the CRUC)

ORAL PRESENTATION SESSION III **1:00 – 2:00**

1:00 Kannon Baker
Mutual Information as a Measure of Association: Results from Simulations
Faculty Advisor: Dr. Debra Hydorn

1:15 Lillian Gruss
Improved Synthesis of the Metabolites of Di(2-ethylhexyl)Phthalate
Faculty Advisor: Dr. E. Davis Oldham

1:30 Garrett Driscoll

Assessing fecal contamination in Fredericksburg waterways: Development of a framework for public awareness and safer recreational practices
Advisor: Dr. Tyler Frankel

1:45 SARALA KENNEDY
Urban-Rural Comparison of Injury-Involved Traffic Crash Risks: An Explainable Machine Learning Approach
Faculty Advisor: Dr. Ping Yin

POSTER PRESENTATION SESSION II **2:00 – 3:00**

(Refreshments served)

KATIE BURGRIDGE
The impact of agricultural and urban development on spatio-temporal sediments trace metals concentration and aquatic organisms bioaccumulation in Chincoteague Bay, Virginia, USA
Faculty Advisor: Dr. Ben Kisila

JAMIE VOLK
Storage Optimization and the Functional Assessment of Oryzias latipes (Japanese Rice Fish) Spermatozoa
Faculty Advisor: Dr. Dianne Baker

EMILY HART
Statistical Analysis of the Recovery Method of Trace Explosives in Sediments
Faculty Advisor: Dr. Sarah Smith

CHARLES BARBARO
Promoting Safer Roads: A Spatiotemporal Analysis of Multi-Vehicle Car Crashes in Fairfax County, Virginia
Faculty Advisor: Dr. Ping Yin

DANNY MARTINEZ
Character Displacement of Native Species and Closely Related Invasive Species
Faculty Advisor: Dr. Bradley Lamphere

JOE HAUN
Weather Sensor Testing and Evaluation
Faculty Advisor: Dr. Matthew Fleenor with Coastal Carolina

ORAL PRESENTATION SESSION IV **3:00 – 4:00**

3:00.....Kaleb Lucas
Probabilistic Selection Strategies in Asynchronous Jacobi
Faculty Advisor: Dr. Evan Coleman

3:15 Eric Torres
Spatial, temporal and ecological impact analysis of trace metals enrichment in a Central Appalachian coal mining watershed
Faculty Advisor: Dr. Ben Kisila

3:30 Sofia Szczepankiewicz
Waking up the body's defenses: Which chemotherapy signals for the immune system to fight breast cancer?
Advisor: Dr. Laura Sipe

3:45 BREAK

POSTER PRESENTATION SESSION III **4:00 – 5:00**

Juniper Creskoff
Determining the Maximum Probability Gain in the Birthday Problem
Faculty Advisor: Dr. Randall Helmstutler

Delaney Thomas
Mutual Information as a Measure of Association: Applications on Florida Lakes
Faculty Advisor: Dr. Debra Hydorn

Joey Gasink
Applying climate change models to improve traditional exposure testing using adult and embryonic Seminole Ramshorn (Planorbella duryi) snails
Faculty Advisor: Dr. Tyler Frankel

Aiddah Rotich
Molecular Madness: Comparing Cloning Methods Involving Arabidopsis and Bacteriophage Genes
Faculty Advisor: Dr. Theresa Grana

Summer Orledge
Assessing the presence and concentration of trace metal contamination around an unlined landfill in King William County, VA
Faculty Advisor: Dr. Tyler Frankel

Elijah Harrington

Marine Atmospheric Boundary Layer Lapse Rates
Faculty Advisor: Dr. Matthew Fleenor with Coastal Carolina

CLOSING COMMENTS AND AWARDS CEREMONY **5:00**

Abstracts

Mutual Information as a Measure of Association: Results From Simulations

Kannon Baker
Faculty Advisor: Dr. Debra Hydorn

Correlation is often used to measure association within data, however this method is limited to assessing linearity and is susceptible to outliers. Mutual information offers an alternative method in quantifying association by measuring the amount of shared information between two variables. The following research seeks to build a better understanding of the value of mutual information when applied to datasets with varying characteristics in shape (linear, exponential, logarithmic, cubic, no association) and the presence of outliers. Using the program *R,* data was randomly generated with differing sample sizes (n=50, 100, 500, 1000) and different degrees of association (high, medium). For each model, 1000 simulated datasets were generated. Mutual information tends to be less impacted by outliers and influential points, but tends to vary more. Additionally, the mean value of mutual information accurately reflects changes in variability when compared to models of similar shape, however the value of mutual information differs substantially when compared to models of similar variance, but differing shape. Results support mutual information as a potential option for measuring association for data that is nonlinear or contains outliers.

Promoting Safer Roads: A Spatiotemporal Analysis of Multi-Vehicle Car Crashes in Fairfax County, Virginia

Charles Barbaro
Faculty Advisor: Dr. Ping Yin

Multi-vehicle car crashes (involving three or more vehicles) cause significantly more property damage and injuries compared to typical collisions. Understanding their spatio-temporal patterns is crucial for informing effective policy-making and urban planning for enhanced road safety. This study presents a spatio-temporal analysis of multi-vehicle car crashes in Fairfax County, Virginia, the most populous jurisdiction in the Washington metropolitan area, from 2021 to 2024. We examined temporal patterns at annual, monthly, and daily resolutions, revealing multi-vehicle trends were consistently proportional to overall trends across all resolutions. Spatially, using a Network-based Kernel Density Estimation (NKDE) method, we identified consistent and emerging crash hotspots, particularly concentrated along major arteries such as Arlington Boulevard and Leesburg Pike. These findings offer valuable insights for targeted safety initiatives.

