



# 10<sup>TH</sup> ANNUAL RESEARCH SYMPOSIUM 2023



UNIVERSITY OF  
**DETROIT  
MERCY**



## COMPARING TRADITIONAL AND DEEP LEARNING APPROACHES IN DEVELOPING CHESS AI ENGINES

Bassam Abdelghani and Jamal Dar

Research Advisor: Shadi Banitaan

Artificial intelligence (AI) has a long and storied history with chess, dating back to the early days of AI research. Chess engines have served as a crucial benchmark to evaluate the progress of AI algorithms, as chess is a complex game with many possible moves and strategies. In this paper, we contribute to chess AI's ongoing advancements by presenting two chess engines. The first engine leverages conventional AI methodologies, including Alpha-Beta Pruning, Quiescence Search, and sophisticated Move Ordering techniques, to construct a formidable and competitive chess engine possessing an efficacious evaluation function. In contrast, the second engine employs a simplified Alpha-Beta Pruning algorithm with a deep learning model, specifically an artificial neural network, which functions as a feature extraction mechanism for identifying optimal moves. We evaluate the performance of both engines against the renowned Stockfish engine, with the traditional engine attaining an ELO rating of 2200. At the same time, the deep learning model secures an ELO rating of 1900.



## INTERACTIVE WEB APPLICATION FOR KIDS: BOOSTING HAND-EYE COORDINATION AND SPARKING IMAGINATION

Omaran Bazna, Enea Cenolli, and Rahul Oad

Research Advisor: Shadi Banitaan

The goal of this abstract is to build an artificial intelligence application for kids aged three to five that will help them improve their hand-eye coordination and allow for better expression of their imagination and emotions. As many young kids these days are spending too much time using electronic devices like phones, tablets, and computers, we learn that this adverse effect on their development of fundamental skills like hand-eye coordination and engaging their imagination. Therefore, to help kids develop these skills and make engaging use of screen time (time spent using electronic devices) given to kids, we propose to develop a web application that kids can use. Our project contains two main user functionalities that utilize AI technology to implement hand detection, facial recognition, and recognize user hand-drawn shapes.



## ATEQ CUSTOMER SERVICE CHATBOT

Grace Hanna, Nathan Boyar, and Nathan Garay

Research Advisor: Shadi Banitaan

This project discusses the development of a chatbot for ATEQ TPMS, a multinational automotive aftermarket company. The purpose of this chatbot is to address questions that customers have that may not necessarily require human interaction. In addition to aiding customers, it alleviates traffic from the company's customer support department. The chatbot was developed using the ES version of Google's Dialogflow AI platform. We break down the basic structure of implementing an agent who is informed on intents and trained on how to respond. We also discuss the use of contexts and parameters in relation to specific questions that the chatbot may be asked.



## EMPIRICAL EVALUATION OF CLASSIFICATION MODELS FOR DEFECT PREDICTION

Rami Naama and Raya Naama

Research Advisor: Shadi Banitaan

Developing high-quality software is a difficult task, especially considering the scale and complexity of modern software. Accurate defect prediction is a critical process in software development, as it enables early identification of potential defects in software systems. This early detection helps improve software quality and reduce costs associated with defects later on. So, many statistical and machine learning techniques are used to predict quality classes in software. In this work, five machine learning classifiers have been used (Naive Bayes, BayesNet, J48, SMO, and Random Forest) to find the best model with the highest Precision, Recall, and F-Measure for the dataset contains 10,885 instances with 21 attributes, the results indicated the Random Forest classifier turn out to be the best one amongst the classifiers used. Three ranking techniques have been applied (infoGain, GainRatio, and CfsSubsetEval) to the Random Forest Model, comparing the f- score measure among different models and finding the relationships between the subset features and the ranking techniques. The study also identified the most critical attributes affecting software defect prediction.



## EXPLORING PREDICTIVE FACTORS FOR ACADEMIC SUCCESS: A MACHINE LEARNING APPROACH

Ricardo Tapia Vargas

Research Advisor: Shadi Banitaan

In academic settings, a recurring challenge is understanding the factors influencing students' end-of-term performance. These factors include scholarships, study time, age, and parental occupation. We aim to employ machine learning to examine data across three categories: personal, family, and education. Utilizing machine learning techniques, we seek to uncover correlations within these categories and their impact on students' academic performance, ultimately predicting their end-of-term results. Using machine learning for performance prediction, we can identify students at risk of academic failure. We leverage the "Higher Education Students Performance Evaluation" dataset from the UC Irvine Machine Learning Repository for our analysis. Several classification methods will be employed, including J48, Naïve Bayes, and random forest. Our research uses machine learning to identify factors influencing student performance, facilitating predictions of end-of-term performance. This research sheds light on the intricate relationships between academic performance and various determinants, offering valuable insights for educators and policymakers striving to improve educational outcomes.



## ENHANCING PEDESTRIAN GROUP DETECTION AND TRACKING THROUGH ZONE-BASED CLUSTERING

Mingzuoyang Chen

Research Advisors: Shadi Banitaan and Mina Maleki

Advancements in self-driving car technology have the potential to revolutionize transportation by enhancing safety, efficiency, and accessibility. Nonetheless, the successful integration of autonomous vehicles into our urban landscapes necessitates robust and reliable pedestrian detection and tracking systems. As we frequently observe pedestrians moving together, tracking them as a group becomes a beneficial approach, mitigating occlusion and enhancing both the accuracy and speed of object detection and tracking. However, utilizing a human-view camera in an autonomous vehicle presents challenges as pedestrians occupy varied fields of view. In some instances, pedestrians closer to the camera may overlap with those farther away, as seen from the camera's viewpoint, which causes the mis-groupings to happen. To address these challenges, we proposed a strategy to divide the image into distinct zones and perform grouping within each, significantly minimizing mis-groupings. First, an object detection method was utilized to extract pedestrians and their bounding boxes from an image. Second, zone detection was applied to separate the image into several zones. Third, clustering methods were applied to detect pedestrian groups within each zone. Last, the object tracking method was utilized to track pedestrian groups. We repeated the process over a ten-frame sequence to achieve better performance, with object detection executed in the first frame and object tracking in the remaining nine frames. The comparison of processing times of different group detection methods indicated that tracking pedestrian groups is more time-efficient than tracking individuals and achieved a 4.5\% to 14.1\% improvement. Furthermore, according to the Adjusted Rand Index (ARI) evaluation metric, our proposed zone-based group detection method outperforms the other commonly used approaches by achieving scores of 0.635 on the MOT17 dataset and 0.781 on the KITTI dataset. In addition, the proposed approach surpasses the other approaches in addressing scenarios where individuals from different fields of view intersect with each other.



## REAL-TIME INDOOR LOCALIZATION USING FINGERPRINTING AND MACHINE LEARNING APPROACHES

Daniel Marku and Benyamain Yacoob

Research Advisors: Shadi Banitaan and Mina Maleki

Indoor positioning is becoming increasingly important, offering location-based services such as energy efficiency and emergency response. Among the various methods, the fingerprint-based indoor localization method using Wi-Fi access point (AP) data stands out for its remarkable accuracy and minimal hardware requirements, making it one of the promising techniques in this domain. In this research, we developed a real-time location system (RTLS) using fingerprinting and machine learning approaches. First, we collect received signal strength (RSS) values from APs within the building, which are then reformatted to form the fingerprints table. The fingerprints table contains relevant information from each fingerprint point including the location coordinates (x, y), floor information, and the respective RSS values from different APs. Then, the fingerprint data is fed into the K-Nearest Neighbors (KNN) classifier to build the machine learning model. This model is used to estimate the location of a user on the map in real-time. The assessment of KNN resulted in a Mean Squared Error (MSE) score of 0.43 along with a coefficient of determination ( $R^2$ ) score of 0.95. An Android mobile application was developed to utilize our method, enabling users to visually pinpoint their location within the building. The mobile application process involves loading previously collected AP data and fingerprint data followed by conducting Wi-Fi scans for localization. These scans then serve as input for the embedded machine learning model, which predicts the user's location, outputting their (x, y) coordinates and respective floor onto the building map.





**FREE-CONVECTION ELECTRONICS COOLING: EXPERIMENTAL  
COMPARISON OF COPPER-AND ALUMINUM-FOAM HEAT SINKS**

Hannah Klatzke

Research Advisor: Nihad Dukhan

Metal foams are highly-porous, solid, sponge-like materials typically made from aluminum and copper. These foams are very efficient heat exchange media since they have high thermal conductivity and huge surface area in per unit volume ( $1715 \text{ m}^2/\text{m}^3$  for the current foam). In this work, two metal-foam heat sinks are compared. One of them is made from copper and the other from aluminum. The dimensions of the two heat sinks were identical 110 mm x 109 mm x 20 mm. The other properties were kept as close as possible: the number of pores per inch for copper and aluminum was 20. The porosity of the aluminum foam was 77.7 % and that of the copper was 78 %. Each of them was connected by thermal epoxy to a 2 mm thick aluminum base plate. The purpose of the work was to compare the performance of the two materials when subjected to constant heat flux of  $1218 \text{ W/m}^2$  and naturally cooled by room air. Results showed that the base temperature for both the heat sinks was very close with a difference of less than 1.9 %. This suggests that no added cooling advantage is realized by employing copper for such a low-heat-flux application; aluminum foam can achieve comparable cooling for less money (72 % savings) and less weight (69.7 % savings). Aluminum metal foam blocks may become more prevalent as heat sinks for future sensors, electronic modules, and batteries of electric vehicles.



## LIBRARY INTELLIGENT ROBOT

Amna Mazen, Wenting Wei, Daojun Teng, and Weiming Chen

Research Advisor: Mariam Faied

The Library Intelligent Robot is an integrated system designed to offer a range of services, including consultation, book retrieval, and reader navigation within the library environment. This technology addresses the challenges students face when locating books in a complex library setting. Within the scope of this project, we have developed a Library Robot capable of assisting students with borrowing and returning books.

The robot employs facial recognition technology to identify and greet readers as they enter its field of view. For those seeking to borrow books, the robot utilizes a face recognition algorithm to identify the reader and inquire about the books they wish to borrow. Subsequently, the robot accesses a database to ascertain the precise locations of the requested books within the library. It then guides the reader to the shortest path. Upon completing this task, the robot returns to its initial position within the library. For readers returning books, a simple process is facilitated by scanning the QR code on the book cover in front of the camera.

In addition to the physical robot, we have also created an interactive library web page. This web page features separate login interfaces for students and administrators, providing access to essential library information and services.



## NAVIGATING COMPLEXITY: ABSTRACTION AND HIERARCHICAL PLANNING IN MULTI-ROBOT SYSTEMS

Eyiara Oladipo and Juliana Nogueira Vilela

Research Advisor: Richard Hill

Multi-robot systems (MRS) are a field of robotics that involves the coordination of multiple agents to achieve a common goal. MRS have many applications, such as search and rescue, large-scale delivery, and disaster management. Yet, the synchronization of such multi-agent systems can become exponentially complex as the number of robots, tasks, and constraints increases. This research seeks to improve the planning efficiency and scalability of MRS by expanding on Supervisory Control Theory (SCT) to introduce abstraction and hierarchy. By developing and implementing a new class of formal abstraction, this research aims to simplify complex problem modeling, reduce search space dimensions, and improve planning efficiency while maintaining plan quality. This new approach can also be applied to other planning problems, offering opportunities for future research endeavors.



