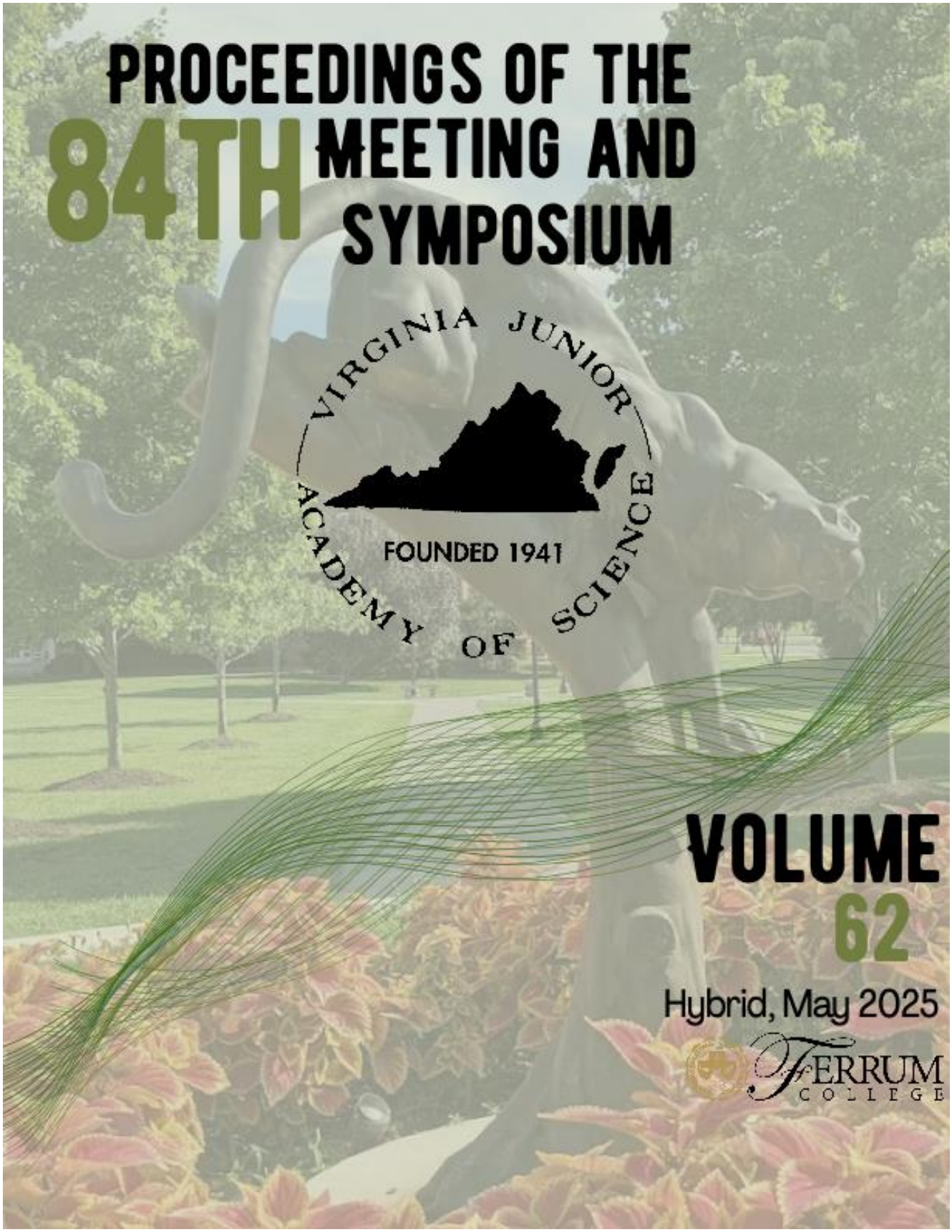
PROCEEDINGS OF THE 84TH MEETING AND SYMPOSIUM



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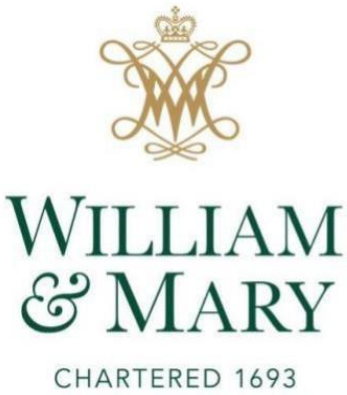

Proceedings of The Virginia Junior Academy of Science Virtual Research Symposium. In-person hosted by Ferrum College, Ferrum, Virginia and Virtual hosted by The College of William & Mary Williamsburg, Virginia
A peer reviewed compendium of Virginia secondary student STEM research.

Edited by
Robin W. Curtis
Associate Director VJAS

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The Virginia Academy of Science (VAS) is the fifth largest state, region, or city academy of science in the U.S.; it was founded in 1923 to promote the civic, academic, agricultural, industrial, and commercial welfare of the people of Virginia. Exemplary programs have included Flora of Richmond and Vicinity, Published, 1930, the first comprehensive multidisciplinary studies of the James River Basin and the Great Dismal Swamp, volunteer research assistance to Virginia in the instance of the kepone pollution disaster, and leadership in establishing the Science Museum of Virginia.

Fall Undergraduate Research Meeting:

The focus of this meeting is support of undergraduate student research. Specific details about the 2025 Fall Undergraduate Research Meeting, including the location and date will be made available on the VAS website (www.vacadsci.org) during the summer.

The Virginia Junior Academy of Science

VJAS is a national model for the new and renewing state junior academies and has been ranked among the top three in the nation for over two decades. Through VJAS and other programs, VAS annually reaches over 40,000 Virginia middle and high school students. Hundreds of volunteers make it possible for Virginia secondary students to experience these activities.

Ferrum

Special thanks to Ferrum for their support in VJAS returning to in-person on the Ferrum Campus. The excellent technology enabled VJAS to run virtual, in-person, and hybrid sections simultaneously.

The College of William & Mary

The Virginia Academy of Science and the Virginia Junior Academy of Science express their sincere appreciation to The College of William & Mary for the generous support in providing web conferencing meeting rooms and service.

Contributors and Supporters

The Virginia Academy of Science and The Virginia Junior Academy of Science notes with appreciation the contribution and support of hundreds of individuals and dozens of organizations to the success of this year's Research Symposium and Annual Meeting.

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American Junior Academy of Science
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Virginia Junior Academy of Science Committee Chair's Welcome Letter

Dear VJAS Symposium Participants:

Welcome to the 84th annual VJAS Symposium. There has been a VJAS Symposium every year since 1941, celebrating student research and scientific investigation. Many changes have taken place both in society and in science since 1941. The VJAS Symposium has adapted to these changes. From an in-person event to a virtual one due to the COVID pandemic, the VJAS Symposium continued. It was with great excitement this year that we returned to an in-person event. The excitement of in-person collaboration cannot be matched.

One thing that has remained constant regardless of the Symposium format or time period is the importance of scientific investigation. It provides the foundation for advancement and an understanding of the world around us. You have all contributed to this understanding through your hard work and efforts in your projects and research over the course of the year. From the identification of a question, to carrying out the investigation and collecting data, to your choice to share your research, much work was done by you. Be proud of your accomplishments and appreciate the journey undertaken.

As you continue your studies and plan your futures after middle and high school, keep your minds open to possibilities and maintain your curiosity. The skills of collaboration, problem solving, and teamwork that you have learned while carrying out your investigations will be useful in the career you choose.

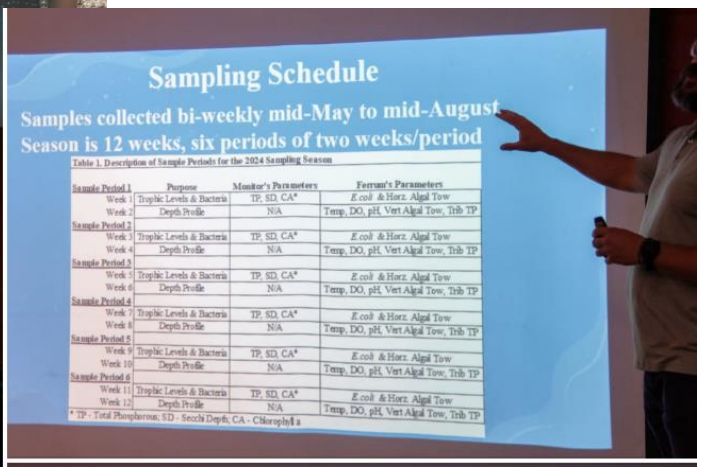
The VJAS Committee hopes that you maintain connections with us and with science, even if you choose careers in disciplines outside of science. We hope to see you as future readers, judges, volunteers, or VAS members. Thank you for participating in the VJAS Symposium. It is through your hard work and dedication that events like the VJAS Symposium can happen. We hope to see you in person at Hampden-Sydney College for Symposium 2026.

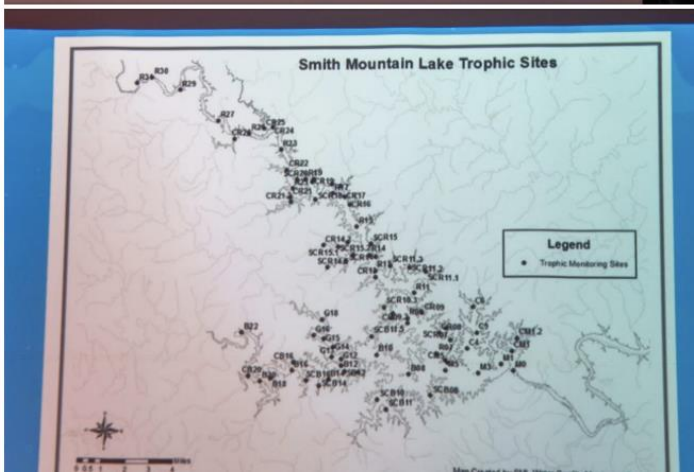
Sincerely,
Mike Lovrencic
Susan Booth
VAS-VJAS Committee Co-Chairs

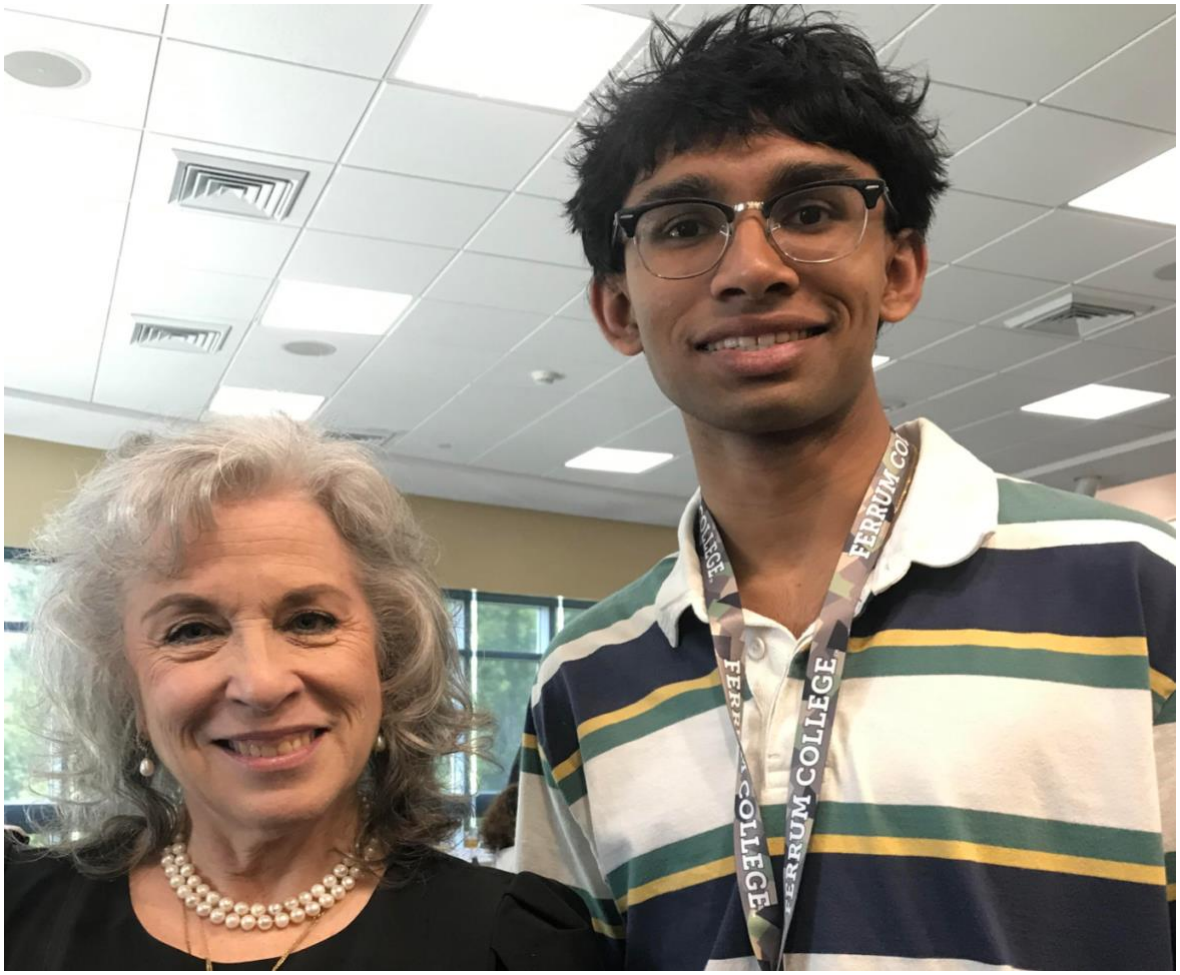
George W. Jeffers Memorial Lecture Dr. Clay Britton, Ferrum University

The School of Sciences and Agriculture pays homage to Ferrum College's rich heritage as a pioneer in environmental science and agricultural studies. Leveraging the resources of our on-campus working farm, students engage as early as their first semester at Ferrum College in experiential learning, exploring the intricate connections between humans, nature, and sustainable agriculture, preparing them to tackle pressing environmental challenges facing our world.

Dr. Clay Britton presented **Smith Mountain Lake Water Quality Program at Ferrum College** results from the years 2020-2024 summer sampling seasons during the Jeffers Speaker at the VJAS Symposium 25 on May 31, 2025.







Dr. Mirta M. Martin, Ferrum College President and Kriesh Tivare VJAS Junior Officer Vice President.
Jeffers Speaker, Dr. Clay Britton and Lunch. Photos by Susan Booth, VJAS Director.

Middle School Sections

Animal Health

First Place
Deen Lateef *Benton Middle School*
Tracing the Trail of Toxins Through our Ecosystems: The Effect of Microplastics on the Lifecycle of the Butterfly

Microplastic pollution poses significant ecological and health risks, yet its effects on terrestrial ecosystems and complex life cycles is not well understood. This study examines the impact of microplastics (MPs) on the life cycle and lifespan of *Vanessa cardui* (painted lady butterflies) using two different experimental models: direct exposure to MPs in the caterpillars' soil habitat and indirect exposure through plants, irrigated with MP-contaminated water, and later consumed by the caterpillars. Results revealed that caterpillars exposed to MP-contaminated soil developed into butterflies with shorter lifespans (7.8 vs. 10.7 days) and experienced an accelerated metamorphosis in which they had a significantly shortened chrysalis phase (5.2 vs. 9.2 days). In contrast, caterpillars fed plants irrigated with MP-contaminated water showed no significant difference in lifespan but still exhibited a similarly shortened chrysalis phase (5.4 vs. 9.2 days). These findings suggest that MPs may disrupt hormonal pathways that guide metamorphosis, and their pervasive presence in the environment can lead to both direct and indirect toxicity and has huge implications for human exposure as well. Although this study was limited by small sample sizes and budget constraints, these findings highlight the urgent need for further research into the ecological and many different biological effects of MPs on terrestrial ecosystems and their inhabitants.

Second Place
Aarav Saxena *George H. Moody Middle School*
Predicting Hatch Rates of Artemia (Brine Shrimp) Using Machine Learning Algorithms on Artemia Egg Shells

Artemia is the most important and influential feed for sought-after fish. Hatcheries worldwide rely on them to uphold their business, yet due to their small stature, they can be difficult to use and track. By using different machine learning algorithms, hatcheries can predict Artemia hatch rates and become more comfortable using them. In this experiment, the researcher gathered eggs that floated to the top as a result of hatching and took 20 pictures per egg value ranging from 1-10. After collecting those pictures, the researcher then downscaled, rotated, and reflected the images, getting 28800 pictures in total. Next, the researcher trained machine learning models such as Decision Trees, Random Forests, Artificial Neural Networks, and Convolutional Neural Networks to learn and make predictions based on the datasets. The researcher hypothesized; If you were to use a convolutional neural network to detect the number of hatched Artemia eggs, then that model would provide the strongest performance. In the training stage, the Decision Tree and Random Forest had a value of 1 for their accuracy, F1 score, precision, and recall score, but in the testing stage, their scores dropped significantly. The Artificial Neural Network had extremely low scores for both the training and testing stages, even scoring a value of 0 for precision and recall for both stages. Convolutional Neural Networks had significantly high scores in both the testing and training stages. The researcher's hypothesis was proven as the Convolutional Neural network did the best, and it can be attributed to its ability to find patterns and analyze the data. Next comes the Random Forest, followed by the Decision Tree whose drop in value from the training to the test stage can be credited to overfitting as it generalized the data set instead of the pattern. Last, comes the artificial neural network, which can be attributed to performing poorly in both the training and testing.

Third Place
Siddhant Naavaal *George H. Moody Middle School*
The Application of a Machine Learning Model with Cross-Validation to Predict Heart Disease

Heart disease, a leading cause of death in the U.S. and worldwide, is a serious health condition affecting the cardiovascular system of the body. This study aimed to develop a machine learning (ML) model to predict heart

disease using a large dataset to assist in early disease detection. The researcher hypothesized that the XGBoost ML model would predict heart disease and achieve a cross-validation mean accuracy greater than 70%. The study utilized a dataset containing 319,795 observations with information on whether the patient had heart disease or not and 17 different features. The top 10 predictive features, such as Body Mass Index (BMI), Sleep Time, Race, Age, Mental Health, and more, were selected using the feature selection process. The researcher utilized a StratifiedKfold cross-validation (a technique that splits the data set across multiple folds while maintaining the exact class balance used to evaluate and minimize overfitting, ensuring generalized results) using a 10-fold process. SMOTE (Synthetic Minority Over-Sampling Technique) and Random Under Sampler (a resampling technique to balance datasets) were used to boost the accuracy and regularization of the model for the training data. The XGBoost model had a 76% test dataset accuracy and an F1-score of 0.85 for predicting no heart disease (Class 0) and 0.34 for having heart disease (Class 1). After resampling, the model achieved a final test dataset accuracy of 71% and an F1-score of 0.82 for Class 0 and 0.32 for Class 1. Resampling techniques had increased the recall (the metric used to determine true positives) from 0.72 to 0.78 for Class 1. A confusion matrix of predicted values of test data (n= 95,939) highlighted that the final test run had 61,781 true negatives (TN), 25,868 false positives (FP), 1,792 false negatives (FN), and 6,498 true positives (TP). The cross-validation had received an average of 71.1% accuracy across all 10. The hypothesis was supported, with a mean cross-validation accuracy of 71.1% and a 95% confidence interval of (70.69%, 71.51%), showing consistent performance over the benchmark of 70%. A one-tailed t-test showed a t-statistic of 6.128 and a p-value of 0.0001, well under the 0.05 significance level. This led to rejecting the null hypothesis, confirming the model's effectiveness in predicting at 70% or more accuracy. Improvements like balanced methods of feature engineering or resampling techniques and additional variables could help tackle precision challenges for heart disease case prediction and further improve ML models in future studies.

Honorable Mention
Anushka Mishra *Gainesville Middle School*
Are Foot Arches Inherited? The Effect of Heredity on Foot Arch Type

Foot arches are known as the base of the human body because they support your body & apos' posture, balance, reduce impact and improve the ability to complete daily life functions. The abilities of a foot arch depend on the arch type- high, normal, low, and flat. Low and flat arches are caused by weak foot muscles and can cause bad posture, limited mobility, poor body mechanics, pain and discomfort. The purpose of this study was to discover whether foot arches are inherited so that people could understand if they should work to achieve a normal arch type to prevent pain and other problems that may arise from a low foot arch in the future. 21 subjects and both their parents were asked to leave a footprint that was later measured for Clarke & apos' angle and classified into an arch type. The footprint was analyzed for similarities between parents & apos, foot arch type and child & apos' foot arch type. After running the experiment, data shows that 71% of subjects had a similar foot arch type to one or more of their parents. One or both parents of all subjects who had an improper foot arch also had an improper foot arch. An equal number of subjects inherited their foot arch from their mom and dad. Foot arches may be inherited from one's parents, but there is no specific parent that it is inherited by. This is supported by the fact that chromosomes (which help build our genes) come in pairs of 2 and following this concept, foot arches are likely inherited at random with neither parent having a stronger influence.

Honorable Mention
Bhavya Uppalapati *Rachel Carson Middle School*
Novel Bio-printed Rice Flour- Vitamin C Trojan Horse Carrier promotes Bactericidal Dual Inhibition of IleRS for the Long-Term Eradication of Methicillin-Resistant S. aureus (MRSA)

Methicillin-resistant *Staphylococcus aureus* (MRSA) is an infection that doesn't respond to common antibiotics, making infections hard to treat. This study explores a new way to fight MRSA by using microencapsulated Vitamin C and a special rice flour-based delivery system, incorporating Isoleucyl tRNA synthetase (IleRS) as a molecular target to enhance efficiency. The goal was to create a safe and simple topical treatment that could stop MRSA from spreading. The experiment focused on two things: finding a strong antibacterial molecule using computer simulations and designing a method to deliver it effectively. First, molecular docking software helped identify how MRSA proteins, including IleRS interact with potential inhibitors. Then, a delivery system was created using rice flour, a natural and non-toxic material, combined with IleRS targeting technology to protect Vitamin C and control its release. The microcapsules were 3D-printed and mixed into a cream made with

coconut oil and beeswax. To test if the treatment could pass through the skin, it was applied to a synthetic skin-like membrane. The results showed that the microcapsules, enhanced by IleRS based targeting mechanisms, allowed for a steady release of Vitamin C, improved skin penetration, and maintained stability. This means the treatment could be an effective way to help wounds heal while reducing MRSA bacteria. The study highlights a new, natural approach to antibiotic delivery that could be useful in future treatments. More testing is needed, but this method has the potential to provide a simple and accessible solution for fighting MRSA infections.

Honorable Mention

Aditya Singhal *George H. Moody Middle School*

Examining the Impacts of Phenol Red, on the Behavioral Changes of the *Daphnia magna*, as a method to simulate the impacts of EDCs on the Human Nervous System.

Ecdysteroids are a hormone within the species, *Daphnia magna*. They are very similar to human hormones, most notably testosterone. Endocrine disrupting chemicals (EDCs) are a class of chemicals that impact the endocrine system and the hormones. The purpose of this project was to see if Bisphenol A, a common EDC, would impact the human nervous system. Instead of the highly toxic BPA, Phenol Red was used, a chemical with similar composition and therefore similar effects. The hypothesis was that a 0.01% concentration of Phenol Red would create the most behavioral changes in the Daphnia magna, without killing the bugs. The experiment was set up with the 4 culture jars, one for each level of IV. Three doses were administered throughout the duration of the experiment. Before each new dose was given, the behavior was observed. Specifically, changes in phototactic behavior were seen along with swimming patterns. Additionally, the number of erratic and clumsy movements were recorded. The end result of the experiment was that yes, the Phenol Red did cause behavioral changes. Less bugs were attracted to the light, more erratic behavior was seen, and the swimming patterns shifted. This signaled that EDCs do impact the nervous system, meaning that they could be impacting human nervous systems as well. The research from this experiment could help healthcare professionals find a cause for nervous system disruption. This experiment also aligned with other studies that examined similar cause and effects. Overall, it is safe to say that BPA can harm the human nervous system, and the EDC must be banned.

Anusha Chakraborty *George H. Moody Middle School*

The Effect of Varying pH Levels in Acne Treatments on Skin Pathophysiology and Efficacy

This study aimed to find the optimal pH level of acne solutions to test the effectiveness of treating acne. Numerous people who have dealt with and suffered from acne do not know which solution is right for their skin or not. Acne solutions tend to have different pH levels, which causes them to have different effects on acne. There are three main acne solutions with varying levels of pH: Retinol, Benzoyl Peroxide, and Salicylic Acid. Extremely acidic or alkaline solutions can negatively affect the skin and cause inflammation or dehydration, making the acne worse. The experimenter's hypothesis stated that if different acne solutions' pH levels were tested, then retinol would be the most alkaline, causing less irritation to the skin, while benzoyl peroxide would be the most acidic, causing more irritation but killing more acne. For each solution, ten Petri dishes were filled with it, leading to fifty total testable Petri dishes. Afterward, the experimenter tested the solutions' pH levels with pH strips, finding which solutions were more acidic versus alkaline. A bar graph and table were created to compare the pH of all solutions, and it was seen that salicylic acid was the most acidic while water was the most alkaline. Retinol was tested to be the most basic experimental group with a pH of 6. After the experiment, it was concluded that lower pH acne solutions, specifically salicylic acid are best for acne. Although highly acidic solutions were known to cause major irritation to the skin, salicylic acid is very gentle for the skin compared to solutions like benzoyl peroxide. Due to its low pH, it is effective in treating and killing acne. Solutions such as benzoyl peroxide and adapalene gel tend to cause major disruptions and irritations to the skin barrier. Retinol was able to treat acne, but its main function was treating fine lines and wrinkles, so it was not the best solution. Water was not acidic enough to be effective in treating acne.

Audrey Bell *George H. Moody Middle School*

The Effect of Species Type on Oral Bacteria Presence

This experiment aimed to compare the amount and variety of bacteria in the mouths of dogs and humans to determine which species had cleaner oral hygiene. The hypothesis posited that humans would have more bacterial colonies due to the greater number of bacteria species found in human mouths. The study examined

the bacterial growth from swabbing the mouths of two dogs and two humans over four days using petri dishes. The experimenter swabbed the mouths of the subjects and placed the swabs on petri dishes, which were then incubated in a controlled environment. The independent variable was the species type (dog or human), and the dependent variable was the amount of bacterial growth. Throughout the experiment, no growth occurred on the first two days. By the third day, the human samples began showing bacterial growth, with more colonies forming by day four compared to the dog samples. While the dogs' samples exhibited more bacterial variety, the human samples had a greater number of colonies. The results confirmed the hypothesis, showing that the human mouth had more bacterial colonies, even though the dog's mouth contained a greater variety of bacteria. Factors such as the dogs' age, diet, and dental hygiene potentially affected the outcomes. Overall, although dogs have a more diverse range of bacteria in their mouths, the human mouth harbored more bacterial colonies overall, supporting the idea that human mouths may be less clean than those of dogs.

Rajat Mallick *George H. Moody Middle School*
The Effect of Sleep Amount on Sleep Quality and Effectiveness

Sleep is vital for human functioning and long-term health in today's society. With good sleep, one would be able to think more clearly, make better decisions, and have good health. However, sleep quality and sleep amount are two different things. Despite this, they are both important and go in correlation. Hence, the experimenter wanted to test if receiving more sleep would lead to better sleep quality. The experimenter's IVs were 6 hours, 7 hours, 8 hours, and 9 hours. Each level of IV would have two participants, each of which would fill out a copy of the Pittsburgh Sleep Quality Index every day for five days, in order to yield ten trials for each IV. The Pittsburgh Sleep Quality Index, or PSQI, is a questionnaire designed to test participants on their sleep quality. The questions on this test will be scored in order to provide a sleep score, ranging from 1 to 3. In this case, the higher the score, the lower the sleep quality of the participant was. Based on the PSQI, the participants had sleep scores of 1, 1.75, 0.5, and 2.75, for 6 hours, 7 hours, 8 hours, and 9 hours, respectively. In conclusion, it was ruled that sleeping for 8 hours was best, but sleeping for 9 hours would hinder sleep quality.

Navin Manoj *George H. Moody Middle School*
The Effect of Caffeine on People's Production and Tasks

This study examines the effects of caffeine consumption on productivity and health. It highlights how an intake of 100 to 150 milligrams daily enhances task performance without any major side effects. The purpose of this experiment is that people all over the world don't know how much a healthy intake of caffeine is. The hypothesis for this experiment is "If people drink about 100-150 milligrams of caffeine, then people will work more productively". This hypothesis was made because people who tend to intake this amount of caffeine have worked more productively. The procedure of this experiment is to get some volunteers and observe their productivity and how many tasks they do due to the amount of caffeine they intake. From the results, something that has been learned is that the people who drank about 2 cups of coffee were the most productive. This experiment concludes that 150-200 mg of caffeine(1 ½ to 2 cups of coffee) should be a healthy amount.

Michael Naod *George H. Moody Middle School*
The Effect of Excessive Fluoride in Drinking Water on the Discoloration of Eggshells

Fluoride is a chemical that is added to food and water to help prevent tooth decay, however, excessive amounts can be harmful. Excessive consumption of fluoride, specifically in rural areas where groundwater with excessive fluoride is used as drinking water, causes dental fluorosis, which is the discoloration of human teeth. This study aimed to investigate how much fluoride in drinking water can cause dental fluorosis on human's teeth. Furthermore, the purpose of this research project is to create awareness for those who live in rural areas, especially near the Great Rift Valley in the African continent, so they can understand the impact of drinking water with excessive amounts of fluoride on their teeth. The hypothesis for this experiment was if there are excessive amounts of fluoride in water then there will be small marks of brown, white, and black on the eggshells, which was supported in this experiment. This study was conducted by soaking eggshells, representing tooth enamel, into water mixed with crushed up sodium fluoride pills. The eggshells were soaked in the water mixed with different levels of fluoride for five weeks and four days and were

assessed based on the observed level of discoloration from a scale of 0 to 10. The data resulted from the experiment showed that as the amount of sodium fluoride was increased, the eggshell discoloration increased. These results suggest that excessive consumption of fluoride in drinking water can lead to dental fluorosis, particularly in children under the age of eight.

Rithvik Reddigari *George H. Moody Middle School*
The Effect of Different Foods on Ghost Shrimp Offspring, Health and Wellbeing.

Pets always have preferences, and some people struggle to find them. Nutrition and enjoyment for your pets are a must. The pet tested for which food it liked in this experiment was Ghost Shrimp (Palaemon paludosus). The conductor hypothesized that they would be healthier if the shrimp ate Shrimp Pellets. This experiment was performed by first setting up the lab. The researcher took two tanks of the same size and shape and decorated them with the same accessories. When touching any parts of the tank inside, clean the tank using gloves and protection to ensure fairness and good water quality for both tanks.
The Conductor facilitated tanks using temperatures of 65-82 °F/18-27.5 °C. That is the optimal temperature for ghost shrimp. There were 10 shrimp in each tank. Each tank had a different assigned food. The conductor tested which food helped the shrimp thrive. One had shrimp pellets and the other had plants and algae. Conclusions were recorded by how much the ghost shrimp ate, the green ball-like structures in their stomach, how active they were, and how many of them survived. There are two levels of IV, shrimp pellets and bite-sized algae and plants. Constants like the type of tank the conductor used, temperature, and facility were considered. Now for the results of this experiment. The conductor followed the rules and expectations set and gave fairness to both tanks. Both Tanks were healthy at first but as time went on, the tank which ate plants became more sluggish and inactive. The Green structures started to become a bit duller than the other tanks. One of the ten shrimp died in the tank that ate plants. All of the shrimp survived in the other tank. The purpose of this experiment was to prove pets do not always enjoy the food they are given and that they have preferences too.

Kairav Shiyhare. *George H. Moody Middle School*
The Effect of HEV Light on Human Sleep and Eyes

This paper compared the effects of HEV light on human sleep and eyes. HEV or blue light is the light that is emitted from screens. The introduction talks about this type of light in more detail. The purpose of this experiment is to compare the effects that HEV light has on people. The hypothesis for the experiment was that sleep would be negatively impacted due to too much HEV exposure. The experiment does not meet a very strong conclusion due to the randomized results but there were some patterns in some of the results. The methods and materials section talks about the procedure that was used to complete the experiment. The experimenter used a smart watch to measure the sleep stages and also required 10 participants to look at a screen for a specific amount of time. Two different datasets were recorded in the experiment. They were the survey results and the sleep data. The survey results summarize the results of the survey and are found in the results section. The sleep data summarizes the time of sleep for all the participants and can be found in the appendix. All of the data was finally compared in the discussions and conclusions section.

Chemical Science A (MS CS-A)

First Place
Ajooni Kaur *George H. Moody Middle School*
The Effect of the Amount of Sodium Citrate on Simulated Blood Clots

Venous thromboembolism, including Deep Vein Thrombosis and Pulmonary Embolism, leads to 100,000 deaths annually in the United States. Anticoagulants, such as sodium citrate, are commonly used to prevent and treat blood clots. While sodium citrate's role in inhibiting blood clotting is well-established, its optimal concentration for maximum efficacy remains unclear. This study explores how different concentrations of sodium citrate impact the size of simulated blood clots, aiming to identify the most effective concentration for treating clotting disorders. The hypothesis for the experiment was, if 2% of sodium citrate is used, then the dimensions of the blood clot will decrease the most. To a blender, the researcher added 240 milliliters of water along with two grams of sodium alginate and mixed it together until a homogenous solution was created. In four different bowls, they added 240 milliliters of water and 1.3 grams of calcium chloride followed by a different amount of sodium citrate in each. She added 0, 2.4, 3.6, and 4.8 grams of sodium citrate to the bowls each representing a different concentration of the anticoagulant. Then, the researcher poured one drop of the sodium alginate solution five times to each of the bowls which created the simulated blood clots. She then measured the height and diameter of each clot. This experiment aimed to determine the optimal amount of sodium citrate to reduce the size of simulated blood clots, with the goal of improving treatments for blood clot-related conditions. Results showed that as the sodium citrate concentration increased, the blood clots became smaller, with a 2% concentration completely dissolving the clots. Although the findings supported the hypothesis, challenges included difficulty measuring the small clots and controlling the droplet size when combining solutions.

Second Place
Mahesh Umika *George H. Moody Middle School*
The Effect of Heat Cooking Methods on the Iron Content in Tofu

Iron is an important mineral that is required to make hemoglobin, which helps transport oxygen throughout the body. However, we generally receive less amounts of iron from the food we consume given that it is a nutrient that is highly sensitive to several factors including heat and moisture and gets destroyed or bound during cooking. The present study evaluates how different heat cooking methods affect the amount of iron remaining in tofu - a soybean derived curd that is a popular high protein source for vegetarian diets. The study evaluated four different commonly used kitchen cooking methods - Roasting, Microwaving, Boiling, and Steaming at different cooking time intervals. The overall hypothesis was that the group receiving the highest amount of moisture and heat as a function of time would result in the maximum loss of iron. A Super Firm Nasoya Organic tofu was diced into smaller cubes and subjected to all the four cooking methods including an Unprocessed Control to determine the iron content before cooking. Two-time intervals for each food processing treatment, representing the minimum and maximum cooking time, were selected based on the final quality of the cooked tofu as typically observed in prepared foods. Iron analysis was conducted using the colorimetric test kit by Hanna Instruments. Roasting at the maximum treatment exposure (10 minutes) resulted in the maximum mean loss of 41% amongst all the treatments. Overall, Microwaving and Roasting, both dry - heat cooking methods, had the highest difference in the loss (32-40%) between the minimum and maximum cooking exposure in contrast to Boiling and Steam cooking - a form of wet cooking method (6-9%). While the data did support the research hypothesis, the level of heat exposed from each treatment was harsher than the amount of moisture present.

Third Place
Gangrade Divit *George H. Moody Middle School*
The Effect of Different Water Purification Methods on how Turbid the Water is and how the pH Level is Affected

Introduction: In recent years, millions of people have suffered from the lack of resources, especially drinking water. This causes them to drink water, which can induce dangerous water-borne diseases. Purpose: The experimenter wants to find the best purification method to help people who can't afford potable water. Procedure: The experimenter will collect water from a local water body and sample tap water. He will pour equal amounts of each water into different filtration methods, fine filtration which consists of sand,

coarse filtration which has gravel, commercial filtration which uses commercially found filters, and control which has no filter. Results: The sand filtration proved to be the least reliable as it made the water more contaminated. The experimenter believes that the best filtration method is the one found commercially as it removes the turbidity and changes the pH level to a healthy level. Purpose: The experimenter believes that this experiment showed that the need for commercial filters is important. Hypothesis: The experimenter's hypothesis is, "If fine filtration is used, then the water will be the least turbid." On the contrary, the experimenter was incorrect as fine filtration contaminated water and increased turbidity. Conclusion: The experimenter's studies suggest that the government should implement strategies to make such filtration systems more affordable to vulnerable populations.

Honorable Mention
Shreya Varma Sooraj *George H. Moody Middle School*
Paper Chromatography: The Effect of Different Solvents on the Sample

The following disquisition was written about how paper chromatography was used to investigate the effects of various solvents on the separation of black ink. The focus was to find cost-effective solvents that would efficiently separate the sample. The hypothesis, independent variable, dependent variable, and constants were accurately outlined in this part of the research paper. The experimenter tested six independent variables, which were the solvents, and they were water, rubbing alcohol, non-acetone nail polish remover, vinegar, seltzer water, and soda. The dependent variable was defined as the Retention Factors (how high or low the separation was). The primary objective of this research was to observe how different solvents influence the separation process. Permanent marker ink served as the sample. A point using the ink was drawn one centimeter away from the bottom edge of the strip of chromatography paper, and without submerging the dot, the separation was visible after approximately thirty minutes. The results showed that water and vinegar were ineffective in separation because they yielded a retention factor (Rf) of 0. Rubbing alcohol, seltzer water, and soda showed minimal movement, and their Rf values indicated some separation. In contrast to the other five solvents, non-acetone nail polish remover worked the best and received high Rf values. This investigation supports the hypothesis, that "If there is higher polarity in the solvent, the separation will yield higher Rf values." Solvent polarity plays a role in separating the components, with polar solvents showing results of distinguished Rf values. The findings also imply that choosing the suitable solvent based on the polarity can improve how the chromatography separates, and it offers beneficial understandings for practical and reliable analytical uses of scientific research.

Honorable Mention
Yellin, Helena *Sabot at Stony Point School*
Testing the Effect of Hydrogen Peroxide Used as s Hair-Lightening Agent on Tensile Strength

Have you ever dyed or bleached your hair with mixed results? Or you were left with damaged, rough or overly frizzy hair. The experiment conducted shows and proves why hair is negatively affected by chemical lightening. Chemical lightening is a very precise process and if done wrong can severely damage the hair. Hydrogen peroxide (H_2O_2) is often used for its oxidizing ability to bleach hair; however, hydrogen can damage a protein called keratin. Keratins makeup and support the tissue of our hair, skin and nails (National Cancer Institute). The purpose of the study was to find how hydrogen peroxide affects the tensile strength of hair. The hypothesis was that if hydrogen peroxide is used to lighten the hair, then the hair will become rough and brittle, and its tensile strength will become weaker. The hydrogen peroxide will cause the hair's natural lipids to be stripped and damage the keratin. The tensile strength of untreated and treated hair samples was tested to understand the effect of the peroxide. It was found that untreated hair overall was stronger, and treatment decreased the tensile strength.

Bodduna Yashwanth *George H. Moody Middle School*
The Effect of Different Chemical Bases on Elimination of Wood Rot

This experiment was conducted to determine which one out of the three most budget wood restoring options (Copper Naphthenate, Urethane, and Boric Acid) would work. This experiment would help prevent the structural development from wooden buildings to decay and weaken, increasing the collapsing probability. It was predicted that, if a Urethane solution was used, then it would increase the rotten wood's structural

strength. A coat of each chemical was applied to 10 different pieces of rotten wood and laid until set. An HCR file set then determined the structural integrity of the lumber. The Copper Naphthenate solution was deemed most effective, and it lived up to its expectations, unlike the Urethane and Boric Acid.

Chokshi Sanam *Kenmore Middle School*
The Effect of the Type of Sports Drink on the Electrical Resistance

A large portion of the human population is athletic. Being athletic means using energy, and energy is necessary for everyday tasks. The increased energy required by being an athlete compared to an inactive person prompts the use of drinks to stay hydrated and energized. This emphasizes the importance of determining which energy drink is best for both physical activity and everyday life. It was hypothesized that if the type of energy drink is Gatorade, then the electrical resistance will be the highest. Three distinct energy beverages were examined to determine which had the most electrolytes within them, to investigate the impact of electrolytes on the human body. In order to determine the electrical resistance of each beverage, a circuit with a digital multimeter was set up. The results supported the hypothesis because Gatorade had the highest electrical resistance. This study shows that Gatorade is the best option to induce energy since it has the highest electrical resistance. Now, people can make an informed choice when deciding which energy and energy drink is best for an active lifestyle.

Jain, Pahel *George H. Moody Middle School*
The Effect of Hydrogen Peroxide's Concentration on Corrosion of Aluminum

Corrosion is when most or all of the atoms on a metal are oxidized. When atoms oxidize, they chemically combine with oxygen. These atoms gain electrons. This damages the surface of the metal. When Hydrogen Peroxide comes in contact with metal like aluminum, the molecules on aluminum exchange atoms with the oxygen molecules in the solution. This is how metals oxidize, also known as corroded. This can cause harm in many ways like collapsing buildings and causing chemical plant leaks. Corroded electronics can cause fires and other issues. If corrosion happens in medical implants, blood poisoning can occur. The purpose of this project was to investigate electronic corrosion and stop this type of corrosion. The hypothesis is that if Hydrogen Peroxide's concentration is high, it will take less time for the aluminum to corrode. To begin this experiment, four cups were placed flat. Each was filled with specific diluted amounts of hydrogen peroxide. After the hydrogen peroxide solution has been diluted, one aluminum nail with a 3.81 cm length each will be placed in it. In this experiment, all five aluminum nails experienced some corrosion. The control variable, water, had the highest average, whereas the 15% Hydrogen Peroxide had the lowest average. However, the control variable had few to no bubbles. The hypothesis made was not supported by the data collected. This is because the control variable which was water had the highest corrosion rate. The findings were that tap water is more corrosive than the 15% hydrogen peroxide solution. This was very unexpected. Although hydrogen peroxide is a strong oxidizing agent, water has a 7.5 pH. This pH level causes them to react with materials like aluminum, corroding them by attacking their molecular structure.

Mulla Abdur Rahman *George H. Moody Middle School*
The Effect of Different Water Filters on Unfiltered Water

This experiment is about the effect that different water filter designs have on the pH of some dirty, sand-contaminated water. This is important as water contamination and water pollution are a large problem in this modern world. The hypothesis was that if there are more materials used in the water filter, then the filter will be more effective. The results of the experiment showed that most filters were effective in improving pH levels and removing contaminants, including ones that used little materials. The procedure was simple; the researcher took contaminated water with a controlled amount of contamination and then used the filter to filter the water. The experiment showed that many different types of filters worked well, including ones like the fruit peel filter, which was very surprising to the researcher as the fruit peel filter did not have many materials in it but still did well.

Tadinada Bhargav *George H. Moody Middle School*
The Effect of Different Water Temperatures on Oil Spill Cleanup Efficiency Using Polymers

The purpose of this experiment is to determine what temperature is ideal for the polymer to act as a catalyst and clean up oil spills. Research in the area of oil spill cleanup can potentially provide an efficient way to clean up spilled oil that can be implemented in bodies of water worldwide. Polymers, a preferred method by scientists to clean up oil, utilizes its absorptive molecular form to solidify oil for easier removal without harming the environment. Additionally, water temperature has been a point of interest for scientists studying oil spill cleanup procedures, as oil spilled in colder waters behaves differently than oil spilled in warmer waters. Water temperature can change the viscosity of the oil, and the polymer has been found to function better in warmer, low thickness, water. It has been hypothesized that if the water temperature is higher, then the polymer will function more efficiently. This experiment can lead to changes in polymer-based absorbent products, modifying them for different temperatures. By utilizing ZEP Instant Spill Absorber and taking proper safety precautions, this experiment can be conducted with 10mL of motor oil per trial, with 20 trials each at 5°C, 10°C, 15°C, and 20°C. After conducting this experiment, it was found that the polymer functions better in warmer waters, a result that supported the hypothesis. Specifically, the maximum amount of oil extracted out of 10mL was 9.6mL, which was at the highest IV level, 20°C. The average amount of oil extracted across all temperatures was 7.8mL Therefore, it was concluded that more 75% of oil was extracted in colder bodies of water. This experiment's results and conclusions are backed by similar published papers as well. To further the study, related experiments utilizing water stabilization techniques and ferrofluids can be conducted.