The impact of agricultural and urban development on spatio-temporal trace metal sediment concentration and aquatic organism bioaccumulation in Chincoteague Bay, USA

Katie Burbridge
Faculty Advisor: Dr. Odhiambo, B.K

This study evaluates trace metals loading in sediments of Chincoteague Bay, a 72.4 square mile lagoon of the coastline of Virginia and Maryland. Thirty (30) surface sediment grab samples, six (6) sediment cores, dagger blade grass shrimp (P*alaemon pugio)* and mummichog *(Fundulus heteroclitus)* were used to analyze the spatio-temporal variability in the sediments and bioaccumulation. All samples were analyzed by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) for concentrations of Al, As, Cd, Cr, Cu, Fe, Pb, Zn, Li, and Ni. Geo Accumulation index (Igeo), enrichment factors (EF), Pollution load index (PLI), Geographic Information System (GIS) based Hot Spot Analysis, and Pearson Correlations (PC) statistical analysis were used to identify potential sources.

Spatial analysis results showed trace metal concentrations increasing alongside Virginia's mainland, with exception to As and Cu. Igeo values ranged from -1.65 (Pb) to 1.44 (Li), Pb and Li being universally unpolluted and moderately polluted respectfully. Similarly, average surface sediment EFs ranged from 1.72 (Pb) to 10.65 (Li), elements being enriched at consistent levels across sampling locations. While all other PLI were classified as lightly polluted (1-2), values adjacent to agricultural areas were moderately polluted (2-3). Temporal sediment core data showed decreased contemporary enrichment near the mainland's declining agricultural land, yet consistent enrichment along natural areas. Spatial and temporal results indicate Virginian mainland agriculture and urbanization as plausible contaminant sources, with modern regulations and declining agricultural practices diminishing contemporary metal accumulation. Elemental concentrations in fish and eDNA data will provide further insight to Chincoteague Bay's trace metal contamination.

Investigating Methodologies for Triggering an Immune Response in Leaf-footed Bugs

Lillian Burbulis
Faculty Advisor: Dr. Lauren Cirino

Animals must partition resources into life history traits resulting in tradeoffs because resources are finite. A tradeoff is the allocation of resources to one trait over another. Theory states energy is allocated in a hierarchical fashion. For example, somatic maintenance should be a higher priority than reproduction resulting in more resources being allocated to somatic maintenance compared to reproductive traits. One example of a somatic maintenance trait is an immune response which supports all upkeep of the body. Our ultimate goal is to examine how resources are partitioned throughout the body using leaf-footed cactus bugs that can trade-off resources between reproductive traits. However, we first needed to find an effective way to trigger an immune system response. We placed late-stage juveniles into two treatments: an abdomen puncture with nylon filament insertion and a thorax puncture only; tracking both of their survivorships. We found at 8 days, all leaf-footed bugs that had a nylon filament inserted into their abdomen were dead. Leaf-footed bugs that were punctured in the thorax lived longer as they are still alive, concluding that the second methodology is more effective in immune upregulation. We plan to use the second methodology for our upcoming trade-off experiment this fall.

Splitting the Bill: An Extension of the Dining Cryptographers Problem

Ashton Crawford
Faculty Advisor: Dr. Randall Helmstutler

The Dining Cryptographers Problem is a well-known problem in cryptography first considered by David Chaum in the 1980s. The solution allows one to know if a trusted member of a network has possession of a key without revealing the identity of the keyholder. While Chaum's solution to the Dining Cryptographers Problem protects the anonymity of the keyholder, it only allows for a single keyholder. In fact, Chaum's solution fails if two keyholders are permitted. Our research extends the problem to allow for two keyholders while maintaining the anonymity of all trusted members.

To allow for two keyholders, our protocol alters the original algebraic structure, changing it from addition modulo 2 to addition modulo 3. With this modification, we show that this new protocol allows for the possibility of one or two keyholders, therefore extending Chaum's original scheme. We show that for two potential keyholders, a minimum of 5 trusted group members is necessary in order to protect anonymity. When additional keyholders are permitted, the complexity of the protocol increases significantly. Future research may consider the algebraic modifications necessary to allow for more than two keyholders.

Determining the Maximum Probability Gain in the Birthday Problem

Juniper Creskoff
Faculty Advisor: Dr. Randall Helmstutler

The *birthday problem* poses the question: given a group of *n* people, how likely is it that at least two people have the same birthday? The mathematics underlying the birthday problem forms the basis for an important class of attacks in cryptography known as collision attacks. If we let *P(n)* denote the probability of a birthday match among *n* people, our project considers properties of the *gain G(n)=P(n)-P(n-1)*. The gain function measures the increase in probability of a match when one person is added to the group. Numerical experimentation shows that gain functions appear to have a unique maximum as the number of birthdays varies.

Using techniques of discrete optimization, we are able to show that each gain function possesses a unique maximum. We construct an interval of length one that determines the location of this maximum. Additionally, we use calculus to approximate the probability functions which yields approximations for the gain functions. These continuous approximations result in accurate estimates for the location of the maximum probability gain. We suggest further research to determine the aspects of these probability functions which result in the unique attributes of the associated gain functions.

Assessing Fecal Contamination in Fredericksburg Waterways: Development of a Framework for Public Awareness and Safer Recreational Practices

Garrett Driscoll
Faculty Advisor: Dr. Tyler Frankel

Fecal contamination from agricultural runoff, septic tank seepage, wastewater leakage, and other anthropogenic activities has led to increased impacts on aquatic environments. These inputs have resulted in reduced ecological health and increased illness rates from pathogenic strains of fecal coliforms. While water quality monitoring programs are prevalent across Virginia, comparably little information is available regarding the Rappahannock River and local waterways. This study explores the presence of *E. coli* and potential areas of concern in the Fredericksburg area. Surface water samples and water chemistry data (pH, temperature, salinity, electrical conductivity, dissolved oxygen (DO), total dissolved solids) were collected across 18 sites weekly over a 6-week period. Samples were mixed with Colilert-18 nutrient indicator and incubated at 35°C for 18-22 hours to assess the estimated quantity of *E. coli*. Principal component analysis was utilized to identify correlations in water chemistry parameters. The EPA *E. coli* limit recommendations utilize geometric mean (GM, 126 MPN/100 mL) and the statistical threshold value (STV, 410 MPN/ 100) to determine severity of fecal contamination. Results indicated elevated Fredericksburg canal *E. coli* levels between 127-474 MPN. Rappahannock River sites 1-2 and 5-8 displayed contamination levels above the GM limit (155-287 MPN). PCA analysis determined positive correlations between rainfall, DO, and *E. coli* and a negative correlation between temperature and *E. coli*. Collectively, these findings 1) suggest sources of contamination in several sites along Fredericksburg canal and the Rappahannock River and 2) the need for frequent monitoring of Fredericksburg waterway health to ensure safe recreational use.