## WHEELED MOBILE ROBOT MODELING FOR LOCAL NAVIGATION USING SYSTEM IDENTIFICATION

Cheng-Lung Lee

Research Advisors: Mohan Krishnan and Mark Paulik

In this work we investigate wheeled mobile robot (WMR) kinodynamic modeling using system identification techniques. The larger context is the development of a novel local navigation algorithm based on long kinodynamic trajectories which account for vehicle drivability. A high-fidelity physics-based differential-drive robot model is used to generate command velocity and ground truth data sets, which are subsequently analyzed using multiple system identification models. Parametric linear ARX and ARMAX models are considered. Experimental results using multiple training and validation data sets corresponding to different driving scenarios and vehicle loading are explored. The resulting model-generated WMR paths demonstrate excellent performance.



## OCCUPANCY PREDICTION: A COMPARATIVE STUDY OF STATIC AND MOTIF TIME SERIES FEATURES USING WIFI SYSLOG DATA

Bassam Abdelghani, Ahlam Al Mohammad, and Jamal Dari

Research Advisors: Mina Maleki and Shadi Banitaan

The prediction of occupancy is an ongoing research area, using various methods and data sources to enhance the accuracy of predictions and improve energy efficiency in buildings. Accurate occupancy prediction is key for optimizing energy use, ensuring comfort for occupants, and improving building management. As the demand for intelligent building management systems grows, the need for robust and accurate occupancy prediction models becomes more critical. This study aims to predict building occupancy using WiFi Syslog files from two different datasets: an open-source dataset from the University of Massachusetts Dartmouth and a new locally collected dataset from the University of Detroit Mercy's dental school. We extracted two types of features, static and MOTIF time series, from the datasets to compare their performance in occupancy prediction. The first step of our proposed framework was to select the best duration for comparing occupancy prediction performance across different datasets. We found that handling it every semester is optimal. The next step involved applying various regression algorithms, including random forest, LightGBM, and advanced ensemble techniques like stacking and blending, to evaluate the model's performance. The Stacking Regressor performs well for static features across both datasets, with a Coefficient of Determination ( $R^2$ ) value of 0.9540 in the first and 0.9482 in the second datasets. However, for MOTIF features, the best algorithm varies between datasets, with all algorithms showing similar performance in the first dataset ( $R^2 \approx 0.956$ ) and the LightGBM and Stacking Regressor algorithms outperforming the others in the second dataset ( $R^2 \approx 0.531$ ).



## ENHANCING THE UNIVERSITY OF DETROIT MERCY FACULTY REIMBURSEMENT MANAGEMENT SYSTEM

Eyiara Oladipo, Andre Price, Ethan Scheys, and Benyamain Yacoob

Research Advisor: Mina Maleki

The reimbursement system project at Detroit Mercy's College of Engineering and Science seeks to simplify and improve the reimbursement process for faculty members within the college. Prior to the implementation of the computerized system, faculty members had to keep track of their expenses and initiate reimbursement claims by sending emails to designated personnel. This manual process involved attaching receipts and FOAPA documentation to the emails. This new web-based system provides a user-friendly platform that lets faculty easily create, manage, and submit reimbursement requests efficiently. It also assists in the tracking of expenses related to academic activities and events. Built on a solid technical foundation, the system utilizes modern frameworks such as Vue.js, Node.js, and MongoDB to provide a seamless and secure experience.



## PERFORMANCE EVALUATION OF SECURE DATA DISSEMINATION IN INTER-VEHICLE NETWORKS

Samar Bayan

Research Advisor: Utayba Mohammad

In the past decade, Vehicular Communication (VC) has been a main subject of research in the Intelligent Transportation Systems (ITSs); particularly, with many emerging communication technologies such as DSRC and cellular networks. Through the exchange of messages in a timely manner, these networks are anticipated to improve ITS functionality and driving experience on roads. Several dissemination algorithms have been created in order to achieve high accuracy and efficiency while minimizing redundant transmissions in VC networks. However, recent cyberattacks on automobiles have introduced cybersecurity as a new dimension in the performance of dissemination protocols. In this paper, delay-based, probability-based, and flooding-based dissemination algorithms are compared in terms of performance then evaluated against different types of cyberattacks using NS-3 and SUMO. According to the results, delay-based dissemination performs better than probability- and flooding-based dissemination in terms of network load, and hop count, for single and multiple packet transmissions. However, probability-based dissemination had superior performance over the delay-based dissemination by around 60\% in terms of end-to-end delay. From security perspective, flooding, delay-, and probability-based algorithms had no defense against message falsification and Denial of Service (DoS) attacks, due to the lack of a content verification procedures. Yet, in position falsification attack, the number of relay nodes increased by 70\% and the network load increased by 62.2\% in both DBD and PBD.



## SYNTHESIS AND CHARACTERIZATION OF FERROCENE AMIDES USING COUPLING AGENTS AS POTENTIAL ANTI-CANCER DRUGS

Allyson Doslak, Salman Fahim, and Karisha Mehta

Research Advisor: Marwa Abdel Latif

Ferrocene amides are crucial organic molecules in the biochemical field due to their versatile applications as anti-cancer, anti-malarial, and anti-fungal drugs. (citation) The ferrocene moiety is reported to have high stability due to metal binding, and low toxicity, low cost, reversible redox and catalytic abilities. Additionally, ferrocene amides are efficient in selective structural modification and interactions with other biological molecules. Conventional synthetic methods of ferrocene amides require the use of ferrocenoyl chlorides, which are expensive, unstable in open atmosphere with associated health hazards. This work investigates alternative syntheses and associated purification and characterization for ferrocene amides that are cheaper, more efficient, and more stable in open atmosphere using a series of combinations of coupling agents dicyclohexylcarbodiimide (DCC), benzotriazole (HBT), and hydroxybenzotriazole (HOBt)). Results from chromatography including column chromatography, thin-layer chromatography, and gas chromatography-mass spectroscopy will be presented.





## ASSESSING THE GENETIC DIVERSITY OF THE NORTHERN SCARLET MACAW USING MITOCHONDRIAL AND NUCLEAR DNA

Juliannie Herrera

Research Advisor: Stokes Baker

The northern scarlet macaw, *Ara macao cyanoptera*, is found in the rainforests of Belize and Guatemala. The northern scarlet macaw is critically endangered with only a small population of approximately 250 birds. Currently, an in situ mating program in the Chiquibul Forest Reserve is being implemented by a Belizean non-governmental organization, Friends of Conservation and Development. Genomic DNA from the calamus of macaw feathers have been extracted and amplified using Sanger sequencing. The mitochondrial D-loop DNA sequences of 10 feather samples exhibited polymorphism in 8 samples. The preliminary results indicate that genetic diversity is being maintained in the population. Further research will aim to sequence more feather samples to support this conclusion. A PCR-based assay will be used to determine the sex of the birds providing feather samples. Additionally, microsatellite analysis of the nuclear DNA sequences will be conducted to examine nuclear genetic diversity.



## IDENTIFICATION OF THE BACTERIA INVOLVED WITH NUTRIENT SEQUESTRATION BY SPIRODELA POLYRHIZA

Yongseon Seo and Jungbin Yoon

Research Advisor: Stokes Baker

Duckweed, a floating aquatic plant, is significant due to its ecological importance as a primary food source for wildlife and use in industrial applications, such as tertiary sewage treatment. Among the essential nutrients for aquatic plants, phosphorous stands out as a limiting factor for the growth of producers. Understanding how aquatic plants (e.g., duckweed) absorb nutrients, is crucial for using duckweed in sustainable industrial practices. Prior studies have revealed that Rhizobium-like bacteria tend to accumulate preferentially on giant duckweed (*Spirodela polyrhiza*) in Lake Saint Clair. Rhizobium species are renowned for forming mutualistic relationships with terrestrial plants and their ability to demineralize phosphorous. The research aims to investigate the relationship between aquatic plants (duckweed) and Rhizobium and to elucidate its potential role in enhancing nutrient absorption, particularly phosphorous.

To test the hypothesis, putative Rhizobium isolates were obtained from Lake Saint Clair. To confirm the identity of the bacteria, the sequence of the 12S rRNA encoding loci will be determined. Subsequently, these Rhizobium strains will be co-cultivated with axenic cultures of giant duckweed in controlled laboratory conditions will be conducted to assess its role in nutrient absorption.

Understanding how Duckweed and similar aquatic plants utilize Rhizobium for nutrient uptake can contribute to a deeper understanding of conservation efforts, wastewater treatment processes, and potentially lead to innovative strategies for environmental management and industrial sustainability.



## COMPARING OWNERSHIP OF AGRICULTURAL ANIMALS IN MACOMB COUNTY AND GENESEE COUNTY, MICHIGAN

Jannath Aurfan

Research Advisor: Amy Bauer

Urban agriculture is a vital movement worldwide. There is an increase in cultivation of both plant and animal species within or adjacent to cities. Different animal species can impact the urban lifestyle in multiple ways – as sources of food, products for sale, or fertilizer. The integration of agricultural species into the urban ecosystem creates the risk of introducing zoonotic diseases, diseases transmitted between vertebrate species and humans. The focus of this research is to examine trends in agricultural animal ownership in Macomb and Genesee counties in Michigan, to better understand which zoonotic diseases have the potential for affecting the people living in these counties.

Data on agricultural animal ownership came from the National Agricultural Statistics Service (NASS) Census of Agriculture. The data gathered focused on the 2002, 2007, 2012, and 2017 censuses. The proportion of premises in each county reporting the presence of each of 12 species or species groups was calculated for each census year and compared between 2002 and 2017. Statistically significant changes in the proportion of ownership between 2002 and 2017 for each county, and between the two counties in 2017 were determined by use of Pearson's chi-square test using SPSS statistical software.

In Macomb County, the only statistically significant increase in the proportion of farms reporting ownership of agricultural species between 2002 and 2017 was for camelids ( $p < 0.001$ ) from 0.9% to 1.5%. However, in 2017 10.9% of participating farms in Macomb county reported owning poultry, 14.6% reported owning cattle, and 24.5% reported owning equids (horses, donkeys, or mules). In Genesee county, there was a statistically significant increase in the proportion of farms reporting ownership of poultry ( $p = 0.007$ ) from 12.7% to 17.2%. As with Macomb county, although there were not statistically significant increases when compared to 2002, 21.9% of premises in Genesee county reported owning cattle in 2017 and 33.0% reported owning equids.

While there were few statistically significant increases in the species investigated in this study between 2002 and 2017 in either county, this does not mean that zoonotic disease risks from these species should be considered negligible. Future research on zoonotic disease risks to the human populations of Macomb and Genesee counties should focus on diseases associated with poultry, cattle and equids. In future, survey data taken at the local level will help to clarify if the county-level trends are reflected at a finer geographical scale within the counties of interest.



## AGRICULTURAL ANIMAL OWNERSHIP IN MICHIGAN'S MOST URBAN COUNTIES: AN EXPLORATORY ASSESSMENT

Courtney Marsh

Research Advisor: Amy Bauer

Zoonotic diseases are caused by the spread of pathogens between vertebrate animals and humans. Zoonotic diseases pose significant worldwide public health concerns because of the close connection between humans and animals. To help plan zoonotic disease prevention strategies in urban environments, researchers must understand the relationship between the presence of agricultural animal species and the human population in these environments. This research study was conducted to determine the prevalence and trends in ownership of certain agricultural animal species within the two most populated counties of Michigan: Oakland County and Wayne County.