Chemical Science B (MS CS-B)

First Place
Arjun Nair *Midlothian Middle School*
Bio-batteries: A Potential Replacement for Conventional Batteries

Conventional batteries convert chemical energy into electrical energy using the electrolyte fluid that runs through it, allowing charge to flow. To complete the several processes required to generate electricity, the battery must include several toxic chemicals, including mercury, cadmium, lithium, and lead. However, several of these substances have harmful effects on the Earth while contributing heavily to the disruption of the natural ecosystem. This occurs when one disposes a battery, which dissolves into the Earth, transfers leftover chemicals into the soil, and contaminates water, impacting ecosystems and all life globally. Additionally, the burning of fossil fuels to produce electricity is harmful to the environment, influencing the increasing rise of global temperatures. The purpose of this project was to determine the efficiency and usefulness of bio-batteries using fruits and vegetables when using them to power devices. These raw materials found naturally on Earth also contain electrolytes, giving them the same abilities as a common battery. Some examples of foods with this power are potatoes, tomatoes, and lemons, all of which were used in this experiment. To conduct this project, copper and zinc strips were placed on opposite ends of the bio-battery to install positive and negative terminals. In this study, fruits and vegetables were connected in series using alligator clips to create a bio-battery that would light up LED bulbs of varying voltage ratings. A voltmeter was used to record the voltages across the LED bulb and across each component of the circuit. The results of the experiment showed that each fruit/vegetable produced approximately 1 volt on average. Addition of up to two fruits to the series circuit increased the voltage significantly (****$p<0.0001$) when connected to an LED bulb of a maximum voltage rating of 3.2 V. However, the voltage produced by the same series circuit seldom showed a significant change upon addition of more fruits/veggies ($p>0.05$), indicating that the LED bulbs capped at their minimum voltage ratings and caused a voltage drop across individual components of the series circuit to prevent a fuse. Statistical analysis was performed using a One-way ANOVA test followed by a post-hoc Tukey comparison test at a 5% significance level. With this knowledge, the number of fruits/vegetables needed to power anything can be estimated relatively easily, allowing people to use bio-batteries as an alternate source of energy to combat climate change.

Second Place
Reya Bansal *George H. Moody Middle School*
The Effect of High Temperatures on the Sugar Content of Bananas as an Indicator of Ripeness

Food deserts have been identified as low-income areas with little availability of healthy and affordable nourishment (Beaulac et al., 2009). Healthy food access in food deserts is challenging to find, especially at various ripening stages (Lee et al., 2024). Instead, most people are forced to turn to fast food chains for their cheap meals, causing serious health problems (Florence et al., 2016). The purpose of this experiment was to discover the relation of high temperatures specifically on the sugar content of bananas. This data would be used as an indicator of banana ripeness to help extend shelf life for people living in areas of limited nutritious food access. The hypothesis for this experiment was if the bananas are placed in temperatures equal to or higher than 35ºC, then the ripening timeline of the banana will increase. The experiment was set up by first cutting bananas into five equal pieces. Then, a banana slice was placed into an incubator set at 25°C. For the following four days of the experiment, the banana slice was taken out of the incubator and the sugar content was remeasured. The experiment was repeated ten times with all four levels of the independent variable, as well as with the control group of room temperature being 20°C. The results showed that the bananas at 40oC had the highest average sugar content whereas the bananas at 20oC had the lowest average sugar content. To improve this study, other factors such as light concentration, humidity, and ethylene could have been taken into account into how they could have been adjusted so as to not have affected the results. In addition, to improve the accuracy and specificity of the results, the experiment could have been observed over a longer period of time with more trials of the independent variable.

Third Place
Sarmed Ahmad *Homeschool*
The Effect of Food Wrappings on Apple Slices' Oxidation

The objective of this research was to determine the best material to use to wrap apple slices. The hypothesis was that if apple slices are placed in aluminum foil, then the apple slices will oxidize slower than if placed in any other type of wrapping, because the foil is strong, and it is stronger than the other materials. The independent variable is the type of food wrapping and the dependent variable is the amount of oxidation on the apple slices. Half apples were placed in different wrapping materials immediately after they were cut. The wrapping materials used were aluminum foil, paper, PE plastic wrap, LPDE plastic wrap, glass containers, and a plastic (Ziploc) bag, after which the amount of oxidation was measured with a chart which uses a 1-16 scale, with 1 being the least brown and 16 being the brownest. The key results of this experiment were that the apple halves that were inside the Ziploc bags were the least brown after 5 days, and the brownest after 5 days were the apples halves inside the paper bags. In conclusion, to prevent apple oxidation, the best wrappings are those with the least exposure to air or are airtight, such as plastic Ziploc bags or glass containers.

Honorable Mention
Anjali Khemka *George H. Moody Middle School*
The Effect of Different Water Purification Methods on Contaminant Removal

Have you ever turned on your kitchen faucet and wondered if the water is safe to drink? Water contamination is a critical global issue impacting billions of people and leading to a huge variety of health problems. Access to pure and safe drinking water is not just a privilege, but a fundamental human right. This study explores the effectiveness of three different purification methods: reverse osmosis (RO), boiling, and both of their combinations—in removing contaminants from water. The hypothesis stated that combining RO and the boiling method would be more effective than either process alone. To test this hypothesis, water samples from different sources went through separate purification treatments. The parameters that were used were; pH (how acidic or basic the water is), turbidity (how clear the water is), total dissolved solids (TDS, which measures the amount of stuff dissolved in the water), and the presence of bacteria. The results demonstrated that while RO effectively reduced TDS and improved water clarity, it did not completely remove bacteria. Boiling, on the other hand, eliminated bacterial contamination but led to an increase in TDS. The combined approach showed the most promising results, significantly reducing contaminants while maintaining balanced water quality. In conclusion, this study confirmed that combining purification methods enhances overall water safety and effectiveness. These findings also highlight the importance of multi-step purification processes for achieving cleaner drinking water, especially in places with limited access to safe drinking water sources. Future research should explore additional techniques, such as activated carbon and UV filtration—to further improve purification efficiency and sustainability. Ultimately, contributing to global efforts in ensuring safe drinking water for all!

Safoora Ahmed *George H. Moody Middle School*
Investigating the Effectiveness of Natural and Commercial Anticoagulants in Preventing Blood Clot Formation

Blood clot formation is very crucial to the human body, as it serves many purposes. This experiment tested different anticoagulants to slow down the clotting process. The study compared natural anticoagulants, garlic, ginger, and turmeric, and commercial anticoagulants, aspirin. The hypothesis states commercial anticoagulants will take longer to clot compared to natural anticoagulants, indicating greater effectiveness. The procedure for this experiment involved the preparation of synthetic blood samples and giving each anticoagulant but under controlled conditions. The independent variables include aspirin, garlic, ginger, and turmeric. The dependent variable measured how long the clotting process was. A control group with no anticoagulant was also included, instead of an alternative such as water. The study ran 15 tests each and all clotting times were recorded to compare. The results showed that the hypothesis was supported as aspirin was the best anticoagulant for slowing down the clotting process which took about seven minutes on average. Among the natural anticoagulants, turmeric was most effective in slowing down the clotting process with an average of 6 minutes. Followed by garlic with an average of 5 minutes and 10 seconds and ginger

with an average of 3 minutes and 55 seconds. The control group had the fastest clotting time with an average of 2 minutes and 30 seconds. In this study, it confirmed that commercial anticoagulants are usually more effective. However, among the natural anticoagulants, turmeric was most effective at preventing blood clots. This study showed aspirin was the most effective anticoagulant. Among the natural anticoagulants, turmeric was best at slowing down clotting. This shows that commercial anticoagulants work best, but natural alternatives work too.

Colin He *George H. Moody Middle School*
How the Amount of Sugar Affects How Foam Stabilizes in Coffee

This experiment explores how adding sugar to coffee affects how long the foam stays stable. Foam in drinks like lattes often fades quickly, which can be disappointing. This experiment aimed to see if sugar could help the foam last longer and find out the best amount of sugar to use. The hypothesis was that adding more sugar would make the foam more stable. In the experiment, different amounts of sugar (0g, 5g, 10g, 15g, and 20g) were added to coffee, and the foam height was measured before and after 10 minutes. The foam's stability was measured by looking at how much the foam decreased. The results showed that adding sugar helped the foam last longer, with the group with no sugar showing the biggest decrease in foam height (18.07%). While the sugar groups had smaller decreases (7.82%, 7.23%, 7.42%, and 6.18%). This shows that sugar helps stabilize the foam. The conclusion shows that sugar can make the foam last longer, which could help improve coffee drinks and other foam-based products. More trials and runs could be used to explore different ways to stabilize foam even better.

Jaime Baker *Kenmore Middle School*
The Effect of Different Natural Antacids on the PH of Vinegar

Many people experience stomach aches frequently and some get acid reflux. Both ailments can be very painful. Natural antacids can help lower pH which helps with stomach aches, but which ones work the best? The goal of this project was to determine how well natural antacids raise the pH of vinegar. The levels of the independent variable were baking soda, ginger, nothing, melon, and banana. The natural antacids were tested by filling bowls with the same amount of vinegar and then putting in each of the natural antacids. The natural antacids were then left in for 10 minutes. After the ten minutes were done, a pH test strip was put into the vinegar and then compared to a chart to determine how much the natural antacid raised the pH of the vinegar. The hypothesis for this experiment is: if the baking soda is added to vinegar, then the pH level of vinegar after 10 minutes will decrease the most because it is the least acidic natural antacid, and is a 8.1 on the pH scale. My hypothesis was supported because the results showed that baking soda raised the pH of the vinegar up 4 levels. The melon and the banana raised the pH level up 1 level and the ginger and control did not change the pH level at all. This experiment shows that ginger and just leaving vinegar out will not make a significant difference for people with acid reflux while melons, bananas, and baking soda will.

Caleb Mathew *George H. Moody Middle School*
The Effect of Sacrificial Anodes on Corrosion of Iron

The corrosion of iron has negative consequences to both the environment and personal safety. The principle of galvanic corrosion of metals can be utilized to extend the lifespan of iron. In galvanic corrosion, the more reactive metal (serving as the anode) gives away its' electrons and hence corrodes faster, whereas the less reactive metal (serving as the cathode) remains protected. Prior literature has shown that metals such as zinc and magnesium can be used as sacrificial anodes to protect iron. The purpose of this experiment was to determine if the combination of zinc and Magnesium together would provide superior cathodic protection to iron compared to using zinc or magnesium alone. The results showed that the combination of the two sacrificial anodes had superior benefit compared to using a single sacrificial anode.

Bhanu Mishra *George H. Moody Middle School*
The Effect of Food Processing on Nutrient Retention

The average American household spends 10% of their annual income. In this experiment, the researcher will test for Protein, Vitamin C, and Sugar with processed foods and organic foods. The testing variables will be

apples, bananas, apple sauce, and banana chips. If it is a processed food, then it is likely to have more sugar and less protein. The purpose of this experiment is to see if processed foods are healthier than organic foods. To prep them, the experimenter will blend each variable and add 6 ml of water. For sugar, the researcher will mix 3 ml of the benedict's solution with 15 drops of the variable and put inside a boiling pan with a beaker, filled halfway with water. The experimenter will wait 3 minutes and then remove the test tube from the beaker and let it cool. The researcher will then mix it and the color that appears compares to how much protein there is. He will do the same 9 more times with each testing variable. For protein, the researcher will then pour 3 ml of the testing solution into the test tubes, along with 10 drops of the biuret reagent. He will then mix it and what color appears is the percentage of protein in the food. He will do the same 9 times to this testing variable and the same to the rest. For Vitamin C, he will place the liquid solutions onto a piece of paper with the Iodine solution spread over it. He will wait 10 mins and then remove the liquid variable and see the color. First off, we saw the different amounts of sugars in each food. In those tests, we clearly saw that organic fruits beat the processed versions of them. Same happened in the protein tests and the vitamin c tests. Our hypothesis is half right, because the organic fruits were healthier, because they had less sugar and more vitamin c, but less protein.

Lily Yang *George H. Moody Middle School*
The Effect of Different Treatments on Hair Damage

This experiment aimed to determine the different methods of hair damage. The hypothesis proposed was that if hair is soaked in hair bleach, then it will sink the farthest in a water bowl. Scalp hair helps protect the body from issues derived from the head and creates a sense of self-identity (Dhami, 2021). However, when hair is damaged, it can cause hair loss, depression, anxiety, and the development of a social phobia (Hussain & Gkini, 2019). The independent variables were pool water, pool water with a shampoo cleanse, a comb, UV flashlight, hair bleach, and no treatment (control.) The dependent variable was the depth to which the hair strands sank in a water bowl. The hair samples were treated with their treatment for three days. Afterward, a few strands from each sample were added to a water bowl to measure the length sunk and porosity. Once the strands of hair can no longer sink, their distance from the surface was recorded. The water bowl measured how damaging the treatments were to the hair samples in place of a real human head. The hair treated with bleach sank the farthest in a water bowl with an average length of 3.43 cm. On the contrary, the hair with no treatment (control) had the least damage inflicted, with an average length of 0.11 cm. The hair bleach treatment was the most damaging and sunk the farthest in a water bowl because it was designed to remove color by eliminating proteins and lipids from the hair (Lima et al., 2020), while the other treatments weren't aimed to do so. In the future, providing more independent variables known to damage hair will create a wider variety of results. Finally, a water bowl with more depth should be provided to allow extremely damaging levels of independent variables to reach their farthest descent, not just the limit of 4 cm.

Ecology & Earth Sciences A (MS EE)

Dorothy Knowlton Award
First Place
Rebecca Zee. *Kenmore Middle School*
The Effect of Cadmium Selenide Quantum Dot Diameter on Photocatalytic Water Purification Efficiency

The global water crisis damages billions of lives, with toxic organic dyes such as methylene blue significantly contributing to water pollution through improperly detoxified industrial wastewater. As the number of people living in areas without safely managed water continues to grow, the need for a sustainable and effective solution becomes increasingly vital. This study aims to assess the capability and effectuality of Cadmium Selenide (CdSe) quantum dots (QDs) as photocatalysts for water purification, and how the size of the QD impacts photocatalytic efficiency. The hypothesis predicts that as the size of the QD decreases, the QD's photocatalytic efficiency will increase. Three different sizes of CdSe QDs were selected (2 nm, 5 nm, and 10 nm) and tested for their ability to degrade methylene blue in water, or, for their photocatalytic efficiency. This efficiency was determined by calculating the percent decrease in the absorbance of the contaminated water across different wavelengths, and these absorbance numbers were found through colorimetry. Results indicate that the size of a QD has a significant impact on its photocatalytic capability, with smaller QDs initiating a greater absorbance decrease, likely due to the quantum confinement effect and their larger surface area-to-volume ratio. However, the observed degradation efficiency suggests that further research in this field is required before practical applications. Even considering the current research gap, this study illustrates the potential of nanotechnology in environmental purification processes, and poses as a possibility to address industrial wastewater, and the global water crisis, more effectively.

Second Place
Saanvi Bejugam *George H. Moody Middle School*
The Effect of Artificial Sweeteners on the Heart Rate of *Daphnia magna*

Most people are born with an unhealthy addiction to sweets, and studies show how high amounts of sugar can increase health risks like obesity. Artificial sweeteners offer a strong sweetening taste with fewer calories than sugar (Sharma, 2016). Many people think of artificial sweeteners as a healthier and better alternative to sugar. Traces of artificial sweeteners have been located in places where *Daphnia magna* thrive, this experiment helps see how these sweeteners affect *Daphnia magna's* survival and heart rate (B. M. Sharma et al., 2019). The hypothesis was if aspartame and erythritol were used then the *Daphnia magna's* heart rate would increase the most out of all sweeteners. In this experiment, three different types of artificial sweeteners were taken, stevia (Splenda Stevia), aspartame (Happy Belly), and erythritol (Whole Earth). Two teaspoons of the artificial sweetener were dissolved in 10 mL of water. 5 mL of each artificial sweetener was taken and placed in one petri dish or for example, 5 mL of Splenda Stevia was placed in one petri dish. This was repeated for all four Petri dishes, there were 40 trials for this experiment, 10 trials in each artificial sweetener group. The Daphnia magna swam in the diluted artificial sweetener water for three days and the heart rate was measured daily. The freshwater mean for three days was 224.4, the mean for erythritol was 141.233, the mean for stevia was 79.267, and the mean for aspartame was 234.4. A major variance appeared in the aspartame group, where the heart rate of *Daphnia magna* increased on Day 2 but then had a rapid decrease on Day 3. Although, it is uncommon for *Daphnia magna's* heart rate to fluctuate but when the organisms are around chemicals or are in a new variable, the heart rate has been observed to fluctuate more. Investigating how *Daphnia magna* reacts to more artificial sweeteners is important, as each sweetener may impact organisms differently.

Third Place
Daksha Talluri *George H. Moody Middle School*
The Effect of Different Layers Above Soil on the Amount of Soil Erosion

Soil erosion, caused by wind or water, poses significant environmental and economic challenges, including the degradation of agricultural land, increased crop damage, and risks to infrastructure. This study investigates the effectiveness of different surface layers—dried leaves, mulch, and rocks—in reducing soil erosion under simulated rainfall. Its purpose was to find the most effective method for preventing soil loss and maintaining land stability in everyday farmlands and neighborhoods. The experiment utilized aluminum trays filled with soil, each covered with one of the three materials or left bare as a control. Water was poured from a consistent height over the trays, and the amount of soil eroded was measured by the mass of soil lost. Throughout the study, the experimenter wore protective goggles, gloves, and an apron to protect the skin and eyes from harmful particles. The results demonstrated that all protective layers reduced erosion compared to bare soil as the control. Rocks were the most effective, reducing erosion to an average of 1.8 grams, compared to 26.5 grams from the bare soil. Mulch and dried leaves also provided some protection, with average erosion rates of 2.5 grams and 3 grams, respectively. The study supports the hypothesis that physical barriers, especially rocks, can significantly mitigate soil erosion by reducing the runoff velocity and maintaining soil structure. These findings suggest that using natural materials like rocks, mulch, or leaves can be a practical strategy for controlling soil erosion in agricultural and urban environments. Future research could explore the long-term impact of these materials and their potential in combination with different soil types and environmental conditions.

Honorable Mention
Arhan Mahapatra *Swanson Middle School*
Discovery of Plastic-Degrading Enzymes from Diverse Environments

Plastic pollution is a big challenge. Every year, around 460 million tons of plastic are produced, but only around 9% of these plastics are recycled. However, in 2016, scientists discovered bacteria that can degrade polyethylene terephthalate (PET) using special proteins called enzymes which work like scissors to cut up plastic. Because bacteria can adapt to use different sources of food easily and PET is found everywhere, I hypothesized that many undiscovered PET-eating enzymes could be found in diverse environments. Using computer tools including artificial intelligence programs like AlphaFold, I analyzed a database of 2.5 billion proteins and found 20 enzymes that looked very similar to known plastic-eating enzymes. I then found out that all 20 enzymes I discovered had the structural and functional features necessary for PET degradation to be possible. These enzymes came from diverse places including marine sediments, polar oceans, sewage, river valleys, engineered bioreactors, and even the microbiome of Hadza hunter-gatherers in Tanzania. My findings showed that bacteria are evolving ways to degrade PET in diverse environments as a response to plastic pollution.

Honorable Mention
Sanjana Nath *George H. Moody Middle School*
The Effect of Algae on Liquid Tree Oxygen Output

A liquid tree is a clear tank container filled with algae and water. In cities and other urban areas where it is only sometimes convenient to grow a tree, a liquid tree can often be easily placed. This could be useful in the real world because it helps us find a solution to create oxygen in places where trees cannot grow. This can help produce more oxygen while taking up less space. The purpose of this experiment was to evaluate how many different algae such as green algae, blue-green algae (Chlorella), and red algae affect oxygen production in liquid trees. It was hypothesized that blue-green algae would generate the most oxygen due to its superior photosynthetic capabilities. Four 1000 ml beakers were used. Beaker one was filled with 500 ml of tap water with no algae, which was the control. Beaker two was filled with 500 g of green algae. Beaker three was filled with 500 ml of blue-green algae. The last beaker, four, was filled with 500 ml of red algae. Beaker two was filled with green algae. Beaker three was filled with blue-green algae. The last beaker, four, was filled with red algae. The dependent variable (DV) was the different types of algae, and the independent variable (IV) was the amount of oxygen produced. Chlorella is a blue-green algae that makes the most oxygen out of all the algae. The most amount of oxygen produced was 2276.5 mm^3. Interestingly, the

results were consistent across the duration of the experiment, showing steady oxygen production over the 10 hours. This indicates that the algae maintained a stable rate of photosynthesis, which is important for the scalability of liquid trees as a sustainable solution for air purification. The lack of significant fluctuations in oxygen production also implies that algae can be reliably used for continuous oxygen generation in enclosed or urban environments.

Vihaan Sai Kandula *George H. Moody Middle School*
The Effect of Different CO2 Absorbing Materials on the CO2 Concentration in an Enclosed Space

Every year, the amount of CO2 released into the atmosphere increases, and this affects the environment. CO2 traps heat, increasing global temperatures which lead to more extreme weather events and the melting of ice caps. Increasing CO2 levels have a human effect, as weather events destroy infrastructure, and increased temperatures are correlated with an increase in illness and respiratory issues. Olivine, Silica Gel, Water, and Soil were all used as the levels of I.V in the experiment. The experimenter conducted the experiment by leaving each level of I.V in an enclosed space for 12 hours and finding the difference between the starting PPM and ending PPM. The results showed that silica gel was the only material that absorbed carbon dioxide, as every other material released carbon dioxide into the enclosed area. Soil stores carbon dioxide, but it doesn't absorb carbon dioxide. Water releases carbon dioxide, as a part of its natural carbon cycle, and it can either absorb or release carbon dioxide. Olivine couldn't produce results, since it must be crushed into olivine sand, but the experimenter merely crushed the olivine into small pieces. The experiment could have been conducted with more efficacy by using different CO2 probes and crushing the olivine to be finer. The hypothesis of this experiment was not supported by the results.

Aarna Vallapureddy *George H. Moody Middle School*
The Effect of Different Fertilizers on the Concentration of Phosphates in the Water drained from Patches of Grass

Many waterways around the world are contaminated with harmful chemicals and bacteria, posing serious risks to public health. Since these waterways serve as a primary source of water for communities, the pollution increases the likelihood of people facing severe medical issues. This experiment aims to address the pollution in waterways around the world. The hypothesis tested was, "If the fertilizer has pesticides, then the water draining from the patches of grass will be contaminated." This is based on the idea that the chemical-containing fertilizers can pollute water when they infiltrate it. In this experiment, several identical grass patches were treated with different fertilizer brands. To measure the amount of chemicals in each fertilizer, water was poured over the patches, and the runoff was tested for chemical contamination. The toxicity of the water was measured to determine if the fertilizers polluted the water with chemicals. The results showed varying chemical concentrations: Vigoro fertilizer ranged from 0.2489 M to 0.2612 M, TruGreen from 0 M to 0.2 M, Organic Neem from 0.0491 M to 0.0601 M, and Scotts Turf Builder from 0 M to 0.3 M. The averages were: Vigoro (0.25736), TruGreen (0.06), Organic Neem (0.05738), and Scotts Turf Builder (0.05). The medians were: Vigoro (0.25895), TruGreen (0), Organic Neem (0.05805), and Scotts Turf Builder (0). The modes were: Vigoro (none), TruGreen (0), Organic Neem (0.0582), and Scotts Turf Builder (0). The experiment concluded that Scotts Turf Builder, which lacks phosphates, caused the least contamination, supporting the hypothesis that fertilizer without phosphorus pollutes water less.

Maya Rzewnicki-Cho *Kenmore Middle School*
The Effect of Rock-Climbing Popularity and Management Policies on the Ecological Health of Popular Climbing Parks

Rock climbing is a rapidly growing sport and as it grows, so do its environmental aspects. With more and more climbers going outdoors, the damage they cause through erosion, harmed vegetation, and harmed wildlife is undeniable. Unfortunately, the management of these devastating impacts is lacking. The purpose of this experiment is to help repair that gap by understanding the effects of climbing popularity and the policies managing it on the ecological health of popular climbing parks. It was expected if a park implements climbing management policies, particularly environmental protection policies, then the park's ecological health score will be better than time periods without such policies and parks with other focuses. For each park and time period, three ecological health factors–access management, environmental protection, and climbing

regulations, were evaluated and given a score of 1-10. These scores were then averaged to find the overall health score of the park during that time period. It was found that after climbing became popular in each park, the ecological health scores went down. Then, even after climbing management policies were implemented, the health scores still dropped–before coming back up in more recent times. This indicates that the growth of climbing's popularity was faster than that of the implementation/improvement of the management policies. Additionally, access management was found to be the most effective type of climbing management policy. The hypothesis that after the implementation of climbing management policies(specifically environmental protection) in a park, the park's ecological health score would improve was not supported.

Vihaan Shirodkar *George H. Moody Middle School*
The Effect of pH Levels on Yeast Fermentation

Global warming is one of the most serious issues occurring in the world today, and they're mainly caused by fossil fuels. An alternative solution to this problem could be to use renewable energy sources like biomass fuel, specifically Isobutanol, a type of biofuel generated by yeast. However, it isn't used much because it can't be produced fast enough. One way to change the speed of yeast fermentation is by altering its pH level, and that's what this experiment was based on. The independent variable was the pH level, which was what affected the amount of fermentation, the dependent variable. The hypothesis for the experiment was if the pH level is set at seven, then it will cause the yeast to ferment the most. The actual procedure included allowing yeast to ferment in a glass with the independent variables of the pH levels of five, six, seven, eight, and nine. After 25 minutes, the height of the yeast fermentation was recorded, and this was done for each level of independent variable with ten trials. In the end, the pH of five had an average of 1.8 centimeters, and the pH of nine had an average of 1.26 centimeters. As the pH level increased, the height of the yeast fermentation gradually decreased which meant that the pH of five had the most yeast fermentation with the least amount of yeast fermentation from the pH of nine. Therefore, the hypothesis was not supported. The reason for this circumstance was because the bacteria, which was serving as a contamination, died in the low pH levels, but the yeast was still able to survive. In summary, a lower pH was best for yeast fermentation according to the experiment.

Engineering & Technology (MS ET)

First Place
Arinjay Ghosh George H. Moody Middle School
Joint Optimization of Vaccination Levels for Covid-19 and Flu

The Covid-19 pandemic has demonstrated the need for vaccination to keep infections under control. Vaccination cost was a major deterrent in this effort and the possibility of coexisting viral strains (such as Influenza and Covid) made such vaccination attempts challenging. The goal of this project was to design a framework to identify optimal vaccination levels that reduces overall cost and simultaneously keeps the total infection counts under predefined levels. The SimPandemic simulator, originally designed to model single strains of different viruses, was extended to handle two simultaneous co-infection modes of Covid and Influenza. Several simulations were executed to create a dataset that considers population demographics, vaccination levels, virus characteristics and vaccination costs. Using this dataset, optimal vaccination levels were estimated. To generalize the framework, a machine learning model was used to predict the total infected counts and vaccination costs, which were the important features characterizing cost-effective vaccination levels for multiple coexisting viral strains. Moreover, a higher number of flu vaccinations were recommended both considering the lower cost of Influenza vaccines and its chances of infecting more people due to the seasonal wave-based nature.

Second Place
Advaith Atulasimha *George H. Moody Middle School*
Energy Produced by a Piezoelectric Crystal When Mechanical Stress is Applied

Piezoelectrics are crystals that possess a unique property, which is to produce a charge when mechanical stress is applied to them. Stress and strain displace the center of the positive charge with respect to the center of the negative charge. (APC International, n.d.).This produces an electric field inside the material called polarization, resulting in charge forming at the electrodes. Conversely applying an external electric field (voltage) to the material produces a displacement or change in shape. This material has found applications in fields such as medicine, for example, producing and sensing ultrasound waves for imaging. (Cafarelliet al.,2021).The aim of this study is to find the voltage that will be produced when a piezoelectric is tapped and how this energy can be transferred to a capacitor. This understanding will help establish if sufficient energy can be harvested by a piezoelectric material placed in a person's shoe to transmit a geolocation signal to find a lost person. The hypothesis is that more piezos will result in a higher voltage being produced and more energy being transferred to an external capacitor. To test this hypothesis different piezoelectric samples (multiple samples of single disks and two disks together) were tapped and the voltage measured by connecting the piezoelectric to an oscilloscope both directly and with an external capacitor added. The results showed that when an external capacitor is connected, two piezoelectric disks produce more voltage and much more energy than a single capacitor. In conclusion, the results show that with many such piezoelectrics, one can produce enough energy to transmit a person's location.

Third Place
Taran Shivkumar *George H. Moody Middle School*
The Effect of Various Liquids on the Load Endurance Capacity of a Hydraulic Device
The experimenter wondered about the potential effects of using different liquids in a hydraulic system. People typically use hydraulic oil to operate hydraulic contraptions, but the experimenter asked what would happen to the load-endurance time if different liquids were used. Hydraulics is the movement of liquid in a cylinder that operates different parts of a machine. The experimenter's hypothesis posited that if honey was used as a hydraulic liquid, then it would demonstrate the longest load endurance possible. The experimenter decided that based on the availability of many liquids, the wisest choices for the independent variables that needed to be tested were water, milk, castor oil, olive oil, and honey. The dependent variable was the load endurance time for the scissor lift. First, the experimenter assembled a hydraulic scissor lift using the manual that came with the kit. The experimenter made sure that all required parts were used. The experimenter grabbed a 2 lb book to use as the load. Next, the experimenter bought a bottle of olive oil and a bottle of honey. The experimenter already had water, milk, and castor oil at home. The experimenter repeated each trial 10 times for each liquid to measure the load endurance time. Then, the experimenter found the average for each liquid. The data that was collected supported the experimenter's hypothesis. For certain liquids, the load endurance data collected were tremendously high, and it became an outlier. The conclusion summarizes the data and how the experiment could be expanded to industry-grade.

Honorable Mention
Arjun Madaan *George H. Moody Middle School*
Biopython Enhancements: Accelerating DNA Sequence Search through Algorithmic Optimization

Unlocking the secrets of biological systems demands the synergy of computing and biology. Despite its potential, current algorithms hinder the full realization of biotechnology. This project pioneers a novel Python program that leverages the strengths of megablast and blastn algorithms to accurately identify species from DNA sequences, rivaling the National Institutes of Health's BLAST database. Through rigorous evaluation, megablast's superior performance was revealed, achieving perfect e-values while reducing alignment time by seven seconds in all trials. This innovation has far-reaching implications for rapid and accurate DNA sequence analysis, propelling our understanding of biological systems and unlocking new avenues for precision medicine and biotechnology.

Honorable Mention
Matthew Polkosnik *George H. Moody Middle School*
The Effect of Different Types of Metals on the Rotations of the Ionic Rotor per Minute

This experiment was conducted to find out what metal is best for an Ionic rotor. The hypothesis is "If copper is used for the rotor, then it will spin the fastest". An ion rotor is two ion thrusters that propel the rotor to spin by blowing ionized gasses in opposite directions. An ion thruster is a form of electric propulsion that is commonly used in satellites because of its low fuel consumption and ability to charge from the sun (Finio, 2022). Ion rotors work by having electrons jump from the anode to the cathode, while traveling some electrons ionize and jump from air particles pushing the rotor (Patel, 2012). The metals used for the cathode and anode of ion rotors are metals that are good conductors of electricity because they have better efficiency for the electricity. Even without being able to refuel with solar power, estimates say that it can even have 90% greater fuel efficiency than most liquid fueled rocket engines (Bowman, 2020). The levels of IV are copper, aluminum, steel, and zinc. The design consisted of a metal cylinder with a hole in the center, both sides with a nail on each end in opposite directions. Once all the metal rotors were assembled, the bottom of the nail was taped securely to the top of a Van de Graaff generator. The different metal rotors were then tested by running the generator for a minute before recording to let it gain speed and recording the time it took for each rotor to complete one full rotation, all while capturing video footage of the tests on a phone for later analysis. The results of this experiment showed that Stainless steel was the best metal for an ionic rotor. My hypothesis that copper would work the best was incorrect because stainless steel had the best conductivity to weight ratio. Possible error in the experiment could have been the difference of positions of the nails on the ends of the rotor. The sources agreed that copper was the best conductor and that it was the best at being an ionic rotor although none of them tested stainless steel. The results I got showed that Stainless steel is the best metal for an ionic rotor.

Honorable Mention
Kayla Sibley *Kenmore Middle School*
The Effect of Different Machine Learning Models on the Ability to Predict Market Success of a Book Using Cover Art

The goal of this experiment was to determine whether it is possible to judge a book by its cover—specifically using machine learning models to predict the success of children's books on Amazon. The hypothesis was that a more advanced model (neural network) analyzing cover art would outperform a simpler model (linear regression) using book attributes such as price and page count. Two datasets were created: one with cover art and the other with attributes. The machine learning models tested included linear regression, decision trees, random forests, XGBoost, and neural networks were trained and tested on each dataset. The accuracy of predictions was found using mean absolute error (MAE), rank/Spearman correlation, and scatter plots. Results showed that simpler models struggled with cover art, while neural networks performed the best after fine-tuning (adjusting epochs, dropout layers, and batch size). The results supported the hypothesis: neural networks using cover art outperformed linear regression using book attributes. This experiment highlights that you can judge a book by its cover, or at least its market success, as machine learning can predict a book's performance based on cover design. These insights may help authors and publishers to design more appealing covers, encouraging young readers to develop a love for books.

Anish Konjeti *George H. Moody Middle School*
The Effectiveness of Reflective Material on Light and Heat

Countries struck by poverty face interconnected issues, specifically the lack of hardware to cook food. These solutions must also be cost-effective in producing large quantities and distributing them to those in need. The process to identify the most effective method begins with testing various reflective materials on an object that will yield a proportional reaction, in this case, a marshmallow. The materials include aluminum foil, mylar film, plexiglass, and the control, which is a non-reflective material, hypothesizing that aluminum foil would most significantly affect the marshmallow's temperature and cause it to melt.
The results differed from the hypothesis. Mylar film performed the best, averaging temperatures of 134 degrees Fahrenheit. All performed better than the base temperature, as the control served as an insulated container for the marshmallow without producing heat. The other three materials generated heat through their reflective properties at varying scales. The findings were also remarkably consistent each day, with variations in output from the solar ovens primarily due to different base temperatures. The findings of this study contributed to the understanding of light and heat's corresponding relationship and finding a mass-produced material to be used for the benefit of society.

Ritvik Guvalla *George H. Moody Middle School*
The Effect of The Helicopter Blade's Curve Angle on The Power/Lift generated by The Helicopter.

This study investigates the effects of various helicopter blade angles on the lift power generated by the rotor, aiming to reduce fuel consumption and minimize environmental pollution. Helicopters are significant emitters of CO2 and lead. The experiment tested four different blade angles (0.5°, 3.5°, 4.5°, and 5.5°) on a model RC helicopter. The results showed that the 5.5° blades weighed the most, proving the hypothesis that the higher the blade angle, the greater the lift. The study also proved that a slight increase in the angle resulted in a proportional increase in lift, showing a potential for fuel efficiency improvement. The experiment reveals that efficiency can be maximized by the angle of the helicopter blade being larger and thus more lift generated with even potential decrease in fuel consumption and resulting emissions. Regardless of some inconsistencies with 4.5° blades, the study displays the pivotal role played by blades in resolving helicopter flights' emissions output.

Millie Pradawong *Thoreau Middle School*
In Silico Analysis of Anisotropic and Helical Bacterial Cellulose Structures for Enhanced Mechanical Performance

Bacterial cellulose (BC) is a biopolymer composed of an organic nanofibril network. The elasticity, flexibility, tensile strength, water-holding capacity, and antimicrobial properties of BC make the material ideal for various practical applications in multiple fields. BC can be structurally modified to enhance its mechanical properties for different uses. Through Blender modeling, distinct BC structures are created and tested: typical, anisotropic, helical, and anisotropic/helical. FEA simulations revealed that the anisotropic BC had high directional strength, helical BC had increased flexibility, and a combination of the two encompassed both attributes. Biomedical applications of this durable anisotropic BC include tendon and ligament repair, whereas helical BC is best suited toward muscle-mimicking applications. Anisotropic and helical BC could be ideal for dynamic wound dressings due to their dynamic characteristics: mimicking joint movements, resisting wear and tear, holding moisture for quicker healing, and having antimicrobial properties. This study illustrates the effect of anisotropic and helical structural modifications in BC and demonstrates their combined impact for versatile mechanical properties.

Nandita Prakash *George H. Moody Middle School*
The Effect of Aerodynamics on Car Models

How does a car's aerodynamics affect the car's speed and stability? This is a question that lots of people have when purchasing a car. To this day, expensive cars cost more than normal cars as they are more

"good looking" and slim. Although that supposedly makes them go faster the experimenter was curious to what extent that was true. This experiment predicted that the tear-dropped car would be the fastest and most stable car.
The reasoning for this hypothesis is that the tear-dropped car shape is the most aerodynamic car as its drag ratio is more than the rest of the cars. Both of these hypotheses were tested using a wind chamber and a ramp tester. The procedure for testing the speed was to put the car at the top of the ramp and let it slide down the ramp in a straight line, then use a stopwatch to record the time it took for the car to reach the floor from the top. Once the car speed was recorded, the next step was to put a different car in the same spot as the first car and then repeat the previous steps ten times for each of the cars. At the end of all the car's tests, the average was found and written down.
The procedure for testing the stability was different. When testing the stability of the cars, a wind chamber was used. Using a PVC pipe one side of the pipe was covered by a hairdryer. The next step was to put the car in the chamber and set the hair dryer to low. After doing this, record how far back the car went using centimeters. Once recorded, do all ten trials for the other cars also. Once all the cars had been tested for speed and stability, the results showed that the said hypothesis on which car was the fastest was the tear-dropped car, and the hypothesis for the car that was the most stable was proven wrong, as the streamlined car did better than the tear-dropped car. After all this data, the experiment proved that the more aerodynamic a car is, the faster it will be, and the more front-headed a car is, the more it will be stable.

Lao Naomi *Kenmore Middle School*
The Effects of Architecture on Airflow

One of the most prominent uses of fossil fuels in the world is air conditioning, and to reduce their use, scientists have been researching passive cooling. Passive cooling is a way to regulate the internal temperature of a structure without air conditioning, mainly using airflow. This study looks into the airflow of termite mounds, as well as traditional Iranian homes and compares them. Two clay models were made, one for the termite mound, and one for the traditional Iranian house. The airflow was measured by evaporation of water in weight, and the hypothesis predicts that if models of a termite mound and a traditional Iranian home are built, then the model of the termite mound results would have stronger airflow. The results did not support the hypothesis, as they showed that the model of a traditional Iranian home lost 0.3 grams or 17.6% more than the termite mound, but these results can help the world transition to more eco-friendly architecture, because traditional Iranian homes use mud as a material, and lack of air conditioning, both of which benefit the environment and lower housing cost.

Human Behavior (MS HB)

First Place
Solace Shivelight & Ezri Smith *Sabot at Stony Point School*
The Effect of Frequency on Heart Rate

Sound has been used in numerous ways throughout history, through music and entertainment and even in warfare, but behind the sound is frequency. People sometimes ask themselves, “Why does this sound make me feel a particular way?” or “Why is this music in a horror movie scary?”, or “ Why are so many of my favorite songs so similar?”. Frequency, the tone rate, is a factor in those questions and could have physiological side effects. This experiment dives into the science behind frequency and its effect on human heart rate. The hypothesis for this experiment was that the participant’s heart rate would increase when higher-frequency tones were played.
Despite the original goal of testing forty participants, only sixteen were tested due to a learning curve in the experimental design process. The participants were tested individually in a quiet environment while sitting in a comfortable chair with their feet on the ground and limited movement. Participants held a Vernier heart rate monitor in their hands and wore *Soundcore* noise-buffering headphones. The experiment results varied and showed that the participant’s heart rate increased when some higher frequencies and some low frequencies were played. The environment, the state of participants before the test was conducted, and the small sample size could have affected the results. The research was still valuable to the scientists and their understanding of frequency and heart rate and will help them design reliable studies in the future.

Second Place
Rheeya Sureshkumar *George H. Moody Middle School*
The Effect of the Time of Day on People’s Color Choices

Color is a fascinating topic many people overlook. There are so many things to wonder about color and why people choose certain shades over others. The main purpose of this research study is to figure out what colors people will choose depending on the time of day. That can be red, orange, yellow, green, indigo, and purple. Some people might choose brighter colors or darker colors depending on their mood, time, or just personal preference. The hypothesis is that more than half of the people choose brighter colors in the morning and people would choose duller colors in the evening. The experiment was taken by surveying people about what color their eyes go to first. Then they were put into a table to see the results. The hypothesis was that people would choose brighter colors in the evening than in the morning. In conclusion, 40 people were surveyed and 22 of those people chose brighter colors than darker ones in the morning.

Third Place
Ruthvik Manjunatha *George H. Moody Middle School*
The Effect of Artificial Intelligence on the Student's Cognitive Abilities

Artificial Intelligence, one of the most useful tools that humans have adopted into their lives. Moreover, Artificial Intelligence in the educational industry has been impacting the school systems in different directions. Tools, such as ChatGPT and Gemini have recently been evolving widely in many schools, and students have been using these tools for many school assignments. To investigate the effects of Artificial Intelligence on the Student’s Cognitive Abilities and Basic Thinking Abilities, an experiment will be conducted where ten students will be taking two tests testing their basic intelligence and ability. As many students constantly use AI tools such as Google and ChatGPT, this can be the perfect method to test their capabilities and skills. With the research and data collected from students, scientists can freely analyze the experiment and the student’s basic capabilities. If artificial intelligence is reliant and constantly used in schools, then students will be negatively impacted, disabling their ability to think and process new knowledge. During the first test of the experiment, many students have scored perfect scores, however some students have struggled to create accurate drawings, hence showing some signs of declining cognitive functions. On the second test of the experiment, there was a wide variety of results with many low scores. Without a doubt, the results are very interesting and provide wide information on the effect of Artificial Intelligence on the Student’s Cognitive Abilities. After observing the results and comparing the results with other sources, the effect of Artificial Intelligence on the student’s cognitive abilities are determined by the usage and reliance on the Artificial

Intelligence. In conclusion, students who are overdependent on Artificial Intelligence to complete their daily tasks will slowly lose their basic thinking abilities, such as critical-thinking and problem-solving skills.

Ritu Manikanta *George H. Moody Middle School*
The Effect of Different Scents on Mood

This research paper examines the effect of different scents on a person's mood. The purpose of the experiment discussed in this paper is to observe if scent can change a person's mood. The hypothesis of this experiment was "if an individual was exposed to different scents, then they feel different emotions causing their mood to change" The scents used in the experiment were Vanilla, Citrus, Jasmine, and Lavender. The scents were placed in different diffusers and defused for the same amount of time each. To obtain the results, participants were placed into a room with a rotation of different scents. Then the examiner observed the data collected from the surveys. The results display that the hypothesis was supported, and most people feel a mood change when exposed to different scents. Ways to improve this experiment would be to move the participants to different rooms with the same conditions, so that the scents don't overlap each other. In conclusion, this experiment proved that different scents can affect a person's mood.

Chloe Sistrunk *Benton Middle School*
Impressions from a Hands-On Engineering Field Trip and Why We Need More of Them

This study explores how a single, half-day hands-on technology activity, during a field trip, might impact upper-elementary / middle-school students. Public school students participated in an approximately 3.5-hour interactive lesson at a state university STEM Lab. After the lesson, students and their teacher took the initiative to send unsolicited "thank-you letters". Under the University's IRB requirements, the materials were used to improve or enhance programs. The 254 recorded notes suggest participants had a strong positive impact from within a month after the one-time immersive field trip: 20% mention the impact of hands-on learning, with an additional 20% mentioning coding and technology as a favorite activity. They appreciated working with mentors, and learning together made students more excited about STEM (science, technology, engineering, and math). It also inspired them to think about future careers in these fields. Additionally, there were other insights about the type of learning and important elements that made this learning experience extraordinary.