MODELING INTERMEDIATE-SCALE OUTFLOW DYNAMICS OF η CARINAE

Edmund J. Garcia
Faculty Advisor: Dr. Matthew C. Fleenor

η Carinae (η Car) is a binary system, with the larger star being an extremely massive, luminous blue variable (LBV) beyond the Eddington Limit. Surrounding the η Car system, numerous multi-wavelength imaging campaigns reveal axisymmetric structures with the expanding bipolar Homunculus Nebula (<1 pc). In combination with the episodic eruptive history of the η Car system, our initial intermediate-scale imaging revealed further axisymmetric structures (1-5 pc). To gain a more expansive view of how the small scale structure connects to panoramic imaging of the η Car region, we constructed a deep, optical, narrowband mosaic of 189 images utilizing the PROMPT-6 telescope in Chile. Now with a contiguous view of the region, we utilized a bulk fluid dynamical approach with Rankine–Hugoniot jump conditions to probe the potential interconnectivity of these structures. Using a constant, strong shock condition and an angular dependence on the expansion velocity, we found that the evolved lemniscate (∞) envelope plausibly filled the observed intermediate-scale structure on a timescale of 4700 years. Given this promising first-order rendering, we have proceeded to account for second-order effects involving geometric projection, pressure and density decreases due to the expansion, energy injection, and non-ideal gas conditions. In establishing an effective model for connecting the recent history of LBV mass loss events, we look forward to investigating systems with similar intermediate structures.

Applying Climate Change Models to Improve Traditional Exposure Testing Using Adult and Embryonic Seminole Ramshorn *(Planorbella duryi*) Snails

Joseph Gasink
Faculty Advisor: Tyler Frankel

Modeling from Shared Socioeconomic Pathways (SSPs) predict temperature increases up to 5°C above preindustrial levels. For many organisms, including poikilotherms, increased heat distress may serve as a chronic stressor and impact responses to environmental contaminants. Traditional exposure methods may not accurately reflect the interaction between target contaminants and changing temperatures. This study assessed the effects of cadmium exposure on adult and embryonic Seminole ramshorn (*Planorbella duryi)* snails at temperatures based on SSP predictions. Freshly laid (<8hr post-deposit) *P. duryi (n=7)* embryonic clutches were harvested from an established adult colony, assessed for viability, and incubated at 20°C (current conditions), 23°C (SSP2), and 25°C (SSP5). Clutches were then exposed to 0, 5, 10, or 25 ug/L of cadmium ($CdCl_2$) solution using static replacement (100% every 72h) and development stage (morula, trochophora, veliger, and hippo) assessed every 48hr for 11 days. Using the same methods, adult snails (*n=6*) were exposed for 9 days and a 3 min locomotor video obtained every 72h and analyzed using Noldus Ethovision XT 17 for total distance traveled, velocity, acceleration, and body fill endpoints. Analysis of Variance (ANOVA) findings suggest that elevated temperatures coincide with faster embryonic development and adult movement, with varied stress response based on cadmium treatment. Changes in sensitivity to trace metal exposure in *P. duryi* and other aquatic invertebrates highlight the importance of temperature modifications to existing testing methods.

Improved Synthesis of the Metabolites of Di(2-ethylhexyl)Phthalate

Lily Gruss
Advisor: Dr. Davis Oldham

The lack of covalent bonding between plastic polymer chains and di(2-ethylhexyl) phthalate (DEHP), a chemical commonly found in plastic products, results in leaching of the chemical into human drinking water sources. Once ingested, metabolism via enzymes including esterase and lipase converts DEHP to mono(2-ethylhexyl) phthalate (MEHP), various further metabolites of which are then formed after interacting with alcohol and aldehyde dehydrogenases. An efficient synthetic pathway towards forming such compounds allows for further investigation into the possible effects of their presence on the body. Three different malonic ester alkylations were performed several times. Following this, decarboxylation reactions were carried out, their pure ester yields increasing consistently, from 23% to 42%. Reduction reactions were then performed using sodium borohydride ($NaBH_4$) in relative excess with a protic solvent. Both a preformed ester and a pure decarboxylation product were successfully reduced to alcohols per gas chromatography-mass spectrometry (GC-MS) data. The improvement in yields observed as well as successful ester reduction via $NaBH_4$ serve to optimize and streamline synthesis of DEHP metabolites in future research.

Marine Atmospheric Boundary Layer Lapse Rates

Elijah Harrington
Faculty Advisor: Dr. Erin E. Hackett and Matthew Fleenor

Temperature lapse rates are important because they help determine the dynamical state of the atmosphere, for example, whether it is likely to be convectively driven, or unstable, versus dynamically stable. The environmental lapse rate (ELR) indicates how the temperature changes vertically in a given environment, while the dry adiabatic lapse rate (DALR) is the rate temperature decreases with altitude due to only reduction in pressure with altitude. However, few studies have examined how much and how frequently the ELR deviates from the DALR, especially over marine surfaces. This study examines how the ELR within the marine atmospheric boundary layer, i.e., lowest ~1000 m above ocean surfaces, varies relative to the DALR. Study data from the Integrated Global Radiosonde Archive was utilized for estimating oceanic ELRs. These databases contain temperature measurements made by ship-launched radiosondes. The data were split into different oceanographic regions, guided by atmospheric wind belts, for both major ocean basins. Temperature data within the boundary layer were isolated and linear regressions were performed on the data to estimate ELRs. Goodness of linear fits were evaluated with coefficients of determination (R^2). ELR deviations from the DALR were computed and normalized by the DALR magnitude. Distributions varied by oceanic region with larger, more frequent deviations observed in the mid-latitudes and artic regions than in the tropics. Overall, the mean ELR was larger (less negative) than the DALR, which indicates that the marine atmospheric boundary layer is more frequently dynamically stable; however, specific regions may be more prone to unstable ELRs.