The data used for this study came from the National Agricultural Statistics Service (NASS) Census of Agriculture from the years 2002, 2007, 2012, and 2017. The proportion of premises in each county reporting the presence of each of 10 species or species groups was calculated for each year. Statistically significant changes in the proportion of ownership of each species between 2002 and 2017 for each county, and between the two counties in 2017 were determined by use of Pearson's chi-square test in SPSS statistical software.

There were statistically significant increases in the proportions of Oakland County premises that reported ownership of poultry ( $p < 0.001$ ), camelids ( $p = 0.035$ ), and hogs ( $p = 0.014$ ) between 2002 and 2017. Although there were no statistically significant changes in the proportion of premises owning cattle between 2002 and 2017, 10% of the premises in Oakland County reported ownership of cattle or calves. In Wayne County, there were statistically significant increases in the proportion of premises reporting ownership of sheep ( $p < 0.001$ ), goats ( $p < 0.001$ ), and poultry ( $p = 0.005$ ) between the years 2002 and 2017. Although there were no statistically significant changes in the proportion of premises owning cattle between 2002 and 2017, 11.7% of the premises in Wayne County reported ownership of cattle or calves.

While Oakland and Wayne counties have the densest human populations in the state of Michigan, agricultural animal ownership is not uncommon in these counties. People living in Oakland County are potentially at risk of exposure to zoonotic diseases associated with poultry, cattle, camelids and hogs. People living in Wayne County are potentially at risk of exposure to zoonotic diseases associated with poultry, cattle, and small ruminants. In the future, researchers should investigate the differences in zoonotic risks of animal agriculture in these counties, as well as the role that human demographics such as race, income, and education may play in access to information about zoonotic diseases in urban premises.



## SYNTHESIS AND FATE OF 2' AND 5' RADICAL PRECURSORS OF URIDINE

Abdoeldame Obeid and Dylan Sygit

Research Advisors: Mel Bedi and Amanda Bryantt-Friedrich

Post-transcriptional modifications such as pseudouridine and 2'-O-Methylation have been shown to provide chemical stability to RNA. Pseudouridine lends a strong sugar-to-base C-C bond to the nucleotide conferring more resistance to hydrolysis compared to the unmodified glycosidic bond and provides additional hydrogen bonding opportunities which contribute to the overall stability of the RNA. The lower reactivity of the 2'-OMe when compared to the 2'-OH in nucleophilic attack on the neighboring phosphate decreases the possibility of strand breaks. Additionally, hydrogen abstractions at the 1' and 2' positions of the 2'-O-methylated analogs result in more stable radicals than their unmodified counterparts. Our aim is to determine if those naturally occurring modifications in RNA provide increased protection against oxidative damage. For this purpose, independent synthesis of site specifically modified RNA models will be explored. Various essential monomers including 5'-pivaloyl-pseudouridine, 5'-pivaloyl-uridine, 2'-acetyl-uridine, and 2'-O-Me-2'-acetyluridine need to be synthesized along with their corresponding amidites or H-Phosphonates. Photochemical site-specific generation of the radicals of interest in monomers under simulated physiological conditions is under investigation. This study will aid in understanding the overall contribution of post-transcriptional modifications to the stability of oligonucleotides under conditions of oxidative stress.



## INVESTIGATING THE COMBINED EFFECTS OF ATRAZINE AND MICROCYSTIN ON HEPATOPANCREAS TISSUE OF CRAYFISH

Sharita G. Reddy, Antonillamarein Hanna, Sarah Awali, Luna L. Jacob, Alzhra N. Alduis, Jada C. Manns, Mariana D. Muskovac, Hanadi H. Chammout, Patrick Ibrahim, and Jennifer S. Elias

Research Advisor: Rachelle M. Belanger

The cyanobacterium *Microcystis aeruginosa* produces the toxin microcystin-LR (MC-LR) and is found in toxic algal blooms in various freshwater environments. MC-LR causes liver and tissue damage in aquatic organisms. Atrazine (ATR) is a commonly applied herbicide in the US and is toxic following acute exposures. These toxins can often be found together in aquatic environments and thus may act synergistically. Very little information is available regarding their cumulative effects on tissues such as the liver. To examine cumulative effects, we exposed crayfish (*Faxonius virilis*) to 10 ppb atrazine, 10 ppb MC-LR, a combination of 10 ppb atrazine and 10 ppb MC-LR, and a control (DMSO diluent only) for 96 hours. Following exposure, we removed the hepatopancreas (liver), examined and compared the lobular morphology of each group of crayfish. We hypothesize that morphological defects such as vacuolization, lumen dilation, and epithelial degeneration will be amplified in the crayfish exposed to both atrazine and MC-LR. Overall, impairment of hepatopancreas tissues could lead to changes in biotransformation, detoxification, digestion and molting, subsequently reducing crayfish populations and negatively impacting the aquatic ecosystem.



## QUANTITATION OF ATRAZINE AND ITS METABOLITES FOR TOXICOLOGICAL STUDIES IN THE KEYSTONE SPECIES FAZONIUS VIRILIS

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Research Advisors: Rachelle Belanger and Kendra Evans

Atrazine (ATR) is a pesticide of the triazine class and is one of the most used pesticides in North America.<sup>1</sup> The effects of ATR exposure on crayfish are of interest because crayfish are a keystone species. ATR has many negative health effects such as disrupting regular hormone function, birth defects, and DNA damage in the hepatopancreas.<sup>2</sup> Furthermore, ATR can cause metabolic changes that diminish the ability for crayfish to localize an odor source, making it difficult to locate food and find a mate.<sup>3</sup> Exposure to ATR also affects the expression and activity of the detoxification enzymes cytochrome P450 and glutathione-S-transferase. To further explore the effects of ATR exposure, crayfish (*Faxonius virilis*) were exposed to ATR for four days.

Liquid chromatography-mass spectrometry (LC-MS) was used to standardize the ATR solutions to which crayfish were exposed. The morphology of the hepatopancreas of ATR-exposed crayfish was examined; lobule lumens were dilated, and tubule tissue was degenerated and contained an increase in vacuoles. We developed and validated an extraction and LC-MS analysis method for quantitation of ATR and its metabolites, desethyl atrazine (DEA) and desisopropyl atrazine (DIA) in hepatopancreas tissue.<sup>5</sup> With this method, we aim to investigate accumulation and metabolism of ATR in the hepatopancreas. Using these data, we will assess correlation between levels of atrazine and its metabolites with observed behavioral and physiological phenotype.



## AN EXAMINATION OF MITOTIC ACTIVITY IN THE HEPATOPANCREAS OF CRAYFISH (*FAXONIUS VIRILIS*) FOLLOWING AN ENVIRONMENTALLY RELEVANT ATRAZINE EXPOSURE

Alzhra N. Alduis, Jada C. Manns, Mariana D. Muskovac, Sharita G. Reddy, Sarah Awali, Antonillamarein Hanna, Luna L. Jacob, Zeinab R. Ahmed, Hanadi H. Chammout, and Patrick Ibrahim

Research Advisors: Rachelle M. Belanger and Gregory M. Grabowski

Atrazine, a known herbicide used in agriculture to control weeds, has raised many concerns. Atrazine's presence in streams and rivers occurs due to runoff and seepage from agricultural areas. Even with the U.S Environmental Protection Agency (EPA) regulating atrazine at 15 ppb ( $\mu\text{g/L}$ ), it has been found at levels above 300 ppb in aquatic environments in the U.S. Midwestern region. Exposure to atrazine has been found to not only diminish the reproductive capabilities and cause behavioral changes in aquatic animals but also leads to DNA damage in tissues of fish and crayfish. Degenerative changes and DNA damage to crayfish hepatopancreatic (liver) tissue has been noted following acute exposures to atrazine. In this study, we injected crayfish with 5'-bromo-2'-deoxyuridine (BrdU) to determine if mitosis or DNA repair occurred in crayfish following an acute atrazine exposure. Our goal was to evaluate the cellular regeneration and repair in the hepatopancreas as well as the efficiency of BrdU to visualize mitotically active cells following exposure. Crayfish were injected with BrdU and exposed to 80 ppb atrazine for 10 days before being transferred to clean water for 30 days. Hepatopancreas tissue was collected every 10 days following transfer into clean water. Our hypothesis stated that atrazine-exposed crayfish would have a higher number of BrdU-positive cells compared to control crayfish. Further, the number of BrdU cells was expected to increase as time in a clean water environment increased. We found that after being exposed to atrazine and placed into clean water, there was a positive relationship between the amount/length of time crayfish spent in clean water and the number of BrdU positive cells discovered. This indicated that cellular repair and regeneration was occurring in hepatopancreatic tissues post-exposure. Due to the important role the hepatopancreas plays in digestion, growth, reproduction, and biotransformation/detoxification, the ability of this tissue to be repaired post-exposure is crucial to the survival of the animal; however, tissue repair is an energetic process. Energy needed for tissue repair will be reallocated from other processes, such as growth, development, and reproduction, leading to potential effects on crayfish population size in areas where atrazine is heavily present.





**BOILING AND FREEZING POINT ADJUSTMENT EXPERIMENTS FOR THE  
GENERAL CHEMISTRY LABORATORY: ELEVATING THE BOILING POINT  
AND DEPRESSING THE FREEZING POINT OF WATER TO EXTREMES, USING  
HIGH MOLALITY SALT SOLUTIONS**

Bianca Gheorghila, Zoe Arrington, Katrina Yeldo, Sara Arment, Joseph Crandall, Leza Jeki, Philomena Anton, Chloe Cole, Genevieve Crocker, Josefina Kusiak, Evelyn Rihacek, Chloe Spitzer, Candice Tayler, Omar Ammoun, Juliana Jakubczak, and Ndeye Ka

Research Advisor: Mark Benvenuto

The boiling point elevation and freezing point depression equations found in most freshmen chemistry textbooks are usually given no more than a passing mention by faculty. We have found that in the laboratory, when large amounts of salts are added to boiling water, or water cooled with dry ice, that remarkably large temperature elevations or depressions occur. Our recent findings will be presented.



## EXPLORING THE TYNDALL EFFECT: BLENDING THE CHEMISTRY AND MATH WITH EASY-TO-USE, INEXPENSIVE MATERIALS

Bianca Gheorghila, Zoe Arrington, Katrina Yeldo, Sara Arment, Sabrina Cacanindin, Reina Seklaoui, Zahra Kanji, Lilian White, Evan Aeck, Angel Alexander, Luke Weisend, Dan Hamze, Jay McKenzie, Renee Kesto, Andreh Khosho, Aranza Ramirez, Albis Spahiu, Ahmad Naeem, Lobaid Murshed, Eryka Ely, Terika Johnson, Zoe Madden, Evgenia Koneva, Michael Caruso, George Brown, Yoona Park, Caliana Shouman, Josh Page, Lara Sabra, Zain Shouman, Renee Trotman, Evan DeVito, Xavier Sterling, Oriekaose Agholor, Andrew Bosah, Luke Adamczyk, Keara Moroz, Nudar Shabil, Zahra Albdaire, Julia Kroha, Jamie Whitener, Katlynn Strnad, Joseph Crandall, Leza Jeki, and Ndeye Ka

Research Advisor: Mark Benvenuto

The Tyndall Effect is often shown simply as a demonstration in a chemistry or other science class, in order to observe the phenomenon. We have found several ways in which it can be used as a starting point for a larger discussion of what materials are composed of, how light is scattered, and how the scattering can be quantified. We will present how to utilize the Tyndall Effect as a teaching tool in chemistry and math, and how to do so with inexpensive, safe, easy-to-find materials.