Mathematics: Patterns & Relationships (MS MP)

Smith Shadomy Infectious Disease Award
First Place
Evie Elgart *Shawsville Middle School*

As drug resistance accelerates, pathogens like *Borrelia burgdorferi* (which causes Lyme disease) often require multiple antimicrobials for effective treatment. Combination therapies, however, are difficult to calibrate, with factors ranging from side effects to drug interaction (e.g., synergy and antagonism) complicating the dose optimization process. Here, I design an optimization problem for the best-possible doses of three common Lyme disease antibiotics: doxycycline, amoxicillin, and ceftriaxone. Specifically, I combine mathematical and numerical strategies to minimize a nonlinear cost function representing the safety and efficacy of an antibiotic combination given drug interaction effects, assuming that the dose-effect relationship is Hill-like and natural bacteria growth follows the Ricker model. I find that, when medication safety is given sufficient weight, ideal drug combinations may mix doxycycline and ceftriaxone, with my model showing doxycycline preferred over ceftriaxone when safety is strongly prioritized.

Physical Science & Astronomy (MS PA)

Joyce K. Peterson Award
First Place
Maedot Ayalew *Kenmore Middle School*
The Effect of Solar Magnetic Flux and Spatiotemporal Interplanetary Magnetic Field Variations on Space Weather Prediction Accuracy

Panic often spreads across regions due to power outages caused by space weather events that damage satellites, disrupting communication, scientific data collection, and financial transactions. Space weather forecasting plays a key role in mitigating the impact of these events. However, forecasting models are prone to errors due to the variability of space weather. This study aims to reduce these errors by identifying which events and their characteristics are most difficult to predict. The analysis compares predicted and actual solar magnetic flux variations and spatiotemporal interplanetary magnetic field (IMF) fluctuations of solar flares, coronal mass ejections (CMEs), and geomagnetic storms through calculating the relevant error. These factors are used to assess the model's accuracy in predicting space weather impacts on both space and Earth. The hypothesis predicts that if the solar magnetic flux variations and fluctuations in the interplanetary magnetic field of solar flares, CMEs, and geomagnetic storms are tested, then the accuracy of space weather prediction will decrease the most when predicting coronal mass ejections. Data supported this, showing the highest standard deviation in predictions for CMEs, indicating the greatest deviation from actual values. The model predicted IMF fluctuations with greater accuracy than solar magnetic flux variations, except for one event in 2022. Based on the results of this study, a new CME prediction model was created with lower error than those used by agencies like NOAA. These improvements enhance the accuracy of space weather forecasting, providing better protection against the harmful effects of space weather events on critical infrastructure.

Second Place
Almond Donald *George H. Moody Middle School*
The Effect of Electromagnetic Shielding on Electromagnetic Shielding

Electromagnetic Field (EMF) radiation, emitted by household devices such as microwave ovens, has raised concerns due to its potential health risks, including fatigue, headaches, and possible links to cancer. This study investigates the effectiveness of various shielding materials in blocking both electric and magnetic fields emitted by microwave ovens. The purpose of the research was to identify which material—aluminum foil, brass wire mesh, copper wire mesh, or metal Faraday fabric—would most effectively reduce EMF radiation exposure. The hypothesis posited that metal Faraday fabric would provide the highest level of shielding. One of the electromagnetic shielding's was taped to a microwave, and after 2 minutes of the microwave being on, the strength of the EMF Radiation of the microwave was recorded using an EMF Detector. This process would be done 20 times for each of the EMF Shielding's, excluding 20 times data was recorded for No Shielding. In total there were 100 trials done over the course of 3 hours and 20 minutes. In each of the 100 trials the data was measured in milligauss (mG) and volts per meter(V/m). The data is recorded with two units because Electromagnetic Field Radiation is a summarization of electric field radiation and magnetic field radiation. The data collected were separated into groups depending on the type of shielding used and the unit recorded in, and then the mean of the data groups was calculated. The mean for No Shielding is 6.25V/m and 89.38mG. The mean for Aluminum Foil is 1V/m and 70.78mG. The mean for Copper Mesh is 0.75V/m and 70.21mG. The mean for Brass Mesh is 1.6V/m and 82.46mG. The mean for Metal Faraday Fabric is 0.15V/m and 57.66mG. The data collected supports the hypothesis that Metal Faraday Fabric will have the greatest effect on the EMF radiation of a microwave.

Third Place
Thomas Yap *George H. Moody Middle School*
The Effect of Molecular Structure on the Intensity and Refraction of Light in a Plenum

The subsequent research aimed to explore light's behavior as it passes through various media, including air, water, annealed glass, and flint glass. Supporting the hypothesis that if the molecular density of a substance is increased, then the light's intensity will be hindered and its refraction will be at a greater angle, the analysis pursued to grasp how molecular density affects light transmissions. This understanding serves as a key tool in

medical advancements such as optical coherence tomography (OCT) and laser surgery as they require the aid of light transmissions. The experiment explores two primary aspects: illuminance strength and the angle of refraction of the light when it travels through varying mediums. The light was directed at a 45° angle of incidence through different materials, and both the resulting angle of refraction and intensity were measured. As the line of illumination entered through water, annealed glass, and flint glass, a notable and corresponding trend was observed in the intensity and angle of refraction. Data presented that water caused the least attenuation, followed by annealed glass, with flint glass producing the greatest reduction in intensity due to its higher refractive index. Comparable statistics concerning the angle of refraction were introduced with the flint glass having the greatest angle due to its increased refractive index compared to the annealed glass and water with it being the media having the least influence. To confirm such outcomes, a t-test was conducted which revealed substantial attenuation in intensity between air and annealed glass, confirming the impact of refractive properties on light transmission. To improve on the inquiry, ensuing studies could focus on testing the effects of different wavelengths of light on materials to expand our understanding of light interaction. Such research would contribute to developing more precise diagnostic tools and enhance the effectiveness of light-based therapies.

Honorable Mention
Yash Arora *George H. Moody Middle School*
The Effect of Different Designs of Crumple Zones on the Impact Forces on a Passenger

Cars revolutionized transportation throughout the whole world in 1886 but brought a danger that affected people's lives. In 1959, a Mercedes Benz engineer named Béla Barényi came up with a new way to reduce the force put upon a passenger in a car by creating a zone in cars that crumples easily. Many cars have different designs and shapes of crumple zones. The purpose of this project was to determine the effect of the different Designs of Crumple Zones on the Impact Forces on a Passenger at the following crumple zone designs, 1 inch long, 2 inches long, 3 inches long, and no crumple zone. Each design was run 12 times each with an accelerometer attached to the vehicles to measure the force. Every car and design was sent down a ramp, to hit a wall at the end. Each car was tested for the force using a formula of acceleration into the mass of the car, and the survival rate of the passenger using an egg and seeing how much it is affected by the crash. The results indicated that the longer/bigger the crumple zone is, the higher the survival rate is, with a survival rate of 100% and the smaller crumple zone had a 58.33%. Survival rate. Additionally, the data showed that the longer the crumple zone, the lower the force with a mean of 1.7565966666667 (N), and the shorter crumple zone had a mean of 1.85 (N). The data supported the hypothesis that if there were 3 cars with different crumple zone designs, then the longest one would have a higher survival rate and lower impact force.

Honorable Mention
Hayes Aaron *George H. Moody Middle School*
The Effect of Tennis String Type on the Speed of a Forehand Tennis Stroke

Tennis strings provide unique benefits to tennis players. Examples include Kevlar, Polyester, Multifilament, and Synthetic Gut. Understanding the benefits and drawbacks of each string material could be useful, so players can enhance their performance on the court. The purpose of this experiment was to analyze the effect of tennis string types on the speed of a tennis forehand stroke. The researcher analyzed 4 different types of tennis string: Kevlar, Polyester, Synthetic Gut, and Multifilament. The researcher hypothesized that if different types of tennis string are used on a Head Tennis 2024 Racket, then the Kevlar string will produce the highest speed on a forehand tennis stroke. The researcher, a 13-year-old, right-handed, experienced and Mid-Atlantic ranked male player, performed the experiment and had no injuries in the past 6 months leading up to testing. First, the researcher demoed four Head 2024 rackets from Tennis Warehouse (Tennis Surplus Shop) with the tension (50) and a racket grip of (10.8 cm) both constant and strung the different strings separately on each racket. The tester hosted the experiment indoors at the Raintree Swim & Racket Club, Henrico, Virginia. For the experiment, an *Oncourt Playmate Slam* ball machine was used for every trial to hit balls at the test subject. The researcher would set the ball machine one foot in front of the baseline and load the machine with new Wilson type balls. During a trial, a ball would be hit from the ball machine at 32.19 (km/h) to the researcher's forehand, and the researcher's ball speed on impact of forehand stroke would be measured with a speedometer. After data was analyzed, Kevlar string performed with the slowest ball speed, while multifilament and polyester string produced the fastest ball speed. Data is consistent with prior research and future directions are discussed.

Honorable Mention

Leif Ledford & Miles Torres-Tresize *Sabot at Stony Point School*
The Effect of Different Amounts of Tire Pressure on Time Elapsed Around a BMX Track

This experiment was conducted in an attempt to find the best tire pressure for speed and control when racing bicycle motocross or BMX. BMX is a sport where riders race each other on a race track in an attempt to get the fastest time around the track. A BMX racing bike differs from a mountain bike or a commuting bicycle because of its small frame and extremely light materials (Palermo, A. 2023, June 1). Many riders do not consider tire pressure a variable when preparing for a race. This information will benefit riders if changing their tire pressure makes a significant difference when racing. For this experiment, two BMX racing bikes were tested. The bikes are popular brands and models but have slightly different designs and tire widths. The hypothesis for this experiment was that if the tire pressure was higher, the time elapsed around the track would decrease and the rider's speed would increase. This experiment consisted of nine trials for each model of bike, three trials for each level of the independent variable (PSI). The results showed that a lower tire pressure increased the time the rider took to complete the track. Lower tire pressure causes the tire to deform more, increasing contact with the track and causing friction. Friction makes the rider expend more energy attempting to make the bike move. When the tires have more tire pressure, they deform less, making the rider expend less energy to move the bike forward.

Kadiri Abhay *George H. Moody Middle School*
The Effect of Different Solubles on the Mpemba Effect

This experiment's purpose is to test an extension of the famous Mpemba effect. The Mpemba effect can help in the real world by providing a quicker option for cooling technologies and if proven right could revolutionize the science of keeping things cool in warmer temperatures. The Mpemba effect is commonly known as the theory that says water that is initially hot will freeze faster than colder water. This experiment used solubles to simulate the varying amounts of collisions in different temperatures of water. Water at a high temperature is more active causing the molecules to have more collisions and this experiment simulated those collisions with different solubles. There was a solution of water and salt, water and baking soda, water and sugar, and pure water as a control. The liquids have been placed in the freezer and monitored as they dropped until 0 degrees Celsius, the freezing point of water. It was hypothesized that the solution with the most collisions would cool the fastest. This was proven right as the water and sugar solution cooled the fastest. This solution was also the most dissolved one as sugar is especially good at dissolving in water. The result of this experiment was sugar in water having the fastest cooling time.

Sajith Shivaani *George H. Moody Middle School*
The Effect of Different Paints on a Light Bulb's Radiance

The following treatise was written on the effect of multiple paints which vary in pigment and chemical composition on the luminescence of consistent light bulbs. The introduction discussed the contrast of the paints used: watercolor, acrylic, and fabric, along with the configuration of each paint. All key components of the experiment, from the types of paint to the basis of the experiment, were summarized in this portion of the writing. The hypothesis was that the numerous trials were based on if fabric paint, acrylic paint, or watercolor paint was applied to a light bulb, then the light bulb would vary in radiance and change in color due to the contrast between the pigment and chemicals in each paint. The purpose of the experiment execution was to determine which paint could be used in the future to produce the most exemplary colored light bulb. The data derived from this could be applied to creating a comfortable home setting for people who prefer a slight tint in their house lighting. The execution of the experiment included applying each of the contrasts of paints exclusively onto 3 of the 10 identical light bulbs, which meant that one remaining light bulb was unaltered. A lumen measurement device was then used to measure all data collected. The results displayed the average lumen of each paint that was applied: 36.7 LUX for acrylic paint, 45.43 LUX for watercolor paint, and 58.07 LUX for fabric paint. The general experiment results, including graphs and charts with authoritative numbers, are all disclosed. The conclusion of the writing was a descriptive comprehension of the data and an imprimatur of the hypothesis. The rest of the writing was recapped at the ending of the monograph, and the final verdict was that acrylic paint had the greatest impact on the luminescence, and no paint had no effect, which was the least reverberation.

Plant Science & Microbiology A (MS PM A)

First Place
Samara Habib *George H. Moody Middle School*
The Effect of Temperature on the Amount of Vitamin C in Lemons

Vitamin C, a vital vitamin for human health, is often found in fruits and vegetables. Inadequate levels of vitamin C can cause many health issues, the most serious of which being scurvy. Temperature is one of the various factors that affects the amount of vitamin C in produce. Those with low levels of vitamin C could store their produce in a certain temperature to best preserve the vitamin C. The hypothesis for this experiment was if lemons are stored at 21.67°C, then the lemons will have the lowest decrease in vitamin C concentration. The levels of independent variables in this experiment were -17.78°C, 2.78°C, 21.67°C, and 37.78°C. To set and maintain a temperature, an incubator, fridge, and freezer were used. The experimenter measured the amount of vitamin C in a lemon using a vitamin C test strip and then stored it in 37.78°C for four days. After four days, the experimenter used the vitamin C test strip on the lemon again and recorded the data. This was repeated 10 times for each temperature. The results show that -17.78°C had the least decrease while 37.78°C had the most significant decrease. This is similar to what other research has found because vitamin C is heat sensitive.

Second Place
Rishwitha Chamarthi *George H. Moody Middle School*
The Effect of Different Preservation Methods on Tomatoes

Many parts around the world don't have access to nutritional food. Food shortages are common, and people have to starve (World Food Program USA, 2022). On the other hand, in places like the USA, food is being wasted in large amounts. Even through production, fruits and vegetables are spoiling quickly, and due to this, they are being disposed of at stores and homes (U.S. Department of Agriculture). The preservation of food can help provide for food shortages and reduce food waste at the same time. People won't have to suffer, and food won't be wasted unnecessarily. This experiment looks further into preservation to help solve these problems. As produce like tomatoes spoil easily and are commonly used, they were experimented on. The methods of canning, drying, and freezing were used as independent variables for the experiment, and no preservation was used as a control. Out of these methods, the researcher's hypothesis was that the method of canning would preserve the tomatoes the longest. The experiment was conducted by applying each of the methods to the tomatoes. The canned tomatoes were sealed in glass jars and processed in a water bath canner. The dried tomatoes were placed in a dehydrator that removed its moisture, and for the freezing method, the tomatoes were frozen in a freezer. The results of the experiment were successful and supported the hypothesis, but it was concluded that all the methods of canning, drying, and freezing are great ways to preserve food.

Third Place
Sophie Guo *George H. Moody Middle School*
The Effect of Antibiotics on the Development of the Antibiotic Resistance of *E. coli*.

Antibiotic resistance is one of the top global public health threats, it is estimated that antibiotic resistance is responsible for 1.27 million global deaths in 2019 ("Antimicrobial Resistance", 2023). As a result, bacterial infections become harder to treat. Antibiotic resistance is dangerous because it limits treatment options and may hinder effective treatment. This experiment hopes to bring awareness to this global problem and teach people as to why doctors prescribe antibiotics the way they do. The hypothesis of this experiment is if the amount of antibiotic added into the *E. coli* increases gradually, then the antibiotic resistance of the *E. coli* will also increase. The procedure of this experiment went as follows; the wild-type E. *coli* was inoculated into tubes with an increased concentration of ampicillin to find the first Minimum Inhibitory Concentration (MIC) of the *E. coli.* Then, the *E. coli* that had survived the first round of ampicillin would then be put into different tubes with higher concentrations of ampicillin. This was then repeated until the *E. coli* had fully developed a resistance to the ampicillin. During the results of this experiment, it was discovered that the *E. coli* only required 3 rounds of exposure to the ampicillin before it had developed a full resistance to the antibiotic. The proposed hypothesis was supported by the results of this experiment because the *E. coli* had developed resistance to the ampicillin as the concentration of the antibiotic gradually increased. The findings of this experiment are supported by the law of natural selection because it states that the best adapted organism will be able to survive and reproduce. This experiment is a prime example as it shows how the *E. coli* was

well-suited for the environment multiply and become more resistant to the antibiotics while the less well-suited *E. coli* die as they are exposed to a concentration of ampicillin, they are not able to handle.

Honorable Mention
Manan Nepal *George H. Moody Middle School*
The Effect of Sugar and Sugar Substitutes on Yeast Expansion

The fermentation of yeast is used in many procedures, such as the production of coffee, bread, pastry, and alcohol. However, the time for the fermentation process to occur is lengthy. The researcher believed this time could be shortened by supplementing different sugars and sugar substitutes. These included jaggery powder, Stevia, white sugar, Splenda, palm sugar, and the control. It was then hypothesized that white sugar would cause the largest growth and fermentation. The researcher then placed ten grams of yeast in each of the six jars used and 100 ml of about 80° water. Three grams of the respective sugar or sugar substitutes were put into their labeled jars along with about 80° water for three days. This three-day trial period was repeated ten times, where the mass of each jar was recorded at the end of each day, and the measurements for each of the same days were averaged at the end of testing. After the data was analyzed, white sugar was the worst-performing supplement, hurting the yeast and causing it to grow the least. Stevia and jaggery powder performed the best of all. The reason white sugar performed poorly was likely due to the extra concentration of the sugar, drying out the yeast faster. The less concentrated Stevia and jaggery powder also have more of the original plant-based material, which is removed in the refinement processes of white sugar.

Honorable Mention
Essam Uddin *George H. Moody Middle School*
Effectiveness of Different Natural Pesticides on Different Pests on Plants

The purpose of this experiment was to evaluate the effectiveness of neem oil and garlic spray in reducing mint plant pest populations. The experiment was centered on the most common garden pests including aphids, mosquitoes, armyworms, and caterpillars. It was hypothesized that neem oil had more effective pest reduction results than garlic spray since its main ingredient, azadirachtin, disrupts insect development and reproductive processes (Mishra, 2013). The experiment used three mint plant groups for testing purposes: neem oil-treated plants, plants treated with garlic spray, and an untreated control group. The pesticides received applications every three days throughout a two-week testing duration. The experimenter noted the pest count daily on each plant throughout the experiment. Environmental conditions including sunlight, soil type, and water quantity remained constant across the experiment to achieve reliable results. The results of the experiment confirmed that neem oil proved to be the most efficient among the tested pesticides. The neem oil-treated plants averaged only 1 pest per plant by Day 14, yet garlic spray-treated plants averaged 4 pests per plant by Day 14. The untreated control group showed a rising pest population that reached 18 pests per plant by Day 14. These findings demonstrate that neem oil is a more effective natural pesticide compared to garlic spray. The results showed that neem oil functions as an effective natural pesticide because it reduces pest populations by repelling and interfering with the pest's reproductive cycle. Future research needs to explore different garlic spray concentrations while testing alternative natural pesticides on different plant types. These results provide beneficial information for gardeners and farmers seeking natural alternatives to synthetic pesticides.

Sethuraman Mithun *George H. Moody Middle School*
The Effect of Two Different Fertilizers on Winter Plants

As someone once stated, "The seed is hope, the flower is joy." The joy that some experience, others may not even have a portion of it. The experimenter thought of this and decided that he must combat starvation around the world and help bring back the smiles of many lives. The introduction of this paper highlights the 60 plants grown consisting of 2 IVs, the type of the plant and fertilizer, along with the DV, the height and health of the plant. There were 4 types of plants times 2 fertilizer groups along with a control, and 5 trials for each, so there was a total of 60 plants. Of the 3 hypotheses, the main one was, if plants are grown with nitrogen and 0-10-10 fertilizer, then nitrogen fertilizer will grow faster while also being healthier. The results were otherwise and proved that 0-10-10 was certainly better than the 46-0-0 with no growth, and healthier/taller than the control plants. The only control plant which did manage to beat 0-10-10 was spinach, a generally slow growing plant.

The basic procedure used to design this experiment was separating 60 cups and potting the same amount of soil in each one along with the certain seeds (15 of each plant). After this, to the 40 of them which were going to endure fertilizers, the 46-0-0, urea beads were applied, and the 0-10-10 liquid fertilizer was applied using the dilution method. The hypothesis was not supported by the data. The experimenter concluded that due to the excess amounts of nitrogen already located in the air, more was only unnecessary, but 0-10-10 with phosphorus and potassium, not commonly found elements, were necessary for healthy and abnormal growth rates.

Plant Science & Microbiology B (MS PM B)

First Place
Eshaan Patel *George H. Moody Middle School*
The Effect of CO^2 Absorption Promoting Light Exposure on Photosynthesis

The project was conducted to discover potential solutions to climate change, and space settlement. The researcher had previously determined that the best color temperature for growing houseplants was 4000K. In the current investigation, the researcher exposed snake plants in a closed, airtight system to 4000K light for a given period over the course of a day (one circadian rhythm), for either 0, 8, 16, or 24 hours. The photosynthesis was monitored through CO^2 assimilation through a CO^2 meter, as well as starch production (iodine staining method). The researcher found that overall, more light over the course of the day is best for photosynthesis, and that more light resulted in greater starch production. A feature to note was that all comparisons in CO^2 level were statistically significant (95% confidence level), but the 24-hour group stood out with a robust significance (confidence level of 99.9995%). The researcher found that over the short term, greater levels of light assist with photosynthesis, despite not always doing so in the long term, according to research. Furthermore, the CO^2 absorption in the control group is likely attributed to CO^2 fixing soil microbes, as starch levels were low, meaning the plant wasn't undergoing photosynthesis. Therefore, future research on the topic should not only monitor CO^2 absorption, but also parameters such as soil and plant food production.

Second Place
Sreetoma Bag *George H. Moody Middle School*
The Effect of Antibiotics on Gram-positive and Gram-negative Bacteria

Antibiotics are the solution to many different problems and illnesses in society today. There are two types of bacteria called gram-positive and gram-negative bacteria. Gram-positive bacteria and gram-negative bacteria have one major difference which is that gram-negative bacteria have an intricate structure which gram-positive bacteria do not contain. The purpose of this experiment was to be able to determine whether gram-positive bacteria or gram-negative bacteria was more resistant to antibiotics. The hypothesis of this experiment was, if antibiotics increased, then the gram-positive bacteria will be more affected than the gram-negative bacteria. The procedure for the experiment was to inoculate equal amounts of bacteria which were *Escherichia coli* (C43(DE3)) and Mycobacterium smegmatis into their respective media, into different levels of antibiotic with each having ten trials. The antibiotics used in the experiment were kanamycin and Chloramphenicol. An optical density reader was used to measure the amount of cell cultures. The result of the experiment was that the gram-negative bacteria was more resistant to kanamycin and Chloramphenicol due to having higher optical density units in each of the ten trials. In conclusion, the gram-negative bacteria was believed to have been more resistant due to its unique and complex outer membrane.

Third Place
Anisha Mandal *George H. Moody Middle School*
The Effect of Organic Fruits vs Conventionally Grown Fruits on Shelf Life

A substantial number of foodborne infections, food waste, economic downfalls, and negative environmental impacts are caused by varying shelf lives in produce which is often rooted in a key difference: whether produce is organic or conventionally grown. Consumers also can have trouble figuring out which type of produce fits more of their lifestyle needs based on their life. The purpose of this experiment was to determine whether the shelf life of produce is dependent on whether it is organically or conventionally grown. Prior to the experiment, the

hypothesis made was if a fruit is conventionally grown, it will have a longer shelf life than its organic counterpart. Fifteen organic and fifteen conventional versions of strawberries, blueberries, and raspberries were used in this experiment, and using separate boxes and compartments, the fruits were checked every 24 hours to see if mold appeared on the fruits until every fruit's trials were terminated. The results concluded that the shelf life of a fruit does have a correlation to whether it is organic or conventionally grown. Based on the experiment, both the blueberry and raspberry trials showed the conventionally grown trials averaging to beat the organic trials by over 35 hours. For strawberries, the opposite was true mainly due to one outlier that skewed the results. The statistical analysis (t-test) conducted also concluded with 95% confidence that shelf life is dependent on the way it is cultivated. In conclusion, this experiment supports the idea that a fruit's shelf life is dependent on whether it is organically or conventionally grown, as well as other characteristics the individual fruit has. Understanding how the shelf lives for organic and conventional fruits compare can put a halt to many national and consumer issues.

Honorable Mention
Mahati Lella *George H. Moody Middle School*
The Effect of Simulated Acid Rain on Soybean Germination

Acid rain, which has a pH significantly below 5.6, is a major problem for farmers since it destroys crops by affecting their germination, growth, and development. To solve this issue, an experiment was designed to examine the effect of simulated acid rain on soybean germination. Information on the optimal pH level for crops would be valuable for farmers to adjust the pH accordingly to make it suitable for crop germination. It was hypothesized that if different levels of pH were tested on soybean crops, a neutral pH would be most suitable for soybean germination. *Glycine Max* seeds were placed in several petri dishes, exposed to simulated acid rain of different pH levels - two, three, four, five, and six - and observed for a period of 10 days. An equal number of soybean seeds were put into petri dishes, then a precise amount of vinegar and baking soda was added to each one, kept under a grow light, and the growth of the shoot was recorded. The results for different pH levels showed that some of the soybeans had a sprout that started to form, while others did not. The experiment proved the hypothesis to be correct, with the neutral pH level of 6 resulting in the best germination. To further prove the validity of the conclusion, a chi-square test was performed, with the chi-square value for the data being 52.65. Assuming a significant value of 0.05, the null hypothesis was rejected, as the data proved that there was a significant difference in soybean germination across various pH levels. Therefore, it was concluded that the ideal pH for soybean farmers to plant their soybean crops would be a pH of 6. Farmers can protect their crops from possible destruction or can alter the acidic soil pH by adding lime to neutralize the acidity in the soil and help with the growth of plants.

Akshith Inukonda *George H. Moody Middle School*
The Effect of Different Colored Rays on Plant Growth

When growing plants, it may be hard to properly set it up to achieve the best results. One of those decisions is picking the proper color to set plants under. By correctly selecting the right color for the right type of plant, people can bring the best out of their crops or plants. Different colors can influence plant growth in many different ways. Since growing houseplants can be difficult, making the process easier can be a relief to plant enthusiasts and to those who simply want a floral feel in their home. The hypothesis for this experiment is that if plants are put into different sections with different LEDs to provide light, then the plants under the violet light will grow the most. In order to perform this experiment, there are a few steps needed to be taken. Plant the seedlings in pots, and then put them under light, and then keep track of their growth every day. After the experiment was finished, the hypothesis was proven completely correct, with red being the worst, and purple the best. However, the plants had varying results from 2 - 5 cm. Also, some plants did better or worse than expected. Overall, while some results obtained were surprising, a lot fell into line with what was expected.

Risheka Patil *George H. Moody Middle School*
The Effect of the Amount of *Raphanus sativus* Roots on the Erosion of Soil

As the world continues to grow, many things start to go and wither away. This includes something precious of ours, soil. Over the timespan of 150 years, half of the topsoil has been lost to erosion. The experimenter had realized this and wanted to grow on this topic, so the experimenter had experimented on 5 different independent variables. No plants (control), 2 plants, 4 plants, 6 plants, and 8 plants. This experiment was done to determine if more plant roots could help reduce the amount of soil erosion that could occur. Each independent variable was given 10 trails and was preceded by seeing the amount of soil eroded from each pot when “rain” falls upon it. The results of this experiment had supported the experimenter’s hypothesis of if there are more plants, then less soil erosion will occur. From the data that was collected, the experimenter found that if more plants were planted, the roots bonded the soil together and prevented major soil erosion from occurring. Overall, this experiment was helpful to understand how soil erosion could be prevented and brought to a minimum occurrence.

Sanjana Thotakura *George H. Moody Middle School*
Effects of Fertilizer and pH Levels on Sprouting Time

There are many factors that can affect the amount of time it takes a plant to germinate. Some of these factors include pH level and amount of fertilizer. This information would be beneficial to the agricultural community by presenting the most optimal conditions for rapid germination. The experimenter’s hypothesis is; if the pH levels are lower and the amount of fertilizer is higher, then the plant will sprout the quickest because a higher pH level and a higher amount of fertilizer would provide sufficient nutrients to the plant. The experimenter tested the pH level of the soil after the addition of fertilizer. The experimenter also used pulverized limestone and aluminum sulfate to adjust the pH level and repeated the process for each independent variable. The results show that the mean of this experiment was 16 days, the mode was 13, and the median was 18. In conclusion, the experimenter’s hypothesis was not supported and there were various factors that affected the results

High School Sections

Botany A (HS BOT A)

First Place
Spencer Sloan *Central Virginia Governor's School for Science & Technology*
Shaking It Up: The Effects of Auxin and Mechanical Stress on *Raphanus sativus* Seeds

The purpose of this study was to determine whether or not auxin and mechanical stress would affect root growth of seeds. This study was conducted in a local school laboratory during December of 2024. One hundred forty-four seeds were randomly distributed to 4 groups. Each group had seeds placed in a covered, square plastic dish line with paper towels. One group was treated with the control solution (consisting of only ethyl alcohol and water) and no mechanical stress, one group was treated with the auxin solution and no mechanical stress, one group was treated with the auxin solution and mechanical stress, and the last group was treated with the control solution and mechanical stress. After 48 hours of treatment, pictures were taken of all seeds, and their root lengths were measured digitally using ImageJ software. After data collection, a two-way ANOVA was conducted to analyze the relationship between auxin and mechanical stress. The mean root length for the no auxin or mechanical stress group was 4.14 cm, 1.18 cm for the auxin-only group, 1.19 cm for the auxin and mechanical stress group, and 4.25 cm for the mechanical stress-only group. The ANOVA test, with an *alpha level* set at .05, revealed a *p-value* of 1.00×10^{-30}. This statistically significant value did not support the research hypothesis, which stated that the auxin only group would produce the longest roots. In summation, the presence of auxin negatively affected germination and root growth.

Second Place
Marshall Blankenship *Central Virginia Governor's School for Science & Technology*
Fusarium Fighters: Examining the Abilities of *Pseudomonas fluorescens* as a Biofertilizer in Radish Plants

This study investigated whether *Pseudomonas fluorescens* is effective as a biocontrol agent against *Fusarium oxysporum*, a fungus responsible for wilt in radish plants. The hypothesis was, if radish plants are pretreated with *P. fluorescens,* then they will increase in height and weight, while reducing disease symptoms compared to plants treated only with *F. oxysporum*. Four experimental groups were tested: a control group (no treatment), a positive control group (only *F. oxysporum* exposure), a pre-treatment group (*P. fluorescens* at planting; *F. oxysporum* exposure after three weeks), and a simultaneous treatment group (*P. fluorescens* and *F. oxysporum* exposure after three weeks). After six weeks, the averages for Plant Height (cm) for the negative control, positive control, pretreatment, and simultaneous treatment were 20.707, 17.42, 15.927, and 16.607 respectively. The averages for Plant Wilt (DSR out of 5) for the negative control, positive control, pretreatment, and simultaneous treatment were 0.467, 2.267, 2.6, and 2.467 respectively. For Average Weight (g) for the negative control, positive control, pretreatment, and simultaneous the averages were 5.669, 3.374, 1.905, and 4.441 respectively. Three one-way ANOVAs revealed p-values of 0.00682, 2.00×10^{-6}, and 3.73×10^{-6}, indicating significant difference as these values are below the alpha value of .05. The results contradicted the hypothesis, suggesting that *P. fluorescens* effectiveness varies depending on exposure timing, but further studies are needed to refine the use of *P. fluorescens* in plant disease management. This study contributes to the ongoing exploration of sustainable alternatives to harmful pesticides in agriculture.

Third Place
Lucy Sloan *Central Virginia Governor's School for Science & Technology*
The Effect of Recorded Versus Authentic Stressed *Solanum lycopersicum* Sounds on Water Mass Percentage of Other *S. lycopersicum*

The purpose of this study was to assess the effectiveness of recorded stressed *Solanum lycopersicum* sounds versus live stressed *S. lycopersicum* sounds on the drought response of other *S. lycopersicum*, measured in water mass percentage. Three groups of *S. lycopersicum*, fourteen in each group and two seeds in each pot, were placed into three separate growth tents with water, soil, lighting, and temperature. The first group had no

added variables; the second group had a laptop playing the sound of a *S. lycopersicum*'s xylem popping at an audible level constantly. The third group had four more *S. lycopersicum*, each in a pot around the other *S. lycopersicum*. They were given half as much water as the others; 10 mL instead of 20 mL, to replicate drought. The plants grew for 5 weeks. Data was collected by cutting the plants, weighing them individually, placing them individually into paper bags and into a heat oven, and then reweighing the plants again. The water mass percentages were calculated as follows: 94.41% for the control, 94.82% for the recording group, and 94.77% for the live group. A one-way ANOVA Test analyzed the data. With an alpha value of .05, the p-value was determined to be .68, thus indicating no significance in the research. The research hypothesis of the live and recorded group plants having a higher water mass percentage was not supported. However, research involving how plants react to sound of dehydrated stressed plants through their water uptake is important.

Honorable Mention
Agam Agrawal *Mills E. Godwin High School*
The Effect of Different Types of Fruit Peel Compost on Growth of *Raphanus sativus*

The purpose of this experiment was to find the effects of various types of fruit peel compost on radish plant growth. Recently, farmers have started to use more and more organic fertilizers like fruit peel compost instead of artificial ones. Radish plants were treated with apple peel compost, banana peel compost, pear peel compost and plum peel compost. The plants were allowed to grow for 15 days and then their height was measured. The control that was used in the experiment was no fruit peel compost. It was hypothesized that plants that were given banana peel compost would grow more than the others. The results revealed that on average, plants with banana peel compost grew about 3 cm more than plants with apple peel compost, 10 cm more than pear peel compost, 14 cm more than plum peel compost and about 16 cm more than plants with none. A t-test was done on the results, and it revealed that the data was significant for all 10 t-tests. This means that the results did support the research hypothesis. It is believed that the results are because banana peels contain more potassium than all the others. This research could lead to further studies that investigate how various types of fruit peel composts may affect other cruciferous vegetables.

Honorable Mention
Amogha Anand Balaji *Mills E. Godwin High School*
The Effect of Magnets on *Capsicum frutescens* Mass

The purpose of the experiment was to find the effects of magnets on *Capsicum frutescens* mass. In the early 1930s, magnets were used in the botany field to increase plant growth, and magnets may have similar effects on plant mass. In the experiment, *Capsicum frutescens*, also known as chili plants, were treated with either neodymium magnets or ceramic magnets. The control used in the experiment was no magnets. The plants were allowed to grow for a month and then their mass was measured using grams. It was hypothesized that chili plants treated with neodymium magnets would produce an increase in mass than ceramic magnets and no magnets. The results revealed that plants treated with neodymium magnets increased, on average, 14 grams more than ceramic magnets and 3 grams more than plants that weren't treated with any magnets. A t-test was done on the data, and it revealed that the data was significant for neodymium versus ceramic magnets and ceramic magnets versus the control. It was not significant for neodymium magnets versus the control. The results did support the research hypothesis. This may be due to the high magnetic force of the neodymium magnets, but more research needs to be conducted.

Honorable Mention
Landon Pollard *Central Virginia Governor's School for Science & Technology*
Snap Digest Repeat: Digestion in Venus Flytraps

This study investigates the feeding and digestion process of Venus flytraps (*Dionaea muscipula*) to gain deeper insights into their predatory behavior and physiological mechanisms. Using a GoPro camera, the traps were monitored to determine the time required for them to reopen after digestion. The primary objective was to explore the correlation between the amount of food fed to the traps and the time taken for digestion. The research hypothesis was supported that when fed more, the Venus flytraps will take longer to digest. The Venus flytraps were carefully watered until saturation and fed an amount between 10 and 40 milligrams to ensure consistent conditions throughout the experiment. Data analysis revealed a significant relationship: for every milligram

increase in food mass, the digestion time increased by approximately 12 hours. A regression analysis confirmed the significance of this correlation, demonstrating that larger prey results in longer digestion periods. When conducted, a *p-value* of 1.6634×10^{-5} was observed, and when compared to an *alpha value* of .05 the null hypothesis was rejected. These findings suggest that Venus's flytraps adjust their digestive processes based on prey size, which could serve as an energy-efficient strategy for nutrient acquisition. By understanding this adaptive mechanism, the study contributes to the broader field of plant physiology and the unique feeding strategies of carnivorous plants. Furthermore, the research provides insight into how Venus's flytraps balance energy conservation with the need to absorb nutrients from their environment, shedding light on their complex and dynamic feeding behaviors.

Aminata Conteh, Rome John Henriques, Ngozi Imala *Governor's School @ Innovation Park*
The Effect of Acetylsalicylic Acid on Various Herbs Under Stress Conditions

This study investigates the effects of acetylsalicylic acid (ASA) on herb growth, particularly in rosemary and basil under environmental stresses such as high temperatures and drought. By applying a 0.5 mM ASA solution via fertigation, the research aims to assess improvements in germination rates, plant height, yield, and color retention. The proposed experiment follows the hypothesis that ASA can enhance plants' resilience and productivity in adverse conditions, providing insights into sustainable cultivation practices for these widely used herbs. The heat conditioned plants were grown on a heat mat to simulate humid environments. The drought-conditioned plants were given half the amount of ASA, simulating environments where plants receive little water. By the third week of experimentation, the basil control had experienced the most growth, reaching a height of 2cm. But during the second week, the heat-controlled basil had surpassed the control, reaching 2.5 cm while the control was still at 0.5 cm. For rosemary, the heat-controlled plant had surpassed the control, by getting to a height of 6 cm, while the control was still at 4 cm. From this data, it is presumed that ASA can affect plants grown in heat not drought conditions.

Hazel Batra *Mills E. Godwin High School*
The Effect of Caffeine Concentrations on Sunflower Growth

This experiment aimed to find the effects of different caffeine levels on plant growth. The purpose was to explore how varying caffeine levels impact plant growth, which can lead to agricultural practices involving caffeine-rich products. It was hypothesized that the height would grow the most if Monster Ultra was fed to sunflower seeds. Four different caffeine levels were tested: milk, Dr. Pepper, Red Bull, and Monster Ultra, with Helianthus growth measured in centimeters over a four-week period. Statistical analysis revealed that caffeine concentrations significantly influenced plant growth, with Dr. Pepper showing the most substantial positive effect on sunflower height. Safety precautions followed, including wearing gloves and goggles. Sunflower growth was measured after 30 days using different liquids (Milk, Red Bull, Dr. Pepper, Monster Ultra) with controlled variables and repeated trials. A t-test confirmed that the difference in plant height between the control and the caffeinated drinks was statistically significant, with Dr. Pepper yielding a t-value of 0.295, while Red Bull and Monster Ultra showed t-values of 3.888 and 4.428, respectively, both surpassing the critical value of 2.021. These findings supported the hypothesis that caffeine consumption can promote plant growth, but they also indicated that higher caffeine concentrations might hinder growth or cause other harmful effects. The variance and standard deviation analysis revealed low variability, suggesting the data is precise and reliable. This research has implications for understanding caffeine's role in plant biology, particularly in agricultural contexts where caffeine-rich waste, such as coffee or energy drinks, could influence the ecosystem.

Avi Gandhi *Southwest Virginia Governor's School*
Testing if Liquid Ashwagandha Supplement Will Increase the Rate of Growth for Cilantro

Ashwagandha is a plant supplement that has been trending in recent years due to its immense health benefits for humans. Ashwagandha also has many proposed allelopathic properties that impact the growth of its surrounding plants and environment. This experiment tested ashwagandha's allelopathic properties by directly adding ashwagandha extract to coriander seeds upon planting to observe its effect on plant height. The goal of the experiment was to determine if a liquid ashwagandha supplement impacted the rate of growth of cilantro. There were eight groups totaling 320 samples of cilantro. Group one was the control group, while the other seven groups received treatments of fertilizer and ashwagandha in various combinations and amounts. Plants were grown under

growth lights for four weeks to ensure consistency in light and temperature. All groups received the same amount of water and had their height recorded weekly for (n=40) per group. The two-way ANOVA test resulted in p-values of 0.0001 for 0.25 mL, 0.50 mL, and 1.00 mL of ashwagandha; fertilizer; and 0.25 mL, 0.50 mL, and 1.00 mL of ashwagandha and fertilizer together. These significant results indicated that the various treatments reduced plant growth rate. Cilantro plants that received 0.25 mL ashwagandha treatment had a mean height in cm (1.7 +/- 0.59) that was significantly lower (p = <.0001) than the control plants (5.27 +/- 0.78). The mean height of the control plants (5.27 +/- 0.78) was significantly higher (p=<.0001) than the mean height of the plants that received fertilizer and 0.25 mL of ashwagandha (0.47 +/- 0.27). Many samples that received ashwagandha supplements did not make it past germination, which aligned with previous studies on other plants. The results of this experiment could be generalized to other plants due to past studies having similar results. Additional experiments could be done focusing on the effect of fertilizer on cilantro due to the unexpected reduction of germination and growth in some groups treated with fertilizer.

Noah Haskins *Clover Hill High School*
The Effect of Growth Medium of Scallions on the Nutritional Value of the Resultant Scallion

The purpose of this experiment was to determine the differences or lack thereof in nutritional value (measured by Vitamin C content) between scallions grown in soil and those grown in a nutrient-enriched hydroponic solution. This experiment was conducted to obtain more information about the nutritional trade-offs of these different growth media for food crops. The hypothesis of this experiment was that if scallions were grown in a nutrient-enriched hydroponic solution, they would have less nutritional value than scallions grown in soil. Groups of thirty-six (36) scallions each were grown in soil-based and hydroponic environments for a period of 14 and 12 days, respectively. The scallions were then tested for their Vitamin C concentration using titration via an iodine solution. The mean Vitamin C concentration for the soil-grown scallions was 2.72 mg/100g, while for the hydroponically grown scallions it was 2.95 mg/100g. The difference in growth media did not significantly affect the Vitamin C concentration of scallions, therefore the research hypothesis was not supported.

Mahith Kalikota *Mills E. Godwin High School*
The Effect of Soil pH on Plant Growth and Mass

The purpose of this experiment was to observe the effect of soil pH on lettuce plant growth and mass. Plants are considered some of the most important organisms and studying soil pH can aid farmers in crop production. Lettuce plants were placed into one of four soil beds which were hydrated lime, burned lime, wood ashes, and regular soil. The plants were observed over a 3-week time period with their height and mass being recorded. A hypothesis was created that stated if a plant is treated with hydrated lime, then it will have the best growth and weigh the most. The control that was used in the experiment was a soil bed with no additional materials added. The results gathered from the experiment proved that plants with hydrated lime soil grew the most and would weigh the greatest with their means being 1.2 cm and 7.1 grams for each dependent variable. A t-test was conducted on the data which concluded that the data for control vs burned lime and control vs wood ashes were both not significant for mass and height, while hydrated lime vs control proved significant in both mass and height. The results were most likely caused by chance as most of the data was not significant and this showed inaccurate results and the independent variable not being the cause of change. This research can be used to help farmers in boosting their crop production.

Dyuti Pradeep *Mills E. Godwin High School*
The Effect of Plants on Mass Affected by UV Lights

The purpose of this experiment was to gain an understanding of the reaction of different plants when affected by ultraviolet light. Over the years, ultraviolet light has been more prominent in agriculture but has the potential for harm when used on specific plants. The growth of these plants is vital for the environment and world, and their surroundings should be considered. It was hypothesized that if there is exposure to ultraviolet light for basil plants, then they will result in the greatest increase in mass. No control was used as there were separate reactions for each plant, and there could not be any comparison group. The experiment was done over one week, but the preparation took around a month. Twenty-five pots were used for each plant type, all separately grown and affected by ultraviolet lights. They were massed before and

after the UV was used and data was recorded based on their change. T-tests were performed, and it was found that three of them were significant while three of them were not. This shows that there is no specific answer to whether the experiment was significant or not. There were multiple errors made throughout the experiment that affected the results. One would be an issue when massing the plants as that might have caused the masses to decrease. For further research, it is essential to be done on the effect of different types of UV light on plants and how UV light could affect different species of cacti.