Statistical Analysis of the Recovery Method of Trace Explosives in Sediments

Emily Hart
Faculty Advisor: Dr. Sarah Smith

Naval bases conduct weapons testing and research over public bodies of water, potentially introducing harmful chemicals into the ecosystem. An analysis of literature revealed the lack of a universally accepted method for extraction and quantification of explosive compounds in sediments and indicated that at least two analysis techniques in parallel are necessary to accurately separate and quantify different explosives. The extraction solvent (methanol or acetonitrile) and number of extractions were optimized for the average recovery of the explosives such as TNT, 1,3-dinitrobenzene, and RDX. Methods utilizing gas chromatography mass spectrometry (GC-MS) and high performance liquid chromatography (HPLC) were developed using a standard composed of 16 known explosive compounds and an internal standard. Statistical analysis, such as a paired t test for comparing individual differences, of the recovery studies conducted using the optimized extraction method determined which instrument resulted in the greatest reproducibility for each individual explosive compound. The results showed that four compounds were best analyzed on GC-MS, six were best on HPLC, five could be analyzed by either, and one could not be quantified by either instrument.

Call For Back Up: Cisplatin Induced Immunogenic Cell Death to Delay Tumor Onset in a Preclinical Model of Triple-Negative Breast Cancer

Mohammad Ali Hassan
Faculty Advisor: Dr. Sipe

Chemotherapy is currently the only systemic treatment option for triple-negative breast cancer (TNBC) yet only provides a pathological complete response in 37% of patients. However, patients with higher levels of tumor infiltrating lymphocytes have shown an increased complete response of 48% (Denkert, 2018). This shows that the immune system plays a significant role in cancer treatment with chemotherapy. Therefore, we aim to determine a chemotherapy that can effectively recruit the immune system by signaling an immune response upon cancer cell death. In this study, we use a syngeneic orthotopic mouse model of TNBC to determine the immunogenicity of platin-based chemotherapies. TNBC cancer cells were killed with two different platin-based chemotherapies, oxaliplatin and cisplatin, and then injected into the right mammary gland of ten mice each, while ten control mice received only saline. One week later, they were challenged with live cancer cells injected into the left mammary gland. If the chemotherapy caused an immunogenic cell death, then the immune cells would be activated and kill the live cancer cells, similar to a vaccine. Evaluating the measured tumor growth over three weeks, we determined that mice injected with cisplatin treated cells had significantly delayed tumor onset when rechallenged. Contrary to cisplatin, oxaliplatin treated cells had induced no significant changes in tumor growth. In this model, we distinguish cisplatin as more immunogenic than other chemotherapies. This research provides evidence on which chemotherapies will work together with the immune system to offer a complete pathological response.

References

Denkert C et al. 2018. Tumour-infiltrating lymphocytes and prognosis in different subtypes of breast cancer: a pooled analysis of 3771 patients treated with neoadjuvant therapy. The Lancet Oncology. 2018;19(1):40–50. https://doi.org/10.1016/S1470-2045(17)30904-X

Weather Sensor Testing and Evaluation

Joseph E. Haun
Faculty Advisor: Dr. Erin E. Hackett

Air-sea interactions make temperature, humidity, and pressure vertical profiles near the ocean surface complex and dynamic; therefore, these profiles are difficult to measure and model instantaneously. Consequently, little data or information about near surface thermodynamic profiles exist. Furthermore, fouling of sensors by water or salt means that near surface weather sensors should be low cost due to frequent replacement. Recently, a buoy-based measurement platform for near surface atmospheric measurements was developed (Stanek et al., 2023). This study evaluates whether Sparv Embedded Windsonds (S1H3) can be utilized for near surface thermodynamic profile measurements on this buoy platform. These Windsonds were tested for accuracy against an industry standard - a Vaisala WXT536 weather station. In terms of accuracy, pressure measurements showed consistent agreement (100%) between the Vaisala and Windsonds, whereas relative humidity agreed nearly 90% of the time. However, temperature measurements generally disagreed during daytime tests, Windsonds having a +2 °C bias relative to the Vaisala, but were in strong agreement during nighttime tests (100%). Strong nighttime agreement suggests insufficient daytime cooling or shielding from solar radiation. In terms of operating multiple telemetered Windsonds simultaneously, a multi-sonde test demonstrated that up to seven Windsonds can operate accurately in close proximity. Overall, results suggest that with mitigation of the daytime over-heating of the Windsond sensor, such as an improved solar radiation shield, the Windsond could be used as a reliable, low-cost telemetry sensor. They could be mounted on the buoy platform to provide instantaneous profile measurements within the marine atmospheric surface layer.

The Universe Sings: An Investigation of Gravitational Wave Cosmology

Sophie Jensen
Faculty Advisor: Dr. Desmund Villalba

The stochastic gravitational wave background (GWB) is widely acknowledged to exist, but its origins remain to be precisely defined. It is proposed that the GWB is caused by cosmic domain walls, sheet-like topological defects that were theoretically created in the early universe shortly after the Big Bang. By studying the origin of the GWB, it is possible to characterize the early universe, as well as the fundamental particles of our universe. After researching current literature on the topic, numerical analysis through Mathematica was utilized to characterize the possible amplitudes of gravitational waves (GW's) caused by domain walls. A relationship between the energy density of domain walls and the vacuum expectation value of the broken symmetry was defined. Finally, constraints on the parameters, including the already observed frequencies of gravitational waves and the current energy content of our universe, restrict the predicted GW amplitudes to an upper limit of $\Omega h^2 < 10^{-21}$. Future research will include further restricting this parameter region by considering the unitary constraints on neutrino oscillations. By building a theory of the GWB's origin, there emerge testable predictions of the waves' amplitudes and frequencies, as well as possible explanations of other mysteries of the universe.