## SYNTHESIS OF A SERIES OF LIGANDS TO BE USED AS COMPLEXING AGENTS, IN THE FRESHMEN CHEMISTRY LAB

Andrew Ivanciu, George Brown, Michael Caruso, Yoona Park, Pahul Bedi, Roxana Nistor, Hazel Song, Marc Naddaf, Nawres Alkhareef, Farah Abdulrahim, Abdullah Al-Wakeel, Alzhra Alduis, Yasmine Fettohy, Naya Kheirbek, Fatima Siddique, Anna Mousaad, Rama Hamo, Roopum Virk, Ndeye Ka, Evgenia Koneva, Gregorios Mihalopoulos, Zain Shouman, Renee Trotman, Leza Jeki, and Joseph Crandall

Research Advisor: Mark Benvenuto

A series of bi-dentate ligands have been produced which have long, non-polar tails and relatively polar heads. The synthesis involves a Schiff's base condensation, and can often be run at room temperature. We will present results of these syntheses, as well as the results of initial trials in producing ligand-metal complexes using various metal salts.



## EXAMINATION OF A CONTEMPORARY COUNTERFEIT BRASHER DOUBLOON

Keara Moroz, Andrew Ivanciu, Phebi Le, and Lester Rosik

Research Advisor: Mark Benvenuto

We have examined an apparent contemporary counterfeit of the famous Brasher doubloon via energy dispersive X-ray fluorescence spectrometry (EDXRF). Although a significant amount has been written in popular print and on-line sources that no contemporary counterfeits of such coins exist, the metal profile of this piece argues very strongly that it is such a coin. We present our study of the coin's elemental composition, concentrating on elements that do not exist in modern counterfeits, and that do occur in those made in past times.



## MAKING AND ADJUSTING GALINSTAN IN THE TEACHING LABORATORY: AN EXAMPLE OF SOME FASCINATING, LOW-MELTING ALLOYS

Phebi Lee, Andrew Fei, Mac Golden, Hadi Obeid, Heather Rice, Liliana Romeo,  
Maryan Yousef, Omar Ammoun, and Juliana Jakubczak

Research Advisors: Mark Benvenuto and Klaus Friedrich

Galinstan is an alloy made from gallium, indium, and tin (hence its name). We have found that not only can galinstan be made in the teaching laboratory, but that its composition can be adjusted in favor of gallium or in favor of tin, resulting in alloys with significantly higher melting points. Since galinstan melts at  $-19^{\circ}\text{C}$  and gallium melts at  $30^{\circ}\text{C}$ , we set a goal of finding some composition which melted between  $0^{\circ}\text{C}$  and  $30^{\circ}\text{C}$ . Our results will be presented.



## EXAMINING THE VIRULENCE OF THE FUNGAL PATHOGEN CANDIDA ALBICANS IN GALLERIA MELLONELLA

Nobel Makonnen and Yahya Jamaledin

Research Advisor: Jonathan Finkel

Center for Disease Control estimates that approximately 25,000 cases of candidemia (fungal bloodstream infection) occur nationwide each year. *Candida albicans* is an organism known for its ability to cause infection from surface-associated microbial communities known as biofilms, particularly on implanted medical devices. A biofilm is a microbial community that forms on surfaces consisting of an extracellular matrix with interspersed yeast and hyphal cell layers. Biofilms form in a sequence that begins with yeast cells adhering to a substrate; yeast cells then spread across the adhered substrate and elongate. During maturation, fungal cells proliferate, initiating the change from yeast to a filamentous cell; once enough hyphae are grown, an extracellular matrix forms and the biofilm has reached maturation. After it has matured, any cells that have not adhered to the matrix are released into its environment. This is the cause of infection by biofilms. The research done was focused on examining the components of adherence to determine a defect that could be a possible drug target. We look for defects by running a virulence assay in-vivo using strains from a mutant library, along with a wild type, and a negative control.



## IDENTIFICATION OF GENE FUNCTION IN THE MYCOBACTERIA PHAGE XENO

Sin Young Park, Zayd Khanm, and Ji Luth

Research Advisor: Jonathan Finkel

Bacteriophages are viruses that target bacteria. The demand for studying bacteriophages has risen by the importance of therapeutic phages. Because of bacteriophages' high specificity for their target bacteria, it can help us develop more targeted and effective treatments for bacterial infections. One limiting factor to understanding and developing better phage therapy is that only 25 % of sequenced genes have a known or even hypothetical function. Our goal as a group is to identify the function of genes in the phage Xeno. Xeno is a siphoviridae bacteriophage that targets *Mycobacterium smegmatis*. Its genome is 42395 nucleotides long and was calculated to contain 69 different genes. Only 27 of the 67 proposed functions. The purpose is to complete the cytotoxicity and defense assays and begin the cloning required for the hybrid experiments.



**PLATINUM-HEXOSE CONJUGATES AS CANCER DRUGS**

Diego Galarza Ramirez, Jacob Zdankowski, Gabriella Greenlaw, Nichol Grafton, Adam Abikhodr, and Sala Al-Ani

Research Advisor: Klaus Friedrich

When cancer cells grow at a high rate, they have an increased energy demand compared to non-cancerous cells. Accordingly, many cancer cells overexpress hexose transporters, integral membrane proteins responsible for the transport of hexoses, the energy sources of cells, across cellular membranes.

This project strives to develop chemotherapeutic drugs designed to focus drug uptake on fast-growing cells and by that to reduce deleterious side effects of the medication. Making substrates for hexose transporters building blocks of cancer drugs, the drug action can to some extent be focused on the intended drug targets.

Here we discuss protecting group strategies applied to obtain drug candidates that are accessible with few synthetic steps, have an advantageous pharmacological profile, and are efficacious.





## COMPREHENSIVE ANALYSIS OF FUNCTIONAL NEAR INFRARED SPECTROSCOPY (fNIRS) SOFTWARE ON GAIT PROTOCOL DATA

Naya Kheirbek, Mariana Gonzalez, and Taylor Takla

Research Advisor: Nora Fritz

Functional Near Infrared Spectroscopy (fNIRS) is an emerging method of measuring cortical activity of participants through infrared light waves of 760 nm and 850 nm. fNIRS software and hardware is relatively new to the neuroscience field so there are many different conflicting protocols published on how to validate data. In this study, we created a basic analyzation pipeline for two popular fNIRS softwares, Homer3 and Satori. Data collected in a gait protocol that focused on identifying if there was a significant difference of oxygenated hemoglobin concentration when healthy participants were walking backwards, and forwards was analyzed. The fNIRS raw data was pre-processed successfully in both platforms, however, only data run through Homer3 was exported and analyzed. Results showed that there was a significant difference of total hemodynamic response function when participants were backwards-walking compared to forwards-walking. Furthermore, there were far more substantial amounts of hemodynamic response functions in the pre-motor and motor cortex of the participants while backwards-walking. Backwards-walking has been found to require more cortical activity and can be used as a method of helping patients diagnosed with Multiple Sclerosis (MS) better manage their disease. These findings allow for a better understanding of where cortical activity is seen in the brain when backwards-walking and can better help people suffering with MS (and other neurocognitive diseases) since they often suffer from falls while walking.



## **PSEUDOMONAS AERUGINOSA INFECTED WITH PHAGE AND ISOLATION OF NUCLEIC ACID**

Jacob Song and Joseph Kachacki

Research Advisor: James Graves

*Pseudomonas aeruginosa* is a rod-shaped bacterium commonly found in watery environments and causes opportunistic infections. Because the microorganism is highly antibiotic resistant, phage therapy has been considered to treat patients with infections. This work investigated the isolation of nucleic acid from phage-infected *P. aeruginosa* in order to discover more about the nature of the phage. The strain of *P. aeruginosa* used in the study was acquired from the American Type Culture Collection (ATCC). The phage was isolated from stream sediment. The phage produced small plaques and high titers (about 10<sup>11</sup> PFU/ml). Nucleic acid was isolated from cells infected with phage and cells alone by a technique utilizing Triton X-100 detergent, lysozyme and boiling. Strands of double stranded nucleic acid were separated and single strands were unfolded by boiling. Electrophoresis was performed with a neutral pH buffer system and an alkaline pH buffer system. Double stranded nucleic acid was denatured to single strands and single strands unfolded by an alkaline pH system. After suspension of samples in lysing buffer containing detergent and incubation with lysozyme, spot test inoculation on plain agar showed some growth of colonies. When spot inoculation of cells infected with phage was performed on agar swabbed with *P. aeruginosa* inhibition zones developed. After the mixtures were boiled and spot tested there was no growth of colonies or production of inhibition zones. With a neutral pH electrophoresis system a mid-gel chromosome band was evident. In alkaline gels a slow migrating band was observed from samples consisting of cells infected with phage. Preparations from cells alone did not produce a band. Because of differences in various phage and host cells some techniques may work better for the isolation of nucleic acid. Phage are known to contain DNA or RNA that can be double stranded or single stranded.



## CORTICAL PRE-SACCADIC ACTIVITY FOR VERTICALLY-DIRECTED SACCADDES

Bennett Addy, Alexis Bantom, Rozaleen Qaisar, Kamilla Kesto

Research Advisor: Harold Greene

Saccades are eye movements that direct attention towards objects in the visual field. The saccade literature is dominated by studies that have relied almost entirely on horizontal saccadic tasks. A critical gap exists with reference to mechanisms of vertically directed saccades. Saccades directed downwards tend to be executed later (by 30-50 ms) than saccades directed upwards (Greene et al., 2023).

The human head sits on top of the torso, so there are distractions from attention-grabbing movement of near-torso objects below the head (e.g., limbs). We theorized that down-directed saccades are executed/released later because they are more inhibited, than up-directed saccades. If not strongly inhibited, humans will continually (and unnecessarily) make reflexive down-directed saccades.

We sought to determine how frontal lobe areas differed in the build-up of pre-saccadic neural activity, for up-, and down-directed saccades. We reasonably assumed that pre-saccadic Event related potentials (ERPs) serve as indices for the preparation of saccades. We utilized an electroencephalography + electrooculography methodology to identify ERPs associated with the preparation of vertically-directed saccades. Given our theory that down-directed saccades are more strongly inhibited, we expected greater pre-saccadic ERP activity for down-directed, than up-directed saccade.

18 adult participants with no reported neurological problems participated in the experiment. A subset of 13 had frontal lobe data available for EEG analysis. The main apparatus was an IWORX IX-EEG (19 electrodes and VEOG) system. Participants were presented 100 trials of an up-, or down-pointing arrow cue at the fixation point, at random. Their task was to make a saccade in the direction cued.

A paired samples t test revealed that saccade reaction times were slightly slower for down-, than up-directed saccades ( $p=.04$ ). A 3 Brain Area (F3, Fz, F4) X 2 Saccade Cue (Up, Down) ANOVA revealed significantly greater absolute ERP amplitude for down-directed saccades ( $p = .01$ ), in the interval 500ms to 300ms before the execution of saccades.