Helen Sackett *Central Virginia Governor's School for Science & Technology*
The Environmental Effects on a Fireweed Seedling's Germination

The purpose of this study was to determine if Liquid Smoke would enhance *Chamerion angustifolium* seeds' growth. Prior to the beginning of the experiment, the seeds were placed in a fridge to undergo a cold stratification. Methods used to conduct the experiment include testing mixtures of DI Water and Liquid Smoke on the seeds, which were kept in a growth chamber for the entirety of the experiment. There were five different groups which all received different ratios of DI Water to Liquid Smoke: 50% Liquid Smoke, 20% Liquid Smoke, 2% Liquid Smoke, 0.2% Liquid Smoke, and 100% DI water, which was the control group. A Chi-Square Goodness of Fit statistical test was used to analyze the results of the study. From this, a critical value of 9.49 at the alpha level of .05 was found. When comparing the critical value to a calculated Chi-Square value of 3.0683 it was evident that there was no significance, and there were no differences in germination rates between groups. The research hypothesis, stating that if more Liquid Smoke was added into the *Chamerion angustifolium*'s mixture, then more would germinate, was not supported by the results of this study. The experiment faced trial and error which prohibited it from collecting a substantial amount of data. In conclusion, this study found that adding Liquid Smoke had no impact on Fireweed Seed germination rates

Eleanor Steele *Southwest Virginia Governor's School*
Effects of Biochar Soil Amendment on *Pisum sativum* Under Flood Conditions

Biochar soil amendment has been found to increase biomass and overall plant growth and has sparked interest in the field of sustainable agriculture. Cover crops, which are commonly used to fixate nitrogen in soil between growing seasons, particularly in no-till agricultural practices, have been sparsely studied with biochar soil amendments. The common pea (*Pisum sativum*) is used in temperate climates as a cover crop due to its high nitrogen fixation properties. The goal of this project was to measure the effects of biochar soil amendment on the common pea when subject to common winter weather conditions, specifically periods of time with saturated soil conditions. Forty pea plants were grown in 10% biochar soil amendment and forty peas were grown in control soil conditions. Twenty from each soil condition were subjected to two cycles of 3 days of flooding and 5 days of draining, while twenty from each soil condition were well watered and well drained for the duration of the project and served as the experimental control. All plants were harvested after the completion of the final flood cycle. Aboveground and belowground dry biomass for each plant were used to calculate the root-to-shoot ratio, which provides comparison of plant tissue development. The biochar soil amendment did not have a significant effect ($p=0.16$) on root to shoot ratio in flood or control conditions, but flood conditions did have a positive significant effect on the root-to-shoot ratio of the pea plants ($p=0.002$) compared to the control condition. No significant interaction was observed between the flood and biochar condition ($p=0.17$). Since there was only a positive statistically significant difference in the flood condition compared to the control condition, flooding increased proportional root growth in the peas in both the amended and control soils. Based on the results of the study, further work is needed to understand the impact of plant maturity on root-to-shoot ratio on peas in biochar amendment and flooding conditions.

Botany B (HS BOT B)

VAS Botany
First Place
Abigail Fang *Clover Hill High School*
The Effect of Applying NO Capsules When Planting Radish Seeds on the Resultant Radish Weight, Plant Height, and Leaf Number of the Radishes

The purpose of this experiment was to determine which number of Nitric Oxide (NO) supplemental capsules applied when planting radishes would yield the tallest radishes, the heaviest radishes, and the radishes with the most leaves. NO in plants has been known to decrease the effects of different external stresses while regulating processes such as germination. This experiment was designed to see if adding NO capsules as an external source would provide similar benefits to radishes. The hypothesis was: Adding more NO capsules to radish soil would improve the growth of radish plants (longer plants, heavier radishes, more leaves). Cherry Belle radishes were used, and they were given 28 days to grow. 0, 0.5, 1, and 2 NO capsules were dissolved in water and added to the radishes at the beginning and halfway through the experiment. The final height of each radish was measured in centimeters using a metric ruler, the mass was measured in grams with an electric balance, and the number of leaves was counted. The mean radish mass was 0.420 g when treated with 0 NO capsules, 0.196 g for half of a capsule, 0 g for 1 capsule, and 0 g for 2 capsules. The mean radish height was 6.29 cm when treated with 0 capsules, 4.54 cm for half of a capsule, 0 cm for 1 capsule, and 0 cm for 2 capsules. The mean number of leaves for radishes was 5.3 when treated with 0 capsules, 5.1 leaves for half of a capsule, 0 leaves for 1 capsule, and 0 leaves for 2 capsules. As the number of NO capsules increased, the radish growth demonstrated through height, mass, and number of leaves decreased. The radishes treated with 1 and 2 capsules exhibited no growth at all, while the radishes treated with 0 capsules exhibited the best growth. Ultimately, the data collected resulted in the rejection of both the null hypothesis and the research hypothesis.

Second Place *Mills E. Godwin High School*
Darsh Daddala
The Effect of Different Types of Strawberries on Pesticide Residue Test Results

This experiment was conducted to find the amounts of pesticide residues in inorganic and organic strawberries. Since organic food is 68% more expensive than inorganic food, it's important to find the difference between the two in pesticide amounts to determine if organic produce is worth the cost. Both types of strawberries were placed in paper cups, soaked in water to extract residues, and tested for residues using testing cards. Each card was dipped in one sample cup, left to stand for ten minutes, and pinched for three minutes before results were recorded by identifying the color change. No control was identified because the study compared two types of strawberries to each other. It was hypothesized that organic strawberries would show lower residue amounts than inorganic strawberries. The results revealed that organic strawberries had 30% more negative results compared to inorganic strawberries. A chi-square test was performed on the data and revealed that data was significant for both inorganic and organic vs. expected distribution, therefore the results did support the research hypothesis. It is believed that the results may have been skewed due to sources of error such as color identification when determining results, pinching force of the testing card, amount of water given to each strawberry to extract pesticides not being constant, and less than 25 trials. This research could lead to further studies that investigate specific quantities of pesticide residues in commonly consumed fruits and vegetables using more advanced methods of extraction and measurement such as liquid chromatography-mass spectrometry.

Third Place
Varnika Padmanabhan *Mills E. Godwin High School*
The Effect of Various Manure Types on Celeriac Growth

This study compared the relative effects of rabbit, chicken, and sheep manure on the root diameter of celeriac (*Apium graveolens var. rapaceum*) to facilitate the intensifying demand for sustainable agricultural technology. Understanding how organic fertilizers affect agricultural crop growth is necessary for today's movement towards an environment-friendly way of farming. According to the hypothesis, rabbit manure is predicted to give the largest root diameter owing to its better nutrient composition. This would be followed by a chicken and sheep manure group, and last is the control group with no manure. In all, one hundred celeriac plants were divided

into four groups of twenty-five and either left untreated or treated with one of the above manures. For performance evaluation, root diameters were monitored during the growing phase. Results revealed that rabbit manure was best in significantly increased root diameter than all other treatments. Moderate growth advantages were experienced with chicken manure, while sheep manure had a minimal effect. The control consistently had the lowest root diameters, implying the need for nutrient enrichment. Statistical analysis indicated rabbit manure had the largest average growth and least variability, thus showing consistency in performance. T-tests confirmed the statistical significance between improvements that animal manure produced over the control. The study underscores the tremendous potential of rabbit manure to serve as an efficient and sustainable organic fertilizer. These findings provide important insights for creating resilient, ecologically friendly food systems globally by promoting eco-friendly farming methods.

Honorable Mention
Ananya Sankepalli *Mills E. Godwin High School*
The Effect of Homemade Floral Preservatives on Post-Harvested Hydrangeas

This experiment aims to discover the effect of homemade preservatives on the various aspects of post-harvested hydrangeas. This experiment can assist the floral industries in using affordable and accessible ingredients to preserve post-harvested hydrangeas' vase life, reduce petal wilting, and increase brightness. Post-harvested florals have been produced immediately after harvest, extracting the roots causing a different type of handling. The independent variables included household bleach and sugar, lemon juice and sugar, and apple cider vinegar, with tap water serving as the control. One hundred trails were organized into groups of four, placing each hydrangea in a recycled water bottle. A t-test was performed with the data and all the tests were significant. This implies that the data was caused by the independent variable. The household bleach and sugar solution worked the test to increase the longevity, reduce the amount of petal wilting, and improve the brightness. This preservative performed the best because sugar gives an immediate source of energy. Household bleach reduces the petal wilting and increases the plant's food supply. The worst-performing preservative was the apple cider vinegar solution. The contributions of this experiment can assist individuals in determining an affordable, accessible, and suitable way to preserve hydrangeas for a longer time. It was found that florals need quick, immediate amounts of energy and ways to gather food to keep the entire hydrangea from wilting. This research could lead to future studies by using essential oils as preservatives for post-harvested florals.

Honorable Mention
Evan Huizar & Kenn Wu *Mills E. Godwin High School*
The Application of Activated Carbon for Reducing Adverse Effects of Runoff Contaminants on *Solanum lycopersicum*

Activated carbon has played a crucial role in the medicinal field due to its adsorbent properties, a trait leading to its application to treat overdose patients. This study aims to evaluate the potential for practical application of activated carbon's properties in the plant and environmental health fields. Through runoff, dangerous contaminants saturate surrounding agricultural fields, vegetation, and waterways. It was hypothesized that the addition of the adsorbent Activated carbon would lessen the effects produced by harmful runoff contaminants, simulated by the use of diluted insecticide and acid and basic solutions. *Solanum lycopersicum ,* also known as the *micro-tom,* was chosen as the medium in which the adsorbent effects of activated carbon on pollutants would be observed due to its low genetic variability and rapid germination period.
Solanum lycopersicum seeds were initially watered solely with distilled water to allow for proper germination before being separated into groups. These groups were then treated with or without activated carbon before treatment with various pollutants (Acid, Base, and Insecticide). Pollutant solutions were applied once every 3 days, after which the plant groups were observed for a 2-month growth period, after which plant height was recorded. Upon data analysis using t-tests at 46 df and a significance of 0.1, results indicated that activated carbon had a statistically significant effect on increasing plant growth on treated contaminant groups of *Solanum lycopersicum* in plants treated with an insecticide solution, with a $p < 0.1$. In addition, all pollutants caused significant detrimental effects to *Solanum lycopersicum* growth when compared to the control group, $p < 0.1$. In contrast, the effect of the activated carbon on the pollutants of both acid and basic solutions was not statistically significant, $p > 0.1$. A reduction in adverse effects caused by contaminant-induced stress is revealed through improvements in plant height when comparing *Solanum lycopersicum* plants treated with insecticide after

activated carbon, versus with pure insecticide. Activated carbon has the practical application of reducing harm to vegetation or crops, if applied prior runoff and acid deposition. Thus, usage of Activated carbon to saturate soil in endangered ecosystems located near chemical plants, industrial farms, or large urban areas is worth consideration and warrants further investigation.

Gamma Sigma Delta
Honorable Mention
Sage Lahmers *Blacksburg High School*
Symbiotic Strength: Evaluating Mycorrhizal & Nitrogen-Fixing Influences on Plant Fitness

This study investigated the effects of mycorrhizae and nitrogen-fixing bacteria on plant growth using a two-way ANOVA with replication. The experiment focused on Big Bluestem and Crimson Clover plants, examining various biomass parameters. Results showed significant differences in above-ground ($p = 0.005650955954$) and below-ground ($p = 0.003338810513$) biomass length for nitrogen fixer presence. However, no significant effects were observed for mycorrhizal presence or the interaction between mycorrhizae and nitrogen fixers across other measured parameters. Factors potentially influencing the limited significant findings include plant species differences, experimental constraints due to ISEF regulations, insufficient growth duration, reduced sample size, and soil composition variations. The study highlights the impact of Crimson Clover on plant growth while suggesting minimal influence of mycorrhizal presence on biomass allocation under the given conditions. Future research recommendations include extending the growth period, increasing sample size, using plant species with similar growth characteristics, implementing more controlled methods for mycorrhizae introduction, and conducting comprehensive soil analysis. These findings contribute to our understanding of plant-microbe interactions and their effects on biomass allocation, while also emphasizing the need for further investigation under varied experimental conditions.

Lilly Lennon *Mills E. Godwin High School*
The Effect of Different Light Sources on Vitamin C Production in Parsley

This project in its present form is the result of light sources on vitamin C production in parsley. The purpose of this research was to determine which light source helps produce the most vitamin C. Sunlight, LED lights, and fluorescent lights were used in gardening to maximize nutrients and assist photosynthesis in plants, and these light sources may have a similar effect on the plant parsley. Each parsley seed was placed in a plant tray underneath either sunlight, LED lights, or fluorescent lights. The plants were allowed to grow for 3 weeks and then their height was measured in centimeters. The control used in this experiment was sunlight. It was hypothesized that parsley plants treated with fluorescent lights would produce more vitamin C than any other variable group. The results revealed that LED lights grew the least on average (0.8cm^2) than the control (1.1cm^2), and fluorescent lights (1.0cm^2). A t-test was conducted on the data, and it revealed that the data was not significant for any experimental group. The results did not support the research hypothesis. It is believed that the results are likely due to chance and not the independent variable. For future continuation, this experiment will be given more time for the plants to grow, the types of light sources will be investigated, and a different way to extract the vitamins will be researched.

Brandon Ding *Mills E. Godwin High School*
The Effect of Natural Fertilizers and Worms on Plant Growth

The purpose of this study is to find the best combination of natural fertilizers and worms to apply to plants to achieve the best growth. The type of plant chosen is the tomato plant. The plants were allowed to germinate first before treatment was applied to the plants. The plants were given 4 days to grow. It was hypothesized that plants treated with banana peels and worms would result in the highest growth. The results revealed that plants treated with nothing resulted in the best growth, with an average growth of 3.8 cm. Plants treated with just worms had the worst growth, growing just 2.8 cm on average. Plants treated with worms and eggshells grew 3.6 cm on average. Plants treated with worms and banana peels resulted in 3.5 cm growth on average. Upon further analysis, the research hypothesis was not supported as the worm's only treatment resulted in negative growth. Multiple t-tests were performed on the data at the level of significance 0.05 with varying degrees of freedom accordingly. The calculated t value for worms only (2.8 cm) compared to the no treatment

(3.8 cm) was higher than the table t value of 2.056, thus, the null hypothesis should be rejected, and there is a significant difference between the control and with worms only. Similarly, t-tests were performed on worms vs. worms with eggshells and worms with banana peels. Comparing worms vs. worms with eggshells (t=3.160) and worms with banana peels (t=3.201) resulted in t values that were greater than the one from the table (2.056 and 2.054 accordingly). This implies the null hypothesis should be rejected, as there are significant differences between worms with eggshells or banana peels and worms only.

Anna Krzyzanowski *Hampton Roads Academy*
Effects of Amino Acids on Plant Growth and Soil Microbes

As the world population continues to grow, the need for suitable food sources grows with it. The farming industry continues to explore new ways to grow food faster to combat this problem. The goal of this experiment is to test the effectiveness of peptide additives in the growth of plants. This investigation also explores potential differences in the type of bacteria found in the soil after peptide addition. Five different crops (corn, wheat, bell peppers, soybeans, and tomatoes) were grown in soil with three different amino acid concentrations (0mL, 5mL, and 10mL). Growth was observed at 15 and 30 days after planting. After two weeks, soil samples were collected, and a 10-fold 5-step serial dilution was performed. The 10^3 and 10^5 dilution samples from each plant were plated in Luria Broth agar and incubated for 72 hours to observe the bacteria growing in the soil of each plant. Colonies in each plate were categorized based on their morphology. This process was repeated two weeks later. Colonies were selected, and DNA was extracted and amplified using 16s rRNA primers. PCR products were run in a gel to confirm amplification and sent out for sequencing. It is hypothesized that adding amino acids to the soil will promote plant growth and result in a change in the bacteria present in the soil. The results suggest that the addition of amino acids did not have an apparent effect on the type of bacteria found in the soil or the number of leaves grown. The increase in growth is dependent on the type of crop used with only low doses of amino acids increasing the growth of soybeans and corn. Through this investigation I hope to find a way to make plants grow faster so they can produce larger yields.

Jason Lin *Clover Hill High School*
The Effect of Varying Amounts of Mycorrhizal Inoculant on the Final Height of Soybean Plants

Mycorrhizae are beneficial symbiotic relationships between the root systems of most plants and fungi and may provide an alternative to traditional fertilizers, with arbuscular mycorrhizal fungi (AMF) being the most abundant and agriculturally viable type. The purpose of this experiment was to determine the point at which increasing the amount of mycorrhizal inoculation would provide a diminishing benefit to plant height in soybeans, if any, and what the most efficient application amount is, if any. The experimental hypothesis was that if 0 g, 0.5 g, 1 g, 2 g, and 4 g of arbuscular mycorrhizal fungi inoculate were applied to pots of soil planted with soybean seeds, pots of soil with 2 g and 4 g of inoculant would both equally yield the tallest soybean plants. To conduct the experiment, 10 0.95 L pots of soil were filled and planted with soybean seeds for each of the following levels of independent variable: 0 g, 0.5 g, 1 g, 2 g, and 4 g. An equivalent amount of mycorrhizal inoculant measured out in measuring spoons was added to their respective levels of independent variable. Afterwards, the plants were regularly watered and let grow for a month before taking final measurements for plant height. The mean final heights were as follows: 2.975 cm for 0 g, 4.933 cm for 0.5 g, 4.555 cm for 1 g, 3.240 cm for 2 g, and 2.458 cm for 4 g. The null hypothesis was not rejected, and the research hypothesis was not supported by the data, as 0.5 g and 1 g had the highest final mean plant height.

Niharika Nair *Mills E. Godwin High School*
The Effect of Rhizobia (Nitrogen-Fixing Bacteria) VS. Nitrogen Fertilizer on Bean Plant Growth

The purpose of this experiment was to find the effects of different methods of nitrogen-fixation on the growth of bean plants. The thought process behind this experiment was to conduct a comparison between natural inoculation and artificial fertilization, since both approaches to nitrogen-fixation were widely used. Snap bean seeds were treated with either 1.4 grams of N fertilizer or inoculated with 1.4 grams of a Rhizobia inoculant. The seeds were allowed to grow for 27 days, and their height, root length, and weight were measured. The control of the experiment was regular bean seeds which were planted into the soil without the application of any fertilizers or chemicals. It was hypothesized that the height of snap bean seeds that went through the process of seed inoculation would increase more than N fertilizer and the control. The results revealed that

seeds inoculated with Rhizobia grew on average, 12.80 centimeters more than N fertilizer and 13.03 centimeters more than the control. A t-test was done on the data, and it revealed that the data was significant for the control versus Rhizobia and Rhizobia versus N fertilizer. However, it was not significant for the control versus N fertilizer. The results did support the research hypothesis. It's believed that the results are due to the fact that the inoculation process has provided more nutrients to the seeds, resulting in enhanced growth. This research could lead to further studies on how inoculation methods can be used to improve crop yield in challenging conditions.

Micah Schuman *Clover Hill High School*
The Effect of Various Combinations of Soil Type and Fertilizer Type on Clover Biomass and Height

The purpose of this experiment was to determine the best combination of fertilizer and soil type to promote the highest biomass and height of clover. The combinations included a compost and potting soil comparison with either 10-10-10 fertilizer, 0-10-10 fertilizer, or no fertilizer at all. The inability of farmland to produce sufficient food contributes significantly to world hunger, but use of different soils and fertilizers can help by increasing food yield. The hypothesis was: If the soils of compost and potting soil were mixed with no fertilizer, 0-10-10 fertilizer, or 10-10-10 fertilizer, the combination of compost and 0-10-10 fertilizer would yield the greatest biomass and height of white clover. Clover was planted in compost or potting soil, and every 7 days, watered with a solution with either fertilizer, or no fertilizer, with its height measured and recorded if it was an increase. Twelve cells with three clover plants each were planted per level, and after 4 weeks, the biomass of all of the plants from each cell was recorded. For the 'Compost' groups, the mean height was 1.766cm, 1.030cm, and 1.005cm for the 'No Fertilizer', '10-10-10', and '0-10-10' groups, respectively. Concurrently, for the 'Potting Soil' groups of 'No Fertilizer', '10-10-10', and '0-10-10', the mean height was 3.151cm, 2.795cm, and 3.227cm, respectively. For the 'Compost' groups, the mean biomass was 0.0061g, 0.0028g, and 0.0049g for the 'No Fertilizer', '10-10-10', and '0-10-10' groups, respectively. Concurrently, the mean biomass for the 'Potting Soil' groups was 0.0189g for the 'No Fertilizer' group, 0.0048g for '10-10-10', and 0.0083g for '0-10-10'. The null hypothesis for both height and biomass was rejected for the individual factors of Soil Type and Fertilizer Type, but not for the interaction between them. The research hypothesis was not supported, as both Compost and fertilizers led to lower Height and Biomass compared to Control and Potting Soil, individually.

Anna Martinez *Clover Hill High School*
The Effect of Adding Different Levels of Roasted Coffee Bean Grounds to Soil on the Growths of Radishes

The purpose of this experiment was to determine which roasts of coffee ground mixed with soil would have the greatest effect on radish plant growth: Light, Medium, and Dark roast. Many agricultural companies struggle in continuously producing healthy plants. A solution to find out what mixtures would yield the greatest plant growth would allow business to profit as well as its buyers. The hypothesis was: If Dark roast coffee grounds were added to the top centimeter of soil after radish seeds germinated, it would increase radish plant growth. Radish seeds were split up and planted into 4 trays. Then small amounts of coffee grounds: Dark, Medium, and Light were mixed into soil and added to the top centimeter of the cells. They were watered every three days and received sunlight from a sun lamp. Once they completed growing, the radishes were measured by using a metric ruler. The mean of the radish height with no coffee grounds (Control) was 3.47 cm, 2.28 cm for Light roast, 1.83 cm for medium roast, and 1.29 cm for Dark roast respectively. The radishes mixed with no coffee grounds (Control) were seen to yield the greatest growth in height of the four groups, as many of the darker roast radishes did seem to die. Although the Dark roast yielded some growth to the radish plant, the Control yielded the greatest increase in height. The null hypothesis was rejected as it stated that Light, Medium, and Dark roasts of coffee grounds would yield equal growth of radishes which did not occur during the tests. Additionally, the data did not support the research hypothesis: If Dark roast coffee grounds were added to the top centimeter of soil after radish seeds germinated, it would increase radish plant growth, because the Dark roast coffee grounds yielded the smallest amount of growth during the tests.

Subah Zareen *Clover Hill High School*
The Effect of Hard vs Soft Water on Duckweed Reproduction Rate

The purpose of this experiment was to determine the effects of various hard/soft water concentrations on *L. minor's* reproduction rate. Duckweed offers itself as a solution to various issues, such as lead accumulation in water, wastewater treatments, antibiotic pollution, etc. It is an attractive solution because it has a reputation for having a fast reproduction rate. Having a detailed understanding of duckweed's growing conditions will allow it to grow faster and healthier and make it even more useful for these problems. The hypothesis was that the concentration of 20 mg Mg^{2+} (48 mg $MgCO_3$) and 20 mg Ca^{2+} (49.9 mg $CaCO_3$), a hard water concentration, would yield an increase in *L. minor*'s reproductive rate. The concentration with 1 mg Ca^{2+} (2.5 mg $CaCO_3$) and 1 mg Mg^{2+} (2.4 mg $MgCO_3$) would stunt the reproductive rate. The hard and soft water concentrations were created by using different amounts of magnesium and calcium carbonate powder into distilled water. Around 5 fronds of healthy duckweed were put on the petri dishes and were observed over the course of 4 weeks. A positive trend was observed amongst the groups. The null hypothesis for this experiment was rejected. The data collected from this experiment partially supported the original hypothesis; the 20 mg Mg^{2+} (48 mg $MgCO_3$) and 20 mg Ca^{2+} (49.9 mg $CaCO_3$) group yielded the largest increase on duckweed's growth, however, the 5 mg Ca^{2+} and 5 mg Mg^{2+} (12.5 mg $CaCO_3$ and 12 mg $MgCO_3$) group yielded the least amount of growth. Dead or yellowed duckweed was not included in any of the data.

Chemistry A (HS CHM A)

First Place
Anna Jane Reed *Saint Catherine's School*
Cobalt Absorption Potential of Hyperaccumulating Plants

This research is aimed at creating a more cost-effective way of purifying the contaminated water produced in the Lithium-Ion battery (LIB) recycling process. The objective of this research was to determine if hyperaccumulating plants had significantly higher uptake of cobalt (Co^{2+}) when compared to non-accumulators, and if so, to measure the hyperaccumulator's ability to absorb Co^{2+} when synthesized into a polymer. An isotherm study and an absorbent synthesis study were performed to gauge the ability of hyperaccumulating plants in absorbing cobalt from LIB wastewater. The results showed that plants in the *Brassica* genus are better at absorbing Co^{2+} when compared to non-hyperaccumulating plants. Additionally, when synthesized, the beads containing *Brassica* plant mass proved to absorb significantly more cobalt when compared to beads without any plant mass.

Second Place
Serena Guo *Central Virginia Governor's School for Science and Technology*
Orange You Curious? The Biocatalytic Capabilities of Peroxidase on the Degradation of Acid Orange 7

Dye effluent from manufacturing industries is one of the most harmful contributors to water contamination worldwide. Research has indicated that peroxidase, enzymes commonly found in living organisms that promote oxidation reactions, have a strong potential across applications such as bioremediation of synthetic dyes. Thus, the purpose of the present study explored the biocatalytic potential of peroxidase from two different root vegetables, horseradishes and turnips, for the degradation of Acid Orange 7. Acid Orange 7 is a commonly used synthetic dye that presents risks, such as skin and eye irritation, as well as potential carcinogenic properties. Various parameters were optimized for the decolorization of the solutions, such as the dilution of H_2O_2 (0.02%), concentration of dye (25mg) and peroxidase (25mL), the temperature and time the reactions took place (50 minutes at 50°C). Once reactions were completed, results indicated that turnip peroxidase (TP) was more effective than horseradish peroxidase (HRP), with TP having a mean absorbance of 0.235 au and HRP 0.5419 au. Higher absorbance suggests higher dye concentration, indicating less decolorization, while lower absorbance reflects greater dye degradation. A one-way ANOVA revealed a significant difference (*p-value* = 0.01343, *alpha* = 0.05), and a Post-hoc Tukey test confirmed where the significance lay, with a Qt value of 3.5 and Dmin of 0.2107. These findings support the hypothesis that turnip peroxidase is more efficient than horseradish peroxidase in the removal of Acid Orange 7, suggesting its potential for bioremediation of textile dye effluent.

Third Place
Phoebe Camp *Central Virginia Governor's School for Science and Technology*
The Effect of Household Lights on the Color Fading of Different Organic Pigments in Paint

The purpose of this research was to investigate how color and lighting environment affect the color degradation of organic pigments. Two different pigments, Indian yellow and phthalocyanine blue, were exposed to halogen, incandescent, and LED light bulbs over the course of 8 weeks in the form of small 3x4 inch paint samples. An environment with no light was used as a control group. In order to analyze the amount of color fading, samples were photographed and taken into Adobe Photoshop to be analyzed. RGB values were converted into CIELAB color space values, and the color difference was then analyzed using the DeltaE2000 formula. A two-way ANOVA resulted in a significant p-value of .005 (compared to an alpha value of .05) between pigment colors in certain lighting. A post-hoc Tukey test identified that the blue pigment samples faded significantly more than the yellow pigment samples. Additionally, the blue incandescent light group faded the least out of any of the blue sample groups. The research hypothesis stating that the LED sample groups would fade the least out of any was not supported by the data. This experiment explored the lightfastness properties of organic pigments and the effects that light has on their color fading. This study into color fading is important as it explores how people view and experience art.

Regan Alber *Central Virginia Governor's School for Science and Technology*
The Effect of pH on the Dissolution Rate of Different OTC Painkillers

The purpose of this study was to determine the effect of pH levels on the dissolution rates of different medications including ibuprofen, aspirin, and acetaminophen. This experiment used water and hydrochloric acid (HCl) to create solutions of three different pH levels: 7, 4, and 1. HCl was used as it is the main component of stomach acid in the body. The pH 7 solution (water) was tested by placing one ibuprofen tablet into the solution and measuring the time it took to completely dissolve. This was repeated until 10 successful trials were achieved for all three medications in each pH solution. The results indicated that lower pH levels significantly reduced the dissolution time of ibuprofen tablets, whereas aspirin and acetaminophen were unaffected. A two-way ANOVA revealed significant effects for pH ($p= .007$) medications ($p= 1.59x10^{-49}$), and the interaction between the two ($p=0019$), all less than the alpha value of .05. The experiment supported the research hypothesis, that out of the three medications tested aspirin would have the quickest average dissolution time in all three pH solutions. Overall, this research helped to determine how changing the pH of a solution lowered the dissolution time for different over the counter (OTC) drugs, and that under certain conditions in the stomach, aspirin will dissolve the fastest when compared to ibuprofen and acetaminophen.

William Heiland *Clover Hill High School*
The Effect of Using Soy Milk and Soy Butter, in a Shortbread Cookie Recipe, on the Length, Width, Weight of the Resultant Cookies

The purpose of this experiment was to determine how soy milk and soy butter would affect the length, width, and weight of cookies when substituted for regular butter and milk in a shortbread cookie recipe. The hypothesis was: The soy milk and soy butter would cause the cookies to increase in length, width, and weight. Soy milk and soy butter were added to the cookies individually and then together at the same time. For the control, the cookies were baked with regular milk and butter. For each level of the independent variable 3 batches of cookies were made with 10 cookies in each totaling 120 individual cookies. The amount of soy milk and soy butter was kept the same as the regular milk and butter and the rest of the recipe was left the same and unchanged. The batches of cookies with the soy milk and soy butter added individually increased slightly in length, width, and weight but the batches with soy milk and soy butter added together increased far greater in length, width, and weight. The null hypothesis was rejected, and the data supported the hypothesis because the data showed that overall, the soy milk and soy butter did cause the length, width, and weight of the cookies to increase.

Ruby Hoerter *Southwest Virginia Governor's School*
Concentrations of β-Carotene in Fresh, Canned, and Frozen Carrots

Fruits and vegetables bring the needed color and nutritional benefits into everyday meals. Fresh fruits and vegetables are most often considered the health-promoting and sought-after variant. However, most people do not have the space, materials, or time to contribute towards a garden to grow fresh fruits and vegetables, which leaves them to purchase fresh foods at the grocery store. Even with these advances in preservation, fresh produce is mainly marketed as the most expensive due to its supposed nutritional benefits, making it "better" than other variants, such as canned and frozen. However, it has yet to be proven that these better benefits exist. This project strived to answer whether there is a higher β-carotene concentration in fresh, canned, or frozen carrots. First, a calibration curve was created using β-carotene tablets and dissolved in acetone. Next, each of the three carrot samples were peeled, cored, blended and mixed into acetone. This acetone carrot mixture was then centrifuged at 3600 rpm for 10 minutes. The absorbance of the supernatant was measured and used to determine the β-carotene concentration. The null hypothesis stated that the concentration of β-carotene would be equal in frozen, fresh, and canned carrots. The alternate hypothesis stated that either the frozen, fresh, or canned carrot sample would have a significantly different concentration of β-carotene compared to one or both of the others. By performing an ANOVA test, the p-value was 0.6253. Using the standard alpha of 0.05, there is not enough evidence to support that there is a significant difference in *β*-Carotene concentration between frozen, fresh, and canned carrots. It would be important in the future to test more samples in order to know if there is truly no significant difference, or if it was just unable to be found using three samples. A final adaptation to this project is to change the brands of the project used. By doing this, the experimenter could find different conclusions.

Noah Wells *Central Virginia Governor's School for Science and Technology*
The Effect of Chlorine on the Color of the Fabrics of a Swimsuit

This study investigated the effects of chlorine on the color of black fabrics. Five fabric types - nylon, polyester, stretch polyester, cotton, and a polyester-nylon hybrid - were tested by submerging samples in four buckets containing 3 gallons of water with varying chlorine concentrations (0 ml, 6 ml, 12 ml, and 24 ml). The first bucket had no chlorine. The second bucket had 6 ml, the third had 12 ml and the last had 24 ml of chlorine. The fabrics were left in the buckets for two weeks, then the amount of light reflected, also known as LUX, was measured. All of the fabrics got lighter in color, especially the cotton and polyester-nylon hybrid, as they had dramatically changed. A two-factor ANOVA was run and produced a p-value of $56x10^{-56}$, compared to the alpha value of .05 which indicated significance. Consequently, the null hypothesis was rejected, and a post-hoc Tukey test was conducted to identify significant differences between groups. The results showed that the data was more significant as the chlorine levels got higher. The research supported the hypothesis that if fabric is left in a higher concentration of chlorine, then it will degrade more than fabric left in less chlorine for the same amount of time. In summary, chlorine exposure caused all black fabrics to become lighter, with higher chlorine levels producing more pronounced effects.

Chemistry B. (HS CHM B)

Rodney C. Berry (Gwathmey) Award, Ertle Thompson Memorial Endowment Award, American Junior Academy of Science Representative

First Place

Hrishi Desai and Raghav Kasi *Thomas Jefferson High School for Science & Technology*

Calcium-Doped Biochar for Optimized Glyphosate Removal in Aqueous Media

Glyphosate is an herbicide that is found ubiquitously in aquatic environments, which has been shown to be adsorbed by biochar. This study aimed to optimize the glyphosate adsorption capabilities of biochar in aqueous media. Biochar was prepared by using recycled aluminum cans to create a TLUD (top-lit updraft) gasifier, and dried wheat straw was used as a substrate for further modification. Two biochar variants were created: one solely consisting of wheat straw (BC), and the second soaked in a calcium acetate solution derived from acetic acid and eggshells prior to pyrolysis (CaBC). UV/Vis spectrophotometry revealed that BC and CaBC removed 81% and 93% of glyphosate, respectively. Kinetic models for CaBC fit both a pseudo-second order and pseudo-second order profile, suggesting a complex adsorption mechanism dependent on both chemisorption and physisorption. However, when data for BC was mapped to the same kinetic models, BC had a significantly lower correlation coefficient towards the pseudo-second order model, indicating limited chemisorption. Moreover, CaBC isotherm studies exhibited high correlation coefficients for both Langmuir and Freundlich models, further suggesting a mixed adsorption mechanism. FTIR characterization for CaBC yielded peaks at 721 cm^{-1}, indicative of Ca-O bonds. Additionally, these peaks were not visible post-adsorption, suggesting that the Ca-O bonds were replaced with interactions between Ca^{2+} ions, OH^{-}, and glyphosate. This research demonstrates the viability of biowaste for water remediation and highlights the novel potential for calcium amendments.

Second Place

Avani Kaur *Mills E. Godwin High School*

Combating Alzheimer's Disease: Design and Synthesis of a Novel Drug Molecule for Targeted Metal Chelation Therapy

Purpose: Alzheimer's Disease (AD) is the sixth leading cause of death, and there is an urgent need for innovative treatments. Metal dyshomeostasis, a hallmark for AD, is characterized by the accumulation of certain toxic metal-ions in the brain. These metals catalyze the production of free radicals, resulting in metal-induced oxidative stress and exacerbating neurodegeneration. Metal chelators selectively bind to metal-ions to form stable complexes that can be safely excreted from the body, thereby alleviating oxidative stress in AD. Therefore, this study aims to synthesize a novel metal chelator as a potential therapeutic agent for targeting. **Methods:** A ligand was synthesized, and its structure was confirmed utilizing Nuclear Magnetic Resonance spectroscopy. UV-Visible spectroscopy was implemented to assess the metal-chelating ability. Finally, the logP test was performed to determine the molecule's ability to penetrate the Blood-Brain Barrier. It was hypothesized that the ligand would effectively chelate toxic metals, specifically targeting Fe(III), Zn(II), and Cu(II), thereby mitigating metal-induced oxidative stress as a potential treatment for AD. **Results:** The

results revealed that the novel ligand exhibits metal-chelating properties and has therapeutic potential for combatting AD progression. A one-way ANOVA was conducted and revealed that the data is statistically significant. The research hypothesis was supported. **Conclusion:** The efficacy of the novel molecule stems from its structural properties, chemical behavior, and drug-likeness. Chemically, Schiff bases form strong coordinate covalent bonds with specific metal centers, possess enhanced binding affinities, and electron delocalization, making them ideal candidates for targeted metal-chelation therapies aimed at mitigating AD.

Third Place
Ian Walters *Chesapeake Bay Governor's School*
Characterizing Contrail Formation Dynamics Over the Continental United States

Air travel mostly impacts Earth's climate because it is responsible for 2.5% of the total anthropogenic CO_2 fossil fuel emissions, which contributes to overall greenhouse gas emissions and global warming (IEA, 2024). In addition to CO_2, jet exhaust affects atmospheric chemistry as it releases nitrogen oxides (NOx), sulfur dioxide (SOx), sulfates, water vapor (H_2O), and soot. Jet contrails form on this exhaust at low temperatures and pressures, and contrails that remain above the ice saturation pressure T_{ice} but below the water saturation pressure T_w are considered persistent, while contrails falling below the ice saturation pressure curve are short-lived. This study aims to determine whether contrail formation is predictable so that adjustments to aviation patterns can be made to mitigate global warming based on reducing persistent contrail cirrus. The online program www.contrails.org by Reviate provides a contrail regions filter that details whether contrails are predicted to be cooling or warming. Data were collected from October 18th-November 1st, November 26-27th, and November 30th-December 1st, 2024. Every day at 9 a.m., 11 a.m., 1 p.m., 3 p.m., and 5 p.m. EST. The predicted contrail coverage varied widely from one day to the next over consecutive days, ie. from 12% on October 31 to 32% on November 1, which is verified by t-test p-values<0.05. Based on the data from days analyzed and the statistical analyses, it is clear that contrail formation behavior over the continental United States is extremely dynamic over short time scales.

Honorable Mention
Aditya Modi *Mills E. Godwin High School*
The Effect of Starches on Digestion Time Using Salivary Amylase

The purpose of this project was to investigate the effects of various starches on digestion time utilizing salivary amylase with the goal of finding out which starch can be fully broken down by amylase in the quickest amount of time. This shows which starch is most beneficial for individuals facing carbohydrate intolerance or in need of quick digestion. A variety of starches have become popularized due to health benefits, so this experiment can help individuals find out which starch out of rice starch, corn starch, potato starch, wheat starch, and tapioca starch is the best for them based on the digestion rates. The hypothesis formulated was, if tapioca starch is used, then it will be digested the quickest with amylase, because tapioca starch contains the least amount of amylose in comparison to the other independent variables. 10mL of the specific 1% starch solution (independent variable) was placed into test tubes followed by 2mL of 1% NaCl solution, 2 drops of iodine, and 1mL of 50% salivary amylase solution and results were measured using a stopwatch. The control was rice starch since it is the most consumed starch globally. The results indicated that corn starch was digested the quickest by salivary amylase and potato starch was digested the slowest, showing the hypothesis was insignificant; the t-tests were significant. The results are based upon the size of the granules of starch and the amount of amylose and amylopectin contained. The research could lead to studies on the enzyme amylase and its ideal temperatures and pH levels during the starch reaction.

Honorable Mention
Aiden Wright *Clover Hill High School*
The Effect of Adding Lignin to Adhesive Solutions on the Grip Strength of the Adhesive Solutions

The purpose of this experiment was to determine if lignin is a viable additive to PVA glues and epoxy resin to increase the adhesion strengths beyond the original adhesion strengths. Current adhesives contain fossil fuel chemicals and polymers that are either hurtful to the environment or the people using them. Therefore, it is imperative that alternatives, substitutes, and additives such as bio-based compounds are tested to reduce or eliminate the use of fossil fuels as well as protect users. Lignin, one of the most abundant polymers in trees, is one of the biggest contenders for this title as a renewable and safe additive. The

hypothesis was that adding lignin to wood glue, Elmer's school glue, and epoxy resin would make them have stronger adhesion in kgs of applied weight, while adding lignin to super glue would have no effect on the strength of the adhesive's adhesion in kgs of applied weight. 20 Control trials and 20 trials with lignin 25% lignin added were made with glue types: Elmer's school glue, wood glue, super glue, and epoxy resin. After each trial cured for 24 hours, the weight testing was conducted. The weight testing consisted of attaching 2 perpendicular wood blocks with a glue joint, securing it in a frame, and extending a bottle jack under it on a scale to measure rotational shear force. The maximum break point was measured by videoing the scale as the bottle jack was cranked and confirming the highest weight recorded. The mean for the Elmer's school glue control was 61.11 kg, 34.20 kg for Elmer's school glue with 25% lignin added, 90.00 kg for wood glue control, 93.62 kg for the wood glue with 25% lignin, 39.73 kg for the super glue control, 22.29 kg for the super glue with lignin, 99.16 kg for the epoxy resin control, and 58.08 kg for the epoxy resin with 25% lignin added. Elmer's school glue, super glue, and epoxy resin all showed a decreasing grip strength as lignin was added, while wood glue showed a small increase in grip strength as lignin was added. The null hypothesis was that adding lignin to wood glue, Elmer's school glue, epoxy resin, and super glue would have no effect on the adhesive's adhesion to wood surfaces in kg of weight withstood, and the research hypothesis was that adding lignin to wood glue, Elmer's School Glue, and epoxy resin would have a positive impact on the adhesive's adhesion to wood surfaces in kg of applied weight withstood, while adding lignin to super glue would have no effect on its adhesion to wood surfaces in kg of applied weight withstood.

Honorable Mention

Minhan Zhao *Clover Hill High School*

The Effects of Environmental Factors on Crystallized Sucrose's Mass and Structure

The purpose of this experiment was to investigate the various environmental factors, including the surrounding temperature and the solvent pH level, on the most beneficial mass and characteristics of the final sucrose crystalline structure. In this experiment, the environmental factors included the surrounding temperature, with conditions at 5°C and 50°C, and the solvent pH levels, with conditions at pH 6 and pH 8. The data in this experiment would allow confectionery industries to modify the sucrose-based products based on the beneficial factors. The process could be refined to improve the texture, appearance, and shelf life of sugar-based products, thereby benefiting producers through improved manufacturing efficiency and consumers by having higher quality sucrose-based products. The hypothesis was stated that varying environmental factors, such as temperature and solvent pH level, would greatly affect the mass and characteristics of sucrose crystals. The different environmental conditions on temperature: 5°C, 50°C, and solvent pH level: pH 6 and pH 8, and the control group were applied to all the sucrose solutions. After the 72-hour period, the qualitative and quantitative measurements were conducted. The crystallized sucrose was observed by a stereo microscope and were recorded according to the categories on a frequency distribution data table. Detailed qualitative characteristics for varying temperatures and pH conditions were presented in the main article. The quantitative measurements were recorded by a digital balance on a data table and bar graph. The mean for the temperature group levels: Low 5°C was 5.306g and high 50°C was 67.874g. The mean for the solvent pH levels: pH 6 was 71.454g and pH 8 was 86.046g. The mean for the control group was 74.974g. As the temperature condition decreased, the crystal formation slowed significantly compared to all the other groups. At pH 8, the sucrose solutions yielded the heaviest crystals.

Tazmeen Ahmed *Mills E. Godwin High School*

The Effect of Temperature on the Degradation of Vitamin C Solution

This study investigates the effect of temperature on the degradation of vitamin C solution over time to determine optimal storage conditions for preserving its stability and effectiveness. Vitamin C is widely used in dietary supplements, food products, and pharmaceuticals. Understanding its degradation can inform consumer practices and improve manufacturing practices. This is important as its stability can be impacted by environmental factors and improper storage, which can lead to reduced potency, affecting health benefits. The hypothesis was that vitamin C would degrade the fastest at 40°C and the slowest at 4°C. This experiment had four temperature levels (4°C, 25°C, 35°C, and 40°C). A control was established at room temperature (25°C) to simulate common storage conditions. Vitamin C solutions were prepared and stored

at the designated temperatures, with their concentrations being measured every two days using iodine titrations over a two-week period. The data was analyzed using inferential statistics comparing temperatures to the control. The results showed that 4°C had the slowest degradation, preserving the highest concentration of vitamin C, while 40°C had the fastest and most significant decline. The t-tests confirmed statistical significance for differences between 40°C and the control, supporting the research hypothesis. These findings highlight the importance of refrigeration for maintaining vitamin C stability. Future research could include exploring other factors such as light or pH to optimize preservation methods further.