Urban-Rural Comparison of Injury-Involved Traffic Crash Risks: An Explainable Machine Learning Approach

Sarala Kennedy
Faculty Advisor: Dr. Ping Yin

Traffic crashes are a leading cause of injury and death and the risk factors contributing to crash severity can vary geographically between urban and rural settings. By understanding the risk factors that increase severity of crashes, crashes leading to injury or death can more effectively be prevented. This study compares risk factors leading to injuries or death in traffic crashes between urban and rural areas, drawing on traffic crash data from the state of Virginia from 2016 to 2024. It includes risk factors describing roadway attributes, crash attributes, environmental attributes, and driver characteristics. To determine the impact of the risk factors in urban and rural crashes, separate Random Forest models were created for the split urban and rural datasets, then the resulting models were interpreted with SHapley Additive exPlanations (SHAP) to identify the relative importance of each input attribute. The factors with the greatest influence on crash injury outcome in both datasets are collision type and road type. In urban areas, the collision type with the greatest influence on injury outcome is pedestrian collisions, while in rural areas head-on collisions have the greatest positive correlation with injury outcome. In both area types, the involvement of alcohol is the greatest influence from driver characteristics, though its influence in rural areas is greater. Generally, the top ten most influential factors are the same between the two area types, though the order and extent of impact of the factors differ. These results show the similarities and differences between crash risk factors in urban and rural areas and the importance of geography-informed crash prevention methods.

Investigation of Trinitrotoluene (TNT) Degradation in Simulated River Conditions using Design of Experiments

Marina Klein
Faculty Advisor: Dr. Sarah Smith

Military training exercises and munitions disposal frequently involve the testing and discharge of explosive materials into aquatic environments. The contamination of rivers with unexploded and residual explosives poses significant environmental concerns. Munitions commonly contain numerous nitroaromatic compounds; however, trinitrotoluene (TNT) is the focus of this study. TNT is known to degrade in water systems into more stable compounds such as 1,3,5-trinitrobenzene and 2,4-dinitrotoluene. A Design of Experiments (DOE), a statistical method, was used to determine how salinity, pH, and UV exposure impact the degradation of TNT. Simulated water samples had a salinity range of 2.0 to 7.6 ppt, pH range of 6.9 to 7.8, and high or no exposure to UV light. Ranges of variables were modeled after that of water samples collected from the Potomac River. The degradation of TNT was monitored over the course of 4 hours in 15 different simulated river conditions. Analysis of the percent recovery of TNT was performed with the use of gas chromatography- mass spectrometry (GC-MS). The DOE determined that the chosen ranges of variables did not have a statistical impact on the degradation of TNT. The investigation leaves room for future work in analyzing wider ranges of variables and the effects of different variables present in aquatic systems such as bacteria and temperature.

Effect of Size Dependent Predation on Eastern Oysters (Crassostrea virginica); Field Experiment

Chessa Lowery

Faculty Advisor: Dr. Bradley Lamphere

The eastern oyster is a commercially important shellfish species with a wide variety of predators in the Chesapeake Bay and Rappahannock river. Knowledge on size dependent predation will help understand the impacts different predators have on eastern oyster populations, while also assist in making educated decisions regarding fishing regulations in the Bay. In this experiment, eastern oysters were raised in predator exclusion cages located in the lower Rappahannock. Eighteen cages each with 100 oysters were designed to measure predation by small, medium, and large sized predators. Cage mortality and Growth were measured weekly, with 20 oysters from each cage marked for individual sampling. When exposed to large predators there was an increase in cage and individual mortality compared to both small and medium predator exposure. A nested logistic regression for individual mortality showed a decreased chance of survival when exposed to large predators, $p=0.0184$. These results indicate large predators in the Chesapeake Bay have the greatest impact on eastern oyster mortality.

Probabilistic Selection Strategies in Asynchronous Jacobi

Kaleb Lucas
Faculty Advisor: Dr. Evan Coleman

In this paper, we extend classical iterative linear solvers, specifically the Jacobi and Gauss-Seidel methods, by incorporating modern computational strategies. We implement a matrix-free solver of the Laplace Equation, $\Delta x=0$ on a two-dimensional grid, as this equation acts as a building block for many crucial problems in High Performance Computing, specifically in areas of computational physics such as heat transfer. We explore how modifications such as asynchronous processing and prioritized randomized updates impact the rate of convergence for linear solutions.

To implement asynchronous processing, we leverage OpenMP to distribute tasks across multiple cores in a system, allowing each core to operate independently without waiting for others to complete. For prioritized random updates, each core updates a random element of a matrix, with the odds of an element being picked determined by their overall contribution to the remaining error of the equation being solved iteratively. Our numerical experiments vary several algorithmic parameters, including the size of the grid, the number of processing threads, and the strength of the prioritization. Preliminary results suggest that a moderate speed-up in convergence is achievable at minimal computational overhead.

Character Displacement of Native Species and Closely Related Invasive Species

Daniel Martinez
Faculty Advisor: Dr. Bradley Lamphere

Introduced species closely related to native species prompt an important question in community ecology regarding coexistence: how do they coexist? When species share similar niches, competition can arise. *Lepomis cyanellus* and *Lepomis auritus*, two sunfish species in Virginia, both live as opportunistic generalists in streams and rivers. This study examines how the introduced *L. cyanellus* coexists with the native *L. auritus* by comparing allopatric and sympatric populations. I collected six samples from each population type (allopatric *L. cyanellus*, allopatric *L. auritus*, and sympatric) and documented their morphology and diet by photographing each fish and analyzing their stomach contents. Using R Studio, I performed a Principal Component Analysis (PCA) to discern the factors contributing to variation between populations. The morphology PCA identified three key components influencing variation: head shape (PC 1 = 63.5%), chest length (PC 2 = 19.4%), and fusiform body vs deep body (PC 3 = 16.2%). The diet PCA revealed three principal components affecting prey size variation: prey size (PC 1 = 13.8%), Insecta vs non-insecta (PC 2 = 11.4%), and PC 3 = 11.1%. Both species exhibited decreased morphological variation but still had significant overlap, which could indicate that both species are starting to undergo habitat segregation. *L. cyanellus* increased diet variation in sympatry, while *L. auritus* decreased it, suggesting that *L. auritus* may be specializing due to heightened competition for food from *L. cyanellus*. With decreased variation in both morphology and diet, coexistence with *L. cyanellus* may be pushing *L. auritus* to specialize.