The results suggest greater early premotor activity for down-directed saccades, possibly to overcome the strong inhibition theorized. WHY WE CARE Saccades occur when they are released from inhibition. Knowledge of saccade metrics in healthy individuals may inform theories of disordered saccadic processing (e.g. in schizophrenia).



## APPROACH/WITHDRAWAL ASYMMETRY IN PRE-FRONTAL CORTEX IN RESPONSE TO VISUAL STIMULI

Jude Rodriguez

Research Advisor: Harold Greene

Activity in the pre-frontal cortex of the brain plays a role in an individual's emotionally motivated actions; when one side of the pre-frontal cortex is more active than the other upon reacting to stimuli, the resulting asymmetry in power leads to an approach or withdrawal response. To measure the asymmetry exhibited in response to visual stimuli, eight participants observed images of babies and snakes while their pre-frontal cortex activity was collected and analyzed with EEG equipment; participants were also asked to numerically score each set of images' level of pleasantness. The data collected demonstrated that according to participants' asymmetry indices, the baby images were more appreciable than the snake images; however, the snake images did not reflect an avoidance response.



## A GENETIC SCREEN TO IDENTIFY ENCHANCERS AND SUPPRESSORS OF THE AIF MOSAIC PHENOTYPE IN DROSOPHILA MELANOGASTER

Emily Daniel

Research Advisor: Jacob Kagey

Genetic screens in *Drosophila melanogaster* offers a simple way to unbiasedly study different biological phenomenon. Identified here is a phenotype of the genetic Apoptosis Inducing Factor (AIF). AIF is found on the gene 2L of the drosophila. AIF is involved with different types of apoptosis, but its role is poorly understood. In fruit flies, a deficiency in AIF causes the flies' eyes to change color and shape. When put on FRT 4.14 and 40A mutant to make clones, the mosaic phenotype is abnormal, and the eye contains little mutant tissue. To understand the molecular role AIF plays in development, enhancer, and suppressor screens for FRT 4.14 and 40A were generated. The genes responsible for the suppression and enhancement of the AIF phenotype can be discovered by mapping the mutant and different deficiencies.



## THE ROLE OF CidI.3.2 IN DIFFERENT STAGES OF DEVELOPMENT IN DROSOPHILA MELANOGASTER

Gabrielle Makonnen and Maryam Qoda,

Research Advisor: Jacob Kagey

A novel allele of Cid (centromere identifier), CidI.3.2, was recently discovered to result in a complete lack of a head in a mosaic eye genetic background. It is important to understand the reasoning behind this so that it can be used to help cancer research in humans. Our research goal is to utilize larval dissection, recombination, and immunohistochemistry to identify how this mutation results in a loss of head during development. The CidI.3.2 allele is an insertion likely eliminating protein function. To utilize a model of reduction, but not loss of Cid, we moved to an RNAi system to reduce expression without complete removal. From these experiments we have found that reducing Cid expression in early eye development results in a dramatic loss of eye size, while reducing Cid expression later in eye development has minimal effects on tissue size. Additionally, we find smaller impacts of Cid reduction in the posterior compartment of the wing. Overall, our findings show the importance of developmental timing with regards the necessity of Cid for Drosophila development.



## AGE-RELATED MYROSINASE ACTIVITY ON MASTICATED BROCCOLI

Amanda Carswell

Research Advisor: Anne-Marie Kosi-Kupe

We selected six individuals from fourteen to sixty-six years old for this study. The question is whether myrosinase activity decreases with age regarding the breakdown of glucosinolates present in Broccoli. The spectrophotometry and agar diffusion tests will serve as methods. Age, as a critical factor, is investigated and discussed. This project's results may provide new insights into the relationship between age and bioavailability of sulforaphane from broccoli glucosinolates.



## THE ACTIVITY OF VEILLONELLA PARVULA ON S. MUTANS IN DENTAL CARIES

Haya El Dana

Research advisor: Eric Krukonis

*Streptococcus mutans* is a major contributor to dental caries (cavities) and forms robust biofilms in the oral cavity as part of dental plaque. *S. mutans* causes enamel demineralization via its production of lactic acid (lactate). Our previous studies have shown that when dense *S. mutans* biofilms are grown overnight in 0.5% sucrose the resulting biofilms are unhealthy with mostly permeabilized cells and the media is acidified to ~pH=4.0. Furthermore, the addition of the lactate-metabolizing bacterium *Veillonella parvula* to *S. mutans* biofilms restores the biofilm to health (no permeabilization) and raises the pH to ~pH=5.0. The goal of this study was to determine if *V. parvula* improves the proportion of healthy bacteria by reducing the acidity of the biofilm or by metabolizing other components accumulating in the medium (like lactate). To distinguishing between these possibilities, *S. mutans* biofilm were grown as usual at a high density (OD<sub>600</sub>=1.0) overnight in the presence of 0.5% sucrose, but in addition, the buffer HEPES was added at varying concentrations to prevent acidification of the media when lactic acid is generated from sucrose metabolism. Using fluorescence microscopy to monitor biofilm health via LIVE/DEAD staining and pH measurements, we found that HEPES was able to reduce acidification of *S. mutans* biofilms and made the biofilms, behaving like Vp. Alternatively, we also added excess sodium lactate or lactic acid to *S. mutans* biofilms initiated at a 10-fold lower density (OD<sub>600</sub>=0.1). Under these conditions, *S. mutans* biofilm are normally healthy (green) after 24 hours with a pH of ~6.0. Addition of sodium lactate at 0.02% (the level found in overnight *S. mutans* biofilms at high density) or 0.6% lactate did not lead to decreased health of *S. mutans* low density biofilms. Similarly, addition of lactic acid at 0.02% or 0.04% did not consistently decrease the health of low density *S. mutans* biofilms, even though the pH dropped to ~pH=4.5.

Additionally, in a series of complementary experiments exploring how the timing of *V. parvula* addition to *S. mutans* biofilms affects its role in biofilm health, fluorescence microscopy revealed that after 48 hours, *S. mutans* alone (plated at a lower starting density) appeared healthy but became less healthy (more red) when *V. parvula* was added simultaneously on day 1. When *V. parvula* at OD<sub>600</sub>=0.1 addition to the *S. mutans* biofilm was delayed by 24 hours, sometimes the addition of *V. parvula* enhanced biofilm health, while other times it did not. Higher concentrations of *V. parvula* (OD<sub>600</sub>=1.0) added after 24 hours maintained biofilm health. These data show the context of the interaction between *S. mutans* and *V. parvula* affect the outcomes of biofilm health.





## ASSESSING THE PHYSICAL INTERACTIONS(S) BETWEEN VEILLONELLA PARVULA AND STREPTOCOCCUS MUTANS DURING BIOFILM FORMATION

Fadi Koria

Research Advisor: Eric Krukonis

*Streptococcus mutans* is a major causative agent of dental caries (cavities). *S. mutans* within oral biofilms (dental plaque) utilizes carbohydrates, especially sucrose, as an energy source and produces the metabolic byproduct lactic acid (lactate). This causes *S. mutans*-containing oral biofilms to have high acidity (low pH) leading to demineralization of tooth enamel. The presence of lactate enhances the growth of other oral species like *Veillonella*, which metabolize lactate made by *S. mutans* to weaker acids. Recent evidence suggests this metabolic interplay between *S. mutans* and *Veillonella* species leads to enhanced health of mixed-species biofilms. In order for *Veillonella* to utilize lactate from *S. mutans* it must be in close proximity to *S. mutans* and various studies have shown that *Streptococcus* species and *Veillonella* species can physically interact. However, the precise nature of these interactions is unknown, especially the interaction between *S. mutans* and *Veillonella*. The goal of our research was to determine the mechanism of *S. mutans* and *V. parvula* physical interaction in mixed biofilms. These two species are known to cooperate to form a thick, robust, and healthy biofilm. Using artificial saliva with sucrose (a disaccharide of glucose and fructose) as a growth medium, we found the addition of *V. parvula* to a pre-grown *S. mutans* biofilm for two hours enhanced the thickness of the biofilm by about 20% to 35%, indicating *V. parvula* adhered to the pre-grown *S. mutans* biofilm. We also assessed the ability of isolated glucosyltransferases (Gtfs) from *S. mutans* to create a glucan matrix capable of supporting *V. parvula* binding. Gtf proteins assemble glucose monomers into polymers (glucans), to which many oral microbes can bind. Gtfs incubated in the presence of glucose enhanced the ability of *V. parvula* to form biofilms by about two-fold (100% increase). This indicates *V. parvula* may bind glucans produced by *S. mutans* within natural biofilms. Finally, the use of several monosaccharides as potential inhibitors of *V. parvula* binding to *S. mutans* biofilms did not show any strong effect on *V. parvula* binding. Future studies aim to identify the surface molecule(s) of *V. parvula* that mediate binding to *S. mutans* biofilms.



## EFFECTS OF AUTOPHAGY ON CELL PROLIFERATION AND CELL DEATH

Jeffrey Brooks and Antonina Pizzo

Research Advisor: Mara Livezey

BHPI (bis(4-Hydroxyphenyl)-7-methyl-1,3-dihydro-2H-indol-2-one) is a preclinical anticancer drug that targets estrogen receptor alpha, inhibits cellular growth, and leads to necrotic death through the unfolded protein response (UPR). BHPI is able to kill cells and inhibit autophagy. Autophagy is the programmed destruction of cell components. This mechanism is essential to cells as they “recycle” these components to prevent and minimize disease. The purpose of this study is to assess the impact that autophagy has on BHPI’s effectiveness, through the use of chloroquine, an autophagy inhibitor. We expect, inhibition of autophagy will lead to decreased cell proliferation compared to BHPI alone. TYS cells were treated with four different concentrations of BHPI and a fixed concentration of chloroquine in a 96-well plate. Cell proliferation was noted to be lower in cells treated with both BHPI and chloroquine than those treated with only BHPI. Inhibition of autophagy and the activation of UPR can be used as a combination to target cancer.



## FERROCENE AND DERIVATIVES SLOW CELL PROLIFERATION

Kailah Collins

Research Advisor: Mara Livezey

Experiments on ferrocene and its derivatives have shown that these molecules work as antiproliferative agents. Ferrocene derivatives contain biological activities, creating antiproliferative activity and cell death. Our research investigates the effects of ferrocene and its derivatives on Caco-2 colon cancer cells. To conduct our experiments, we employed the Alamar Blue Assay method. This enabled us to identify ferrocene drugs that exhibit significant antiproliferative activity against these cells. Higher concentrations of ferrocene result in a more pronounced decrease in cell growth. We are keen to further explore whether ferrocene and its derivatives induce cell death in Caco-2 cells. This would be a significant development in the search for effective cancer-fighting agents.