Natalia Glahn *Clover Hill High School*
The Effect of Various Types of Glue on the Temperature at Which the Glue Decomposes

The purpose of this experiment was to determine which type of glue would most rapidly decompose when exposed to various temperatures: Elmer's Super Glue, Elmer's All-Temp Glue, or Elmer's Liquid School Glue. The physical properties of glue can drastically change when in contact with high temperatures, despite having dried for extended periods of time. Being knowledgeable on the strengths of the different glue types can aid in enhancing home projects and creating items that will last longer in all environments. By exposing drops of different types of hardened glue to heat, the properties and decomposition temperatures of the glues were tested. Drops of glue were created with a diameter of one centimeter and left overnight on a piece of parchment paper. Later, the drops were set on a melting point apparatus over a hot plate. Once set, heat was applied at specific intervals. At the same time, the drops were examined for any change in color, which is a method in determining that the test drops were undergoing the processes of decomposing. The temperatures were taken when the glue turned brown from the center. This was measured by two different thermometers: one which was inside of the apparatus that the drops were set upon and an infrared thermometer that was used to record the surface temperature of the apparatus. The mean of the two thermometers was calculated in order to create more precise, accurate results. The temperatures were then recorded on a sheet of paper. The hypothesis was that the Elmer's Liquid School Glue would show signs of decomposition at the lowest temperature. The mean temperature for Elmer's Liquid School Glue was 165.42 degrees Celsius, 219.02 degrees Celsius for Elmer's All-Temp Glue, and 195.20 degrees Celsius for Elmer's Super Glue, therefore the null hypothesis was rejected and the alternative hypothesis was accepted.

Anya Mathew *Mills E. Godwin High School*
The Effect of Albumin Concentrations on Coomassie Blue Absorbance in Indicating High CRP Levels Associated with Cardiovascular Disease

Cardiovascular disease (CVD) is the leading cause of death worldwide and affects a majority of women and low-income populations. Inflammation, a key factor in CVD, is often monitored using C-reactive protein (CRP) levels. However, as heart disease presents differently in women, the unique symptoms females experience is greatly understudied, thus highlighting the need for more accessible diagnostic tools. Using a modified Bradford Assay, the study aimed to develop a cost-effective, non-invasive diagnostic tool. The research aimed to explore this by utilizing egg albumin as a natural biosensor for CRP detection as CRP and albumin are inversely related. The experiment tested varying concentrations of egg albumin and measured the absorbance at 595 nm, a wavelength optimal for the dye-protein binding reaction. The results demonstrated a direct correlation between albumin concentration and absorbance which supported the hypothesis that higher albumin concentrations result in higher absorbance values. A statistical analysis confirmed the significance of the results, with the highest concentration of albumin (1.4 mg/mL) showing the greatest absorbance. This study offers a potential approach to early CRP detection exploring the use of readily available materials to build a foundation for the development of low-cost diagnostic tools for CVD in women.

Anwitha Methari *Mills E. Godwin High School*
The Effect of Different Solvent Mixtures on Extraction of Lipids from *Chlorella vulgaris* algae powder.

The purpose of this experiment was to find the effects of different mixtures on lipid concentration obtained. Over the years, pollution has become more and more abundant on Earth and is affecting the atmosphere in extremely negative ways. Different mixtures were mixed according to ratios to one gram of *Chlorella vulgaris*

algae powder. They were decanted for 3 weeks, and the solvents were extracted then evaporated. The lipid residue was weighed in grams. It is hypothesized that if n-heptane and ethanol are used, then it would result in the highest lipid yield. The results revealed that the ethanol and ethyl acetate mixture resulted in the highest yield of lipids. A t-test was done on the data it revealed that the data was significant for each independent variable level. It is believed that the results are because ethanol and ethyl acetate attract more polar lipids, and *Chlorella vulgaris* algae powder contains much more polar lipids than neutral lipids needed for biofuel. This research could lead to further studies that investigate further use for polar lipids or exploration of new probiotic organisms containing similar lipid concentration.

Rishab Nanduri *Oakton High School*
Quantum Dot Bayesian Adaptive Parameter Tuner: A Novel AI-Optimized Computational Simulation of QD Binding to HER-2 Cancer Receptors

Quantum dots (QDs) have emerged as advanced fluorescent nanomaterials offering high photostability and tunable emission spectra, making them ideal for molecular targeting in cancer diagnostics. Traditional imaging methods, including MRI and CT scans, provide valuable insights but can be costly and less effective at detecting early-stage malignancies. QDs, however, specifically bind to overexpressed receptors on tumor cells, facilitating earlier and more precise detection. In this experiment, a computational framework is developed and implemented that harnesses Bayesian optimization to systematically enhance QD binding interactions. Initially, a baseline QD-simulator is established that evaluates ligand density, receptor clustering, and binding radius. Then an AI-driven module is introduced that iteratively refines these parameters based on their outcome metrics. Each approach is tested on a segmented dataset measuring gains in binding efficacy and specificity to capture how closely the optimized parameters align with biologically relevant conditions. Results showed that the AI-optimized approach approximately achieved an 856.64% increase in binding performance relative to the baseline simulator. Parametric evaluations further revealed that precise tuning of binding radius and receptor clustering thresholds significantly improves sensitivity and specificity from this method. This level of optimization holds extreme promise for clinical translation by potentially reducing false negatives and accelerating cancer detection timelines. This study demonstrates a transformative strategy that not only improves diagnostic accuracy but also sets a clear pathway for future integration of AI-enhanced QD simulations into oncological diagnostics.

Srivedha Veerapaneni *Mills E. Godwin High School*
The Effect of Different Substances on Heat Protection of Hair

This experiment was conducted to find the effect of different substances on heat protection of hair. It is currently a common practice to straighten hair with a heated iron. The medical literature on this topic in recent years can be considered not as abundant as would be preferable. The research hypothesis stated that if the regular silicone heat protectant was used then it would result in the most elasticity in the hair. The control in this experiment was the hair samples not given heat protectant. In this experiment, the hair samples were separated into 100 separate groups of 50.8-centimeter-long samples. The 100 hair samples were separated into four groups, each with 25 hair samples. Each group was assigned one independent variable. The hair samples were applied with the independent variable. The samples were then straightened with the iron at 210 degrees Celsius. The elasticity of each individual sample was determined and recorded. This process was repeated two more times. The results showed that the regular heat protectant and plant-based heat protectant both worked better than the avocado oil and control. The chi-square test conducted at an alpha value of 0.05 showed that the data was statistically significant. The results found seem to show that solutions intended to be used as protectant work better and prevent more damage. Further studies can be conducted to test the effectiveness of sprays compared to serums in the heat protectant industry.

Misha Yella *Mills E. Godwin High School*
The Effect of Different Wraps/Containers on the Browning of Apples

This experiment is trying to find the impact of various wraps/containers on the browning of apple slices, aiming to reduce food waste and improve storage solutions. Browning, caused by oxidation when apples are exposed to air, presents a challenge for both consumers and the food industry, leading to decreased visual appeal

and increased waste. The hypothesis for this experiment is if the apple slices are wrapped in plastic wrap, they will brown fa. The control group was a group without any wraps or containers. It was used to provide a baseline for comparison. The procedure was done by wrapping and storing apple slices in different wraps/containers. AI was then used to rank the browning of the apples on a 1-5 scale, 1 being the lowest and 5 being the highest. The results of the experiment showed significant differences. The chi-square tests proved that all the data was significant. Both the inferential and descriptive statistics proved that glass jars and silicone lids worked better than plastic wrap. The conclusion that came from this data is that wraps or containers that sealed the air much tighter than normal plastic wrap, proved to work better. With this the hypothesis was proved. These findings bring more benefits to consumers. This gives the consumers an eco-friendly and airtight storage option that can reduce food waste and better food quality.

Computational Biology A (HS COM A)

First Place
Josiah Martin *Central Virginia Governor's School for Science and Technology*
A Comparison in the Accuracy of Multimodal Large-Scale AI Models Identifying Images of Varying Resolutions

Artificial intelligence (AI) is becoming ubiquitous worldwide, integrated into industrial applications, self-driving vehicles, and Urban Search and Rescue (USAR) operations. In particular, USAR operations are becoming increasingly reliant on AI as natural disasters continue to rise. This comparative experimental study evaluates the capability of large-scale AI models to recognize traffic signs at varying image resolutions, aiming to propose a new solution for survivor identification in USAR missions. In this research study, 10 standard traffic signs at 10 different resolutions were employed to test and compare the multimodal, large language models

(LLMs) ChatGPT-4o, Claude 3.5 Sonnet, and Gemini 1.5 Pro for recognition accuracy. Images were uploaded to each model's graphical user interface on their respective websites, and the responses were analyzed. The first research hypothesis suggests that increasing image resolution will enhance AI model accuracy. Three chi-square tests demonstrated that accuracy improved significantly across all models as resolution increased, supporting the first research hypothesis. However, the second research hypothesis was only partially supported, indicating that ChatGPT would achieve the highest overall average resolution accuracy. Three pairwise *z*-tests revealed no statistically significant accuracy differences between the models despite ChatGPT performing the best. Further research can build on these findings by accounting for the effects of different environments, signs, and image weather effects on the models. The results of this study highlight the potential to leverage general or specialized multimodal LLMs in USAR operations by utilizing their machine vision and text generation capabilities together to enhance disaster responses.

Second Place
Khartik Uppalapati *Oakton High School*
Algorithmic Regeneration in Neuroplastic Mechanical Neural Networks Enables the Manufacturing of Self-Healing DNA Gel Polymers as Biomimetic Agents for Personalized Synthetic Organ Scaffold Bioprinting

Despite advances in tissue engineering technology and regenerative medicine, over 106,000 people across the United States are unable to access life-saving transplants, with 7 people on transplantation waitlists dying every day. This issue stems from an inadequate number of organic materials needed for transplant procedures, with only 10% of donor capacity being met. In order to combat the lack of biological resources required for transplants, taking advantage of naturally abundant resources to make biomimetic synthetic organs is pivotal. I propose RegMNNs: A highly efficient Mechanical Neural Network platform which uses mathematical models of neuroplasticity and regenerative algorithms in order to teach highly-adaptive cross-linked DNA hydrogels how to regenerate and adapt to complex environments, particularly the human body. Taking advantage of the bioavailability of DNA, RegMNNs uses 3D bioprinted DNA hydrogel polymers, which have strong morphological and mechanical flexibility, for sustained self-learning behavior. Computational Peridynamics testing revealed a 96.2% (±2.3%) Regeneration Index which was further corroborated by phase field modeling tests which showed a damage variable (φ) reduction from 0.6 to 0.1 within 12 hours, highlighting the ability of DNA polymers which are tuned with RegMNNs to regenerate under daunting environmental circumstances. Additionally, the DNA polymers showed a high rate of real-time learning with an adaptation time constant of 0.8 seconds. RegMNNs enable the scalable, and efficient manufacturing of synthetic organs by creating biologically-accurate behavior within polymers, showcasing the potential to become a substitute for traditional tissue engineering techniques.

Third Place
Aarish Patel *Central Virginia Governor's School for Science and Technology*
Using Convolutional Neural Networks to Detect and Classify Early Onset Alzheimer's

The purpose of this study was to see if convolution neural networks (CNNs) can be used to diagnose early onset Alzheimer's at a higher accuracy than contemporary methods. The study was conducted using a data set of MRI brain images obtained through Kaggle, an online database for machine learning projects. With this dataset, programs including TensorFlow and the Keras API were used to code the CNN. Such APIs are used to facilitate the coding process of the CNN. Once the model was coded, it was trained at 45 epochs and reached a high accuracy of 98%. Post training, a confusion matrix was created to show if the model can correctly predict which category each image should be classified in. Using this, the model was shown to correctly predict the diagnosis of MRI scans. The accuracy of 98% also shows that it is better than conventional methods such as blood testing, which ranges from an accuracy of 88% to 92%, clinical trials, which has an accuracy range of 61% to 73%, and cerebrospinal fluid testing, which has an accuracy of 85%. These results support my research hypothesis: If a CNN is used to detect early onset Alzheimer's, then it will be more effective than contemporary methods. This study uses the application of a novel technology to diagnose Alzheimer's Disease in a more accurate method that will help people get the treatment they need as early as possible.

Honorable Mention
Connor Beasley *Southwest Virginia Governor's School*

Integrative Identification and Analysis of Fungal Ice Nucleation Candidate Proteins with Computational Biochemistry

This study sought to identify the fungal ice nucleation protein (INPro) in Fusarium acuminatum strain 3-68 in silico. Over 3 million open reading frames (ORFs) were filtered for weight and secretion signals. Dimensionality reduction techniques narrowed this list down to 8 candidates. Both the sequence and structure of these candidates were analyzed to glean their capacity to nucleate ice. An emphasis on downstream analyses were on the candidate most expected to be an INPro. Of the eight candidates, four demonstrated significant similarity to a known ice-binding protein (p-values < 0.01), leading to rejection of the null hypothesis. One protein, designated JFP1, based on both qualitative structural inspection and quantitative metrics, was deemed most likely to nucleate. Although molecular dynamics simulations are ongoing, initial findings suggest JFP1 has strong potential for ice binding. This research lays the groundwork for experimental validation as a fungal INPro and real-world applications of JFP1.

Honorable Mention
Shiv Davay *Thomas Jefferson High School for Science & Technology*
NeuralODEs for Biological Memory Dynamics: A Computational Model of Synaptic Tagging and Capture

Understanding memory consolidation at the molecular level remains a computational challenge to model biological processes accurately. Traditional backpropagation, the most efficient optimization algorithm to train neural networks, is biologically implausible because of its bidirectional gradient access approach to optimize synaptic weights. This study explores prospective configuration, a biologically plausible optimization algorithm to substitute traditional backpropagation, by applying Neural Ordinary Differential Equations (NeuralODEs) to model and predict the Synaptic Tagging and Capture Hypothesis (STC). The STC hypothesis showcases that synaptic plasticity, through synapses tagging themselves, plays a key role in long-term potentiation (LTP) leading to stronger memory consolidation. Despite advances in computational models based on Scientific Machine Learning (SciML), few studies have applied prospective configuration or NeuralODEs to biological processes, particularly within neuroscience. Using robust modeling in Julia, NeuralODEs effectively simulated the STC hypothesis by achieving an accuracy of 89% while capturing the timing and molecular interactions during these processes. Through hyperparameter optimization, key factors were identified such as network architecture and activation functions that significantly enhanced model accuracy and minimized the loss. These findings aim to bridge the gap between computational neuroscience and molecular processes by providing insights into the importance of synaptic plasticity in memory formation and strengthening neural connections and pathways. NeuralODEs show great potential through their ability to model complex biological processes to further research toward therapeutic implementations in neurodegenerative and memory-based conditions.

Honorable Mention
Juyeop Noh *Central Virginia Governor's School for Science and Technology*
Detecting Fusarium Wilt using Convolutional Neural Network

Fusarium wilt, caused by *Fusarium oxysporum,* poses a significant threat to chickpea crops worldwide, creating substantial yield losses. Traditional detection methods mostly rely on visual assessment, which is time-consuming and prone to human error. The purpose of this study was to propose a convolutional neural network (CNN)-based approach to detect, and furthermore, classify the severity of Fusarium wilt, in this case, into five categories: highly resistant (HR), resistant (R), moderately resistant (MR), susceptible (S), and highly susceptible (HS). Various frameworks, including TensorFlow, CatBoost, and Keras, and a dataset of annotated chickpea plant images were used to train and validate the model. The CNN achieved a high validation accuracy of 99.8% with a low loss of 1.2%, demonstrating its effectiveness in distinguishing disease severity. Analysis of the confusion matrix, a table summarizing predictions versus actual outcomes in classification tasks, revealed a strong diagonal trend, indicating accurate predictions, though occasional misclassifications were observed. Such findings highlight the potential of CNNs as a reliable and efficient tool for plant disease detection, offering

significant advantages over traditional methods in speed and precision. This technology could aid farmers and agricultural professionals in implementing timely interventions, mitigating crop los6s2es, and ensuring food security. Future research could integrate advanced architectures, expand datasets, and apply this approach to other crops affected by fungal diseases.

Rishi Nair *Blacksburg High School*
AI-Augmented Computational Modeling of Bispecific antibody targeting B7H4+ cancer cells and CD3e+ CAR T-Cells for Targeted Therapy in Solid Tumor
A solid tumor is an abnormal mass of uncontrolled cell growth, typically originating in the breast, lung, or prostate. Its physiological features make treatment by traditional methods difficult. In Solid tumors, the B7H4 receptor is overexpressed on the surface of the cancer cells, i.e., the number of receptors on cancer cells increases. This makes them an essential target for cancer diagnosis and targeted therapy. DuoBody is a bispecific antibody with two halves of antibodies designed to target two specific receptors and enhance therapeutic effects by bringing T cells to cancer cells, resulting in cancer cell apoptosis by the T cell. In this paper, I am working on the B7H4 receptor, which is highly expressed in solid tumors, and the CD3e receptor, which plays a role in activating T-cell response. I hypothesize that these DuoBody antibodies can be used to target the B7H4+ solid cancer cells by inducing the CAR T-cells toward the cancer cells. In the current research, I have performed computational modeling to design DuoBody antibodies targeting cancer (B7H4 receptor) and CAR T cells (CD3e receptor). Initially**,** I got the 3D structures of the receptors by using the AlphaFold 3 web server. The 3D structure of antibodies was downloaded from the protein data bank. The downloaded antibodies were docked on the predicted receptor structures utilizing the HDOCK2.0 software to understand the antibodies'; binding interaction and affinity. The docking results were validated using the graph neural network (GNN). The antibodies were selected based on visual inspection, binding energy, and hydrogen bond interactions of the output obtained from the molecular docking simulations. The Binding energies calculated by the PRODIGY software showed that the antibody 4a6y strongly bonded to the CD3e receptor and that 1il1 strongly bonded to the B7H4 receptor. This research can be used in pharmaceutical drug development to engineer Duobodys targeting cancer cells.

Computational Biology B (HS COM B)

American Junior Academy of Science Alternate,Cancer Research Award
First Place
Pranav Sundarrajan *Mills E. Godwin High School*
Computational Design of Novel CD117-Specific RNA Aptamers for Targeted Therapy of Glioblastoma Multiforme (GBM)

Glioblastoma multiforme (GBM) is a high-mortality brain cancer that causes 50% of all brain tumors and has an average survival rate of 12-15 months. CD117 is a transmembrane glycoprotein that is largely overexpressed in GBM cells. Its cytoplasmic kinase domain contains an ATP binding site, a promising druggable target. Aptamers are short single-stranded nucleic acids that serve as effective cancer therapeutics due to their selective targeting of tumor cells and minimum toxicity. This investigation aimed to computationally evaluate parent (already-existing) RNA aptamers: V15, W3, V5, and H5/V36 as ATP-site specific CD117 inhibitors and design novel GBM drugs by mutating the best-performing parent aptamer. Molecular docking was performed to determine each parent aptamers' binding strength towards CD117's ATP site. Five mutants of the best parent aptamer were created via in-silico mutagenesis and subjected to molecular docking again. The V15 aptamer had the highest binding strength due to its low binding energy (-300.65 kcal/mol), but mutants M1 (-304.99 kcal/mol) and M3 (-355.96 kcal/mol) of V15 displayed stronger binding to the ATP site, particularly M3. The parent aptamers were further assessed for structural motifs, shared nucleotide sequences across the aptamers that enhance binding to the ATP site. The analysis revealed a statistically significant motif ($E < 0.05$) AGUGUCNA that enhances aptamer binding to the ATP site. Molecular dynamics (MD) were performed with the M3 and M1 aptamers due to their superior performance in molecular docking. Variations in RMSD and Rg values were quantified to determine the aptamers' stability over a dynamic timeframe when bound to CD117. The MD simulations revealed that the M3 aptamer was the most stable due to its lower RMSD and Rg variation throughout the simulation's timeframe. The M3 aptamer was further analyzed through molecular docking with blood brain barrier (BBB) receptors: transferrin receptor and leptin receptor as well as RNase T2. A high binding strength towards BBB receptors was determined, suggesting strong brain permeability, yet strong binding to RNase T2 was also observed, implying high

risks for degradation. Hence, structural modifications are required to optimize M3's design and lower degradation susceptibility. In conclusion, this research designed a novel aptamer, M3, for GBM therapy which can potentially be tested with GBM cell lines and live patients.

Second Place
Aashritha Penumudi *Thomas Jefferson High School for Science & Technology*
Understanding the Structural Basis of Ribosomal Stalling by Cellular Arresting Peptides

With billions invested in cancer research annually, therapeutic development burdens patients financially, highlighting the need for targeted approaches. Adenosylmethionine decarboxylase 1 (AMD1), a key enzyme in polyamine biosynthesis, is upregulated in breast cancer, contributing to cancer cell growth and tumorigenesis. Polyamine metabolites are essential for cell growth and development by regulating protein and nucleic acid synthesis. Recent studies indicate that AMD1 expression requires ribosomes to pause within the 3′ untranslated region (3' UTR) of its messenger RNA (mRNA). Therefore, understanding the stalling mechanism of ribosomes translating AMD1 may allow researchers to toggle its expression in cancer cells without the use of cytotoxic chemotherapeutic agents. This study integrated biochemical, structural, and machine learning approaches to investigate factors influencing ribosomal stalling by AMD1. In-vitro translation reactions were performed under varying polyamine and mRNA concentrations to identify optimal conditions for isolating ribosomes stalled at the 3′ UTR of AMD1. These stalled ribosomes were then purified and analyzed by cryogenic electron microscopy. Structural analysis revealed that the AMD1 3′ UTR contains an arresting peptide that stalls translating ribosomes by interacting with the polypeptide exit tunnel through aromatic and positively charged amino acid side chains. Additionally, a supervised machine learning model using k-mer encoding guided by the structure and trained on MCF-7 breast cancer ribosome sequencing data predicted specific residues critical for ribosome stalling for follow-up mutagenesis experiments. Collectively, these findings uncover the mechanism of AMD1 stalling on ribosomes and provide a new strategy to control AMD1 expression to target polyamine synthesis in cancer cells.

Third Place
Jonah Schuman *Clover Hill High School*
The Effect of Using TensorFlow vs. PyTorch to Interpret Data on Amount of Time until Data is Interpreted at 70% Accuracy

The purpose of the experiment was to evaluate the training speed of the common libraries for deep learning PyTorch and TensorFlow. The hypothesis was that PyTorch was faster than TensorFlow at training to interpret data at 70% accuracy. Both libraries were imported into their own JupyterLab notebook, with equivalent models being defined in each framework. The models were then defined, and training data was supplied from a dataset of 32x32 normalized cat and dog images. The training was then started, with the individual epoch training times for each model timed and recorded, restarting the training if the model failed to reach an accuracy greater than or equal to 70%. After recording the data, the mean average epoch time was 5.508145 seconds for the control TensorFlow and 6.760595 seconds for PyTorch. The null hypothesis was rejected, with the data not supporting the research hypothesis.

Honorable Mention
Sreeram Gourineni *Rock Ridge High School*
Targeted Inhibition of Oncogenic p300 Proteins Using Novel PROTACs for Hepatocellular Carcinoma Therapy

The p300 protein helps control gene expression and other essential cell processes. When p300 doesn't work the way it's supposed to, it can lead to cancer by assisting tumors to grow. PROTACs are innovative agents designed to degrade target proteins by recruiting them to E3 ligases for ubiquitination. Recently, a novel PROTAC targeting p300 protein has been discovered targeting hepatocellular carcinoma, one of the most common solid tumors. I hypothesize that chemical modifications in PROTACs can enhance their potency, developing more effective structures for therapeutic applications. To test this hypothesis, molecular docking simulations were employed to identify PROTACs capable of binding to both p300 and E3 ligase with high affinity. First, the p300 and E3 Ligase proteins were obtained from AlphaFold 3, a deep learning-based method. Next, molecular docking simulations revealed the p300-E3 ligase complex structure. In the

next step, chemical alteration in the PROTAC 3D structure was performed to design the PROTAC library. Finally, the PROTACs interactions with p300-E3 ligase protein were computed to get the p300-PROTAC-E3 Ligase complex. These simulations provided insights into the interactions between PROTACs and the protein complexes, guiding the design of improved compounds. The docking results were further validated using a deep learning-based method, P2Rank. Based on my knowledge, this is the first computational modeling study on PROTAC-mediated p300 protein degradation. The current research will aid in developing personalized cancer treatments, utilizing PROTACs to target specific oncogenic proteins like p300, thus offering a promising strategy for precision medicine.

Honorable Mention

Srishanth Ravi *Thomas Jefferson High School for Science & Technology*
MSallNet: A Deep Learning Approach for Multiple Sclerosis Lesion Analysis

Multiple sclerosis (MS) is a common neurodegenerative disease that occurs due to the accidental attack of the immune system on the myelin sheath in the central nervous system (CNS). This inflammation causes significant demyelination to occur in the CNS, which hinders signal transmission. As a result, MS can cause varying symptoms, including sensory and motor impairments. Furthermore, the National Multiple Sclerosis Society says MS affects around 2.9 million people around the world; therefore, diagnosis and classification of MS remain as vital aspects. Although no treatment is currently available to cure MS, specific medications and therapies can be prescribed, with these diagnoses having been made, to mitigate the severity of symptoms and the progression of the disease. This study presents MSallNet, a novel architecture that classifies and segments MS, using the white matter lesions present in MRI scans. White matter lesions are the largest indicators of MS as they show bright, white spots of demyelination in scans. Using a convolutional neural network (CNN) for the classification model and transfer learning paired with a random forest classifier for the segmentation model, MSallNet presents deep learning techniques put to use to achieve an efficient and accurate diagnosis. After being trained with axial and sagittal view MRI scans, the model achieves an accuracy of 90.42% for the classification model and 96.69% for the segmentation model. MSallNet serves as a vital advancement in MS detection as it pairs superior efficiency with accuracy and presents a complete, novel framework for MS diagnosis.

Alex Tarun *John Champe High School*
Design and Validation of CRISPR-Cas9 gRNAs in Targeting the HBB Gene Mutation in Sickle Cell Anemia

Sickle cell anemia is a genetic condition that is caused by a single nucleotide mutation in the HBB gene. Specifically, the mutation replaces glutamic acid (GAG) in hemoglobin's beta chain with valine (GTG). The goal of this project is to design and evaluate a therapy based on CRISPR-Cas9 in order to effectively target and correct the mutation. With the use of bioinformatics tools like Benchling, guide RNAs (gRNAs) were identified, assessed, and tailored to the mutated HBB sequence. Minimizing off-target effects and ensuring precise genome editing was a priority in this project. From the gRNAs that were evaluated, the best was chosen based on three factors: proximity to the mutation, editing efficiency, and risk of unintended targets. To confirm the method's accuracy, computational predictions were used for identifying and analyzing the potential off-target sites. The selected gRNA was then paired with the associated PAM sequence (NGG) in order to guide the Cas9 enzyme to the mutation site for precise DNA cutting and correction. This project demonstrates the capabilities of CRISPR-Cas9 as a therapeutic tool for genetic disorders and establishes a foundation for further experimental studies that target sickle cell anemia.

Aisha Baccouche, Dylan Borek, Lauren Kim *Governor's School @ Innovation Park*
Analyzing the Implications of Additives on Alzheimer's & Dementia Symptoms in *Drosophila melanogaster*

Alzheimer's Disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline and the accumulation of amyloid-beta plaques, with minimal current treatment available. The research incorporates bioinformatics through genotype distribution analysis, principal component analysis (PCA), correlation analysis, and hierarchical clustering, levels of amyloid-beta protein, Tau and U1 protein expression, and gene expression alterations. Genotype distribution analysis (Chi-Square Test: 0.235, p-

value: 0.999) presented an even sample distribution, ruling out statistical bias in downstream protein expression analyses. PCA showed no significant clustering between control and APP-expressing groups, indicating low variation in Tau and U1 protein expression. Correlation analysis showed a perfect correlation of (r=1.0) between APP and both Tau and U1, while Tau and U1 had a weaker correlation of (r=0.3375). ANOVA results (p>0.05) suggested that observed differences in protein levels were due to biological factors rather than technical variability. This study advances Alzheimer's research by including multi-methodological approaches in *Drosophila* models and allows for the potential of future translational studies in mammalian systems, highlighting the potential therapeutic implications of dietary additives in neurodegenerative diseases.

Geunyoung Chung *Maggie L. Walker Governor's School*
Application of Machine Learning on the Reoccurence of Thyroid Cancer

As AI grew in popularity, a branch of AI known as Machine Learning has begun to be adopted by different career fields, especially in healthcare. Machine learning is a program that can learn to predict and make inferences by analyzing and building connections by analyzing data. This experiment aimed to explore the reoccurrence of thyroid cancer by using machine learning to identify the top three traits that were the most important to the program and see if there was a difference in the accuracy rate between the model that used all the features and the model that only used the top three features. The study used a data set from the UC Irvin Machine Learning Repository and focused on key characteristics of thyroid cancer based on clinical recommendations. The model was first trained with all the features and then retrained with only the top three features. The researcher hypothesized that the features that would be the most important to the program would be the Stage, Pathology, and whether or not the patient smoked or not. This was because these traits were the most well-observed in a real-life medical scenario. The top three features that were identified by the program were "Response", "N", and "Adenopathy" disproving the hypothesis. Model #1 (the model that used all features) had an accuracy rate of about 98.7% and Model #2 (the model that used the top three features) had a slight drop in the accuracy rate of 97.4%. However, not a big difference was observed between the two accuracy rates. A ROC curve was also produced recommending the experiment to have a larger sample size in future experiments. Overall, this study highlighted the importance of machine learning models, and how they can be applied in medical fields and provided insights on how to refine models for better accuracy and efficiency in predicting cancer reoccurrence.

Allison Davenport *Osbourn Park High School*
From Data to Diagnosis: Predicting Thyroid Cancer Recurrence

Thyroid cancer is one of the most commonly diagnosed in oncology, affecting approximately 44,000 people each year. It has a generally favorable prognosis; however, recurrence remains a significant clinical challenge as cancer overall remains incurable, and it poses a threat to long-term disease management and a patient's quality of life. Early identification of patients at higher risk for recurrence is critical to improving outcomes and guiding clinical decision-making. Physical examination plays a vital role in identifying initial signs of appearance and recurrence, such as palpable neck nodules, asymmetrical thyroid enlargement, or enlarged cervical lymph nodes. This project aimed to determine if the data found from physical examination could be integrated into a logistic regression model in R to predict an outcome of recurrence. When calculated and graphed, the Receiver Operating Characteristic curve delivered poor discrimination in the area under the curve, establishing that a model of this nature would not be able to provide reliable predictions of thyroid cancer recurrence for use in the medical field.

Esha Madamalla, Aditya Khandelwal *Thomas Jefferson High School for Science & Technology*
MRI and EEG Utilization for Early Detection of Frontotemporal Dementia using a Semi-Supervised Machine Learning Model

Frontotemporal Dementia (FTD) is a progressive neurodegenerative disorder affecting behavior, language, and executive functions, with an onset typically between 45 and 65 years of age. Early diagnosis remains challenging due to the subtle nature of initial symptoms and limitations in existing diagnostic tools. Using Magnetic Resonance Imaging (MRI) and electroencephalogram (EEG) data, we utilized a semi-supervised machine learning (ML) model to improve early detection of FTD. Leveraging the combination of unlabeled

and labelled data, we processed the unlabeled data using probabilistic imputation methods, which estimated missing or uncertain values, using a Bayesian probability distribution. Mean and variance statistics were calculated to standardize features across the dataset, ensuring compatibility between labeled and unlabeled samples. Once our data was prepared, we fed it into a Random Forest Classifier algorithm due to its ability to handle multi-dimensional data and provide feature importance rankings. To evaluate the validity of our semi-supervised model over a traditional supervised model, we tested both pipelines. The supervised model achieved an accuracy of 87.4% with IFS_cognitive_total identified as the most important feature. Conversely, the semi-supervised model significantly outperformed, using pseudo-labeling and softmax confidence threshold labels to improve accuracy to 96.7%. Feature analysis revealed API total as the most predictive variable. This study highlights the integration of probabilistic imputation and a semi-supervised ML model to enhance early detection of FTD, with MoCA_total as the most predictive factor. These findings highlight the potential for advanced ML frameworks to improve diagnostic precision, paving the way for earlier interventions and treatment strategies.

McKay Pradawong *James Madison High School*
In Silico Bioassays of Polyphenol-Enhanced Cephalosporin Composites Targeting Penicillin-Binding Protein 2a in Methicillin-Resistant *Staphylococcus aureus*

As a leading cause of bacteremia, superficial tissue infections, and hospital-acquired infections, Methicillin-resistant *Staphylococcus aureus* (MRSA) has seriously threatened public health. This issue is only exacerbated by MRSA's evolution of new resistance mechanisms of currently efficacious treatment options, the high cost of current treatment options, and underdeveloped healthcare capacity in resource-limited areas. The peptidoglycan-regulating penicillin-binding protein 2a (PBP2a) is responsible for conferring β-lactam resistance, expressing the gene mecA to reduce the binding affinities of this notable antibiotic class. However, research in polyphenol-induced PBP2a modulation has shown the potential for enhanced binding for β-lactams, and 5th-generation cephalosporins have already proven efficacious. As a result, molecular docking and dynamics simulations were performed to explore a novel relationship between polyphenols and the cephalosporin class. The in-silico design tested the efficacy of polyphenol-enhanced cephalosporins, finding an antibacterial synergy that facilitates stronger binding and inhibition of PBP2a. Flavonoids exhibited variable moderate-to-strong binding affinities, while tannins exemplified weaker but more consistent data. However, when paired with polyphenols, generally ineffective lower generation cephalosporins presented binding affinity values (< -8.0 kcal/mol) acceptable for potential use in clinical applications. Future research should perform in-vivo and in-vitro analysis to confirm values and further explore additional molecular factors, such as steric clashes when enhancing cephalosporins with large side chains. Subject to in vivo and in vitro validation, polyphenol-enhanced cephalosporins may improve the effectiveness and applicability of this major β-lactam class, potentially leading to effectual therapeutic regimens for emerging virulent clones and similar antibiotic-resistant bacterial infections.

Yashvir Sabharwal *Patriot High School*
BrainStorm: Reconstructing Natural Vision From fMRI & EEG Using Generative Models for Communication and Covert Awareness in Neurological States

With an estimated 60,000,000+ individuals worldwide suffering from disabilities such as mutism and over 850,000 coma patients in the United States each year, enhancing communication capacities and deciphering internal cognitive processes becomes paramount to health. BrainStorm aims to reconstruct natural images and videos from functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) signals with large-scale datasets by harnessing generative models to translate neural activity from the striate, prestriate, and V3 areas of the brain into visual representations. BrainStorm's techniques facilitate real-time visualization of these processes, aiding comatose stage classification and treatment: a vital step towards understanding neurological functions in decades. BrainStorm also facilitates mental health investigation by elucidating the neural correlates associated with suicidal ideation and reconstructions of negative, salient images. The ability to reconstruct images and videos from fMRI using these methods—which integrates novel techniques such as mapping to latent space via CLIP and employing cosine similarity—provides a powerful tool for addressing these matters. Decoding visual stimuli from these signals, however, presents unique challenges including low temporal

resolution, high noise, and intricate nonlinear mappings of the data. This study uses a diffusion prior within the generative model to overcome these obstacles. Further, a secondary image and brain retrieval pipeline is integrated alongside stimuli reconstruction, achieving top metrics such as 0.456 PixCorr, 0.493 SSIM, and a 142.4% improvement in real-world expression. This study extends previous efforts by incorporating EEG signals using the Alljoined1 dataset, enhancing temporal resolution in neural decoding. The EEG signals are integrated alongside fMRI to bolster image reconstruction, capturing rapid neural dynamics that were previously inaccessible with fMRI alone. This positions BrainStorm as state-of-the-art research that has momentous implications for medical imaging, communication, and neuroscience.

Arav Srivastava *Grafton High School*
Convolutional Neural Network for Histopathology images: Classification of Breast Cancer Tumor Tissue types

Breast Cancer is one of the most common cancers, disproportionately impacting women with approximately 2.3 million new cases worldwide and around 700,000 deaths annually, 99% of those being women. Early detection could save hundreds of thousands of lives, with survival rates of 86%-99% in a 5-year period, depending on whether the Cancer is In Situ or Invasive. Developing regions often face challenges accessing timely Breast cancer classification due to shortages in key specialist fields such as Pathologists. In this project, I developed a machine learning algorithm that can classify tumor images into four categories: In Situ, Invasive, Normal, and Benign. Accurately differentiating between these categories is crucial, as it guides treatment decisions if needed. I used a dataset from the BACH Grand Challenge on Breast Cancer Histopathology Images consisting of 400 high-resolution images and applied data augmentation to expand the batch size to 2800 high-resolution images with an 80/20 training-validation split. MobileNetV2, pre-trained on ImageNet, served as the base model. Custom layers and callbacks like Dense, Dropout, and ReduceLROnPlateau were added to prevent overfitting, and help in regularization and generalization of the model for higher accuracy. The model achieved an accuracy of 96.79% compared to current clinical methods with 90-95% accuracy. My model was saved and deployed as a web-based detection tool for efficient, effective, and affordable access globally. This novel tool is a cost-effective preliminary screening tool that can assist hospitals in developing regions and reduce financial and logistical barriers to care.

Engineering A (HS EGR A)

First Place
Cohen Gabriel *Yorktown High School*
Binary Classification of Human-Created and AI-Generated Music Using a Convolutional Neural Network

There is a growing need to develop accurate methods to detect AI-generated music. Tools for written text exist, such as ZeroGPT and CopyLeaks, but a sufficient tool does not exist for music. This research involved creating a machine-learning pipeline to distinguish between AI-generated and human-composed electronic music. The pipeline processes audio files by converting them into a series of Mel Frequency Cepstral Coefficients (MFCCs) and analyzing one-second segments of audio with a convolutional neural network. The neural network includes five convolutional blocks and one dense layer. The training dataset comprises 284 songs: human-created music from Bandcamp, Battle of the Bits competitions, and original compositions (148 songs), along with AI-generated music from the platforms Suno and Udio (116 songs). The validation dataset comprises 60 songs: 30 AI songs (from services other than Suno and Udio), and 30 human songs. The model achieved 97.9% training accuracy and 81% validation accuracy when all 1-second segments were pooled. The model evaluated full songs by calculating an "AI-generation confidence score" - the percentage of one-second segments classified as AI-generated within the song. The model had an accuracy of 86.67%, precision of 89.29%, and recall of 83.33%. The model is effective

for detecting AI-generated electronic music and generalizes to detect a variety of AI music-generation services that were not in its training set.

Second Place
Ian Yu *Blacksburg High School*
A novel approach to Martian obstacle detection through Ultrasonic Transducers

Obstacle detection in a Martian environment is currently approached using cameras. Regional and global-scale dust storms occur every year on Mars, that greatly impact the rovers on the surface. The dust from these storms reduces the visibility making cameras difficult to use. This study aims to propose a novel solution through the use of ultrasonic transducers for a sonar-based approach. A key focus was to examine the performance of such systems under atmospheric conditions similar to those on the surface of Mars. Six commercially available piezoelectric ultrasonic transducers with a peak voltage between 3.3 and 5V and a frequency of 40khz were tested in a simulated Martian environment with temperatures between 296.15K to 253.15K and pressures from 5,000 to 9,000 mTorr. The transducers included three bimorphs, one monostatic, 1 one bimorph hydrophone, and 1 monostatic hydrophone. A microprocessor-controlled communication and displayed the results which were compiled and filtered using a Kalman algorithm to reduce noise and outliers. Results compiled from the transducers suggest under Martian atmospheric conditions, an error of 2.5% at worst and 7.6% at best can be observed. This indicates that with the usage of piezoelectric transducers, it is possible to detect obstacles in a Martian environment and judge their distance. While this research has the potential to be expanded under more accurate conditions by including variables such as dust or using more specialized transducers, the applicability of ultrasonic transducers in the Martian environment remains positive.

Third Place
Devin Wanchoo *Osbourn Park High School*
Evaluating Biomimetic Surface Patterns for Heat Resistance

With the increasing frequency and severity of wildfires as a result of climate change, there is a growing need for advanced thermal protection materials, specifically in aerospace and wildfire mitigation applications. Conventional thermal management solutions, such as insulation and active cooling, often add weight, cost, and complexity, making them impractical for lightweight systems like drones. This study investigates the impact of biomimetic surface patterns (honeycomb, scales, and channels) on heat resistance and failure characteristics compared to a smooth, plain control surface. Heat resistance testing involved measuring time to reach 100°C, maximum temperature, cool to room temperature, and thermal distribution, while failure testing evaluated time until structural degradation and heat-induced deformation. The honeycomb pattern demonstrated superior thermal resistance, delaying heat absorption the longest (approximately 1:58 minutes to 100°C) and maintaining structural integrity better than the other patterns. The scales and channels patterns displayed moderate heat resistance, with scales dissipating heat unevenly and channels creating localized hot spots. The control surface heated up the quickest, confirming the lack of passive thermal regulation in smooth surfaces. These findings highlight the potential of biomimetic structures to improve thermal performance in extreme environments.

Honorable Mention
Larah Clemons *Southwest Virginia Governor's School*
The Effect of Mass Distribution on a Rotating Mass Wave Energy Converter

The increasing global demand for sustainable energy has led to a growing interest in wave energy as a potential solution. The Rotating Mass Wave Energy Converter (RM-WEC) has shown promise in converting ocean wave motion into electrical power, yet optimization of its design remains necessary for enhanced efficiency. Variations in the distribution of ball bearings within the RM-WEC's gyroscopic assembly were investigated to measure their impact on energy conversion performance. How does the distribution of ball bearings within the gyroscopic assembly affect the efficiency of the Rotating Mass Wave Energy Converter in generating electrical power? Three models were constructed and tested, each with different ball bearing distributions: edge-heavy, mid-point-heavy, and center-heavy. The experiment was conducted in a wave simulation tank, with each model being tested individually for two hours. Power output

was measured using voltage and current data. Statistical analysis of variance (ANOVA) revealed that ball bearing distribution influenced energy yield, with some configurations demonstrating improved efficiency. These findings contribute valuable insights toward optimizing RM-WEC designs and advancing wave energy conversion technology.

Honorable Mention
Ingrid Jora *Blacksburg High School*
The Accuracy of an American Sign Language-Recognition Deep Neural Network (Transfer Learning Approach) under Simulated Healthcare Conditions

This study evaluates the accuracy of the deepASL deep neural network in recognizing ASL fingerspelling under healthcare-specific conditions, aiming to address communication barriers faced by Deaf and Hard of Hearing (DHH) individuals in medical settings. Effective communication in healthcare is essential, yet DHH individuals often experience challenges due to limited interpreter availability, inadequate physician awareness of DHH culture, and technological limitations in ASL recognition. To assess deepASL's performance, the network was tested using an ASL alphabet dataset of 87,000 images across various conditions, including fine hand tremors, right- and left-hand dominance, and four glove colors (clear, pink, green, and purple). Each letter was signed three times under controlled experimental conditions, generating a dataset that measured recognition accuracy. Results indicated that fine hand tremors significantly decreased recognition accuracy ($p=0.02$), while no difference was observed between right- and left-hand use ($p=0.5$). Among glove colors, the purple glove significantly improved recognition accuracy ($p=0.006$), whereas the clear glove resulted in the lowest accuracy ($p<0.001$). These findings suggest that factors such as hand stability and visual contrast affect the performance of ASL recognition models, presenting challenges for their real-world application in healthcare environments. Improving ASL recognition technology could reduce communication barriers, ensuring better access to medical care for DHH individuals. Future research should focus on optimizing deep learning models to enhance ASL recognition accuracy in dynamic healthcare conditions, ultimately contributing to more inclusive and effective healthcare interactions for the DHH community.

Honorable Mention
Henry Pratt *Central Virginia Governor's School for Science and Technology*
The Effects of Improper Bicycle Helmet Usage

The purpose of this study was to determine if the way a bicycle helmet is worn affects head injury in case of an impact. This study was conducted at a local high school during October through December of 2024. Twelve identical helmets were each tested in six different ways: front, side, and rear impact, each of them with proper usage and improper usage (tilted too far back). There were also front, back, and rear tests for a no helmet group. This multiplied out to nine test groups and twelve trials, totaling 108 tests. The average acceleration of each group was sorted by helmet usage to run a two-way ANOVA test. An alpha value of .05 was used and compared to the p-value from the interactions between helmet usage types, which was .006, which showed that the data had statistical significance. A post-hoc Tukey test determined between which groups the significance lay. The calculated Dmin value of 14.8831, was compared to the difference between the means of the groups. The proper usage group had a significantly lower average acceleration than the no helmet group. The data partially supported the research hypothesis, which stated that all of the groups would be significant from each other, because the improper usage group was not significant from any other group. In summation, the way someone wears a bicycle helmet has a significant effect on the acceleration that their head will experience.