Celebrities of the Microbia world: What Does it Take to be a Model Organism?

Nora McMullen
Faculty Advisor: Dr. Theresa Grana

What characteristics give an organism the term “model?” This research will aid students and new scientists in understanding the nature of organisms they are working with. The goal is to clearly explain what makes laboratories use these organisms for research by comparing the growth and ease of use of three different model bacteria. The growth rate of the bacteria will be collected from both liquid and plate cultures. For “ease of use,” questions will be used to quantify the term “ease”. Like: How easy is it to pick a colony from a plate, does it grow well with standard lab practices, is it predictable, and so on. The answers will be compared to closely related “non-model” bacteria to show why these model organisms were chosen. *Escherichia coli* (E. coli) and *Bacillus thuringiensis subsp. kurstaki* (Btk) have similar growth rates. E. coli came out to grow fastest, closely followed by Btk. M. Smegmatis mc2 155 (M. Smeg) lags behind the others. E. coli and Btk are easy to pick from plates and grow great in a normal set up. Both are predictable and perform well even in subpar situations. M. Smeg, grows significantly slower, and requires extra lab set up for it to grow at a fast pace. Picking from a plate, Smeg colonies crumble and smear, making it difficult. When compared to related bacteria, all these organisms are non-pathogenic, grow quickly, and are manipulatable. These characteristics give them their “model” status in the laboratory world.

Assessing the presence and concentration of trace metal contamination around an unlined landfill in King William County, VA

Summer Orledge
Faculty Advisor: Dr. Tyler Frankel

Municipal waste landfills commonly generate leachates during waste decomposition, which can introduce trace metal toxicants into the surrounding environment. The King William County Old Sanitary Landfill (Permit No. 153; active 1974-1994) encompasses approximately 16 acres and is flanked by Indian Town Swamp which flows northeast through the Mattaponi tribal reservation and into the Mattaponi River. Post-closure monitoring at this site was discontinued in 2022 after ground- and surface water sampling indicated minimal metal contamination. However, possible sediment contamination remains unaddressed. Therefore, this study aims to investigate the presence, concentration, and potential impacts of metals in the landfill's vicinity. Eleven surface water samples and twelve sediment samples were collected from Indian Town Swamp. Water samples were acidified to pH < 2 using 0.600 mL HNO_3 then filtered. Sediments were oven-dried, disaggregated, and sieved to 63 µm. One g sieved sediment was digested in 20 mL aqua regia ($3H_2O$:3HCl:1HNO_3) for 4h at 80°C, then filtered and diluted to 100 mL. Samples were analyzed for Al, As, B, Ca, Cd, Co, Cu, Cr, Fe, Li, Mg, Mn, Ni, Pb, V, and Zn concentrations using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Results include elevated Al, As, B, Ca, Cd, Co, Cr, Fe, Ni, Pb, V, and Zn ($p < 0.05$) in sediments near the landfill. Al, Fe, Mn, and Pb in surface waters exceeded EPA maximum contaminant levels. Collectively, findings demonstrate the need for continued monitoring at this site and indicate risks to wildlife and human health.

Improved Synthesis of Indazole-Based Sulfonamides for Use in Treating *Mycobacterium tuberculosis*

Jillian N. Pabalan
Faculty Advisor: Dr. E. Davis Oldham

Tuberculosis (TB) is a respiratory infection caused by *Mycobacterium tuberculosis* (MTB). Drug-resistant TB presents an ever-growing threat to global health, necessitating the development of new antitubercular drugs. MTB proliferation is facilitated in part by KasA, an enzyme critical to the formation of the bacterial cell wall; high-throughput screening has identified indazole-based sulfonamides as viable molecules to inhibit KasA function. Previously, only alkyl sulfonamides have been used for this purpose. We have synthesized a series of aryl sulfonamides employing a new synthetic route with the intention to improve yields from those present in the current literature basis. Accordingly, we propose a new synthetic route for the production of *N*-(1-alkyl-1H-indazol-6-yl)arylsulfonamides (where alkyl groups include methyl, ethyl, and isopropyl substituents) through the alkylation and reduction of 6-nitroindazole, with subsequent sulfonamide formation. A total of 10 out of 15 desired sulfonamides have been synthesized and purified, to later be tested in MTB viability assays.

The Role of Aggressive Vibrations in Male Combat of Red Milkweed Beetles

Autumn Pembelton
Faculty Advisor: Dr. Lauren Cirino

Herbivorous insects commonly produce vibrations across plants to exchange information. These vibrations may be produced in a variety of social and ecological contexts including during male fights. However, little is known about the role that these vibrations play during male fights. We hypothesize that the function of these vibrations made during fights communicate the fighting propensity of the male. Thus, male responses to a playback of these signals would have negative effects on vibrotaxis, fighting, and their own vibration production. To test this hypothesis, we used red milkweed beetles, which can produce vibrations during high intensity male combat, and played back one of three vibrations to a milkweed plant where we staged male fights. Each male pair received one playback signal type: a fighting vibration, a white noise vibration, or no vibrational signal (i.e., control). We recorded when males fought, vibrated themselves, and got away from the plant entirely (i.e., dropped or flew off the plant). Our results will allow us to make inferences on the information being communicated through the substrate between males. It is possible the information being signaled predicts male-male competition, and through this experiment, we endeavor to uncover the significance of vibrations during male fights.