## THE APPLICATION AND HISTORY OF GOOSYPOL

Mia Cassar

Research Advisors: Mara Livezey and Prasad Venugopal

The aim of this project is to study gossypol, a small chemical compound that is found in the root, stem, and leaves of the cotton plant. It's effects on cancer cells will be studied, while incorporating historical narratives centered on slavery, race, gender, and indigenous knowledge in the context of cancer cell biochemistry. From a historical perspective, the cotton root was used as a form of contraception and as an abortifacient in the times of slavery in America. In some regions the cotton plant was regarded as a symbol of fertility. From a biochemistry perspective, gossypol has been studied for its anti-cancer properties and its use as a male contraceptive. While this more recent biochemical work is important, much of the indigenous African knowledge regarding the cotton root being used as an abortifacient and contraceptive has been left out. Gossypol has a much more complicated history concerning women's reproductive health and resistance during slavery than solely the biochemical outcomes of modern labs. Additionally, the field of cancer biology research has not sufficiently addressed issues of equity and justice in the practice and history of biomedicine. The effects of Gossypol on cancer cells from two different origins, testicular and ovarian tissue, will be studied. These tissue types originate from endocrine tissue, thus are relevant to human fertility. Through experimentation, we expect to see what effects gossypol has on the proliferation and viability of the cells and will monitor the effects of gossypol on traditional hormone signaling pathways via western blot. This project is a scientific research project that includes social and historical research from a variety of literature sources. The University of Detroit Mercy holds a mercy critical concern of women as well as combating racism. Additionally, there is a Jesuit universal apostolic preference of walking with the excluded, which tie into the inspiration for this research. As a student in the honors program at a mission driven university, I am interested in combining the scientific data that we find in the laboratory setting with the history that can be understood with context from the fields of ethnobotany and ethnogynecology. For future application, we have a goal of expanding the conversation that was started about how to adopt diversity, equity, and inclusion-inspired research projects within our greater campus community at large.



## OPTIMIZING SUSTAINABILITY PLANS FOR U.S. STATES

Aya Alomari

Research Advisor: Matt Mio

My mission is to optimize the most efficient sustainability plan taken so US states can adopt this model. In order to construct the optimization model, I analyzed the current state of sustainability within each state, looking at 10 total factors of carbon emissions per capita, total carbon emissions, total energy consumption, energy emissions, energy intensity, carbon intensity, consumption of specific fuel types, waste management, recycling rates, and greenhouse gas emissions. After reviewing relevant factors contributing to the overall sustainability of each state, I was able to rank states relatively on their emissions. I focused on identifying environmental efforts that may have affected where states were ranked. Additionally, I identified that states with a better sustainability ranking also had a range of stakeholders, including government agencies, businesses, non-profit organizations, and community members that help build support for sustainability initiatives. After establishing components that caused certain states to be more environmentally friendly, I began to establish a model of how these efforts in sustainable states could be translated to states that ranked lower. I created a target for each of the ten factors for states based on population, state size, and population density. These target numbers were found by calculating the mean and standard deviation of factors for the first 25 best-ranked states, then running a significance test at the 95% confidence level to look for an optimal interval of where states should be in order to meet environmental goals. Ultimately, the optimal model depends specifically on the previous factors listed, however, I believe our model encapsulates the necessary elements that make it achievable and equitable. Furthermore, the model also encourages more sustainable steps like environmental legislation, encouraging stakeholders, and promoting clean business practices.



## DETERMINING THE MOLECULAR FUNCTION OF PDH1

Carvin Coleman

Research Advisor: Nicole Najor

Putative 2-methylcitrate dehydratase (PDH1), is a *Saccharomyces cerevisiae* mitochondrial protein that plays a role in respiration. It is known to be involved in the propionate metabolic process, but its specific molecular function has not been identified. To determine this function, cells deleted for PDH1 deletion cells were grown on a series of medias to test its fitness. Glycerol media is a non-fermentable carbon source and is used to identify whether a deletion mutant can withstand the diauxic shift, which is when the yeast undergoes cellular respiration instead of glycolysis, the preferred energy generating mechanism in high glucose. Additionally, another fitness treatment that was employed in this study was exposure to ultraviolet radiation, which is known to trigger DNA damage checkpoints. Some reports have shown that oxidative stresses from UV can hinder the growth of mitochondrial proteins resulting in a defect. Interestingly, our results indicate that cells deleted of PDH1 are able to grow on glycerol media, which was surprising given most mitochondrial proteins show defects on non-fermentable carbon sources. Additionally, we found an increase in fitness when exposed to UV. Further research is required to identify the mechanism by which cells deleted for PDH1 are unaffected by glycerol media and display an increase in fitness upon UV exposure.



## DETERMINING THE MOLECULAR FUNCTION OF SHE9

Kieli Phillips

Research Advisor: Nicole Najor

In the inner membrane of the mitochondria, *Saccharomyces cerevisiae* gene SHE9 is required for normal mitochondrial morphology. Studies have indicated that upon loss of SHE9, yeast display large-ring like mitochondrial structures. Despite the work performed identifying the phenotype caused by the loss of SHE9, the overall molecular function of SHE9 is unknown. Through a series of fitness assays, we identified a decrease of growth in *she9Δ* cells in glycerol media. The use of a non-carbon source media causes a diauxic shift where mitochondria are primarily employing oxidative phosphorylation to generate ATP versus glycolysis in high glucose medias. Through additional bioinformatics analysis, we developed a model of SHE9 function, particularly through its association with mitochondrial proteins Mdm31 and Mdm32. While future experiments are required to validate this model, we propose that She9 functions to maintain mitochondrial phospholipids.



## ALEXITHYMIA MODERATES THE RELATIONSHIP BETWEEN MEMORY FOR EMOTION AND COMPANIONSHIP

Rebecca De La Garza, Darius Vann, Robiann Broomfield, Gavin Sanders, and Robin Hanks

Research Advisor: Lisa Rapport

Moderate-to-severe traumatic brain injury (TBI) has been linked to impairments in emotion processing such as alexithymia (difficulties identifying, describing, and expressing one's own emotions), and receptive skills in perception and memory for others' emotions. These impairments have been demonstrated primarily using questionnaires and experimental tasks. Little research has examined the extent to which these impairments relate to real-world interpersonal outcomes, such as companionship. We hypothesized that alexithymia would be inversely related to companionship, and objective abilities in perception and memory for emotions would be positively related to companionship. Additionally, we tested the hypothesis that the relationship of companionship to receptive skills (perception accuracy and delayed memory for emotions) would be moderated by level of alexithymia.

Participants included 119 adults: 51 with moderate-to-severe TBI, and 68 neurologically-healthy comparisons (NHC). Participants completed the PROMIS Companionship and Toronto Alexithymia Scale (TAS-20) questionnaires, as well as a computerized task assessing perception and delayed recall of facial emotion, the Facial Recognition and Memory for Emotion (FRAME).

Independent-sample t tests indicated the TBI group showed significantly greater alexithymia and impairments in emotion perception and memory for emotions than NHC. Within the TBI group, alexithymia and companionship showed strong inverse correlation. Among NHC, inverse correlations were also observed between alexithymia and companionship; however, solely in the aspect of difficulty identifying feelings. Neither TBI nor NHC demonstrated linear associations between companionship and emotion perception or memory for emotion. However, as predicted, alexithymia and cognitive status moderated the relationship between memory for emotions and companionship: Adults with TBI who also experienced alexithymia showed a positive correlation between FRAME emotion recall and companionship. Unexpectedly, NHC with low levels of alexithymia showed an inverse correlation between FRAME emotion recall and companionship.

Among adults with TBI and alexithymia (impaired experienced emotion), memory for others' emotions seems especially important to maintaining companionship. In contrast, neurologically-healthy adults with high emotion-focused personalities, good memory for emotion was associated with low companionship. The reason for this pattern is unknown, but it may reflect a reaction to low companionship (i.e., increased focus on emotions experienced by self and others) or a cause of it (i.e., driving others away). These findings may be useful for identifying adults at risk for low companionship and implicate future interventions to address these critical issues of psychosocial well-being.





## THE EFFECTIVENESS OF THERABREATH ORAL RINSE AGAINST STREPTOCOCCUS MUTANS

Zaid Aboona

Research Advisor: Joshua Thomson

*Streptococcus mutans* is a Gram-positive coccus that has the ability to metabolize dietary sugars and produce lactic acid as a byproduct. The acid in the local environment of a tooth surface can cause demineralization of tooth enamel leading to caries (tooth decay). *S. mutans* also encodes glucosyltransferase enzymes that convert sucrose into insoluble extracellular polysaccharides, which are a vital component for biofilm formation of *S. mutans* and provide binding sites for other oral microorganisms, ultimately aiding in the development of dental caries. Prevention of dental caries requires routine mechanical removal of plaque biofilm to reduce the number of acid-producing bacteria, including *S. mutans*, near tooth surfaces. Prevention may also include the use of antiseptic or therapeutic mouthrinses to kill or remove bacteria that are difficult to reach mechanically. The goal of this study was to determine the antibacterial and antibiofilm activity of various TheraBreath™ oral rinses compared to other commercial mouthrinses, using *S. mutans* as a model oral pathogen. In vitro biofilms of a type strain of *S. mutans* were grown for 24 hours in the presence of sucrose. Oral rinses were added to wells and rotated at 100 rpm for 15 minutes. Three separate experiments were conducted, each with duplicate treatment wells. Following treatment, biofilms were assessed using a Live/Dead vitality stain to assess antibacterial activity and crystal violet stain to measure total biofilm remaining after treatment. Additionally, liquid killing assays were performed to determine bactericidal activity. Our findings suggest that Thera Breath™ products do not exhibit antibacterial or antibiofilm against in vitro *S. mutans* biofilms and have reduced bactericidal activity compared to other brands of oral rinses in liquid killing assays.



## A MULTI-YEAR QUANTATIVE ANALYSIS OF DUODENAL PAPILLA RELATIONSHIPS

Natasha Mazahreh, Batoul Dia, Sereena Baydoun, Merna Baqa, and Madeline Andrzejak

Research Advisor: Mary Tracy-Bee

The duodenum, as the first part of the small intestine, is crucial in the complex process of digestion and nutritional absorption. This organ is vital in breaking down ingested food, which aids in the digestion of essential nutrients into the bloodstream. The duodenum is distinguished by its various morphological and physiological properties, including the duodenal papilla, which links to both the pancreas and the gallbladder, controlling the release of digestion enzymes and bile. Furthermore, the duodenum is distinguishable by its short length. The duodenum is in the abdominal cavity, specifically the upper abdomen, which lies distal to the stomach as the small intestine's first part. The pyloric sphincter, a muscle valve that functions as a critical step in the digestive process, separates the duodenum from the stomach. Over a seven-year study involving 89 cadavers, our research aimed to determine the measurements of the distance between the pylorus and the major papilla and the distance between the minor papilla and the major papilla. The study confirmed the anticipated 8 cm distance from the pylorus to the major duodenal papilla, consistent with prior observations. However, the 2 cm distance between the major and minor duodenal papilla is notably shorter than commonly documented in textbooks and journals. This research offers valuable insights into the precise measurements of duodenal structures. Grasping the measurements between the pylorus and the major papilla, as well as the distance between the minor papilla and the major papilla, is not only indispensable for precise medical practice but also for advancing our knowledge, improving patient care, and promoting early detection and prevention of gastrointestinal diseases.



## THE INFLUENCE OF MISCARRIAGES ON WOMEN'S MENTAL HEALTH

Rayan Akhdar

Research Advisor: Theresa Wyatt

Miscarriages are very common; in fact, it is the number one reason for the loss of pregnancies. After a Miscarriage, 30-50% of women experience anxiety and 10-15% experience depression, usually lasting up to four months. A miscarriage can have a major influence on a mother's mental health, often leading to depression or some sort of post-traumatic stress disorder. This study is being done to understand how loss can influence a women's mental health and how they respond after discovering the loss of a child. Using a Phenomenological approach, a Life Story Interview will guide the interviews on women ages 20 – 40 who have experienced a miscarriage.