Brodey Smith *Central Virginia Governor's School for Science and Technology*
The Effect of Class F Fly Ash on the Compressive Strength of Portland Cement

This paper presents an experimental study on the compressive strength of Portland cement mixture containing class F fly ash. The study used a total of 36 samples, with nine in each category. The categories were the control group, 20%, 40%, and 60% concentration of fly ash by volume. The samples cured for 42 days. Then the samples were tested by placing the cement coupons individually on a hydraulic press, crushing them, and recording the compressive strength in MPa of each sample in Excel. The resulting p-

value from the Excel data was .22, compared to an alpha of .05, meaning that there was no significant difference, and I had to retain the null hypothesis. This refuted the research hypothesis that the fly ash would increase the compressive strength of the concrete. The results conclude that the use of the class F fly ash had no significant effect on the compressive strength of the concrete.

Onur Sogutlu *Mills E. Godwin High School*
Effects of Design on Structural Characteristics of 3D Printed Tissue Scaffolds

Scaffolds are crucial tools in the field of tissue engineering as they are used as platforms for growing cells. By providing support for cells, they allow the formation of large, complex tissue structures. The study aimed to determine the characteristics of an effective tissue scaffold. This information has the potential to allow researchers to create the best tissue scaffold for their desired application. Creating better scaffolds can advance research in tissue engineering, providing solutions for difficult challenges such as growing large tissues, organ systems, and bone tissues. The study involved the development of various tissue scaffold designs which featured different types of connections between each of the layers. It was hypothesized that a scaffold with staggered layers and a 90-degree angle at each connection point would perform the best due to a more evenly distributed load. No control was present since the study only aimed to determine the effects of specific design elements on the overall effectiveness of a scaffold. Each of the scaffolds were modelled using computer-aided design. Static stress simulations were used to conduct stress-strain tests on each of the scaffold designs. Extrusion based 3D printing was used to print each scaffold with silicone. The best performing scaffold design featured staggered layers with 90-degree angles at each connection point. This design had the greatest minimum safety factor and the least maximum von Mises stress. The staggered design allowed for the load to be spread out over each layer.

Grace Stevens *Central Virginia Governor's School for Science and Technology*
The Effect of Blade Angle and Blade Coatings on a Wind Turbine's Efficiency

The purpose of this study was to determine whether the blade angle and the blade coatings on a wind turbine's blades correspondingly affect the power output. A KidWind Basic Wind Experiment Kit was used as the wind turbine and ten, 30-second trials were conducted with each angle and coating combination, providing 180 trials in total. A two-way ANOVA test, with an alpha value of .05, was conducted and revealed a p-value of 3.54× 〖10〗 ^(-36). Three Tukey tests were conducted to analyze significant differences in blade angle, blade coating, and their interaction. The blade angles had a D_{min} value of 5.21, the blade coatings had a D_{min} value of 6.37, and both of the variables correspondingly had a D_{min} value of 7.82. The results partially supported the hypothesis, which predicted that a 20° blade angle and polyurethane coating would yield the greatest efficiency. I found that the blade angles at 10° perpendicular to the flow of air and the polyurethane coating produced the most efficient wind turbine. In conclusion, the blade angle and the blade coating significantly affected the power output of the wind turbine.

Atharva Vaidya *Mathematics and Science Academy at Ocean Lakes High School*
AI-Powered Wearable Navigation System for the Visually Impaired

Visually impaired individuals face significant challenges in navigating the world independently, and current navigation systems often fail to provide real-time, context-aware assistance. Existing solutions, such as guide dogs and basic auditory feedback systems, may not offer the precision or adaptability needed in dynamic environments. This project introduces an AI-powered wearable navigation system that integrates YOLOv8, an open-source object detection model, and Gemini, an advanced language model, to provide real-time feedback for users. The system uses a Raspberry pi4 Model B as the central processing unit, a Raspberry Pi camera Module V2 for visual input, and a text-to-speech output module for communication. YOLOv8 detects and localizes objects, including small and overlapping hazards, while GEMINI offers broader environmental context and generates text-to-speech alerts, enhancing the users' situational awareness. The dual AI approach ensures both detailed object detection and a contextual environmental understanding, offering a more accurate and efficient solution than current navigation systems. Designed for use in diverse environments--such as indoor spaces, streets, and parks--the system is optimized for real-time performance. Testing demonstrated the system's ability to navigate indoor and outdoor

environments effectively, providing real-time feedback that improved users' awareness and reaction to obstacles. While challenges remain in refining its design for portability and privacy, future iterations aim to incorporate more compact, ergonomic solutions and advanced sensors for enhanced mapping and usability. In conclusion, this system has the potential to significantly improve the safety and independence of visually impaired individuals by leveraging the latest advancements in AI technology.

Sam Williams *Central Virginia Governor's School for Science and Technology*
Comparing the Aerodynamics of Different Angles of Airplane Wing Sweep

This study aimed to determine the aerodynamic properties of different angles of wing sweep at a constant airspeed. The hypothesis was that forward-swept wings at 45°, 40°, and 30° angles would exhibit differing aerodynamic properties compared to backward-swept wings at equivalent angles relative to a straight wing arrangement perpendicular to the centerline, with variations in lift and drag ratios compared to control wings with no sweep. Seven wing sweep angles were used for this experiment: a control, which was not swept, and ±45°, ±40°, and ±30° angles used. Each wing array was tested for both lift and drag in nine, ten-second trials. Then the lift-drag ratio was calculated in Excel. A one-way ANOVA test of lift-drag ratios determined no significance, with a p-value of .217 and an alpha level of .05. The control variable demonstrated the greatest lift-drag ratio. The research hypothesis was not supported, as forward- and backward-swept wings showed negligible differences in aerodynamic properties. The findings suggest that at the tested airspeed, variations in wing sweep angle have minimal impact on lift-drag ratios.

Engineering B (HS EGR B)

Virginia Peninsula Engineering Award
First Place
Hart Miller *Clover Hill High School*
The Effect of Varying Materials, Used as Obstacles to Block a WiFi Signal, on the Resultant WiFi Strength and Speed

The purpose of this experiment was to determine which household items when used as an obstacle would reduce the strength and speed of WiFi signals the most. The hypothesis was that the more metallic materials like aluminum foil and stainless steel would weaken the WiFi signal and speed the most. A smartphone was used to measure signal strength and speed from a WiFi router at a certain distance away. A control of no obstacle and obstacles of aluminum foil, wood, plastic, stainless steel, and drywall were all placed one at time between the WiFi router and the smartphone to measure the strength and speed in those positions. Each material was placed so that it completely covered the WiFi router. The mean speed for the control group, aluminum foil, wood, plastic, stainless steel, and drywall was 24.06 Mbps, 24.10 Mbps, 26.08 Mbps, 19.61 Mbps, and 20.61 Mbps respectively. The mean strength for the control group, aluminum foil, wood, plastic, stainless steel, and drywall was -47.2 dB, -60.9 dB, -46.5 dB, -48.9 dB, -58.1 dB, and -49.1 dB respectively. The null hypothesis was rejected, and the hypothesis was partially supported by metallic materials like aluminum foil and stainless steel that weakened the WiFi signal the most; however, there was no trend in the WiFi speed to support or not support the hypothesis.

Second Place
Justus Gibbs *Central Virginia Governor's School for Science and Technology*
The Effect of Temperature on Curing Foamed Concrete and Compressive Strength

This study examined the effects of extreme temperatures on the performance of foamed concrete (FC) during its curing process. The primary objective was to examine how and to what extent temperature influences FC's strength. In the procedure, Cement, Vegetable Glycerin, Drexel-160, and water were mixed into 3x3 cylindrical coupons and tested at various temperatures ((21o C, Control); (0o C, Chilled); (65.6o C, Heated)) with identical concentrations. Tensile strength data were collected using an Instron machine, which measured the maximum stress (kPa) at which each coupon failed. The results were analyzed for statistical significance using Excel, with compressive strength averages of 1457.41 kPa for Control, 437.17 kPa for Heated, and 1364.06 kPa for Chilled coupons. To uncover any significance, a one-way ANOVA

was performed with an alpha value of .05. This yielded a p-value of 2.66 x 10-12 which indicated statistical significance. The ANOVA test was followed by a post-hoc Tukey test which revealed that the Heated coupons significantly differed from the other groups, with a Qt value of 3.51 and Dmin of 213.27. These findings partially support the hypothesis that extreme temperatures negatively impact FC's stress resistance, but specifically at higher temperatures. This research underscores the importance of considering temperature effects in concrete strength for construction and infrastructure safety

Third Place
Ian Jora Macrea *Blacksburg High School*
Repeated Impacts on Cycling Helmet Efficacy

Although cycling helmets are intended to be replaced after every impact, cyclists often continue to use impacted helmets despite liner damage, polystyrene foam deformation, and shell cracking. Evidence suggests that prior impacts worsen helmet efficacy in the context of preventing concussions. In the present study, two Bell Vert 2.0 helmets were equipped to a National Operating Committee on Standards for Athletic Equipment (NOCSAE) Hybrid III head-and-neck surrogate and strikes with a pendulum impactor in order to collect peak linear acceleration (PLA) and peak rotational acceleration (PRA). Front boss, side, and back locations were tested. One helmet (BV1) experienced three low energy (3.6 m/s) impacts on the front boss, three high energy impacts (5.4 m/s) on the side, and three low energy impacts on the back. The second helmet (BV2) also experienced three impacts in each of these locations but with the opposite energy level for the front boss, side, and back. Data were analyzed using a two-way ANOVA test, two Tukey HSD tests, and a T-test. The two-way ANOVA test resulted in a statistically significant overall p-value of under 0.0001, with the results of the following tests being significant as well. Repeated impacts increased concussion risk in all impact locations, at all energy levels, and when considered with both impact location and energy level combined. This strongly suggests that cyclists should replace their helmet after every impact. More research investigating the effects of repeated impacts is warranted.

Honorable Mention
Apollo Guanzon *Central Virginia Governor's School for Science and Technology*
Comparing the Impact Resistance of Mycelium Biomaterials to that of Common Use Polystyrene Plastics

The purpose of this study was to determine whether mycelium-based packaging alternatives could meet or exceed impact resistance levels of polystyrene-based plastics. The predicted outcome was that if mycelium-based packaging alternatives could meet or exceed the impact resistance levels of polystyrene-based plastics, then they could be viable alternatives to plastic-based packaging foam. In this experiment, a mycelium-based packaging alternative was grown in a school lab. This alternative packaging material's impact acceleration was then compared to a polystyrene-based packaging foam where each material was dropped from two different heights (0.9144 meters (3ft) and 1.524 meters (5ft)) for 20 trials. The impact acceleration of each material at each height was measured using a Vernier accelerometer, which was stored in the Vernier Graphical Analysis program. With the data collected, a two-way ANOVA with replication determined that there was no interaction with a p-value of .303 compared to an alpha value of .05. A series of 4 t-tests comparing the impact resistance of each material and each height were run to determine significance, where none of the t-tests showed any significance (all p-values were greater than the alpha value of .05: .4423975115, .4946021861, .7470351755, and .268789534). The data acquired did not support the predicted outcome. These results suggest that more research is needed before this mycelium-based packaging can replace polystyrene packing foam.

Honorable Mention
Braeden Hall *Central Virginia Governor's School for Science and Technology*
The Effect of Filament Type on the Tensile-Strength-to-Mass Ratio of a 3D-Printed Object

The purpose of this study was to determine which of the filaments tested (PC, PLA, PETG-HF, PET-CF) had the highest tensile-strength-to-mass ratio (N/kg). This study was conducted at a local high school during the 2024-25 school year. Four groups of 3D printed models, each printed from a different filament,

were massed and tested to determine the average tensile-strength-to-mass ratio of each filament. These models were tested using a scientific scale, and a Vernier Structures and Materials Tester to determine this ratio. Vernier Graphical Analysis was used to retrieve this data, and Excel was used to store this data and compile various statistical tests of significance. The average tensile-strength-to-mass ratio for each filament was as follows: PC (78,261.704 N/kg), PLA (52,250.545 N/kg), PET-CF (46,010.329 N/kg), and PETG-HF (42,063.924 N/kg). A one-way ANOVA with a set alpha value of .05 revealed a p-value of 1.18×10^{-12}, which then prompted a post-hoc Tukey Test with a Dmin value of 8919.882 and a Qt value of 3.79. The result of this test suggested that Polycarbonate filament had a significantly higher tensile-strength-to-mass ratio than all other tested filaments. This affirmed the research hypothesis which stated that if a Polycarbonate (PC) filament is tested, then this filament will have the highest tensile-strength-to-mass ratio. In conclusion, the choice of filament material significantly affects the tensile-strength-to-mass ratio of 3D-printed components.

Honorable Mention

Erin Jansen *Patriot High School*

Halting Fast Fashion to Impart Sustainability to the Textile Industry: The Effect of Glycerin Concentration on Mechanical Properties of Sodium Alginate- and Gelatin-Based Biofabrics

Fast fashion is the rapid production of inexpensive, low-quality clothing in response to ever-changing fashion trends. The fashion industry has become a major source of water consumption and pollution, carbon emissions, energy consumption, and solid waste. Derived from natural and renewable sources, biofabrics offer a sustainable, eco-friendly solution to fast fashion's environmental consequences. This study quantitatively and qualitatively evaluated mechanical properties of sodium alginate- and gelatin-based biofabrics containing varying amounts of glycerin to determine their feasibility as alternatives to conventional textiles to mitigate current fashion industry environmental impact. Prepared sodium alginate and beef gelatin biofabrics underwent tensile and torsional strength testing for quantitative analysis. Flexural response testing provided qualitative results. Samples of 100% cotton and genuine leather fabrics were tested for comparison. Tensile strength decreased with increasing glycerin concentration for all biofabrics. The 4% sodium alginate/glycerin and 7.5% gelatin/glycerin sample results were comparable to cotton. Biofabrics with the lowest concentrations of glycerin matched or exceeded the minimum tensile strength of leather. Torsional strength increased with increasing glycerin concentrations for all biofabrics, but none approached that exhibited by cotton. Only the sodium alginate-based biofabric containing 4% glycerin did not break when folded but retained its fold line. None of the gelatin-based biofabrics broke, but only the 10% glycerin sample returned to its original form without a visible fold line. This matched the performance of leather. This study's results suggest that custom-engineered gelatin-based and high glycerin concentration sodium alginate-based biofabrics could be suitable for textile applications currently using leather or faux-leather fabrics.

Veness Chen *Central Virginia Governor's School for Science and Technology*

Effects of Varying Infill Density and Structure on the Tensile-Strength-to-Mass Ratio of a 3D-Printed Object

The purpose of this study was to determine how infill density and infill pattern affect the tensile strength-to-mass ratio of PLA 3D printed objects. The hypothesis was that an infill pattern of concentric and an infill density of 50% would yield the highest ratio. Five infill patterns were tested: concentric, tri-hexagonal, rectangular, gyroid, and honeycomb. Each infill pattern was split into 5 groups of different infill densities: 25%, 37.5%, 50%, 62.5%, and 75%. Ten samples per group were weighed and tested for tensile strength using a Vernier Structures and Materials Tester. A two-way ANOVA found p-values of 2.55 × 10-126 for infill pattern, 1.13 × 10-1 for infill density, and 7.01 × 10-10 for the interaction between variables. With an alpha value of .05, these results indicated significant effects of infill pattern and variable interactions but not of infill density alone. Two Tukey tests were used to determine the significance between groups. The infill pattern Tukey test, which used a Qt value of 4.02 and a Dmin of 2452, supported the hypothesis that concentric would yield the highest tensile strength-to-mass ratio. A second Tukey test for variable interaction (Qt = 5.24, Dmin = 3197) indicated that concentric infill, regardless of density, yielded the highest ratio. The results suggest that concentric yields the highest strength-to-mass ratio, however, infill density does not appear to have a significant effect on the strength-to-mass ratio.

Jacob Flint *Central Virginia Governor's School for Science and Technology*
The Effect of Angle and Protective Coatings on Solar Power Output

My research study aimed to maximize solar panel power output, contributing to the broader adoption of renewable energy as a solution to environmental challenges. The experiment utilized a solar panel and a light source just above it. I then used an energy sensor to measure the power from the panel. I had four groups, each with two solar panels. Each group had different protective coatings applied. Each solar panel was tested at four fixed angles: 0°, 15°, 30°, and 45°. With the collected data I ran a two factor ANOVA test and received a p-value of 5.41010-24. I compared that to an alpha value of .05. The results were statistically significant, leading to the rejection of the null hypothesis and acceptance of the research hypothesis. My research hypothesis stated that if the solar panels were at a steeper angle and had more coating on them, then the solar panels power will be

Vishal Manikanden, Aniketh Bandlamudi *Oakton High School*
Designing a Convolutional Neural Network for High-Accuracy Oral Cavity Squamous Cell Carcinoma (OCSCC) Detection: Investigating the Impact of Image Resolution on Computer Vision-Driven Diagnosis

Background: Oral Cavity Squamous Cell Carcinoma (OCSCC) is the most common type of head and neck cancer. Due to the subtle nature of its early stages, deep and hidden areas of development, and slow growth, OCSCC often goes undetected, leading to preventable deaths. However, properly trained Convolutional Neural Networks (CNNs), with their precise image segmentation techniques and ability to apply kernel matrices to modify the RGB values of images for accurate image pattern recognition, would be an effective means for early detection of OCSCC. Pairing this neural network with image capturing and processing hardware would allow increased efficacy in OCSCC detection. The aim of our project is to develop a convolutional neural network trained to recognize OCSCC, as well as design a physical hardware system to capture and process detailed images, in order to determine the image quality required for accurate predictions. Methods: A CNN was trained on 4293 training images consisting of benign and malignant tumors, as well as negative samples, and was evaluated for its precision, recall, and Mean Average Precision (mAP) in its predictions of OCSCC. A testing dataset of randomly assorted images of cancerous, non-cancerous, and negative images, was chosen, and each image was altered to represent 5 common resolutions. This testing dataset was thoroughly analyzed by the CNN, and predictions were scored based on accuracy. The designed assistance hardware was employed to capture detailed images, and its impact was scored. An application was developed to facilitate the testing process and bring access to the CNN. Images of increasing resolution resulted in higher-accuracy predictions on a logarithmic scale, demonstrating the diminishing returns of greater pixel counts.

Margot Marcais *Central Virginia Governor's School for Science and Technology*
Comparing PET Plastic Experimental Stuffing to Common Stuffing Materials

This project built upon last year's research (2023-2024), assessing the quality of stuffing made from recycled plastic. For this study, stuffing was made by putting PET plastic water bottles through a paper shredder, a spice grinder, and then finally into a cotton candy machine. This machine was modified to heat to 490° Fahrenheit. The relative density and resilience of the experimental stuffing was compared to store-bought stuffing (high quality stuffing) and scrap yarn (low quality stuffing). The averages for relative density were: 0.0429g/ml for experimental, 0.0520g/ml for store-bought stuffing, and 0.0424g/ml for scrap yarn. An ANOVA test showed a statistical difference in these values with a p-value of 3.202 x 10-14 compared to the alpha value of .05. A post-hoc Tukey test showed significant differences between experimental and store-bought stuffing. The averages for relative resilience were: 0.79cm for experimental, 0.88cm for store bought stuffing, and 1.51cm for scrap yarn. An ANOVA test showed a statistical difference in these values with a p-value of 5 x 10-6 compared to the alpha value of .05. A post-hoc Tukey test showed significant differences between experimental and scrap yarn. The research hypothesis, stating that the experimental stuffing would be better than scrap yarn but worse than store bought in both categories wasn't supported. The experimental stuffing was equal to store-bought resilience, but equal to scrap yarn density. In conclusion, this process can be refined and modified to create a better experimental stuffing.

Ruger Young *Central Virginia Governor's School for Science and Technology*
The Effect of Winglet Angle on Lift and Drag

The purpose of my research was to determine what angle of winglet provides the most lift and least drag. To test this, I placed a model of a wing with winglets in front of a fan and used force sensors on top of and behind the model to register lift and drag. From this testing, I determined that my 30-degree winglet provided the least amount of drag, and my constant provided the most lift. To determine this, I completed 6 one-way ANOVA tests with an alpha value of 0.05. I then completed a Tukey test on the 5 significant tests to determine where in my samples the significance lay. This opposed my hypothesis, as the constant had no winglets and still generated the most lift across my tests.

Engineering C (HS EGR C)

First Place

Victor Cho *Langley High School*
Real-Time Concussion Detection: A Helmet-Integrated Sensor Device for Youth Football Safety

According to the CDC, over 300,000 concussions occur annually in youth football alone with traditional sideline evaluation missing up to 50% of these traumatic injuries. This diagnostic gap exposes young athletes to serious neurological harm such as chronic traumatic encephalopathy (CTE), impaired cognitive function, and increased rates of depression. My project addresses this issue by developing a helmet-integrated sensor system that instantly detects and reports dangerous impacts, ensuring no concussion goes unnoticed. My device pairs an ESP32-C3 microcontroller with an H3LIS331DL triaxial accelerometer, which transmits impact data via MQTT protocol to a cloud-based processing center. This data is then visualized on a mobile dashboard app that provides real-time g-force readings and sends automated alerts to coaches, medical staff, and parents within seconds. I validated the device's accuracy by comparing the theoretical g-force calculations of controlled drop tests with the sensor's readings. My results demonstrated exceptional accuracy within ±2g for forces below 100g and ±5% above 100g. Unlike existing solutions requiring specialized helmets, my solution can be retrofitted to existing helmets at a significantly lower cost and includes live tracking capabilities. This breakthrough technology is poised to transform player safety in all contact sports by providing instant detection, potentially preventing thousands of devastating neurological injuries.

Second Place
Rohit Rajakumar *Lightridge High School*
Evaluating Image Segmentation Models on Drone-Based Flood Imagery

Deep learning architectures such as Pyramid Scene Parsing Network (PSPNet), U-Net, and Fully Convolutional Networks (FCN) have shown great success in image segmentation tasks. In this paper, these architectures will be evaluated on the Floodnet dataset, which contains images of flood-affected areas captured by UAVs. Each architecture was trained for approximately 15 epochs, with varying hyperparameters, such as batch sizes and learning rates, to determine their effects on each architecture. The best hyperparameters were then used to train the models. The results show that the Fully Convolutional Neural Networks have the highest accuracy and Mean Intersection over Union (MeanIoU) score for the Floodnet dataset. Furthermore, a larger batch size and a higher learning rate tend to perform better for all architectures, except for FCN, where a smaller batch size performed better. These findings illustrate considerations when developing image segmentation models based on UAV flood imagery.

Third Place
Sanaya Bothra *Maggie L. Walker Governor's School*
Characterizing a Fiber Based Synaptic Device Using Transcranial Magnetic Stimulation

Transcranial magnetic stimulation (TMS) therapy uses the induction of magnetic fields to stimulate regions of the brain and is an FDA-approved treatment for mental illnesses such as depression and OCD. However, optimizing TMS would require an accurate brain model on which TMS treatments can be practiced. To address this, brain phantoms—replicas of the brain—have been developed, but accurately modeling the effects of TMS on neurons within these phantoms remains an ongoing challenge. Recently, a fiber-based synaptic device that mimics neuronal activity was created using PET stainless steel. This memristor fiber has been shown to change its resistance in response to increased current, demonstrating the potential to replicate the integrate-and-fire behavior of neurons. To define the ability of this fiber to mimic neuronal behavior, TMS stimulations were pulsed at 25%, 50%, 75%, and 100% strengths (in amps), and the resulting resistive response was measured. Typically, a firing signal waveform would show oscillating peaks with a steeper increase and a shallower decrease. The analysis of the data revealed a gradual decrease in resistivity while still creating peaks at each pulse, mirroring this neuronal behavior. This pattern of excitation and damping in the oscillation of the resistivity was observed in three of the four magnetic field strengths, with this pattern being most prominent at 75% of the full magnetic field strength; the resistive behaviors of the synaptic device best resembled those of neurons at this strength. Thus, understanding the range at which this neuron-like fiber displays similar behaviors is crucial for improving the accuracy of brain phantoms. Additionally, this opens up the possibility of implementing this device in other fields such as neuromorphic computing and neural prosthetics.

Honorable Mention

Vivian Foutz *Western Albemarle High School*
AI-Powered Learning Companion: Algorithm Design and Performance Evaluation

Worldwide, 251 million children lack access to education; and 20% of the global population (1.6 billion) is neurodivergent, facing challenges in classrooms largely designed for neurotypical learners. The declining test scores and overburdened educators further highlight the need for scalable AI-driven solutions. This research thus explores Large Language Models (LLMs) as learning companions for automated quizzing and personalized feedback. It proposes an end-to-end AI algorithm, RoboQ, that processes input learning materials and outputs personalized assessments. It integrates document chunking, token-wise optimization, prompt engineering, position bias remedy, LangChain, OpenAI API, Python, and JavaScript. Testing shows that RoboQ achieves nearly 100% comprehensiveness in covering input concepts across all subjects. It also reaches close to 90% accuracy in output quizzes for memorization-based subjects, such as Biology and History, albeit much weaker performance for logic-based subjects, such as Math. Building upon this research, a user-friendly, gamified app is further developed. With planned multilingual and multimodal (text, image voice) expansions, it aims for global adoption by neurodivergent and neurotypical learners alike, both in the classroom and across industries (e.g., for workplace training). By democratizing education, this research offers an AI-powered, scalable solution to learner cognitive differences and teacher shortages worldwide.

Honorable Mention

George Homiller *Clover Hill High School*
The Effect of Ping Pong Ball Temperature on Bounce Height

The purpose of this experiment was to determine which ping pong balls would yield the highest and lowest bounce heights with the balls staying at different temperatures before dropping them on a ping pong table: 22.0 C, in room temperature, 71.1 C, in a heat pad, 2.8 C, in a refrigerator, and -18.0 C, in a freezer. Varying temperatures in ping pong balls could affect how professional matches are played with the setting or temperature of the game. If the ping pong ball's temperature changed before or during the match, the player could be at a disadvantage, leading to inaccurate results towards determining the winner. The hypothesis was: If the ping pong ball were warmer, then it would bounce higher compared to cooler balls. The ping pong balls were placed in the designated temperatures: room temperature, heat pad, refrigerator, and freezer. Once the balls were left at the temperatures for 15 minutes, the Bounce Height Test was conducted. The Bounce Height Test consisted of the different temperature balls placed down a slanted 2.13-meter pipe 142 centimeters above the ping pong table. The bounce height was measured by footage from a cell phone recording the maximum height of the ping pong ball's first bounce height along with a

meter stick. The mean of the balls in room temperature (22.0° C), in the heat pad (71.1° C), in the refrigerator (2.8° C), and in the freezer (-18.0° C) was 0.4669 m, 0.4606 m, 0.4682 m, and 0.4691 m, respectively. As the temperature of the balls increased, the bounce height of the balls decreased. Although each individual temperature showed no significant change in height, the difference in height between the freezer and the heat pad balls was significant. The null hypothesis was rejected and the hypothesis was not supported.

Colton Eam *Clover Hill High School*
The Effect of Different Types of Running Shoe Insoles on the Depth of the Insoles After Being Compressed Repeatedly

Foot pain, often caused by ill-fitting shoes, affects a large portion of the population, particularly the elderly. Insoles are known to provide relief, improve foot positioning, and reduce injuries caused by physical activity. This study aimed to evaluate the durability of four types of insoles, cheap foam, orthotic, memory foam, and basic insoles (control), when subjected to repeated compression. The hypothesis was that orthotic insoles would retain the most depth, displaying the highest durability. Depth measurements were taken at 100-roll intervals up to 1,000 rolls using a rolling press, and the retained depth was calculated as a percentage of the original depth. Statistical analysis, including one-way ANOVA, was performed to assess significance. Results showed that orthotic insoles retained the most depth (77.44%), followed by memory foam (65.60%), cheap foam (50.60%), and basic insoles (38.00%). Orthotic insoles also demonstrated the lowest variance, indicating consistent performance. The null hypothesis was rejected ($p < 0.05$), showing significant differences in durability among the insole types. The study concluded that orthotic insoles are the most durable, likely due to their rigid foam and plastic materials, while memory foam provided moderate durability with high cushioning. Improvements for future research include testing additional insole types and allowing enough decompression time between measurements.

Quinn Fiscus *Clover Hill High School*
The Effect of Model City Layout Designs on Number of Standing Buildings After a Simulated Hurricane

The purpose of this experiment was to measure the effectiveness of a seawall versus a city built at a higher elevation at protecting from hurricane wind damage. Hurricanes are one of the most dangerous natural disasters, not only to the environment but to the people and the buildings they inhabit. It is imperative for society to find the best ways to prevent hurricane winds from causing large amounts of damage. The hypothesis for this experiment was that a model city with higher elevation or a seawall would have more standing buildings after simulated hurricane winds than a typical model city, and that the city with the higher elevation would be the most effective. The procedure was to 3D print twenty model houses, and test them against simulated hurricane winds to see how resilient they were, then test with a seawall, and then test with higher elevation. The typical, or control city performed poorly, as there was an average of 15.3 displaced buildings. The model city with the seawall performed significantly better, with an average of only 6.9 displaced buildings. Finally, the final layout, with the higher elevation performed the best, with an average of 4.1 displaced buildings. The overall conclusion was that utilizing either seawalls, or higher elevations in city planning, could greatly decrease the amount of coastal wind damage that commonly occurs during hurricanes. The null hypothesis was rejected, and the data fully supported the research hypothesis.

Vincent Guo *Clover Hill High School*
The Effect of Plasma Treatment on PET Filter Media and Flow Rates on Water Filtration Efficiency of Filter Media in Diesel Fuel

Water in diesel fuel is one of the major causes of diesel engine maintenance problems. Effective water removal from diesel fuel is considered an essential requirement to improve the performance of diesel engines. The purpose of this experiment was to improve the water removal efficiency by surface-treated polyethylene terephthalate (PET) filters using the plasma technique, and to understand the impact of flow rate on water removal efficiency. There were two hypotheses for this study: 1) If the plasma treatment was applied on the PET filter media, the water droplet removal efficiency would increase; 2) If the diesel fuel

flow rate increased, the water droplet removal efficiency would decrease. Plasma treatment was applied to (PET) filter media for 5 minutes to reduce surface hydrophobicity. The ratio of water flow rate to diesel fuel flow rate was kept constant upstream of the filter media. The water filtration efficiency was calculated by measuring water content in diesel fuel at the upstream and downstream of the filter media using a Karl Fischer titration technique. The mean of the filtration efficiency for filter media without treatment was 91.68% at the flow rate of 0.25 L/min, 89.15% at 0.50 L/min, and 61.42% at 0.96 L/min. The mean of the filtration efficiency for filter media with treatment was 93.26% at 0.25 L/min, 91.64% at 0.50 L/min, and 92.16% at 0.96 L/min. Water removal efficiency was higher for treated filter media as compared to untreated ones at all three flow rates, a significant increase of 30.74% at the high flow rate of 0.96 L/min. The water removal efficiency decreased with increasing flow rates. The effect was more pronounced for untreated filters.

Coleman James II *Clover Hill High School*
The Effect of Various Organic Additives on The Compressive Strength of Concrete

The purpose of this experiment was to test the compressive strength of concrete using different organic additives to mix into the concrete. Concrete can fail due to all sorts of problems, one of which is the compressive strength is too weak to hold up the concrete. By using fibers, the compressive strength of concrete could improve the amount of weight and overall strength of the concrete used in everyday structures. The hypothesis was that concrete cylinders using cotton would increase the compressive strength of concrete more than any of the other organic additives, such as wool, bamboo fiber, straw, and coir. To make the concrete for the experiment, 60 cylinders of concrete were poured with 6 groups of 10 all having different fibers. Once the Concrete dried, it was taken to a private property to be smashed and tested for the strength of the concrete cylinders. Overall, at the end of the experiment, the concrete with fibers were all weaker than concrete without any organic fiber. The difference between the concrete cylinders with fiber additives and the cylinders without was that the fiber concrete cylinders had more consistent results. The null hypothesis was rejected as there were differences in the data on the data table. Also, the research hypothesis was rejected as concrete cylinders using cotton were still weaker than the control group, so it was not the strongest.

Megan Nyffeler *Mills E. Godwin High School*
The Effect of Fire Retardants on the Ignition Time of Cotton

This study aims to determine the most effective fire retardant for fabrics. The study tests three types of fire retardants and their application on cotton fabrics. Most homes have cotton furniture or clothes that can easily catch fire and be turned into fast fuel. Home structures are made to be fireproof, but fabrics and upholstery that lie within are not. By knowing what fire retardant is most effective, homeowners and people who own flammable fabrics can protect their homes and fabrics from fires. The three fire retardants tested were an environmentally safe formula called Flame Guard, a plant-based formula called Fire Block, and an alkaline salt-based formula called No Burn. There was a control of no flame retardant applied. The hypothesis for this experiment is that if the fire retardant No Burn is used, then the ignition time will be the longest and has the highest temperature. This hypothesis was rejected because the Fire Block and Fire Guard had higher ignition times than No Burn. This experiment was conducted by spraying cotton fabric and holding a lighter one centimeter below the fabric. If it ignited, the seconds were written down. There was a time limit of 30 seconds due to flame hazards with the lighter. This, unfortunately, resulted in similar outcomes for most of the tested trials compared to the control. Ultimately, Flame Block and Flame Guard had the highest average ignition times, each reaching 30 seconds. However, the time limitations imposed for safety reasons were insufficient to test each variable thoroughly. These results are likely attributed to the specific formulas of each independent variable. The formulations used in Flame Guard and Fire Block proved to be superior compared to both the control and No Burn. Overall, the tested fire retardants demonstrated statistically significant effectiveness.

Stacer Raddin *Clover Hill High School*
The Effect of Type of Fishing Line Knot on Amount of Mass Required to Break the Line

The purpose of this experiment was to find out which fishing knot would sustain the most weight before the line snapped or slipped. The knots tested were the Two Half Hitch Knot(Control), the Palomar Knot, the Uni Knot, the Improved Clinch Knot, and the Rapala Knot. In the world of fishing, the topic of fishing knots has been debated for years. Fishermen often have a fishing knot that they prefer to use based on a combination of strength and tying complexity. Many fishers say they prefer to use the Palomar Knot, while others argue that the Uni Knot better fits their purposes. The hypothesis was that the Rapala Knot would sustain the most weight before breaking or slipping. First, the fishing knot that was being tested was tied to a hook. The line with the hook was then attached to an overhead bar. Once the line and hook were in place, an empty bucket was placed on the hook, and then slowly filled with sand. Once the fishing line snapped or the fishing knot slipped due to the weight of the bucket, the bucket of sand was weighed on a scale. The mean weight at which the fishing line snapped, or the fishing knot slipped was 0.811kg for the Two Half Hitch Knot, 2.6204kg for the Palomar Knot, 1.7558 for the Uni Knot, 1.5615kg for the Improved Clinch Knot, and 2.1090kg for the Rapala Knot. On average, the Uni Knot sustained the most amount of weight before breaking, followed by the Palomar Knot, the Rapala Knot, the Improved Clinch Knot, and the Two Half Hitch Knot. Therefore, the null hypothesis of the experiment was rejected, and the data did not support the research hypothesis, as the Rapala Knot sustained the third most amount of weight.

Essam Shah *John Randolph Tucker High School*
The Effect of Varied Electrical Insulation

Electrical insulators are materials that can resist the flow and current of electricity, effectively barricading electrons from transmitting through them because of their atoms' tightly bound electrons. Many laws and principles describe the way electricity flows and responds to different environments; one such principle, Ohm's law, describes how the electromotive force behind a current, voltage, is directly proportional to the strength of the current itself. As such, in the form of an Alternating Current, many developed countries and locations distribute power to residents as high-voltage electricity which can be controlled via various electrical devices placed along transmission lines. These devices along with sophisticated electrical insulators can also significantly reduce electrical leakage: the loss of electricity over long-distance conducting mediums. Developing localities, however, cannot access this luxury and operate with outdated materials, unsafe equipment, and defective resources that can result in 40% power loss in severe cases. The results of this experiment would yield the most effective common resistor of rubber, fiberglass, and polyethylene plastic and determine the most practical alternative to sophisticated insulators of the modern world. To method of study was to construct a simple circuit with a multimeter assessing voltage acting as a payload to a weak battery power source. The device's positive probe was indirectly attached to the battery's positive terminal via a copper wire. The negative probe was directly in contact with the chosen insulator that rested just on top of the battery's negative terminal. The insulator which resulted in the lowest voltage reading in the multimeter, rubber, had reduced the transmitted electromotive force the most and thus was deemed the best functional resistor. Thus, the hypothesis that rubber would occlude the most electricity was supported; however, considering practical uses, economics, and ubiquity, polyethylene was considered a better overall option for developing nations. To improve the experiment for future purposes, more and longer repeated trials, more consistent constants, and more exact measuring instruments would be needed. Overall, while statistical analyses revealed insignificant differences in some comparisons with the data, other investigations yielded results similar to that of this study.

Caiden Thompson, Aiden Goto, Adit Adhikari *Governor's School @ Innovation Park*
Seed Cyclone: Reforestation through Aerial Seed Dispersion

Deforestation is a major contributor to the escalating global issue of climate change. The removal of trees and other sources of carbon absorption occurs for various reasons. However, it is crucial to counteract this by planting seeds in these barren areas to promote restoration. This research aims to design a device that can be paired with unmanned aerial vehicles to carry out this task in a cost-effective and more efficient manner than physical and active methods of reforestation. The device takes the form of a 3D-printed spiral that will use gravity and wind resistance to rotate and release stored seeds during freefall. Three designs were created, a grooved cylinder design, an Archimedes spiral-based design, and a seedling design. Each design was analyzed in a CFD software (Ansys Student) and found that the seedling design created the most angular velocity while falling. However, due to its fragile body and its inability to scale up, the

Archimedes design was tested instead. The goal was to reach 150 square meters from a constant 25 m altitude drop. The results show an average radius of 8.64 meters and an average coverage of 234.7 square meters. The ability to cover large areas efficiently aids in the goal of restoring lands that have lost vegetation due to fires, logging, or other causes. Additionally, this opens opportunities for future research on new models and designs that could further improve coverage and rotational dynamics.

Shadi Tissire *Osbourn Park High School*
Effectiveness of Different Materials in Soundproofing

Soundproofing is crucial in recording studios, offices, homes, and even vehicles. Understanding how different materials affect sound can lead to more cost-effective and efficient solutions. This project tests the effectiveness of different materials and methods like adding vacuums, foam, plastic bags, and carboard boxes. This whole project used both a phone speaker (baseline 64 dB) and google mini speaker (baseline 78 dB) as a product of sound to make sure my data was reliable and correct. All measurements were taken with a phone decibel meter app at the same distance. Each test had 3 trials and was averaged out at the end. Based on my test results, the plastic bag and carboard barley reduced sound at all. As adding foam, a second box, and removing air dampens sound waves significantly. When adding layers of foam and a homemade vacuum to the phone speaker the decibel level went from 64 dB to 46dB which is an 18 dB difference, as I change the speaker to the google mini the decibel level was lowered 12-13 dBs. This experiment shows how layering materials and reducing air can affect the travel of sound.

Environmental & Earth Science A (HS ENV A)

First Place
Alexandria Swenson *Southwest Virginia Governor's School*
Mechanical and Aesthetic Properties of Alginate-Based Yarn and its Commercial Counterparts

Estimated to range from 30,000 to over one million species, algae is an untapped source of energy and potential in our world (Guiry, 2012). Four types of algal yarn were created. Test one examined the effects of chitosan, test two examined the effects of glycerine, test three examined the effects of both within the same solution, and test four served as a control group. The test that produced the most malleable algal yarn was reproduced for comparison with common yarns. The tested qualities were tensile strength, colorfastness, breathability, and wear resistance. A universal testing machine was used to perform the tensile test by stretching a skein of yarn via clamps until the fibers broke (How to Perform an ASTM D2256 Thread and Yarn Tensile Strength Test, ADMET). Colorfastness was tested by soaking dyed strands of each type of yarn in warm water before patting on a white cloth, resulting in the staining of the white cloth. Breathability was tested by observing each woven textile's ability to absorb moisture when placed over a container of hot water. Wear resistance was tested by observing the quality of the woven textile before and after being washed and dried in machine washers and dryers. An ANOVA statistical analysis was performed for the tensile, colorfastness, and breathability tests, and a p-value of 0.001 was found for each test. A follow-up Tukey HSD test revealed several significant differences for each test. The null hypothesis was therefore refuted, stating that there is a significant difference in the tensile strength, colorfastness, and breathability of the tested textiles. Although further research is most certainly needed, the results of this study have impressive implications for the future of the fashion industry and the study of material sciences.

Second Place
Abby Dodson *Chesapeake Bay Governor's School*
A Study of The Effect of Varying Levels of Iron Supplementation on Lettuce (*Lactuca sativa*) Growth in Media-bed Aquaponics

Climate change, soil degradation, and water scarcity are just some of the challenges being faced by modern day agriculture. Due to these pressing challenges, non-traditional methods of farming have been increasingly emphasized to decrease environmental impact. One of these methods is aquaponics: a system of aquaculture in which the waste produced by fish supplies nutrients for plant growth hydroponically. Iron is an essential

micronutrient in plant development in aquaponics systems. Due to low amounts of iron in commercial fish feeds, aquaponics systems are often iron deficient. Therefore, iron supplementation is recommended to ensure optimal plant performance. This study explored the effect of varying levels of iron supplementation – 0, 1, 2, and 3 mg/L – on lettuce (Lactuca sativa) growth in media-bed aquaponics. Four aquaponics systems were built and maintained simultaneously. Growth of lettuce was measured by the plants' height, leaf width, and mortality after 5, 10, and 20 days. The null hypothesis for this study was that the supplementation of varying levels of iron will have no effect on the mean growth rate of lettuce. The alternative hypothesis was that mean plant growth will increase as the amount of iron supplemented increases. The results demonstrate a statistically highly significant difference between the treatment groups. The medium group with 2 mg/L of iron supplemented was found to produce optimal growth and had the least mortality. This experiment served as a proof-of-concept study to determine the importance of iron supplementation in aquaponics and offer a level for optimal growth.

Third Place
Aiden Eanes *Chesapeake Bay Governor's School*
Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) "Forever" Chemicals Presence in Virginia Drinking Water and Household Usage

PFAS are a major concern for environmental and public health as they have a plethora of potential negative health effects, including reproductive and developmental deficiencies, immune system deficiencies, increased cholesterol, liver damage, and increased risk for certain cancers. This study aims to determine the breadth, depth, and severity of PFAS concentrations in Virginia waterways via a meta-analysis, specifically focusing on potential point and nonpoint sources. Additionally, a survey was conducted to determine the local exposure of individuals to PFAS via PFAS-containing products in their daily lives. H01:: PFAS concentrations will not vary in proximity to point sources was rejected because PFAS concentrations at sites with a known point source were significantly higher than sites without a point source, with a t-test of p=0.002. Further, this study indicated a statistically significant difference, p=0.009, between PFAS concentrations at high-intensity and low-intensity point sources. Based on the household survey, 64% of respondents reported being exposed to PFAS every day and 27% were exposed a few times a week; therefore, H03: A significant number of people are not exposed to PFAS-containing products in their daily lives was also rejected. Virginia's lack of PFAS data, combined with little nationwide research and a lack of education about PFAS creates major gaps in understanding, leading to little nationwide legislation on PFAS. While there is a lack of legislation in Virginia, people must proactively educate themselves on their exposure to PFAS through proximal point sources and the products they use daily.

Honorable Mention
Jaeden Morgan *Mills E. Godwin High School*
Effects of Different Fertilizers on Soil Microbial Activity and Production

This study investigated the effects of phosphorus-rich, nitrogen-rich, and calcium-rich fertilizers on soil microbial activity and the growth of kale (Brassica oleracea) over a four-week period. The hypothesis was that nitrogen-rich fertilizer would significantly increase soil microbial activity and plant growth compared to other treatments. The experiment included four groups of 25 kale plants each: a control group (no fertilizer), a phosphorus-rich fertilizer group ("Sta Green - Bone Meal"), a nitrogen-rich fertilizer group ("Sta Green - Blood Meal"), and a calcium-rich fertilizer group ("Garden Lime"). A control group was included to isolate the effects of the fertilizers. Plant growth parameters, including height, leaf count, and biomass, were measured at the end of the experiment. The results indicate that the nitrogen-rich fertilizer significantly increased soil microbial activity and plant growth compared to the control and other treatments. The phosphorus-rich fertilizer showed a moderate increase in microbial activity and enhanced plant growth. The calcium-rich fertilizer had a minimal effect on microbial activity but slightly improved plant growth compared to the control. The findings suggest that nitrogen is a key nutrient driving both soil microbial activity and kale growth in the short term, while phosphorus also plays a beneficial role. These results are consistent with previous research showing the importance of nitrogen and phosphorus for soil health and plant productivity and align with studies demonstrating the impact of fertilizers on soil enzyme activity. The study also highlights the need to consider soil health in fertilizer management practices, as emphasized in recent reviews on the topic and the potential benefits of integrated nutrient management systems.