Effects of Perfluoroundecanoic Acid (PFUnDA) Exposure on Thyroid Gene Expression in Japanese Medaka (*Oryzias Latipes*)

Ashlynn Peszko
Faculty Advisor: Dr. Dianne Baker

Per- and poly- fluoroalkyl substances (PFAS) are man-made environmental contaminants, of which many short-chain variants are known thyroid disruptors. However, less is known about the thyroid disrupting effects of long chain PFAS, such as perfluoroundecanoic acid (PFUnDA). We hypothesized that PFUnDA disrupts thyroid hormone synthesis and signaling during development. To test this hypothesis, we exposed Japanese medaka (*Oryzias latipes*) to PFUnDA and measured transcripts of genes encoding factors essential in thyroid hormone function. Pools of embryos were exposed through the 10-day embryonic period to 0 µg/mL (control), 0.01 µg/mL, or 0.1 µg/mL (nine replicate pools per treatment). RNA was extracted from each homogenized pool of 7 embryos, and cDNA was synthesized from each RNA sample. qRT-PCR was used to measure RNA transcript levels of the genes encoding thyroid stimulating hormone subunit β, deiodinase 1 (DIO1), deiodinase 2, sodium-iodide symporter, thyroglobulin, and thyroid hormone receptor β. These genes were normalized to transcript levels of the housekeeping gene elongation factor 1 alpha. Mean relative transcript levels of each gene were compared among treatment groups using Kruskal-Wallis tests. We found that DIO1 transcript levels increased nearly two-fold after embryonic exposure to 0.1 µg/mL PFUnDA, compared to control and low-concentration exposures ($p < 0.01$). Transcript levels of all other genes did not significantly differ among treatment groups. While this study provides some evidence supporting the hypothesis that PFUnDA can disrupt the thyroid system, more studies are needed.

Molecular Madness: Cloning Arabidopsis and Bacteriophage Genes for Genetic Characterization.

Aiddah Rotich
Faculty advisor: Dr. Theresa Grana

Gene cloning involves creating multiple identical copies of cells embedded with foreign DNA for the purpose of further studying gene function or altering the genes. Plasmids in bacteria cells act as vessels for the foreign DNA once they are cut open using restriction digest enzymes. To produce genetic recombinant plasmids containing genes from the bacteriophage Larva or the *seuss* gene from *Arabidopsis thaliana*, selected DNA regions were amplified by Polymerase Chain Reaction (PCR) and their sizes confirmed using Gel Electrophoresis. Larva genes were inserted into the pExTra01 plasmid, using Gibson isothermal assembly cloning, while *seuss* amplicons were inserted into the pGEM-T Easy plasmid using T4 ligase. Each plasmid was transformed into NEB 5-alpha F'*Iq E. coli* strain. Plasmids with Larva genes were plated on LB plates supplemented with an antibiotic while those with *seuss* genes were plated on IPTG/X-Gal plates to distinguish which colonies had the recombinant plasmids. Cultures of recombinant colonies were further amplified for future characterization and generation of glycerol stocks. Overall, both cloning methods were excellent and efficient ways of generating clones. The recombinants with Larva genes will be used to conduct phenotypic assays to determine whether gene products are harmful to the growth of the *M. smegmatis* bacteria and can prevent invasion of other phages into the cells. Recombinants with *Arabidopsis* genes were used in the UMW Summer Enrichment Program to explore common molecular biology processes: Polymerase Chain Reaction (PCR), Restriction Digest, and Gel Electrophoresis.

Waking up the body's defenses: Which chemotherapy signals for the immune system to fight breast cancer?

Sofia Szczepankiewicz
Faculty Advisor: Dr. Laura Sipe

Investigating new ways to reduce tumor recurrence is crucial in triple negative breast cancer (TNBC), as patients with this subtype are up to 2.6 times more likely to experience recurrence compared to patients with other breast cancers [1]. One way to prevent tumor recurrence is by engaging the immune system, enabling it to recognize and exterminate cancer cells that would cause recurrence. This work aims to determine the immunogenicity of cell death caused by platin-based chemotherapies, oxaliplatin and cisplatin, in the EO771 murine TNBC line using in vitro and in vivo methods. In cell culture plates, we identifiy damage associated molecular patterns as evidence of immunogenic cell death (ICD), including membrane expression of annexin V and ATP release after treatment with chemotherapy. We found that oxaliplatin and cisplatin treatment increased expression of annexin V on the cellular membrane, with only the cisplatin treatment significant compared to the control treatment. Yet, only oxaliplatin, not cisplatin, significantly increased ATP release compared to control. We also conducted a a syngeneic orthotopic model in living C57BL/6 mice, a “vaccine-like” measure for ICD. EO771 cells were first killed with chemotherapy in vitro, then injected into the right mammary gland of a mouse. After one week, the mice were challenged with an injection of living EO771 cells into the left mammary gland. We reveal that in mice, injection with cisplatin-treated cells significantly delayed tumor recurrence compared to injection with oxaliplatin-treated cells. While these results are significant, we determine that there is no significant difference in tumor volume between treatment groups at three weeks of growth. Overall, we conclude that E0771 cells with cisplatin treatment promote a slight immunogenic response. This is the first time that this ICD vaccine experiment has been done in this model, and we offer great insight to future directions and optimization. Engaging the immune system with chemotherapy is an important treatment strategy to improve recurrence outcomes for patients with TNBC.

[1] Dent, R., Trudeau, M., Pritchard, K. I., Hanna, W. M., Kahn, H. K., Sawka, C. A., Lickley, L. A., Rawlinson, E., Sun, P., & Narod, S. A. (2007). Triple-negative breast cancer: clinical features and patterns of recurrence. *Clinical cancer research : an official journal of the American Association for Cancer Research*, *13*(15 Pt 1), 4429–4434. https://doi.org/10.1158/1078-0432.CCR-06-3045

Mutual Information as a Measure of Association; Applications on Florida Lakes

Delaney Thomas
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The purpose of this project was to research how Mutual Information (MI) can be used as a measure of association. Mutual information measures the amount of information one variable contains about another variable. Alternate measures of association are useful when working with nonlinear associations. This is useful because not all association measures are appropriate for every type of association. Research was conducted by calculating a variety of measures of association on simulated data and on data for several Lakes in Florida. The goal was to determine what measure would be best for different types of associations. The results for the lake data suggest that when the association is linear, the value of MI is similar to Pearson's correlation coefficient, r. However, when the association is not linear, the value of MI is less impacted by the degree of curvature. It can then be concluded that MI is a better method of association measure for any variable relationship including linear, nonlinear, monotonic, and non-monotonic relationships.