## IDENTIFICATION OF BACTERIOPHAGE RESISTANCE MECHANISMS IN THE DENTAL PATHOGEN, STREPTOCOCCUS MUTANS

Fatima Herrera

Research Advisors: Laura Young and Joshua Thomson

Early Childhood Caries (ECC), in which primary teeth are affected by caries, is a significant public health problem. ECC is highly correlated with the presence of the cariogenic bacterium, *Streptococcus mutans*. Bacteriophage therapy to prevent or reduce disease associated with *S. mutans* has drawn recent interest. However, increasing evidence of widespread resistance to bacteriophage within *S. mutans* complicates its potential utilization. Therefore, we aimed to identify bacteriophage resistance mechanisms employed by *S. mutans* using bacterial strains isolated from saliva and the *S. mutans* bacteriophage,  $\Phi$ APCM01. As one potential resistance mechanism, we tested  $\Phi$ APCM01-resistant *S. mutans* strains for growth arrest signatures that may indicate the presence of abortive infection (Abi) systems. For this, early-log phase *S. mutans* were mixed with  $\Phi$ APCM01 at various multiplicities of infection and growth was observed for 18 hours. If an Abi system was activated in resistant strains, growth curves would abruptly plateau while in the presence of phage. We observed that phage-resistant strains maintained normal growth in the presence and absence of phage, indicating these strains of *S. mutans* do not employ an Abi system. While our work did not identify signatures of Abi systems in phage-resistant strains, these techniques do not fully eliminate their possible presence. For example, alternate phage resistance mechanisms may be triggered prior to Abi systems, as they are generally considered last lines of defense. Therefore, our next steps will focus on discovering other if other phage-resistant mechanisms play a role in resisting phage infection and the point at which the phage replication cycle becomes blocked.



## DO COMPANION PLANTS AFFECT THE STOMATAL DENSITY OF TOMATO PLANTS

Adam Allam, Isaac Yeldo, Mati Dawood, Nicole Gapoyan, and Katelyn Ayar

Research Advisor: Joel Bonney

Whether a tomato plant is grown next to a companion plant could have a significant impact on how that plant behaves, is grown, and especially, how much stoma the plant has. So, in science, it is always important to identify these differences to better understand how the ecology around us works. The objective of our study was to determine if a tomato plant being grown next to companion plants affected the stomatal density of the tomato plant. In tomato plants that are grown next to companion plants, we expect to be a higher stomatal density, as opposed to there being a lower stomatal density in the tomato plants not grown next to a companion plant. Our group collected 5 leaves from tomato plants grown next to companion plants and 5 from tomato plants grown without a companion plant. We then analyzed them under a microscope to get our data. Our study shows that the leaves on tomato plants grown without a companion plant have a higher stomatal density. This means they have a higher need for water to enter their leaves and more carbon dioxide leaves from them than their companion plant counterparts.



## THE ROLE OF STOMATAL DENSITY IN WILD STRAWBERRY LEAVES CONTAINING FUNGUS IN COMPARISON TO THOSE THAT DO'T IN URBAN GARDENS OF DETROIT, MI

Dalia Khoshe, Sabrina Tallu, Maryana Khudhur, Deniya Cowart, and Katelyn Ayar

Research Advisor: Joel Bonney

The presence of fungus on wild strawberry leaves has a significant effect on stomatal density of the wild strawberry leaves and possible influence on the ability of the plant to uptake nutrients and maintain its growth and development. The objective of our study was to see if stomatal density deferred in wild strawberry leaves for the leaves that contained fungus compared to the leaves that did not. In leaves that contained fungus, we expected to see less stomatal density which would indicate less water/nutrient uptake. In leaves that did not contain fungus, we expected to observe a higher stomatal density meaning more water and nutrient uptake. Our group collected 10 wild strawberry leaves from Urban Gardens of Detroit; 5 of which containing fungus and 5 of which did not. We then performed a stomatal peel and analyzed it under a microscope paying close attention to stomatal density and the proportion of open to closed stomata. Our study shows that in leaves containing fungus, the plant will have a reduced stomatal density as well as a lower number of open stomata. As a result, this would decrease the uptake of water and nutrients that nourish the plants.



## THE IMPACT OF VARIABLE SOIL TYPES ON STOMATA DYNAMICS IN BASIL PLANTS AT CADILLAC URBAN GARDENS OF DETROIT, MI

Taveon Colston, Miranda Jasinski, Kristianna Mikha, Noor Mora, Jannath Aurfan, and Zahra Kanji

Research Advisor: Holly McQuithey

Stomata dynamics are crucial for plant survival as they facilitate the uptake of CO<sub>2</sub> that is used to produce energy. The purpose of our study was to evaluate whether the stomata density, stomata length, and the proportion of stomata open in basil plants is different between different plants grown in different soil types. We collected 5 leaves from a basil plant growing in one soil container and 5 leaves from a basil plant in a different soil container, then made imprints of the underside of the leaves using clear nail polish and tape to evaluate the impact soil type has on stomata density (per mm<sup>2</sup>), length (mm), and proportion of open and closed stomata (percent). We found that stomatal densities were similar in each soil type. Using a two-tailed t-test, we found that stomata density, length, and proportion of open stomata were not significantly different between the two soil types ( $n = 5$ ;  $p > 0.05$ ). This may benefit agricultural practices by allowing farmers to use the same soil for different plants, which could be more cost-effective for farmers and beneficial for the environment.



## THE IMPACT OF LEAF LOCATION ON STOMATAL DYNAMICS IN JALAPENO PLANTS AT URBAN GARDENS ON MERRITT

Ricardo Lopez, Josephene Dertinger, Jisoo Kim, Noor Ali, Mary Courtright, Zahra Kanji, Jannath Aurfan

Research Advisor: Holly McQuithey

This research study investigates the influence of leaf location on stomatal density in jalapeño (*Capsicum annuum*) plants. Stomata play a crucial role in the regulation of gas exchange and water loss in plants, and their distribution across different leaf positions within a plant can provide valuable insights into physiological adaptations and growth strategies in response to environment conditions. In this study, 10 leaves from the uppermost portion of a jalapeño plant and 10 leaves from the lowermost portion were collected. To determine stomata density, length, and proportion of open stomata, imprints were made of the underside of each leaf and were placed on a slide to analyze. A two-tailed t-test comparing mean stomata density between leaf location ( $n = 10$ ;  $p < 0.05$ ) revealed significant differences in stomatal density between the upper and lower leaves, suggesting that environmental conditions, light exposure, and developmental factors may contribute to these variations. Understanding the spatial distribution of stomata within the jalapeño plant can have practical implications for optimizing cultivation practices and improving overall crop productivity. This research contributes to our knowledge of plant physiology and may inform future agricultural strategies for enhancing the yield and resilience of jalapeño plants.





## MEASURING THE RELATIONSHIP OF STOMATAL DENSITY OF STALKED TOMATO PLANTS IN URBAN GARDENS OF DETROIT, MI

Samina Abedi, Andree Diryawish, Angelina Randazzo, Allena Williams, Fiona Nyugen, and Rayan Akhdar

Research Advisor: Eva Nyutu

The height of the tomato plant has a significant impact on the stomatal density of its leaves and the overall growth and rate of photosynthesis in the plant. The objective of our study was to determine if tomato plants that were supported with a stick had higher stomatal density than those not supported by a stick. We collected 10 leaves from tomato bushes that used a stick to support them and 10 leaves from tomato bushes with no support of a stick. We made leaf impressions of all the 20 leaves on clear slides and determined the stomatal density and stomata open/closed. Our results showed that the mean stomatal density and stomata length of the tomato leaves did not differ significantly between those supported by the stick and no stick. However, the percent of open stomata did differ significantly between those supported by the stick and no stick. Our results suggest that staking tomato plants at Cadillac Urban Garden will affect their rate of photosynthesis hence their growth rate.



## DIFFERENT COLOR PIGMENTATION IN KALE LEAVES DOES IMPACT STOMATAL DENSITY

Emma Arnold, Amira Shaheen, Rianna Shrewsberry, Saniyah Syed, Fiona Nyugen, and Rayan Akhdar

Research Advisor: Eva Nyutu

The color pigment of leaves has been shown to affect how plants conserve water and their photosynthetic rate. In Cadillac Urban Gardens, we observed the Kale plants that had both green and yellow pigmentation. Pigmentation is important in plant as they help them to block UV radiation and protect lower leaves in the plant from an overabundance of sunlight. We predicted that there would be a difference in stomatal density, stomatal size, and stomata percent open between the green pigmented leaves and yellowish pigmented leaves. We collected a total of 20 leaves from different plants, 10 green and 10 yellow. We used stomatal peel technique in order to assess stomatal density, stomata size, and percent of open stoma. We found that there were significant differences in stomatal density, stomata size, and percent of open stoma between the two types of leaf pigmentation. Our study found that stomatal density, stomata size, and the proportion of open stoma were significantly greater in the green kale leaves compared to the yellowish kale leaves. Our study suggests that yellowish leaves negatively impacted plant photosynthesis and contributed to plant water stress, effectively decreasing the productivity of kale plants at Cadillac Urban Gardens.



## RELATIONSHIP BETWEEN LEAF POSITION OF TOMATO PLANTS ON STOMATAL DENSITY

Alyssa Bachert, Connor McDonough, Maria Denha, Eliona Islami, Fiona Nguyen, and Rayan Akhdar

Research Advisor: Eva Nyutu

All leaves have stomata, which are tiny openings present on the epidermis (skin) of leaves. Stomata are essential to every single plant and its function. The location of tomato leaves has significant effects on stomatal density, the length of stomata, and the percent of stomata open. The objective of our study was to evaluate whether leaves at the top or bottom of the tomato plants affect stomatal density, stomata size, and stomata open/closed. We sampled 10 leaves from the top of the tomato plant and 10 leaves from the bottom of the tomato plant. We made leaf impressions of all the leaves using clear tape and slides and then determined the stomatal density, stomata size, and stomata open/closed. Our results showed that the mean stomatal density of the tomato leaves did differ significantly between the top and bottom leaves. The percent open stomata, and the length of stomata of both top and bottom leaves did differ significantly. Our results suggest that the height of the leaves does affect the rate of carbon dioxide uptake in the tomato plants.



## STOMATAL DENSITY IN CURLY KALE AND DINOSAUR KALE IN CADILLAC URBAN GARDENS OF DETROIT, MI

Mohammed Bleible, Roseann Karana, Iryna Lapshynska, Mariam Shalaby, Rayan Akhdar, and Fiona Nguyen

Research Advisor: Eva Nyutu

Stomata play a key role in plant development as it contributes to gas exchange and transpiration. Stomata density is also an indicator of adaptation to certain environments, therefore identifying factors that affect stomata density could change productivity and plant growth. The objective of our study was to evaluate the relationship between leaf shape and stomata density, stomata size, and percent open stomata in kale plants. We hypothesized that there is a correlation between stomata density and its leaf shape in kale plants. We conducted an experiment by measuring the leaf shape of 10 kale plants and collected leaves from each. We performed the stomata peeling method with the use of a microscope to identify three variables, stomata density, stomata size, and percentage of stomata open. We assessed how these two variables related to leaf shape. Our results showed that there was no significant difference in the stomata density, stomata size, and percentage open in the leaf shape of Kale plants. We suggest that future studies should compare different morphology of leaves from different plants.