Lyndon Bierlein *Central Virginia Governor's School for Science and Technology*
What is The Most Effective Way to Increase Nitrogen in a loamy-textured Soil?

The purpose of this experiment was to determine which nitrogen application method added the most nitrogen to a loamy-textured soil after two weeks. Application groups included chemical fertilizer, composting, and a control group, which had nothing added. Nitrogen levels were determined by the Vernier Nitrate-Ion Probe which measured the levels in mg/L and was the only instrument used in this experiment. After the data was collected, the means of each group were calculated: control group, 1.57 mg/L; composting, 1.65 mg/L; and, chemical fertilizer, 2.41 mg/L. There were three groups, so a single-factor ANOVA with an alpha value of .05 was used to determine if there were significant differences between groups. The corresponding p-value was 6.7 x 10-10. Since the p-value was lower than the alpha value, the data could reject the null hypothesis. A post-Hoc Tukey test determined which difference of groups were significant and showed that the difference between the chemical fertilizer and both other groups were significant. The ANOVA and Tukey test supported the hypothesis, which stated that the fertilizing group would have the highest level of nitrogen compared to the composting and control group. These findings suggest that chemical fertilizers benefit loam-textured soil the most after two weeks and explain why that is. This experiment matters because of the decreasing amount of available nitrogen in the soil and the increasing need for agriculture goods.

Kelly Butt *Central Virginia Governor's School for Science and Technology*
The Effects of Inorganic and Organic Fertilizer on Soil Quality

The purpose of this study was to find if organic fertilizer had a better effect on soil quality than inorganic fertilizer by comparing how the two affect the soil's NPK levels, pH, and porosity. There were 32 samples of soil split into groups of three: one with no fertilizer, another with organic fertilizer, and the last with inorganic fertilizer. These groups sat and were watered for five weeks and then tested. In the order of control, organic, and inorganic, the average Nitrogen levels were 40 lb/ A/6" (pounds per acre in 0-6-inch depth), 40 lb/ A/6", and 280 lb/ A/6"; average Phosphorus levels were 18.5 lb/ A/6", 11 lb/ A/6", and 47.5 lb/ A/6"; average Potassium levels were 130 lb/ A/6", 140 lb/ A/6", and 140 lb/ A/6"; average pH levels were 6.7, 6.81, and 5.9; average porosity percentages were 48.71%, 57%, and 52% respectively. To test for significance, a one-way ANOVA test was conducted for each variable with an alpha level of .05. This resulted in the p-values for Nitrogen (9.55x10^-11), Phosphorus (6.72x10^-5), and pH (1.05x10^-8) to be below the alpha level and therefore significant, while the p-values for Potassium (.18) and porosity (.07) were higher and not significant. The research hypothesis that there would be higher NPK levels and moderate porosity and pH in the organically fertilized soil was not fully supported. This study provides sufficient insight on fertilizers, soil quality, and the agricultural world.

William Coughlan *Central Virginia Governor's School for Science and Technology*
Effect of Microplastics on Growth and Reproduction of *Daphnia magna*

Microplastics are an increasingly common pollutant in waterways around the world. These pollutants are commonly ingested by aquatic animals, posing a potential risk to the long-term sustainability of their ecosystems. This study sought to determine whether or not microplastics have a significant effect on the population size and physical growth of *Daphnia magna.* Six groups were used to test three concentrations of microplastics and were then counted and measured to collect data. Two one-way ANOVAs with an alpha value of .05 were then used to determine if the microplastics had a significant effect on the daphnia. The means of the population were almost identical, and with a p-value of .98481, it was determined that microplastics did not have a significant effect. The means of the population size were then tested with an ANOVA and were found to have a p-value of .13416, meaning that microplastics did not have a significant effect. These results did not support the research hypothesis that stated if microplastic concentration increased, then the size and number of offspring would decrease. Overall, the microplastics did not seem to have any significant effect on the daphnia, which may suggest that further research into the effects of microplastics is required.

Connor Lord *Clover Hill High School*
The Effect of Uraninite-Simulated Phospho-gypsum-Based Roadways on Red Worms and Pill Bugs Living in the Soil

The purpose of this experiment was to determine how and to what extent radiation affected pill bugs and red worms living in the soil using uraninite as an analogue to phosphogypsum, a mineral that was approved for use in roads despite its ability to produce radon, a carcinogenic gas, and emit radiation. Through the use of different levels of exposure, the reduction of the growth of a soil community was assessed gradually, allowing for a better understanding of how man-made waste impacts the environment. The hypothesis was that as the creatures were exposed to radiation, the population of worms would progressively stagnate and possibly die off, while the pill bugs would be more or less unaffected, given their natural radiation resistance. After the creatures were placed in their prepared containers, they were fed weekly and exposed to radiation daily, with their populations recorded when they were fed. The populations were measured by manually counting each creature, and the exposure any non-control group received was always one day of exposure per week. After 8 weeks, the experiment concluded and any materials and creatures were properly stored, removed, and/or released. The means for the worms were: 6.60 (mean population between containers) for the 0 disintegrations per minute (DPM) exposure group or control, 4.05 for the 160 DPM group, and 2.10 for the 1600 DPM group. The mean populations for the pill bugs were: 1.35 (mean population between containers) for the control, 2.55 for the 160 DPM group, and 1.65 for the 1600 DPM group. The pill bug populations generally stagnated for the duration of the experiment, while the worm populations grew exponentially for any containers that did not drop below 2 worms. The relatively higher mean in the 160 DPM pill bug group was caused by a singular statistical outlier and is not a significant difference when compared with the means of the worm groups. The null hypothesis was rejected, and the results supported the research hypothesis. The differences within the worm group were determined to be significant, as were the differences between the worm and pill bug groups. There was no significant difference within the pill bug group.

Alexandra Ni *Southwest Virginia Governor's School*
Machine Learning–Driven Analysis of Temperature and Proximity Effects on Landfill Greenhouse Gas Emissions

This study explores the impact of temperature and distance from landfills on carbon dioxide (CO2) and methane (CH4) concentrations in surrounding soil. Landfills are a significant source of greenhouse gas emissions, contributing to climate change and global warming. Understanding how proximity to landfills and environmental variability influence greenhouse gas levels is essential for developing effective waste management policies and mitigating environmental impacts. In this study, CO2 and CH4 concentrations were measured at varying distances from several landfill sites and across different temperature conditions. A multiple regression analysis performed on the collected data identified statistically significant relationships between distance, temperature, and CO2 levels (p-value < 0.05, $R = 0.774$). Every CH4 measurement was less than the lower limit of detection of the gas detector, so no statistical evaluations were performed on those data points. To improve predictive performance, several machine learning (ML) models were employed: random forest regression, support vector regression, and neural networks provided enhanced insights into nonlinear interactions between temperature, distance, and CO2 concentrations. Additionally, an unsupervised clustering approach (k-means and hierarchical clustering) was applied to classify sites based on gas emission patterns, allowing for a more refined understanding of landfill-related environmental risks. The integration of machine learning methodologies enabled the development of a data-driven predictive model, which can enhance policymaking, risk assessment, and the implementation of sustainable waste management strategies. The proposed ML-based framework provided a scalable and adaptable tool for analyzing landfill emissions, supporting future studies in environmental monitoring and greenhouse gas mitigation efforts.

Kavya Uppalapati *Mills E. Godwin High School*
The Effect of Temperature Abuse on Ascorbic Acid Concentration

This experiment was performed with the purpose to see if extreme temperature changes or temperature abuse affected the vitamin C content in fruits, specifically lemons. In recent studies, cooking and preservation techniques, such as boiling, roasting, freezing, and room temperature, have become increasingly more

common. However, exposing fruits to these processes could decrease their nutritional quality. Thus, this experiment was conducted to understand temperature abuse and whether it affects ascorbic acid or vitamin C content in lemon, and if domestic and industrial practices affect the nutritional value of food. The control of this experiment was room temperature lemons and the three temperature abused levels were boiled lemons, roasted lemons, and frozen lemons. The research hypothesis was that boiling could help achieve the highest concentration levels. Concentration was measured using ascorbic acid test strips regarding color change and whether that color indicated low, normal, or high amounts of concentration. The results revealed that boiling had the lowest amounts of concentration for lemons and room temperature had the highest with normal to high amounts of concentration. A chi-square test was conducted on the data and revealed the data was significant for all levels of the independent variable. However, the results did not support the research hypothesis since boiling imposed the least vitamin C when it was originally predicted to contain the most vitamin C. This research could lead to further studies that investigate the highest and lowest temperature fruits, specifically lemons, can be exposed to for optimum vitamin C concentration and nutritional quality.

Gabriella Webb *Mills E. Godwin High School*
Exploring The Effect of Changes in Water Temperature on *Pyrocystis fusiformis*

The purpose of this study was to investigate the effect of water temperature changes on the bioluminescent behavior of Pyrocystis fusiformis. Given the rising ocean temperatures due to climate change, it is crucial to understand how these changes impact marine organisms, particularly those involved in harmful algal blooms (HABs) such as dinoflagellates. Though the dinoflagellate used in this experiment was a non-toxic dinoflagellate, the results from this experiment can be applied to better understanding the behavior of toxic dinoflagellates that can form HABs. The hypothesis proposed that if greater deviations from the optimal growing temperature (22.7°C) occurred then more significant changes in the number of bioluminescence flashes procured would occur. To test this, P. fusiformis cultures were exposed to three temperature conditions: cooling to 18.3°C, cooling to 12.7°C, and heating to 29.4°C, with a control group maintained at 22.7°C. Flash frequency was measured under each condition. The results indicated that the most extreme change in temperature (22.7°C to 12.7°C) led to the greatest change in behavior, supporting the hypothesis that greater temperature deviations cause more changes in the bioluminescent behavior. Statistical analysis confirmed that temperature changes significantly impacted flash frequency. The results occurred because temperature changes stressed P. fusiformis, causing increased bioluminescence before potential photoinhibition. These findings suggest that increasing ocean temperature variability could contribute to HAB formation by altering dinoflagellates' bioluminescent behavior. Further research should explore long-term exposure effects and other environmental stressors to better predict ecological consequences.

Victoria Whitt *Chesapeake Bay Governor's School*
Effectiveness of Different Substrates and Textures on the Settlement of Eastern Oyster Larvae (*Crassoterea virginica*) Using a Spat-on-Shell Aquaculture Method

Eastern oysters (*Crassostrea virginica*) have experienced a major population decline within the Chesapeake Bay. As eastern oysters serve many essential ecological roles, their abundance is desirable for the health and support of the environment and economy. Aquaculture systems have been developed to control cultivation of aquatic organisms and have also been employed as a restoration technique. Advances in aquaculture result in economic boosts, increased food production, and cleaner waterways. With declining oyster shell abundance, aquaculture can no longer only rely solely on oyster shells as substrates. This study examined larvae recruitment on natural and artificial substrates of varying textures in a spat-on-shell aquaculture system. Natural eastern oyster shell was compared to PVC pipe and ceramic tile, both smooth and rough. This study compared the density of spat recruitment on each substrate after 14 consecutive days within a monitored industrial spat-on-shell system. After the 14-day span, it was found that oyster shells outperformed both PVC pipe and ceramic tile in both textures. When comparing artificial substrates there were no differences between their larvae settlement. Oyster shells are the most conducive for spat-on-shell aquaculture when compared to the alternative substrates and textures. As aquaculture continues to cultivate aquatic organisms, the search for feasible substrates should continue, in order to maximize the various benefits that aquaculture can provide. Finding these substrates will allow for the restoration and conservation of eastern oysters in an environmentally, biologically, and economically favorable way.

Carolanne Whorley *Central Virginia Governor's School for Science and Technology*
The Effect of Sand Filtration Ratio of *Escherichia coli* Removal from Water

The purpose of this study was to determine the efficiency of different sand filtration ratios in the removal of *Escherichia coli*. This study was conducted using water from a contaminated local river, in a laboratory, during November and December of 2024. 100 ml of water was used for each sample; testing the amount of *E. coli* in the water before and after the filtration. The Tests consisted of ratios of coarse gravel, fine gravel, and fine sand respectively. A one-way ANOVA revealed a p-value of 6.27×10^(-20). If I use a 100:50:50 mm ratio of coarse gravel, fine gravel, and fine sand on 100 ml of water, then less E. coli will be removed from the water compared to a 50:100:50 mm ratio on 100 ml of water, and the 50:50:100 mm ratio will remove the most E. coli from the water. A post-hoc Tukey with a D-min of 0.0329, suggested that the control group was significantly different from my filtered groups, but there was no significant difference between the ratios of filtration. All the sand filters showed to be a very practical and efficient solution in removing bacteria from water. This study showed a significant improvement in the cleanliness of the water quality and a safer solution to removing bacteria rather than using toxic chemicals.

Ella Winn *Central Virginia Governor's School for Science and Technology*
The Phytoremediation Efficiency of *Elodea canadensis*

This research aimed to investigate the effectiveness of *Elodea canadensis* plants in phytoremediation Methylene blue (MB) dye from a model aquatic environment. This study sought to determine if increasing the number of *Elodea canadensis* plants would affect the MB absorbed from the water and to understand how MB affects the plants. Three experimental groups were set up, each with two tanks with different numbers of plants: 0, 5, and 10 plants. In each tank, 750 µL of MB dye and 1 µL of aquatic fertilizer was added. Over the course of the two-week experiment, the absorbance (au) of the water was measured using a spectrophotometer every other day (collection days were named Sampling Days 1 through 4; Start Day as initial planting in the MB solution) as well as qualitative observations of plant health. A two-way ANOVA test resulted in significant p-values of 7.51 x 10-6 (number of plants), 4.15 x 10-15 (Sampling Days), and 9.93 x 10-4 (interaction) with an alpha level of .05. A post-hoc Tukey test identified significant differences between specific groups (Qt: 4.37; Dmin: .01444). On Sampling Day 3 (observed optimum chemical uptake) the 5 and 10 plant groups had the greatest difference in absorbance when compared to their Start Days: 0.385 and 0.357, respectively. The 5 and 10 plant groups showed significant differences compared to the control. This partially supported the research hypothesis and indicated that an increased number of *Elodea canadensis* plants significantly impact MB absorbance after two weeks.

Environmental & Earth Science B (HS ENV B)

First Place
MacKenzie Duncan *Central Virginia Governor's School for Science and Technology*
The Effect of Nitrogen Filtration on Duckweed Blooms

The purpose of this study was to investigate the factors contributing to harmful algae, duckweed blooms, and potential preventative measures to mitigate their occurrence. *Lemna minor* specimens were used in three experimental groups, each with different filtration treatments: no filtration (control), reverse osmosis, and activated carbon. Each aquarium tank contained one gallon of spring water, six drops of fertilizer, and stayed under controlled temperature and lighting. Nitrate concentrations were measured using a Vernier nitrate probe, and *Lemna minor* population growth was tracked weekly by measuring plant mass. Data was analyzed using ANOVA tests to examine the effects of filtration on growth and nitrogen levels. The resulting p-values from the single-factor ANOVA analyses, .052 and .085, for nitrate levels and population count, both exceeded the alpha value of .05. Due to the resulting p-values, the study found no significant differences in Lemna minor growth or nitrate levels between groups. Nitrate levels and population counts were highest in the control group. The research hypothesis stated that if nitrogen water filtration was used in a model freshwater aquatic environment with a population of *Lemna minor*, then duckweed population growth would not occur in this group, *Lemna minor* concentrations would decrease, and nitrogen levels would be reduced sufficiently to

prevent large population growths leading to duckweed overgrowth. Although the absence of duckweed overgrowth partially supported the research hypothesis, the overall data was not supportive. To conclude, this study found that nitrogen filtration techniques had no significant effect on *Lemna minor* growth, nor nitrate levels.

Second Place
Charlotte Phillips *Southwest Virginia Governor's School*
Investigating Microplastic Trapping Efficiency of Coral Reef Regrowth Structures in Simulated Ocean Currents in the Presence of Modeled *Acropora cervicornis*

Coral reefs are vital ecosystems to the health of the planet and many economies, yet they have experienced extensive man-made destruction. Reef regrowth efforts have been initiated, and many restoration attempts involve an artificial structure which assists juvenile coral in surface latching. Unfortunately, restoration endeavors have been hindered by microplastic pollution. Collection of microplastics results in infection and immense death within affected regrowth colonies. Thus, it is necessary to develop coral regrowth structures designed to minimize microplastic trapping. Utilizing modeled *Acropora cervicornis*, this project investigated three different regrowth structures (T=Table, B=Block, Te=Tent) with attached modeled *Acropora cervicornis*. The structures were tested in an environmental flume, which ran at 0.41 m/s and 0.45 m/s to simulate ocean currents. Microplastic deposition was accessed through the implementation of a net, scales, scrapers, cameras, and ImageJ.JS software. The masses and ImageJ.JS pixels were then analyzed through ANOVA and Tukey HSD tests. The Tent structure had significantly less microplastic accumulation (Te: 2.71+/-0.37) for mean +/- SE compared to Table (T: 31.23+/-2.18) and Block (B: 17.99+/-1.59) structures; Tukey HSD analysis yielded $p<0.0001$ for each comparison. The Tent structure had significantly lower ($p<0.0001$) mean microplastic deposition (Te: 124.90+/-0.61) compared to the Block (B: 142.53+/-0.88) and Table structures (T: 160.30+/-1.07). These results demonstrate significantly less microplastic trapping in the Tent Structure, indicating this regrowth structure design may be optimal for reducing microplastic trapping in ocean environment and yielding hope for the health of coral regrowth colonies utilizing the style. In future research, the student will develop and evaluate more structure modifications to further reduce microplastic trapping in coral regrowth structures.

Third Place
Kathryn Simal *Chesapeake Bay Governor's School*
The Effect of pH on the Disintegration Rate of Coral Skeletons

In the 1800's, fossil fuels became the largest used energy. A consequence of this was the release of CO2 into the atmosphere at astronomic levels. This affected the ocean due to excess CO2 gradually being absorbed by the water. Since then, the oceans' pH has slowly started to decrease, creating a more acidic and therefore harmful environment for the organisms that live there. Many marine organisms build shells or other body parts out of calcium carbonate, and the decrease in pH and increase in hydrogen ions has made it easier for those parts to break down. Researchers hypothesized that as the pH of water decreased the mass would decrease as well. This study compared disintegration rates of coral in different pH's: 8, 7.5, 7, 6.5, and 6, all of which were made naturally by adding CO2 into the salt-water. Two studies were conducted: the first was a 7-day study with a 5-day drying period and the second was a 31-day study with a 7-day drying period. Each study showed that as the pH lowered, the coral's mean mass decreased as well. There was a steady decrease in mean mass with each 0.5 drop on the pH scale. These results show the effect ocean acidification could have on coral reefs, the most biodiverse communities in the ocean. Coral reefs could be deteriorating due to anthropogenic acidification.

Honorable Mention
Elijah Callahan *Central Virginia Governor's School for Science and Technology*
The Effects of Natural Based Weed Killers on the Heart Rate of *Daphnia magna*

The purpose of this study was to determine if there was a significant effect of natural weed killer on the heart rate of *Daphnia magna*. The study was conducted in a local high school's laboratory through November and December of 2024. The *Daphnia magna* that were used in this study were randomly selected from a population to simulate natural selection. Each group was exposed to 0.75mL/L concentration of Weed Zap,

a cinnamon and clove oil-based weed killer, for 24 hours and continued exposure for 48 hours. There was also a control group that was not exposed to any Weed Zap. The heart rates of the *Daphnia magna* were measured by the researcher every 24 hours, using a Zeiss Microscope equipped with a camera. The heart rates were measured in real time playback by using an app called "Big Tap Counter." This app allowed for an accurate count of the beats per minute due to its reactivity to a tap. After the collection of the data, a single-factor ANOVA statistical analysis test, using an alpha-value of .05 was compared to the resulting p-value of .776 displaying no significance. As a result, the research hypothesis—if I expose *Daphnia magna* to natural weed killers, then there will be an increased heart rate—was not supported. While this study does not show a significant impact of weed killers on *Daphnia magna*, it only evaluated one brand, and further research looking into more varied chemicals would be beneficial and more conclusive.

Honorable Mention

Lucas Holland *Southwest Virginia Governor's School*
The Relationship Between Heat and Income in Virginia: A Correlational Study

Heat is the leading weather-related cause of death in the United States, with its impacts exacerbated by climate change and socioeconomic disparities. This study examines the relationship between heat-related illness rates (HRI) and socioeconomic and environmental factors in Virginia from 2017–2021, aiming to identify vulnerable populations and inform mitigation strategies. Data from the Virginia Department of Health, U.S. Census databases, and prior studies were analyzed at the county level using Bayesian statistical inference and modeling, Ordinary Least Squares (OLS), and Generalized Linear Models (GLMs). Despite employing multiple regression models, log-transformations, and outlier adjustments, findings revealed consistently weak or negligible correlations. Comparison with existing research highlighted the limitations of county-level analyses, as significant relationships between environmental factors and heat disparities observed at finer scales, such as census block groups, were obscured in aggregated county-level data. Challenges included small sample sizes, the geographic grouping of HRI data, and the lack of publicly available granular data due to privacy concerns, limiting the ability to capture nuanced relationships. These findings underscore the importance of high-resolution data and advanced spatial analysis in addressing heat-related health disparities. Future research should prioritize finer-scale analyses, incorporate additional variables such as occupational exposure and urban planning, and advocate for improved public access to granular health and environmental data to support equitable climate adaptation strategies.

Garrick Axtell *Mills E. Godwin High School*
The Effect of Pollutants on pH of Water

The purpose of this experiment is to determine if pollution has a noticeable effect on the pH of water. Recently, pollution has grown and its impact on pH affects aquatic ecosystems, agriculture, and human health. The pH was obtained from two natural and two industrial sources and allowed to sit in the water for 15 seconds. There was no control in the experiment. It was hypothesized that the parking lot would have the greatest change in pH from the neutral 7 due to its intense exposure to multiple pollutants affecting the pH. Multiple t-tests were performed on all levels of IV against each other resulting in all but one (Residential Area V Creek) being statistically significant. The research hypothesis was proven and the null hypothesis was rejected. It is believed that the significant tests are due to the amount of pollutants exposed to the water and for the insignificant test the creek may have been exposed to pollutants from buildings along the water, the residential area's water was not exposed to many pollutants, or the data was due to chance. These results could lead to research on cleaner modes of transportation, making polluted water safer, or further analysis of pollution's effect on ecosystems.

Elizabeth Bauer *Central Virginia Governor's School for Science and Technology*
Which Access Point in the James River has the Most Microplastics in the Sediment

The purpose of this study was to determine if the amount of microplastics found in the sediment along a river varied based upon location. Eight samples were collected from four different access points along a local river. Each sample contained 100 mL of sediment, with 20 mL of distilled water poured on top. The containers then rested for two weeks, so that any microplastics would float to the surface. The top layer of the sampling container, which included the microplastics, water, and small debris or sediment, was then

poured into a funnel filter over standard grade medium flow rate cellulose filter paper. The funnel was placed into an airtight vacuum pump which drained leftover water. Once the funnel was dry, the filter paper was removed from the funnel filter and placed under a microscope for inspection. The amount of microplastics was recorded for each sample, from each location. Data was analyzed by a Chi-Square Goodness of Fit test. The chi-square value of 14 was compared to a critical value of 14.07. This showed that the data was not significant, so the null hypothesis was retained. The research hypothesis, which stated that the most urban location would have the highest amount of microplastics found in the sediment, was not supported. In conclusion, the location along the river had no significant effect on the amount of microplastics found in the sediment. However, microplastics were found from each location, urban, suburban, and rural, suggesting that microplastics are ubiquitous in most fluvial environments.

Aneesha Bharti *Mills E. Godwin High School*
The Effect of Different Types of Microplastics on Radish

The purpose of this experiment was to find the effects of different types of microplastics on the growth of *Raphanus sativus*. Recently, microplastics have been detected all over the world including places such as surface water, soil ecosystems, and coastal areas. Radishes were treated with either no microplastics, polyethylene, polystyrene, or polypropylene. Their growth was measured in two ways: germination and height. One week of planting the seeds, the germination rate was measured. Each week after germination rate was measured, the height was measured in centimeters. It was hypothesized that radishes treated without microplastics would grow more than polypropylene, polystyrene, and polyethylene. The results revealed that plants treated without microplastics grew on average, 4 cm more than the other IV levels. For germination, there was no significant difference between the control and the experimental groups. For seed germination, A t-test was performed on the data, and it was revealed that the data for control vs polyethylene and control vs polypropylene were not significant. For plant height, a t-test was done on the data, and it was revealed that all the levels of IV were significant. The results supported the research hypothesis and did not support the research hypothesis. It is believed that the results are due to the fact that microplastics interfere with plants' ability to absorb vital nutrients and water. This research could lead to further studies that investigate the effect of microplastics on soil properties and how other types of microplastics affect different types of plants.

Ilakkiya Guganathan *Mills E. Godwin High School*
The Effect of Different Pesticide Amounts on Earthworm Health

The purpose of this study was to examine the effects of different amounts of pesticide on the health of earthworms, given their critical role in maintaining soil health and ecosystem stability. Earthworms are essential for soil aeration, nutrient cycling, and organic matter decomposition, all of which support plant growth and biodiversity. Due to the rising global use of pesticides, concerns have been raised about their negative impact on non-target organisms like earthworms, which would ultimately threaten agricultural sustainability. The hypothesis suggested that earthworms exposed to 0 mL (control) would exhibit better health compared to those exposed to higher pesticide levels, as the absence of pesticides fosters optimal conditions for their vitality. In this experiment, earthworms were subjected to four pesticide treatments: 0 mL, 5 mL, 10 mL, and 15 mL. Over 25 days, weight changes were recorded after a 24-hour exposure for each group. Results indicated significant weight loss in earthworms exposed to higher pesticide concentrations, particularly at 15 mL, while the control group showed weight increases. These findings exhibit the detrimental effects of pesticides on earthworm health, primarily through oxidative stress. The research highlights the need for sustainable agricultural practices and regulatory policies that limit pesticide use, thereby preserving the health of soil ecosystems. This study advocates for balanced pest management strategies that consider the vital role of earthworms in promoting soil quality and supporting food security.

Virginia Museum of Natural History
Amelia Hanks *Central Virginia Governor's School for Science and Technology*
The Effect Biomes and Climates Have on the Preservation of Fossils

The purpose of my project was to determine whether or not a fossil found in a marine environment would have better preservation. This study was conducted at a governor's school during November and December of 2024. This study collected data on four sub-species of Dinosauria, seven locales on earth, and the three sub-eras of the Mesozoic. The four sub-species were Theropoda, Saurischia, Ornithschia, and Avetheropoda. The locales were the US Mid-West Seaway, Chile/Argentina, Uzbekistan, Mexico, South Korea, Niger, and India. The three sub-eras were Triassic, Jurassic, and Cretaceous. A Chi-Square Test for Independence identified significant values for specific regions and sub-species, including US Mid-West Saurischia (109.7483), Chile/Argentina Saurischia (378.1874) and Ornithischia (142.2189), Mexico Avetheropoda (574.6549), and India Saurischia (301.715818) and Ornithischia (165.341969). Using an alpha value of 0.05, p-values from the Chi-Square tests demonstrated significant results, including 0 (Total), 0 (US Mid-West), 2.2098x10-103(Chile/Argentina), 2.10388x10-59 (Uzbekistan), 2.38622x10-30 (South Korea), 4.38163x10-80 (Mexico), 3.15951x10-5 (Niger), and 1.13204x10-87 (India). The data supported my research hypothesis, which stated that if a fossil was found in a marine environment during the Cretaceous era, then it will have the best preservation as determined by the quantity of fossils found during the selected era and biome. In conclusion, marine environments significantly enhanced fossil preservation, particularly during the Cretaceous era.

Anne Motley *Chesapeake Bay Governor's School*
The Impact of Salinity and Temperature on the Total Population and Species Distribution of Jellyfish in the Rappahannock River

The Chesapeake Bay is experiencing degradation due to climate change and nutrient runoff impacting many species. Jellyfish are a keystone species that are important in Chesapeake Bay food webs. Their occurrence has been linked to temperature and salinity, parameters forecast to change in the Bay due to Climate Change. This study tested whether different water quality parameters were impactful to the distribution of three different species of jellyfish: the Sea Nettle, Moon Jelly, and Lions Mane. This was done by selecting three sites along the Rappahannock River, a tributary of the Chesapeake Bay, one near the mouth of the river with high salinity and temperature, one in the middle of the peninsula with moderate salinity and temperature, and one upriver with low salinity and temperature. Each site was tested weekly for 13 weeks during the summer to determine the water temperature, salinity, dissolved oxygen, nitrate, phosphate, total number of jellyfish, and species of jellyfish at each site. There was a significant difference in jellyfish occurrence with most jellyfish at the mouth site and no jellyfish at the upriver site ($p=0.027$). Salinity was the only parameter that was different between sites with increasing salinities toward the mouth site. Moon jellies showed a significant trend with decreasing salinity and Sea Nettles had a highly significant trend with increasing temperature. This study illustrates how different jellyfish species may be resilient to environmental changes.

Aesha Parekh *Mills E. Godwin High School*
The Effect of Opuntia Ficus-Indica on Water Clarity

The purpose of this experiment was to determine the effectiveness of the coagulant O. Ficus-indica on the clarity of water. Compared to inorganic flocculants, the use of a natural coagulant like O. ficus-indica is beneficial because of lower costs, worldwide accessibility, and its environmental sustainability. Five concentrations of O. Ficus-indica mucilage were tested on dirty water, the control group being distilled water. The clarity of water was measured in Absorption Units, using a spectrophotometer. A research hypothesis was formulated that the higher the concentration of mucilage, the greater the clarity of water. The results found that as the concentration of mucilage increased, the clarity of water decreased and became cloudier. The research hypothesis was not supported because of this. However, the null hypothesis was rejected as a t-test was done on the data and proved it to be statistically significant. It was theorized that the results are due to an absence of colloids in the tested water, as well as an inadequate time given to agitate the coagulant and let the coagulation process occur. The results of this experiment and its data should be confirmed in further study and compared with other natural coagulants to determine O. Ficus-indica's true effectiveness as a natural coagulant and flocculant.

Nandika Zala *Clover Hill High School*

The Effect of Varying Amounts of Different Types of Paint, Added to Water, on the Reproductive Rate of Duckweed

The purpose of this experiment was to determine the effect of varying amounts of different types of paint, specifically Acrylic and Watercolor, added to water on the reproductive rate of duckweed (Lemna minor). Duckweed is a natural water purifier, removing pollutants and toxins to promote a healthier aquatic environment. Industrial paint products often contain harmful toxins such as acrylic paint containing microplastics which are harmful to the aquatic environment. The hypothesis proposed that if petri dishes were filled with 0 mL, 1 mL, and 2 mL of acrylic paint and Watercolor paint, the duckweed's reproduction rate would be negatively impacted with the dishes containing acrylic paint. After the duckweed was given 24 hours to adapt to the new environment, the paint addition process began. The paint concentrations of 0 mL, 1 mL, and 2 mL were added to the duckweed groups, each group containing 10 petri dishes with 4 fronds of duckweed in each. The reproductive rate was determined by calculating the average values for each of the six weeks during which the paint addition process was implemented. These weekly averages were then used to evaluate the overall mean reproduction rate for each group. The average number of fronds observed in the acrylic samples were 8.0 for the 0 mL concentration, 4.5 for 1 mL, and 3.9 for 2 mL. In the Watercolor samples, the average number of fronds was slightly higher in the experimental groups, with a mean of 7.9 for the 0 mL concentration, 4.6 for 1 mL, and 4.4 for 2 mL. Results indicated a clear trend: as the concentration of paint increased, the reproductive rate of duckweed decreased significantly, with acrylic paint exhibiting the most pronounced negative effect. In response to the significant change, the null hypothesis was rejected.

Environmental & Earth Science C (HS ENV C)

First Place
Saanvi Jain *Mills E. Godwin High School*
The Use of Various Sorbents as an Eco-friendly Oil Spill Treatment

The purpose of this study was to evaluate the effectiveness of various eco-friendly sorbents to enhance oil absorption during a simulated oil spill. Oil spills cause immense damage to marine ecosystems. Due to the environmental hazards created by traditional oil spill methods, this research aimed to investigate sustainable alternatives obtained from natural materials. The experiment tested four independent variables: sawdust, volcanic ash, zeolite, and a control with no additives. Each sorbent was mixed with a saltwater and motor oil solution, and the sorption capacity was measured after one hour. It was hypothesized that if sawdust was used as a sorbent, then it would display the highest sorption capacity. The results revealed that sawdust had the highest sorption capacity, an average of around 4 grams more than the other levels of the independent variable. The results provided clear support for the research hypothesis. All the t-tests conducted confirmed the statistical significance of these findings, leading to the rejection of the null hypothesis. The superior performance of sawdust was because of its porous structure, large surface area, and low density, which facilitated oil adhesion. These findings suggested that eco-friendly sorbents, particularly sawdust, could serve as an effective and sustainable solution for oil spill remediation. Future research should focus on the best amounts of sawdust and compare it with other eco-friendly sorbents. Testing sawdust with different crude oils, exploring composite materials for absorption, and using real ocean water in experiments could also provide more accurate and reliable results.

Second Place
Rhea Maruvanchery *Mills E. Godwin High School*
The Effect of Natural Pesticides on *Ocimum basilicum's* Pest Vulnerability

The intent of this experiment was to identify the effects of natural pesticides on *Ocimum basilicum* plants' (Basil) vulnerability to the larvae of *Vanessa cardui* (Painted Lady butterflies). Synthetic pesticides are the cornerstone of the agricultural industry but come with many drawbacks, such as risks of environmental pollution and acute pesticide poisoning in humans. This experiment sought to evaluate the efficacy of natural pesticides, which could serve as a less toxic, effective alternative to their synthetic counterparts. Basil plants

were administered with either neem oil, castile soap, or jalapeño (Hot-Pepper) sprays on alternating days for seven days. Plants given no natural pesticide spray served as a control group. After seven days, the number of leaves eaten by caterpillars per plant and averages for each group were totaled. It was hypothesized that when natural pesticides are applied to basil plants, the group given “Neem Oil Spray” would be most successful at preventing caterpillars from eating their leaves. The results indicated that basil plants given “Neem Oil Spray” best repelled *V. cardui* with an average of 0.0 leaves eaten. Additionally, the “Hot-Pepper Spray” and “Soap Spray” groups were effective to a lesser extent, while the control performed worst. A t-test was conducted and found that all data were significant besides “Soap Spray vs. Hot-Pepper Spray.” The results supported the research hypothesis and are likely due to azadirachtin, a larvicidal chemical in neem oil. This research could lead to further studies on the efficacy of neem oil against other pest groups besides caterpillars.

Third Place
Hannah Kim *Central Virginia Governor’s School for Science and Technology*
The Effect of Microplastics in Soil on Prevalence in Corn Tissue

The purpose of this research was to determine whether or not the amount of microplastics in soil had a relationship with the amount that was present in corn. Microplastics were dyed using a Nile Blue powder stain. Three groups of ten plants were set up: control (no microplastics), low-concentration (.2236 grams of fluorescent beads), and high-concentration (.4473 grams). The plants grew for three weeks and were given 10-20 mL of water two to three times a week, depending on soil moisture. After growth, they were cut at the bottom of the stem and thinly sliced manually using a razor blade. These samples were then analyzed under a microscope and a fluorescent flashlight to illuminate the microplastic beads. Each sample was independently examined by two researchers, and the numbers were averaged to provide group values for the statistical test. A single-factor ANOVA determined no significance in the relationship between the variables. The test yielded a p-value of .247, a value larger than the alpha value of .05. The group with the most microplastic presence was the low-concentration group, followed by the high-concentration group, then the control. Although the groups with incorporations in the soil had larger numbers of microplastics in the plant, my research hypothesis was not supported: if there are more microplastics in the soil, then there will be a proportional increase in the amount that is found in the corn. To conclude, this study showed that microplastic incorporation in soil does not affect the microplastic prevalence in plant tissue.

Honorable Mention
Olivia Allen *Chesapeake Bay Governor’s School*
Potential for Coastal Alkalinity Enhancement Using Calcium Ion Supplementation Under Normal and Acidified Conditions

Ocean acidification causes the calcium carbonate ($CaCO_3$) saturation site to decrease. The combination of eutrophic and atmospheric CO_2 dissolving into estuarine waters has caused the coastal ecosystem to become more acidic. In order to determine how supplementation affects acidified and non-acidified sources, calcium supplements were added. These supplements consisted of chalk, ooid sand, dolomitic limestone, fossil shell sand, and crushed oyster shell which were added to samples of PRW and acidified PWR. In both the raw water and acidified water experiments, there was an increase in Ca^{+2} concentration for all samples with the five added calcium supplements. Chalk outperformed all other supplements in the acidified experiment, while ooids outperformed the other supplements in the non-acidified experiment. The change in calcium concentration differed between each supplement when acidified; chalk had the highest percent change of 1600% and dolomitic limestone had the lowest of 408%. Supplements in the non-acidified water did not have as dramatic changes in calcium concentration with the highest being ooids with 130% and the lowest being chalk with 75%.

Honorable Mention
Ishaan Patankar *Maggie L. Walker Governor’s School*
Concentration Dependent effects of Endocrine-Disrupting Chemicals on *Daphnia magna*

Endocrine-disrupting chemicals (EDCs) such as phthalates and triclosan are common in pollutants and damage endocrine systems in both humans and various animals. These compounds are found in many everyday products, such as plastics, care items, and industrial waste. They also often end up in aquatic environments. This study aims to investigate the effects of these EDCs on Daphnia magna, a freshwater organism vital to aquatic ecosystems. The goal of this research is to determine how EDCs impact aquatic organisms, specifically through varying concentrations of triclosan and dimethyl phthalate, to simulate varying levels of pollution. By discovering the mechanisms by which these pollutants harm aquatic species, this study seeks to provide valuable data to assist with the increase in regulatory policies which would allow for the reduction of the use of these EDCs. The experimental design exposed D. magna to concentrations of dimethyl phthalate and triclosan (10 µg/L, 100 µg/L, and 1,000 µg/L), with a control group maintained in uncontaminated water. This study hypothesizes that increasing concentrations of phthalates and triclosan will result in statistically significant reductions in heart rate, reproductive output, and survival in Daphnia magna compared to the control group. Specifically, the 1,000 µg/L of triclosan concentration would result in the lowest heart rates. Factors including heart rate and mortality were measured to test the harmful effects of the EDCs. This was done by exposing D. magna to four drops of these EDCs for 60 seconds then measuring their heart rate under a microscope. The results highlighted a decrease in heart rate which was dependent on the dose, with the control group returning an average of 263.8 beats per minute (bpm), while the highest concentration of phthalates (1,000 µg/L) and triclosan (1,000 µg/L) resulted in lower average heart rates of 152 bpm and 142.07 bpm, respectively. Statistical analyses, including t-tests, confirmed the effects of all the concentrations as significant ($p < 0.001$). The data also displayed minimal variability and no outliers, exemplifying the reliability of the results. These findings highlight the adverse impacts of dimethyl phthalate and triclosan on D. magna, which suggest great consequences, which include disruption of food webs through the biomagnification of these chemicals. The study highlights the need for lawful policies and more effective wastewater treatment processes to reduce the number of EDCs in aquatic environments.

Honorable Mention

Stephen Welch *Chesapeake Bay Governor's School*

SAV's Role in Combatting Climate Change and Nutrient Pollution: A Comparative Analysis on SAV Water Quality Impact

In recent years, the Chesapeake Bay's health has declined with key contributors being climate change and nutrient pollution. Excess CO2 makes the water more susceptible to acidification, while rising temperatures and phytoplankton blooms create hypoxic conditions, making the water inhospitable to aquatic life. SAV (Submerged Aquatic Vegetation) is one of the few natural preventions between climate change and the harmful influences of human interaction. Studies have shown SAV's ability to uptake nutrients, respirate dissolved oxygen, and restore altered pH in the upper regions of the Bay during the warmer months of the year. This study predicted similar results in the lower areas of the Chesapeake Bay in the fall-winter months. SAV and non-SAV areas were surveyed and water quality parameters were tested to understand the vegetation's influence on Bay conditions. Nitrate levels were low, but significantly higher in SAV sites while phosphate levels were lower in SAV sites. Temperature and dissolved oxygen levels were not significant between sites. These results are likely due to the fall/winter season diminishing photosynthesis and causing SAV die-off. A statistically significant difference in pH between sites suggests that SAV buffer pH from ocean acidification. The buffering capacity of SAV through cold and warm months may provide resilience for the Chesapeake Bay in light of global warming and nutrient pollution year long. SAVs play a crucial environmental role in the Bay and efforts should be made to maintain and restore these degraded SAV beds.

Carys Casper *Hampton Roads Academy*

Everyday Algae: The Effects of Pollutants on Algae Growth

Algae is well known as scum in ponds, creeks, and rivers, but few truly realize how much its growth can affect the environment and, in turn, many people's lives. Algae growth is usually a positive phenomenon for ecosystems because it is a large photosynthesizer, but like many organisms, microalgae need to be kept at a careful growth balance to avoid the negative effects of over or undergrowth. This experiment aims to test the effects of various water pollutants on the growth of beneficial and destructive algae species over fourteen days. Four individual algae species (*A. variabilis, N. oculata*, *T. pseudonana,* and *C. calcitrans*) were added to saltwater environments containing five different pollutants (basic, acidic, phosphorus-rich, pesticide, and

oil). The growth of each sample was recorded for five days over a 14-day period by measuring the concentration of algae per milliliter of the sample. The algae growth rate was expected to be higher in phosphorus, pesticide, and basic pH water pollutants compared to the control and lower in acidic and oil pollutant environments. The results showed that basic pH water and phosphorus-rich environments increased the concentration of algae in the water, while acidic, oil and pesticide-polluted environments showed a decrease in algae concentration. The algae in pesticide-polluted environments appeared to decrease initially and then bounced back, increasing their growth. This means that in a natural environment, algae would grow faster because of phosphorus-rich pollutants, which can become toxic to the marine ecosystem. In an environment with a spike in acidic or oil pollutants, most algae populations will decrease, harming the ecosystem. The results for pesticide pollutants are too inconclusive to identify a trend, and the amount of algae growth in basic pH environments appeared to vary depending on the algae species.

Kaylynn Christensen *Chesapeake Bay Governor's School*
Coliform Levels in Aquatic Ecosystems

Water is essential to carbon-based lifeforms, making its contamination especially impactful to the organisms relying on that water source. One of the most harmful ways waters can be affected is contamination through harmful bacteria. These bacteria have a much higher chance of entering a host when it resides in a natural body of water where animals, including humans, drink from frequently. One example of these harmful bacteria is *Escherichia coli*, otherwise referred to as *E. coli*. Certain strains of these bacteria, especially Shiga toxin-producing *E. coli*, can have a significantly negative impact on human health, causing symptoms such as stomach cramps, fever, bloody diarrhea and, in extreme cases, Hemolytic Uremic Syndrome or HUS, which affects a human's kidneys and the ability of their blood to form clots. This project utilized the total coliform abundance as a means of predicting the likelihood of harmful E. coli presence in aquatic environments, specifically the Chesapeake Bay estuarine environment immediately next to human-occupied land. Samples were taken from bodies of water based on their proximity to the Colonial Beach Wastewater Plant, with samples taken from near the plant in the Goldman Creek, downstream of the plant on the Potomac River near the Colonial Beach Municipal Pier, and near the treated wastewater outlet point in the Monroe Bay. The water quality indicators examined in this experiment included coliform abundance, proximity to the wastewater plant, water temperature, salinity, pH, and dissolved oxygen level. This study intended to examine the relationship between coliform abundance and a location's proximity to Colonial Beach's wastewater treatment plant, along with the relationship between coliform abundance and pH level, temperature, and salinity of a water sample. While no significant correlation was found between the variables, the relationship between the position relative to the wastewater treatment plant was trending toward significance, indicating there may be a correlation between location and coliform abundance.