SPATIAL, TEMPORAL AND ECOLOGICAL IMPACT ANALYSIS OF TRACE METAL ENRICHMENT IN A CENTRAL APPALACHIAN COAL MINING WATERSHED

Eric Torres
Faculty Advisor: Dr. Ben Odhiambo Kisila

This study investigates the spatial distribution of toxic trace metal in the Levisa Fork and its primary tributaries across Buchanan County, VA, and Pike County, KY; regions with extensive coal mining histories. Coal mining is known to mobilize trace metals into surrounding waterways. Pike County reports elevated cancer rates and both counties report elevated disability rates, suggesting potential public health burdens. To assess trace metal exposure, we analyzed sediment, surface water, and groundwater samples using inductively coupled plasma–optical emission spectrometry (ICP-OES) for As, Al, Cr, Cd, Cu, Fe, Li, Mg, Mn, Ni, Pb, and Zn. Standard curves showed R^2 values of .998 to 1.000 for all elements indicating high analytical fidelity. Environmental DNA sampling was also conducted to evaluate aquatic biodiversity. Results indicate widespread anthropogenic enrichment in all elements, ranging from enrichment factors of 1.85 to 48.37. As, Cd, Cu, Mg, Ni, and Zn were particularly enriched with the highest sediment enrichments found at downstream river bends and near the town of Grundy. Manganese in surface water was strongly correlated with proximity to slurry impoundments. Groundwater sampling indicated concerning levels of As (5.44ppb), Mn (1,319.23ppb), and Pb (11.31ppb); which suggests increased risk for residents using well water. Many sites showed Ecological Risk Factors above 40 for As and Pb, indicating moderate ecological risk; several exceeded 80, indicating considerable risk in relation to these elements. These findings suggest the anthropogenic redistribution of trace metals may be contributing to an increased public and environmental health risk.

Developing a Method to Analyze the Effect of Proton Pump Inhibitors on Cancer Cells

Francisco Trujillo
Faculty Advisor: Dr. Randall Reif

Cancer cells are known to acidify their tumor microenvironment by excessively utilizing proton pumps because of their rapid metabolism. Cancer cells rely on proton pumps to regulate inner pH levels. Thus, by inhibiting the functionality of proton pumps, apoptosis may be induced. Dexlansoprazole is a proton pump inhibitor (PPI) medication used to treat patients with gastric ulcers and heartburn. A method to evaluate the toxicity of dexlansoprazole on Jurkat T-lymphocytes (Jurkat cells) was developed using fluorescent dyes, calcein-AM (Cal-AM) and propidium iodide (PI), in order to measure the viability of the Jurkat cells. Fluorescence microscopy was utilized to identify the presence of Cal-AM and PI in the cells, determining their status as alive or dead, respectively. In addition, doxorubicin, a commonly used chemotherapeutic drug, ethanol fixation, and a solvent-only sample were used as controls to validate these methods. It was established that the methods used to evaluate the effect of dexlansoprazole on Jurkat cells were valid as the control groups provided their respective expected results. Additionally, it was determined that dexlansoprazole is toxic to Jurkat cells, as the cell population had a survival rate of 1.3 ±0.9 % when exposed to 100 μM of the drug over a 48-hour period.

Storage Optimization and the Functional Assessment of Oryzias latipes (Japanese Rice Fish) Spermatozoa

Jamie Volk

Faculty Advisor: Dr. Dianne Baker

The Japanese rice fish (Oryzias latipes), also known as medaka, is an emerging model in vertebrate toxicology. Understanding the effects of toxins on sperm quality, namely motility, is crucial in the assessment of male reproductive health and fertility. Therefore, to utilize this species as a model fish, a reliable protocol for medaka sperm storage is required. Previous research found that zebrafish sperm retain motility after storage in L-15 medium supplemented with glucose, fetal bovine serum (FBS), bovine serum albumin, and penicillin-streptomycin. However, research in our lab has found that medaka sperm become inviable in this medium within two days. To extend viability, I sought to improve the medium by independently testing the effect of FBS, and by also determining the optimal osmolality. Dissected testis samples were stored under four conditions: 300mOsm/kg (±3% FBS) and 600mOsm/kg (±3% FBS). Sperm function was assessed using Computer-Assisted Sperm Analysis (CASA), measuring both motility and progressive movement. After 24 hours of incubation, sperm stored in 300mOsm/kg medium better retained motility and progressivity compared to those in 600mOsm/kg medium (Tukey's HSD: motility $p=0.039$; progressivity $p=0.015$). However, between 24-48 hours, the effect of osmolality was no longer evident. Instead, the presence of FBS significantly enhanced both motility ($p=0.0064$) and progressivity ($p=0.015$) regardless of osmolality. Among the four conditions, the 300mOsm/kg +FBS treatment most effectively minimized total and progressive motility decline over the two-day period. This work provides a foundation for improving medaka sperm handling protocols, expanding the utility of this species in toxicological research.

Machine Learning for Block Preconditioners

Kassandra Williams
Faculty Advisor: Dr. Evan Coleman

Generating effective preconditioners for solving large sparse linear systems is often a difficult and computationally expensive task. The performance of Krylov-subspace methods is heavily reliant on the quality of its preconditioner. In this study we focus on the block Jacobi preconditioner in particular, aiming to improve the speed of convergence with the use of a convolutional neural network (CNN) to predict optimal block sizes for the preconditioner. The model is trained on artificially generated matrices. The matrices are generated to mimic the structure of real scenarios, such as the matrices that arise from problems in computational physics. In addition, the model can accurately predict the optimal block size to use in the block Jacobi preconditioner. Our preliminary results show that the CNN has the potential to accurately match the labels of our synthetic data and speed up GMRES convergence.