## EFFECT OF COMPANION PLANTS ON STOMATAL DENSITY OF TOMATO PLANTS

Gianna Khami, Angelina Stojanoski, George Swanney, Rayan Akhdar, and Fiona Nguyen

Research Advisor: Eva Nyutu

Companion planting is the practice of planting different plant species in close proximity which can be used as a pest control strategy. The Cadillac urban gardens, a southwest Detroit community vegetable garden, is using Chive and Marigold plants as a companion plant with tomatoes as a method to control beetles since they do not use pesticides on their plants. We collected ten leaves from tomato plants that are grown together with Marigolds and ten leaves from tomato plants that grow together with Chives. We used clear nail polish that we applied to the underside of all the leaves and observed the stomata density and open/closed stomas. Our results showed that the mean stomatal density, size of stomata, percent of open stomata of the tomato leaves did not differ significantly between tomatoes with Marigolds and Chives. Our results suggest that companion plants like Marigolds and Chives that are grown together with tomato plants at Cadillac Urban Garden do not increase the amount of carbon dioxide tomato plants can take in, resulting in lower rates of photosynthesis. Future studies should be conducted to compare tomato plants grown with and without companion plants like Chives.



## RELATIONSHIP BETWEEN LEFT MORPHOLOGY OF PLANTS STOMATAL DENSITY AND OPENNESS

Brooke Kouza, Nourhan Ayoub, Frixia Batalla-arias, Alissa Dado Fiona Nyugen, and Rayan Akhdar

Research Advisor: Eva Nyutu

The outer layer of a leaf is the first line of defense against the outside world. It acts as a protective shell, reducing water loss and protects active tissues from potential hazards. Stomata, which are pores dispersed throughout the epidermis, are important components of this outer layer. The size, density, and percentage of open stomata play a crucial role in the overall health of a plant as they act as gatekeepers, allowing gases required for photosynthesis. The objective of our study was to evaluate the difference in stomata size, stomata density, and stoma open/closed between lettuce leaves at the top (outer) and bottom (inner). We collected 0 lettuce leaves from the inner part of the lettuce and 10 leaves from the outer part of the lettuce. We made leaf impressions of all 20 leaves using clear tape, clear nail polish, and slides. We then observed the stomatal density and the stoma open/closed using compound light microscopes and recorded our results. Our results showed that the mean stomatal density of lettuce leaves did not differ significantly between inner and outer leaves. The percentage of open stomata of lettuce leaves in the inner and outer parts did not differ significantly. The size of stomata did not differ significantly between inner and outer leaves. Our results suggest that both the inner and outer leaves might have been receiving the same amount of sunlight and water and this did not affect their photosynthesis rate.



## EFFECT OF LEAF PIGMENTATION ON STOMATAL DENSITY OF RED AND GREEN CABBAGE

Omar Monajid, Madison Kakoz, Olivia Doci, Ali Reda, Fiona Nyugen, and Rayan Akhdar

Research Advisor: Eva Nyutu

Leaf pigmentation can provide valuable insight into the physiological performance and function of leaves which can be correlated to the yield and productivity of the plant. Moreover, leaf pigmentation can affect the rate of photosynthesis which is very important to plants in order to produce their own food. The objective of our study was to measure the stomatal densities and percent open stomata of the cabbage plant that had both red and green pigmentation. Pigmentation is important in plant biology to block UV radiation and protect lower leaves in the plant from an overabundance of sunlight. We predicted that there would be a difference in stomatal density, stomata length and percent of open stomata between the red and green pigmented leaf. We collected a total of 20 leaves from different plants, 10 red and 10 green. We used stomatal peel technique in order to assess stomatal density, stomatal length, and percent of open stoma. We found that there was no significant difference between the two types of leaf pigmentation. Our study suggests that leaf pigmentation does not affect stomatal density of the cabbage plant.



## EFFECT OF STOMATAL DENSITY AND COLOR PIGMENTATION IN GREEN AND PURPLE CABBAGE IN URBAN GARDENS OF DETROIT, MI

Jozi Roberts, Nour Hamdan, Heewoong Kim, Jewels Haisha, Fiona Nguyen, and Rayan Akhdar

Research Advisor: Eva Nyutu

Cabbage is a widely produced crop valued for its nutritional value and variety of colors. Leaf color pigmentation may play a role in how plants conserve water and their rate of photosynthesis. In Cadillac Urban Gardens, we observed the Cabbage plant that had both green and purple pigmentation. Pigmentation is important in plant biology to block UV radiation and protect lower leaves in the plant from an overabundance of sunlight. We predicted that there would be a difference in stomatal density, stomata size, and percent open stomata between the green and purple pigmented leaf. We collected a total of 20 leaves from different plants, 10 green and 10 purple. We used stomatal peel technique in order to assess stomatal density, stomata size, and percent of open stoma. We found that there was no significant difference in stomatal density, stomata size, and percent of open stoma between the two types of leaf pigmentation. Our study suggests that leaf pigmentation does not affect stomatal density, stomata size, and percent of open stoma of cabbage plants. We propose that the garden can use the cabbage plants as a companion plant to block UV radiation.





## THE EFFECT OF PLANT PROXIMITY ON STOMATAL DENSITY IN RED LETTUCE CROPS AT CADILLAC URBAN GARDENS ON MERRITT

Liam Tenzer, Yajat Govardhan, Zahraa Dourra, Jamie Vergara, Anisa Shyti, Zahra Kanji, Jannath Aurfan, and Holly McQuithey

Research Advisor: Eva Nyutu

Stomatal density impacts the growth and well-being of plants as it directly affects their ability to convert energy from the Sun and synthesize food. The objective of our study was to understand how plant proximity affects stomatal dynamics, such as stomata length, and relative number of open stomata in red leaf lettuce crops (*Lactuca sativa*). We collected 20 samples of red leaf lettuce from two plants with different proximity to other plants. We applied nail polish to each leaf, pressed clear tape after they dried, and removed and then attached them to microscope slides. We then analyzed the leaves underneath a microscope to determine their usability in our study based on the appearance of stomata. Following this, we conducted a two-tailed t-test for each stomata response variable ( $n = 10$ ;  $p > 0.05$ ). Our data suggests that plant spatial proximity does not have an impact on stomata dynamics, which may be beneficial in developing new agricultural practices.



## WATER STRESS EFFECT ON STOMATAL DENSITY IN MARIGOLDS

Chrestina Yaqoob, Grace Lemanski, Hailey Cholagh, Marcus Thundercloud, Fiona Nyugen, and Rayan Akhdar

Research Advisor: Eva Nyutu

Stomatal density plays a large role in photosynthesis because the greater the stomatal density, the more carbon dioxide the stomata can take in, and this increases rate of photosynthesis, which results in greater plant productivity. The objective of our study was to evaluate how the amount of water the marigold plant receives affects stomatal density, stomata size, and stomata open/closed. We examined ten leaves from marigold plant that had obtained more water and ten leaves from a marigold plant that did not receive as much water. We made leaf impressions on slides and determined the stomatal density, stomata size, and stomata open/closed for all the leaves. Our study found that stomatal density and the proportion of open stoma were significantly greater in leaves that received more water than the leaves that received less water. The stomatal density of marigold leaves that received more water did not differ significantly from leaves that received less water. Our results can serve as an important metric in regulating the watering of marigold plants in order to obtain the optimal net production of biomass from the plant.



## HOW DO DISEASES AFFECT THE STOMATAL DENSITY AND WATER STRESS OF GRAPE LEAVES IN URBAN GARDENS OF DETROIT, MI

Abdulqader Naser, Deaira Chaney, Lia White, Channoh Yun, Anna-Simone Mousaad, and Zahara Kanji

Research Advisor: Maris Polanco

Several studies show that the stomatal density and water stress of a grape leaf are significantly impacted by diseases. The illnesses can cause stomatal closure through pathogen-associated molecular patterns, preventing penetration through the stomata. The objective of our study was to figure out if there was a difference in water stress between diseased grape leaves and non-diseased grape leaves. Our hypothesis is that the non-diseased leaves would have significantly less water stress than the diseased leaves, resulting in more open stomata than closed ones. We collected 3 diseased and 3 non-diseased grape leaves from the Cadillac Urban Garden. We then performed a stomatal peel, on 12 different slides, and analyzed it under a microscope. We calculated the stomata density and the number of open stomata percent. Our study showed that the diseased grape leaves will have a lower total number of stomata, a reduced stomata density, and a lower number of open stomata. Our results suggest that diseases will have detrimental effects on the plant's physiological processes and overall health.



## APPENDIX A

### SCHEDULE AND EVENTS

Rotations	Group A	Group B	Group C	Group D	Group E	Group F
9:30 am-9:55 am	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	CASEE LAB Demo <b>Engineering Highbay</b>	Student Panel <b>Innovation Space Engineering Building</b>	Chem/Physics Demo <b>Engineering Highbay</b>	Admissions Presentation <b>Student Union Fountain Lounge</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>
10:00 am-10:25 am	CASEE LAB Demo <b>Engineering Highbay</b>	Student Panel <b>Innovation Space Engineering Building</b>	Chem/Physics Demo <b>Engineering Highbay</b>	Admissions Presentation <b>Student Union Fountain Lounge</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>
10:30 am-10:55 am	Student Panel <b>Innovation Space Engineering Building</b>	Chem/Physics Demo <b>Engineering Highbay</b>	Admissions Presentation <b>Student Union Fountain Lounge</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	CASEE LAB Demo <b>Engineering Highbay</b>
11:00 am-11:25 am	Chem/Physics Demo <b>Engineering Highbay</b>	Admissions Presentation <b>Student Union Fountain Lounge</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	CASEE LAB Demo <b>Engineering Highbay</b>	Student Panel <b>Innovation Space Engineering Building</b>
11:30 am-11:55 am	Admissions Presentation <b>Student Union Fountain Lounge</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	CASEE LAB Demo <b>Engineering Highbay</b>	Student Panel <b>Innovation Space Engineering Building</b>	Chem/Physics Demo <b>Engineering Highbay</b>
12:00 pm-12:30 pm	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	Research Poster Viewing/Robotics Demo <b>Student Union Ballroom</b>	CASEE LAB Demo <b>Engineering Highbay</b>	Student Panel <b>Innovation Space Engineering Building</b>	Chem/Physics Demo <b>Engineering Highbay</b>	Admissions Presentation <b>Student Union Fountain Lounge</b>
12:30 pm-1:15pm	LUNCH/Poster Winners Announcement <b>Student Union Fountain Lounge</b> <b>EE/CS Demonstrations located in the Ballroom</b>					

#### CASEE LAB DEMONSTRATION

The Center for Automotive Systems Engineering Education (CASEE) is a live demo to demonstrate teamwork on collaborative projects including competitive vehicle design, robotics and autonomous vehicle development. It highlights an engine room and other collaborative spaces for presentation and visualization and much more hands-on activities in the design and autonomous engineering and design.

#### CHEMISTRY AND PHYSIC DEMONSTRATION

Detroit Mercy Physics Club and Physics students will be hosting an electrifying demonstration where you can discover how electricity behaves in various forms through static electricity, plasma and more!!!



## ADMISSIONS PRESENTATION

Learn about UDM academic programs, student organizations and what a well-rounded university education can provide in your future education and careers.

## STUDENT PANEL

Listen to what our engineering and science students' experiences have been like at UDM. Learn about their research, coop or internship experiences, their experiences living on campus and the fun activities and organizations they are active in.