Anthony Fiorino *Washington-Liberty High School*
The Effect of Liquid Medium Aeration on the Decolorization of Crystal Violet by *Trametes versicolor*

Crystal violet, a triphenylmethane dye commonly used in the textile industry, often contaminates aquatic ecosystems through manufacturing effluents and is ecologically toxic. Biological decolorization methods employing fungal ligninolytic metabolic pathways, like those used by *Trametes versicolor*, effectively degrade xenobiotics such as textile dyes. This study evaluates how aerating liquid media enhances *Trametes versicolor's* ability to decolorize crystal violet. The aim of this experiment was to optimize textile dye biodegradation through various agitation methods. Three agitation techniques were compared: stirring, aeration, and no agitation. Absorbance measurements at 590 nm were taken two weeks after inoculation and compared to pre-inoculation samples. Additionally, Triticum aestivum seeds were germinated in the filtrate from each group to assess phytotoxicity levels based on germination rates, providing a practical measure of decolorization. The most significant change in absorbance was noted in the aerated group (26.2%), followed by the still group (21.5%), and then the stirred group (18.7%). In the phytotoxicity analysis, aerated solutions showed the highest germination rate (93.6%), closely followed by the still (83.2%) and stirred (82.4%) groups. An ANOVA test performed on the phytotoxicity data yielded a statistically significant p-value of 0.026. A post hoc Tukey test indicated that aeration significantly surpasses still and stirring solutions in reducing phytotoxicity, with no statistical difference found between still and stirring solutions. These results suggest that aeration notably enhances *Trametes versicolor's* decolorization effectiveness and boosts the efficiency of bioreactors used to treat textile effluents and remediate dye-polluted ecosystems.

Aditi Vasudev *Mills E. Godwin High School*
The Effect of Natural Water Filtering Materials on the Heavy Metal Concentration in Drinking Water

Heavy metal pollution in drinking water and aquatic environments is a growing global issue and has been linked to a rapid increase in various physical and neurological illnesses. Water filtering was tested as an efficient method for purifying water in developing countries. This experiment aimed to determine which natural filtering materials are most effective at purifying water. The control in this experiment was using no filter, meaning a 10% heavy metal and distilled water solution would be measured. The independent variable (IV) levels, ceramic dome, maifan stone, and activated charcoal were tested. The hypothesis was that the ceramic dome would produce the cleanest water. This was hypothesized because research has proven that this method has been used for centuries against water borne diseases. The experiment was conducted by constructing three water filters from the IV levels and using these to filter the 10% solution. 25 samples were collected for each IV level, including the control. The data supported the hypothesis, showing that the ceramic dome removed more heavy metal. Six t-tests were conducted with the data recorded. It was found that the data was significant, and the null hypothesis was rejected, supporting the research hypothesis. A possible explanation for these results could be due to the fine pores of the ceramic surface trapping the heavy metals. In contrast, the maifan stones may have absorbed contaminants, while activated charcoal likely chemically bound them rather than completely expelling them. Future research could explore different methods of water purification.

Mason Walker *Chesapeake Bay Governor's School*
Determining The Effects of Fiddler Crabs on *Spartina alterniflora* Based on Height, Density, and Dissolved Oxygen

This study investigates the effects of fiddler crab (*Minuca pugnax*) burrows on the growth, abundance and root mass of *Spartina alterniflora*, a dominant marsh plant in the Chesapeake Bay. Fiddler crabs, as ecosystem engineers, create burrows that potentially affect sediment oxygenation, nutrient cycling, and plant development. The study measured plant height, density, and root mass across two zones: one with abundant fiddler crab burrows and one with minimal burrows. It was hypothesized that burrows would promote plant growth by increasing oxygen availability to plant roots but might reduce plant density due to physical disturbances to root systems. Over a 13-week period the change in plant height was measured, a density reading of plants per square meter, as well as an average root mass was also taken. Plant density was higher in areas without fiddler crab burrows, while the change in plant height ($p = 7.8E\text{-}22$) and root mass ($p = 0.000724$) were significantly greater in areas with burrows. The increased root mass in the burrow zones indicates higher oxygen availability, which may increase plant growth. The results suggest an overall mutualistic relationship between fiddler crabs and Spartina alterniflora, where burrows enhance soil aeration and nutrient availability, promoting plant growth, but may also disturb plant density by disrupting root systems. This study contributes to understanding how fiddler crabs influence shoreline wetlands, which are vital for erosion control and habitat stability, and highlights the potential drawbacks of increasing shoreline development.

Xavier White-Barfield *Collegiate Schools*
The Effect of Acid and Lime Fertilizer on Soil Acidity (pH), Soil Quality and Crop Growth: Soybean (Glycine Max) Growth

Lime and acid fertilizers are important for growing and cultivating plants. These fertilizers can affect soil pH, quality, and the development of crops. This study investigated how acid and lime fertilizers influence these properties on soybean plants grown in a laboratory. The experiment was conducted at a Richmond based Independent School and took 7 weeks. The experiment had four treatments: acid, lime + water ratio, acid + lime, and a control treatment. The soil treatment groups with acid + lime and acid individually show poor soil quality and decreased growth rates and development, while the lime and control treatment groups saw an increase in pH growth rates and quality of both the soil and the soybean plant. The lime fertilizer allows the soybean plant to have a high intake of nutrients such as phosphorus and nitrogen, two key elements that affect soil quality but have a significant effect on plant development. Acid fertilizer, on the other hand, creates an environment that is detrimental to the growing process of crops such as soybeans. Acidic soil, unlike basic soil

or neutral soil, decreases nutrient intake and lowers the pH to a significant degree, so much so that it is lower than the recommended pH level for a crop. Increasing aluminum content and other harmful nutrients creates a toxic environment for soybeans and other crops.

Ava Wilson *Chesapeake Bay Governor's School*
The Growth of Barnacles and Other Fouling Species on Various Surfaces in Autumn

Changes in Earth's climate, specifically warming temperatures which allow water temperature to remain higher despite the onset of autumn, may have an effect on organisms that inhabit the water. Biofouling species that are better supported by warm water may have a longer growing season due to climate change. Biofouling species, small organisms that utilize structures in the water column as their lifeline and habitat, have profound impacts on the natural and man-made aspects of a body of water. Their season of high growth rates has been extending due to increasing temperatures of bodies of water in which they inhabit. As their rapid growth takes over the water column, the nutrients in the water column can become lacking as fouling species consumes suspended materials and nutrients. Fouling species attach to man-made structures in the water as well. Their presence damages and creates issues for structures such as shipping vessels. The result of this is costly maintenance and higher shipping costs to account for the effects of fouling growth. This study compared growth across a variety of surfaces including fiberglass, glass, plastic, oyster shells, and fiberglass coated with copper paint. Fiberglass and oyster shell surfaces led in total growth, supporting the hypothesis comparing surface type to total growth. Species richness was also highest on fiberglass as well was biodiversity when not broken down in comparison between the three testing sites. Fouling growth was prevalent among two of the three sites throughout the course of the experiment which took place for roughly three months in the fall. The material boats are often constructed of, fiberglass, support the most growth as well as the most species of fouling growth. As climate change may continue to cause increased water temperatures, this effect may increase and create additional issues for recreational and shipping vessels. The natural surface, oysters also supported an abundance of fouling growth. The future of increasing fouling growth supported by oyster shells may disrupt the ecosystem and productivity of some areas.

Environmental & Earth Science D (HS ENV D)

Virginia Sea Grant
First Place
Devansh Kumar *Maggie L. Walker Governor's School*
Evaluating Water Pollution Through the Effect of Organic Kelp Fertilizer on Brine Shrimp (*Artemia salina*)

This study examines the ecological effects of agricultural runoff by analyzing how different concentrations of organic kelp emulsion fertilizer impact Artemia salina, a model organism used in aquatic ecotoxicological assessments. The Artemia salina were exposed to solutions containing kelp emulsion to stimulate widespread agricultural pollution in aquatic ecosystems. The fertilizer served as the independent variable, with over 12 repeated trials for each concentration level of the independent variable. The frequency of the thoracic appendage motion as well as movement behavior was evaluated as the dependent variable. The experimental setup used 12 petri dishes, each containing four Artemia salina, with a control group at 0% fertilizer, 1% fertilizer, 3% fertilizer, and 5% fertilizer. After a 24-hour period of experimentation, the specimens were evaluated. The greater concentration of kelp fertilizer caused drastic alterations and issues for the Artemia salina. The 5% solution represented a death percentage very close to the lethal concentration 50, at a 42% death rate. Other deformities such as appendage disintegration, antennae loss, abdominal deterioration, and irregular movement were observed. This supported the hypothesis that a higher concentration of seaweed fertilizer would influence mortality and cause heightened decomposition. This study was able to assess valuable insights into the potential ecological impacts of agricultural pollution, taking account of a popularity shift to organic farming. Future research can determine whether different fertilizers impact organisms less.

Second Place
Swati Aggarwal *Southwest Virginia Governor's School*
Testing Natural and Store-Bought Stain Removers on Different Color Cotton Fabric

This study compares the effect that natural and store-bought stain removers have on removing coffee stains present on different color cotton fabric. Having stains present on clothing can lead to potential bacteria being grown, which can transmit diseases and illnesses from wearing your clothes. Removing stains has many benefits, such as saving time and money, as well as saving resources and materials needed to make new clothes. Removing stains is beneficial, but stain removers that you can buy at a store can potentially harm your clothes due to the chemicals present in these stain removers. They are also not environmentally friendly compared to other stain removers that are more natural. The experiment was done by using yellow, red, and blue color cotton fabric and applying coffee stains on them. After the fabrics were stained, the natural and store-bought stain removers were tested to see how much of the coffee stain was removed depending on the color of the fabric. The natural stain removers are vinegar and baking soda, and the store-bought stain removers are OxiClean Max Force Laundry Stain Remover and Shout Triple Acting Laundry Stain Remover. An ANOVA test revealed that there is a significant difference in the amount of stain removed depending on the color of the fabric, and the p-value was less than 0.0001. A follow-up Tukey test was done to see the differences between all of the stain removers. Arambulo found that lemon peel as a stain remover performed slightly worse than the commercial stain remover. This research found similar results in that the natural stain removers performed slightly worse than the store-bought stain removers, but more testing needs to be done to see if this is truly the case.

Third Place

Ann Holmstrom *Clover Hill High School*

The Effect of Various Types of Bulbs, used in the Same Light, on the Night of a New Moon, on Star Visibility, Measured Using ImageJ Software

Light bulbs used in households, streetlights and outdoor stadiums all contribute to the low visibility of stars in the night sky, which is why it is important to understand how each individual light bulb affects the night sky. The purpose of this experiment was to determine which type of light bulb would have the greatest negative impact on the visibility of stars, and this was measured using ImageJ software. The hypothesis was that LED lights would have the greatest negative impact on the visibility of stars, over both incandescent and fluorescent light bulbs with the same wattage. Pictures of the sky were taken at night with each light bulb at 11 different locations on two nights. These pictures were then put into ImageJ software and individually measured to find the mean, maximum, and minimum gray value of each photo by measuring each individual pixel on a gray value scale. The mean gray value for the control, which was photos of the night sky with no bulb on, was 11.563, which differs little from the LED bulb, fluorescent bulb, and incandescent bulb which all had means of 11.767, 11.751, and 11.665 respectively. In this experiment the null hypothesis was accepted, and the hypothesis was not supported because the mean data from the photos taken of the sky showed an insignificant difference between the control and LED bulb.

Honorable Mention

Jullian Abuan *Mills E. Godwin High School*

The Effect of Differing Obstructions on Wind Erosion

The purpose of this experiment is to find relations between obstructions and wind erosion to help lessen losses in farming areas. This would help in keeping soil healthy and increase yield in crops with areas which struggle highly with soil erosion. The experiment of this research utilized a wooden platform which held an eight-centimeter tall, 0.610x0.610 pile of soil that weighed 500g. A blow dryer was then used to indicate wind, and the fallen soil was then measured to account for soil erosion. This experiment hypothesized that if sprouts are used as an obstruction, then there will be less soil erosion. The results of the experiment supported the hypothesis due to a difference of 12.4g of fallen soil between sprouts and control with sprouts being the lesser. A t-test was then performed to give significance to the data, and all comparisons were shown to be statistically significant. This means that this experiment was due to the independent variable and not due chance. These results are correlated as it has been proven that plants help in binding the soil together making it more resistant to soil erosion. Though there is a lot more research to be done. Further studies could include how soil topography helps aid or harm soil erosion.

Honorable Mention

Anna Foster *Clover Hill High School*

The Effect of Exposing a Wildflower that is Native to Canada, to Smoke, Over Time, on the Growth of the Plant

The purpose of this experiment was to determine the effects smoke has on plant life, specifically Vinca periwinkle. There has been an increasing rate of human caused wildfires, and the effects they have on the environment could be detrimental. This experiment would provide valuable information on how plants react to smoke, allowing for precautions to be put in place for the future. The hypothesis was: The Vinca periwinkle plants that were exposed to smoke would have less growth in height than the Vinca periwinkle that were not exposed to smoke. Vinca periwinkle sprouts were placed in a greenhouse and exposed to smoke for 30 minutes every day for 20 days. Their heights were measured in centimeters every five days and recorded. All of the heights from each five-day set were then averaged together. The mean growth for the Vinca periwinkle exposed to smoke was 1.12 cm, and the mean growth for the Vinca periwinkle not exposed to smoke (control) was 1.87 cm. The null hypothesis was rejected, and the data supported the hypothesis.

Honorable Mention

Zainah Malik *Mills E. Godwin High School*

The Effect of Various Microplastics on *Pisum sativum* DNA

This experiment was conducted to explore the effects of various microplastics on the DNA of *Pisum sativum*. Microplastics are small broken-down pieces of plastic that are resistant to weathering and biodegradation. Thus, they accumulate in the environment, especially in agricultural runoff that leads into rivers and oceans. Ultimately, some of these particles enter crops grown in farms through the stomata and can enter the human bloodstream when these crops are consumed (Alomar et al., 2020). One hundred *Pisum sativum* seeds were allowed to germinate with three types of microplastics: polystyrene, polyethylene, polyurethane. Twenty-five seeds were grown without plastic to examine the overall effects of plastic on the growth of Pisum sativum. Then, a gel electrophoresis procedure was produced to observe how the plastic affected the DNA banding of the plants. It was hypothesized that polystyrene would have the greatest effect on the DNA banding, causing many smaller fragments to be sorted through the gel. The results showed that polystyrene created the poorest quality of DNA banding of the Pisum sativum plants. A chi-square test was performed on the data and revealed that the data was significant, and the null hypothesis was rejected, indicating that the results were due to the independent variable and not to chance. Additionally, the results supported the research hypothesis. This was due to the styrene released by polystyrene that damages the mechanisms that repair DNA.

Sahana Kannan *Mills E. Godwin High School*

The Effect of Homemade Cleansing Methods on Pesticide Removal from Capsicum

The purpose of this experiment was to identify the effect of various homemade cleansing methods on pesticide removal from peppers. As the world's population increases, farmers have resorted to pesticides to produce crops which are marketable, which had increased the need for a cleansing method which was effective against pesticide residue. The peppers were either rinsed with cold water, soaked in warm water or soaked in water mixed with 1 tsp of baking soda. With the control being peppers which were not cleansed at all, the amount of pesticide residue remaining was measured using PestiEye. It was hypothesized that peppers cleansed with water mixed with baking soda solution will have the least pesticide residue. The results revealed that peppers washed with cold water had less pesticide residue than when soaked in warm water, when soaked in baking soda and water solution or when not cleansed at all. A t-test was performed on the data, and it showed that the data was significant for control vs warm water, control vs cold water, control vs baking soda, warm water vs cold water and warm water vs baking soda but it wasn't significant for cold water vs baking soda. The results didn't support the research hypothesis. The reason behind the rg enabled more dirt and pesticide residue to be released. This research could lead to further studies that investigate the effect of soaking rather than rinsing on pesticide residue and how cleansing methods may affect other fruits.

Finn Lucas *Southwest Virginia Governor's School*

Effectiveness of Water Treatment Processes

People need freshwater in everyday life whether that is to drink, to clean oneself, or for the numerous other instances that people use clean water. Recent flooding has damaged many of the reserves which contain freshwater that humans had access to and put any type of clean water at risk for consumption. It raised the likelihood that the once drinkable water had been contaminated by runoff, bacteria, or any type of infectant. This project sought to understand more about which water cleaning and filtration system is the most effective to remove Bacillus subtilis from the inoculated water. Once the processes were tested 35 Tryptic Soy Agar plates were plated and incubated. The processes included solar uv exposure, direct uv exposure, boiling, water treatment drops, and a commercial water filter. With a p-value of <0.0001 from the ANOVA this results in rejecting the null hypothesis of there being no difference between all of the different processes, and this then supports the alternate hypothesis that there is a difference between the bacteria growth between these processes. The Tukey-Kramer was used to see which methods were significant. The Tukey-Kramer test supported that the bacteria growth from the commercial water filter was significant compared to every other test. The commercial filter had a p-value of <0.001 when every other test had a p-value ranging from 0.98 to 1.0. The importance of this project lends itself to a wider study about the environment and safe drinking water. The importance of freshwater can never be underestimated as it allows for all life to continue living.

Hayden Neuman *Mills E. Godwin High School*
The Effect of Photocatalysis on the Purification of Lake Water

The goal of this experiment was to find the effects of different photocatalytic substances on the purification of water. Photocatalysis is an advanced water purification technique that accelerates chemical reactions in the presence of light. In the field of science, research has been done and titanium dioxide, zinc oxide, and cellulose-supported photocatalytic have all been studied for photocatalytic purification. In this experiment solo cups filled with lake water were treated with these substances. The Solo Cups were then exposed to UV light overnight. After this, the number of bacteria present was measured. The control in this experiment was the lake water with no added substance. A hypothesis was created that if titanium dioxide is used to purify lake water using photocatalysis, then the lake water will have the least bacteria present in the end. The results proved that zinc oxide worked better as a photocatalytic substance than titanium dioxide. A t-test was performed on the data, and it showed that the data was significant for Titanium Dioxide vs. No Additive (Control), Zinc Oxide vs. No Additive (Control), Titanium Dioxide vs. Zinc Oxide, and Zinc Oxide vs. Cellulose supported photocatalytic. The results did not support the research hypothesis, although the results did not support the research hypothesis, they did have a great effect. This is because zinc oxide performed better than titanium dioxide. This research opens to further studies that investigate the best duration of time for the UV light to shine on lake water and the best methods of photocatalytic purification.

Lauren Obeng *Osbourn Park High School*
Improving Water Conservation in Agriculture: The Potential of Biodegradable Hydrogels

Agriculture is one of the most water-intensive industries, employing enormous amounts of water for plant growth, soil care, and crop cultivation. With growing freshwater demand, as well as climate change and intermittent droughts, new water-conserving methods are essential, especially in arid regions. In this research, the use of biodegradable hydrogels—gel-like substances that can absorb and retain water—is examined to enhance the water retention in soil and reduce irrigation needs. By releasing water to plant roots slowly, hydrogels minimize evaporation and improve drought resistance. The study will test their effectiveness, their impact on the environment, and their potential in sustainable agriculture, aiming to obtain maximum utilization of water without decreasing productivity

Anne Shackleford *Chesapeake Bay Governor's School*
How Salinity and Size Grade Affects the Molting of Blue Crabs

The Blue Crab (*Callinectes sapidus*) finds it home in the Chesapeake Bay. The Blue Crab itself is important to the bay's economy and environment. An essential process that Blue Crabs go through is the molting process which involves the crab shedding exoskeleton to be able to grow and develop. This study specifically investigated how salinity and the grade of the crab affect the molting process. The variables were tested by creating a mock tank that replicated the conditions of a commercial facility. The salinities were set at 0, 5, and

10 parts per thousand. The grades used were prime, jumbo, and whale. The primary objective was to figure out if the variables positively or negatively affected the molting process. The results found that the crabs in the lower salinity had a higher molting success rate, and the prime grade had the highest shed rate. When the statistical tests were run the data was found to not be significant. From the study, it suggests that salinity might play a role in the molting process. The study brings awareness to how these force changes can also turn into natural changes that could severely impact the population. Acknowledging and understanding the environmental factors around blue crabs could improve the industry and environment around the Chesapeake Bay. Many of these changes come from climate change and water quality fluctuations.

Samantha Winter *Mills E. Godwin High School*
The Effect of Simulated Acid Rain on Shingles

This experiment was conducted to observe the change in mass (g) of asphalt, slate, clay, and wood shingles when exposed to simulated acid rain. This was tested by exposing the shingles to simulated acid rain through a drip system and recording the change in mass over 30 days. The change in mass and observations were used to determine the varying effects of simulated acid rain on shingles and how they compare between shingle types. The shingles were attached to a support structure and run under a pH 4 buffer solution for the duration of the experiment to simulate acid rain. The mass of each shingle was recorded daily and analyzed to find the change in mass over time. A t-test was used to determine the significance of the collected data. The t-test results showed that the data for asphalt vs. slate, slate vs. clay, and slate vs. wood were statistically significant with calculated t-values of greater than ~2.010 and a probability of error less than 0.05. Test results also showed that asphalt vs. clay, asphalt vs. wood, and clay vs. wood were not statistically significant with calculated t-values of less than ~2.010 and a probability of error greater than 0.05. The data showed that slate shingles were the most resistant to simulated acid rain erosion, with the smallest change in mass over time by a significant amount.

Environmental & Earth Science E (HS ENV E)

First Place
Reed Hass *Yorktown High School*
The Effect of Location on Water Purity in pH, Ammonia, Nitrates, and Nitrites

The purpose of this experiment was to determine what and how large of an effect location has on water quality. The hypothesis was if the location of water samples is changed then there will be a fluctuation in pH, Ammonia, Nitrates, and Nitrites because of population density, contamination, pollution, runoff water, and bacteria build up, while the null hypothesis was that there would be no change in water quality based on location. There were four dependent variables, being pH, ammonia, nitrites, and nitrates, which were tested with four independent variables. These independent variables were the four different testing locations, with two locations in a more urban location of Arlington, Virginia and two in a more rural location outside of Manassas, Virginia and Shenandoah, Virginia. Based on the data collected, the urban Arlington stream sample proved to be the most contaminated. Testing 8 samples per group using two different testing kits, the collected water from the four different independent variable locations was tested for all four dependent variables. The results proved to be statistically significant in both the T-Test and Anova test. The Anova test scores for each tested dependent variable were 0.095, 0.003, 0.001, and 5.59x10-08, all being below 0.05. As the research conducted states, the positive correlation seen in water quality based on location corroborates with the conducted research. This experiment also gave valuable information on the quality of water in the four tested locations, which is key to the understanding of what water is safe for use or not by local inhabitants.

Second Place
Alessandra Reyes *Mills E. Godwin High School*
The Effects of Lake Location on the Amount of Heavy Metal Pollution in the Water

The purpose of this experiment was to understand the effects of lake location on the number of heavy metals present in the water. Excessive exposure to heavy metals can cause numerous medical problems for humans and animals. Heavy metal testing strips were used to detect the presence and concentration of lead, zinc, and copper in Lake Anna, an industrial lake, Lake Wellesley, a residential lake, and the rural Essex Millpond. Most lakes are polluted, therefore there is no pure water source with which to compare results. The formulated hypothesis was, if the lake is residential, then there will be fewer heavy metals present. The results revealed that Lake Wellesley contained the same amount of zinc as Lake Anna and the least amount of lead of all three locations. The results of the t-tests were not significant for revealing the presence of lead for Essex Millpond vs. Lake Wellesley or zinc values for Lake Anna vs. Lake Wellesley. Other zinc tests, Lake Anna vs. Essex Millpond and Essex Millpond vs. Lake Wellesley and lead tests Lake Anna vs. Essex Millpond and Lake Wellesley vs. Lake Anna, were statistically significant. Although there were some non-significant values, most results were significant. The processes that occur in and near residential and industrial lakes resulted in the presence of nearly equal amounts of zinc. Similarly, processes in and near residential lakes compared to rural lakes did not result in significantly higher levels of lead pollution.

Third Place
Kristine Edassery *Mills E. Godwin High School*
The Effect of Quantity of Polyethylene Microbeads on the Concentration of Chlorophyll a in *Chlorella vulgaris*

The purpose of this experiment is to test the effects of the amount of polyethylene microbeads on the concentration of chlorophyll a in Chlorella vulgaris. There has recently been an increase in the quantity of microplastics produced, and they are shown to cause stress on many different algae species and can then affect the rest of the food chain. A hypothesis was formulated that if there are no polyethylene microbeads in the algae culture, then the concentration of chlorophyll will be higher than if there were polyethylene microbeads present. A Chlorella vulgaris culture was separated into 4-liter jars, and different amounts of microplastics (0 tablespoons, 1 tablespoon, 2 tablespoons, and 3 tablespoons) of polyethylene microbeads were added into each culture. After 10 days, a spectrophotometer was used to measure the concentration of chlorophyll a for each level, and the experiment was repeated to create 25 trials. The results showed that as the amount of plastic increased, the concentration of chlorophyll a decreased, and there were significant differences between all of the IV levels and the control. The data was tight, as implied by the standard deviation values.

Honorable Mention
Abigail Fannin *Christchurch School*
A Study of the Difference in Birdsong Frequencies Between Urban and Rural Locations

This experiment is to identify if birdsong frequencies are higher in more urban settings compared to rural locations. Based on research, birds in more urban environments should have overall higher birdsong frequencies to communicate around the noise pollution found in more populated areas. These results will show the effects of noise pollution on bird species. After finding the frequencies of two differing locations there was a 28% higher difference in frequency averages in urban locations having a higher average than rural locations.

Honorable Mention
Grayson Griffith *Chesapeake Bay Governor's School*
How Do PVA and PEG Affect the Regeneration of Planaria Worms?

When chemicals from wastewater get into the aquatic environment, they can affect biological systems of life which can potentially affect the health of the food chain. Polyethylene glycol (PEG) is a chemical that originates from the chemical scent distributor in Downy Scent Beads laundry products, and Polyvinyl Alcohol (PVA) is the thin plastic surrounding dishwasher tabs and Tide Pods, both chemicals commonly found in laundry wastewater. Planaria worms are a genus of flatworms that can regenerate when cut or injured. This study is trying to determine if PVA and PEG are pollutants in the aquatic environment that can affect the regeneration and survivorship of Planaria worms. The planaria were segmented approximately

0.01 mm behind the auricles. There were the two dilution experiments with a control and three treatments that ran for three weeks.: melatonin, polyvinyl alcohol (PVA), polyethylene glycol (PEG) and a spring water control. Results for survivorship of the anterior segments in the low concentration experiment were: control 100%, PEG 80%, melatonin 100%, and PVA 100%. In the high experiment, the survivorship dropped for the anterior segments: control 20%, PEG 0%, melatonin 60%, and PVA 60%. The significance of this study was to study the effect of PVA and PEG in low dosage solutions in the planaria worm environment. Planaria were able to withstand the conditions of the polluted environment in lower concentrations, but not high. This study shows that PVA and PEG both affect the regeneration rate of planaria worms at the higher concentration.

Honorable Mention

Braeden Musser *Southwest Virginia Governor's School*
Levels of Dissolved Oxygen, pH, and Nitrate in Water

Freshwater ponds and springs in the Appalachian regions are very important to the environment. When high levels of dissolved oxygen, nitrate, and the levels of pH are higher or lower than the norm it can cause the aquatic organisms and organisms that are intaking the water to be harmed. In this experiment a spring and a pond are tested for the three different levels. The effect of this study was to figure out if there is a difference in the locations and the surroundings that affect the pH, dissolved oxygen, and nitrate levels and discuss how that may affect the ecosystems. Measuring the amount of dissolved oxygen with a probe and using the pH indicator strips when the water samples were collected. Ten samples were used to get the data collected. To get the calibrations to continue with the nitrate testing in water is a long process that consists of finding the absorbance of nitrate in urea, ammonia, and nitrate. Along to the finished data of the spring and pond levels. The samples were analyzed using a two-sample t-test. The p-value was 0.0082 this was the difference in the yellow colors that were compared. This shows that there is a statistically significant difference in the calibration and the samples tested. The samples were all compared to the yellow color using the spectrophotometer. This evidence supports that there is a change in the spring and pond on how much nitrogen is present. Further studies will be necessary to find the extent of how much the water cannot withstand in order to be the safest habitats and consumption of all species.

Shiven Bisnath *Mills E. Godwin High School*
The Effect of Phosphate Based Detergent on *Daphnia magna* Mortality.

This experiment aimed to determine the effect of phosphate-based detergent causing Eutrophication of Algae on *Daphnia magna* mortality. The hypothesis was that if there was more P-based detergent, then the number of *Daphnia magna* deaths would increase. This study aims to determine if P-based detergent could have a significantly negative effect on aquatic wildlife due to detergent runoff in freshwater ecosystems. To test this hypothesis, 100 *Daphnia magna* were placed in four freshwater tanks. Within these tanks, the amount of P-based detergent increased by 15 ml with the control being 0 milliliters of P-based detergent. Over 10 days, the mortality rates of the *Daphnia magna* were recorded. The results showed that the control had the least amount of *Daphnia magna* deaths. A chi-square test was run on the data for the results and revealed that the data was significant. The results supported the research hypothesis, with the reasoning being that with more P-based detergent, the amount of phosphate increased. Due to the increase in nutrients, the algae increased significantly due to a process called eutrophication, which caused dead zones to occur, killing more *Daphnia magna*.

Reagan Harding *Christchurch School*
The Impact of Anthropogenic Noise on Wildlife Biodiversity in Three Different Locations on the Christchurch School Campus

This study aimed to determine whether anthropogenic noise affects the biodiversity of wildlife species. It was hypothesized that the more human activity near wildlife habitats, the less biodiversity there will be. Three motion-sensor cameras were set up in three locations on the rural school campus to collect data. Areas farther from human noise had a higher species diversity, as indicated by the Simpson's Diversity

Index, with an index of 0.426 when farther away and 0.303 when closer to anthropogenic noise. The results partially supported the hypothesis, with camera three being an outlier as it only recorded deer.

Shriyans Joyasawal *Mills E. Godwin High School*
A Study on The Effects of Microplastic Concentration on *Daphnia magna* Population

This study sought to establish the impact of varying microplastic concentrations on the survival, growth, and reproduction of the freshwater's keystone species, Daphnia magna. The necessity to carry out the study comes from the concern about the impact of microplastic pollution, whose effects on aquatic life and the broader ecological system are well established. Understanding the impact helps in making predictions about ecological disruption predictions and the formulation of mitigation measures. It was predicted that greater concentrations of microplastics would be harmful to the populations of the Daphnia magna, and the influence of the size of the microplastics would increase due to greater absorption and longer retention. A control group exposed to the solution without any microplastics (0 minutes boil) was added to check if the microplastics were having any influence on the survival and health of the Daphnia magna, in addition to experimental treatments exposed to 5, 10, and 15 minutes of boiling to eliminate microplastics by size. The test involved exposing the Daphnia magna to the solution in five Petri dishes for 31 days. The health of the populations was determined in terms of survival counts by day, reproductive rate, and growth parameters. The environmental conditions in terms of light, temperature, and food availability remained consistent to provide reliable outcomes. The findings from the study established the most significant increase in the rate and size in the case of the 10-minute boil and the least in the case of the 15-minute boil. The tests confirmed a significant difference between the control and the 10-minute boil and a toxic effect at the greater concentrations. The findings, in conclusion, establish the evidence from the study to support the assertion made by the previous research. This study captures the necessity of controlling microplastic pollution to maintain the integrity of freshwater and sets the groundwork for future research into the long-term impacts of this issue.

Liam Murphy *Mills E. Godwin High School*
The Effect of Water pH on Microplastics

This study investigated the impact of different water pH on the breakdown of microplastics. pH solutions of 3.0, 5.0, 7.0 (control), and 8.5 were prepared using lemon juice, acetic acid, distilled water, and baking soda. Plastic containers filled with these solutions were microwaved for three minutes. Microplastic concentrations were measured after a heat treatment with a microwave and filtration. Results demonstrated a significant increase in microplastic count in the acidic solutions (pH 3 and pH 5) compared to the control and the alkaline solution (8.5 pH), supporting the hypothesis that acidic environments accelerate plastic degradation. Statistical analysis confirmed the difference between treatments, with the highest microplastic count observed in pH 3,0. The null hypothesis was rejected, indicating that pH plays a role in microplastics. These findings suggest that microwaving plastics in different conditions may increase the amount of microplastics humans are exposed to, causing health concerns. Further research should investigate the effects of different plastic types, more exposure and different environmental factors.

Mathematics: Theoretical & Modeling (HS MTM)

Carpenter Mathematics Award

First Place

Aneesh Kandimalla *Academies of Loudoun*

Identifying Optimal Metal-organic Frameworks for Adsorption-based Carbon Capture Using Natural Language Processing

Excessive carbon dioxide (CO_2) emissions from energy usage contribute to climate change, creating severe environmental issues. Carbon capture aims to mitigate these effects by siphoning CO_2 from the atmosphere; a promising subset of this technology is adsorption-based carbon capture, a process that uses adsorbents to separate CO_2 from other gases with minimal energy usage. Metal-organic frameworks (MOFs) make for effective adsorbents due to their cage-like shape; however, insufficient research has been conducted on finding MOFs with the highest ability to capture/separate CO_2 at an acceptable level of reusability, especially at standard temperature and pressure (STP). Fortunately, transformer models have been created that can use natural language processing (NLP) to convert text representations of these materials into features for machine learning. Using this, three models were trained to predict an MOF's CO_2 adsorption, N_2 adsorption, and regenerability by fine-tuning MOFormer (Cao, Magar et al., 2023) on three dedicated datasets (all returning an acceptable loss). Then, modified versions of MOFs in the training data were passed back into the model to predict their adsorption metrics. The results were compared with SIFSIX-Cu-i, an existing optimal MOF, and 38 hypothetical MOFs were found to have a higher adsorption capacity and selectivity with an acceptable regenerability value. This study demonstrates a machine learning-powered process that can significantly speed up material discovery for adsorption-based carbon capture; it identifies high-performing MOFs at STP without the need for expensive physical testing.

Second Place

Nadia Lach-Hab *Washington-Liberty High School*

SeizNow: A Highly Accurate Mathematical Model for Automated Diagnosis of Pediatric Seizures

The purpose of this experiment is to examine the mathematical relationships that exist within electroencephalogram (EEG) data and to determine if those relationships can help diagnose pediatric seizures. There is currently no cost-efficient automated way to detect seizures solely based on EEG data. This research aims to find a reliable way to detect seizures by determining the relationship between the discrete energy differences of pediatric seizure EEG data and pediatric non-seizure EEG data. A neural network was coded to analyze the discrete energy differences and classify EEG data into seizure and non-seizure groups with an 87% accuracy. The discrete energy differences between the two groups were statistically different, so the null hypothesis was rejected. Non-seizure data had higher discrete energy values, indicating that the EEG graphs for the seizure group's discrete energy differences were smoother overall and had less distinct changes between the relative minimums and maximums. This project highlights the importance of examining mathematical properties, such as discrete energy, to indicate seizure activity. This project was the first to successfully apply discrete energy to medical research. This neural network could be expanded to help automate seizure diagnosis in pediatric patients in real-time, assisting healthcare professionals. Notably, since the project was developed at no cost, it can also be applied to low-income communities, ensuring broader access to essential healthcare technology.

Third Place

Mason Minkler *Central Virginia Governor's School*
Which Satellite Mega-Constellation has the Greatest Impact on Ground-Based Observatories

The purpose of this study was to determine which satellite mega-constellation, such as Starlink or OneWeb, has the greatest photometric impact on ground-based observatories. To accomplish this, the study employed the use of four formulas, one of which was modified over the course of the study. These formulas are the number of satellites in a constellation; the number/fraction of visible, illuminated satellites in a constellation; the magnitude (brightness) of the constellation; and the threshold magnitude of the constellation. The number of visible, illuminated satellites was determined by calculating the exact number of satellites that would be visible at astronomical twilight, where most astronomical observations take place. The study determined that Telesat Lightspeed has the lowest magnitude (highest brightness), Amazon Kuiper has a slightly higher magnitude, and Starlink Generation 2's magnitude falls just above Kuiper's. Starlink Generation 2, however, has the greatest number of visible, illuminated satellites of any constellation. The Analytical Hierarchy Process, or AHP, was used to determine which mega-constellation actually has the largest photometric impact on ground-based observatories. Based upon the AHP priorities, which ranked magnitude as the first most influential characteristic, the number of visible and illuminated satellites second, and the number of visible satellites last, Starlink Generation 2 became apparent as the constellation with the greatest impact on ground-based observatories. While this conclusion supported the research hypothesis and rejected the null, the study also revealed that all satellite constellations are brighter than the recommended thresholds.

Speleological Society Award
Shriya Bandla, Tess Vithoulkas *Mills E. Godwin High School*
Using Modeling Methods to Analyze Environmental Effects on Coral Regeneration

Coral reefs are vital ecosystems threatened by rising ocean temperatures, turbidity, and reduced oxygen levels. This study used a NetLogo agent-based model, a Python-based ODE model, and Monte Carlo simulations to assess these stressors' effects on coral regrowth. Results showed that increased temperatures and high turbidity hindered coral recovery, while moderate turbidity had limited benefits. Corals in optimal conditions (23-26°C, stable oxygen) had the highest regrowth, while extreme stressors led to inconsistent recovery. Monte Carlo simulations demonstrated coral resilience variability. Statistical analyses supported the hypothesis that temperature, turbidity, and oxygen fluctuations impact regrowth, reinforcing coral vulnerability to climate change. Findings align with research by Smith et al. (2007) and NOAA (2024), emphasizing temperature's critical role. While moderate turbidity mitigated thermal stress, excessive levels remained harmful. The study's limitations include the exclusion of ocean acidification and extreme weather. Future research should integrate these stressors and refine predictive models with real-world data. Effective conservation efforts should prioritize mitigating temperature fluctuations, reducing sediment runoff, and stabilizing oxygen levels to enhance coral resilience Further studies should explore multiple interacting stressors to improve conservation strategies.

Logan Houlihan *Central Virginia Governor's School for Science and Technology*
The Effect of Spoiler Length and Depth on Drag and Downforce

The purpose of this research was to see the effect of varying depths and lengths in a rear-spoiler on drag and downforce, and the effect of such forces on braking distance. The experiment was conducted using the SOLIDWORKS student software, specifically its CAD creation and fluid simulation software. In total, eighteen different spoiler models were created and tested, with three variations in depth ranging from 0 cm to 10 cm, and six variations in length ranging from 10 cm to 30 cm. The data was then processed in excel using the 2-way ANOVA with replication feature, using multiples of each mean. These tests all indicated significance, achieving F-values of 65535, which are far greater than the F-critical values, which were each beneath five in value. This significance led to the requirement of a post-Hoc test specifically, a Tukey Test. These tests had a Qmin of 6.34. Significant values over this were found more often than not with increases in overall size and depth having the largest effects, specifically on downforce. In the end the data found held significance and supported the research hypothesis: If the size and depth of a rear-spoiler is increased, then both the drag and downforce would also increase. Although the values found for drag were low the significance found still holds importance for possible extensions upon research.

Sidh Jaddu *Thomas Jefferson High School for Science and Technology*
A Novel Framework for Efficient Discovery of Synthesizable, Biodegradable Plastics Using the Simplified Molecular Input Line Entry System and a Transformer-Based Synthesizability Assessment Tool

While plastics are versatile and convenient, they have severe environmental impacts, with about 400 million tons of plastic waste produced annually. Existing biodegradable alternatives are either expensive or not easily biodegradable. Given the time-consuming nature of developing new alternatives, researchers are turning to deep-learning methods to identify promising copolymer alternatives. However, there is currently no method to ensure copolymer chemical synthesizability faster than manual testing. Using deep learning, this study created a novel framework for identifying biodegradable copolymers with properties similar to conventional plastics that are also synthesizable. In this study, two deep-learning models were first created. To assess copolymer synthesizability, a synthesizability assessment tool was created by fine-tuning the ChemBERTa transformer on PSMILES sequences of 43,830 synthesizable polymers (including augmented data) through masked language modeling with a custom loss function, attaining an accuracy of 92%. Next, to predict copolymer properties, property predictors were built by training gated recurrent units on the PSMILES of thousands of copolymers and five corresponding properties, achieving an average R^2 of 0.911 across these five properties. After the models were built, 1,837,970 biodegradable candidates with corresponding PSMILES sequences were computationally created. Then, using the property predictors and the k-Nearest Neighbors algorithm, 250 candidates with predicted properties most similar to plastics were chosen. Finally, using the synthesizability assessment tool, these 250 candidates were further narrowed down to 40 synthesizable, biodegradable, plastic-like candidates. This AI-driven framework significantly reduces the number of candidates requiring further evaluation, addressing a key challenge in biodegradable materials development.

Medicine & Health A (HS MDH A)

Dr. & Mrs. Preston Leake Award in Applied Chemistry
First Place
Arinan Johri *Maggie L. Walker Governor's School*
Using SGLT2 Inhibitors to Treat Medically Induced Nephrotoxicity and Kidney Injury

Cisplatin is a widely used chemotherapy agent with significant efficacy in treating various cancers. However, its clinical utility is often limited by nephrotoxicity, a severe side effect characterized by kidney inflammation and oxidative stress. Pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6 play pivotal roles in cisplatin-induced renal damage. Dapagliflozin, an SGLT2 inhibitor, has demonstrated renoprotective, anti-inflammatory, and anti-fibrotic effects in treating chronic kidney disease (CKD) and type 2 diabetes, making it a promising candidate for mitigating cisplatin-induced nephrotoxicity. This study aims to evaluate the protective effects of dapagliflozin on cisplatin-induced kidney injury in a mouse model, focusing on cytokine expression and collagen deposition as markers of inflammation and fibrosis. If dapagliflozin's anti-diabetic properties can be used to treat cisplatin-induced kidney injury, then it can be prescribed alongside cisplatin to aid cancer patients and retain renal health. Kidney tissues from four experimental groups—negative control, positive dapagliflozin control, cisplatin, and cisplatin with dapagliflozin—were analyzed. Tissues were homogenized, and cytokine levels (TNF-α, IL-1β, and IL-6) were quantified via immunoblotting. Collagen deposition was assessed using Sirius Red staining. Statistical analyses were performed using ANOVA and Tukey's HSD ($\alpha = 0.05$). Dapagliflozin significantly reduced cytokine levels in cisplatin-treated tissues. IL-1β levels decreased by 0.54-fold ($p = 0.0051$), IL-6 by 0.72-fold ($p = 0.0265$), and TNF-α by 0.72-fold ($p = 0.0294$) compared to the cisplatin group. Sirius Red staining revealed reduced collagen levels in cisplatin-treated tissues with dapagliflozin, comparable to control groups, indicating decreased fibrosis. Cytokine levels in the cisplatin group were significantly higher than in the other groups ($p < 0.05$), while dapagliflozin co-administration effectively restored cytokine levels toward normal ranges. Dapagliflozin mitigates cisplatin-induced nephrotoxicity by reducing pro-inflammatory cytokines and collagen deposition in kidney tissues. These findings suggest that dapagliflozin has potential as a co-therapy with cisplatin to protect renal function without compromising anti-cancer efficacy. Further studies are warranted to translate these results into clinical settings.

Second Place
Nuveena Sooriya *Maggie L. Walker Governor's School*
Presence of CB1 Receptors in the Fundus and Antrum of the Stomach

Background: The endocannabinoid system (ECS) is a complex signaling network that regulates numerous physiological functions, including mood, memory, appetite, pain sensation, and immune response. Key endocannabinoids such as anandamide (AEA) and 2-arachidonoylglycerol (2-AG) play crucial roles in maintaining homeostasis. Cannabinoids, both endogenous and exogenous, interact with the ECS and have been implicated in various neurological and gastrointestinal processes. This study aims to investigate the presence of CB1 receptors in the fundic and antral regions of the rat gastric mucosa to better understand their potential role in gastrointestinal function. Methods: mRNA was extracted from rat gastric fundic and antral tissues to assess CB1 receptor expression. Due to the instability of mRNA, it was converted into complementary DNA (cDNA) using reverse transcription (RT). Oligo(dT) primers were mixed with extracted mRNA in a sterile reaction tube to facilitate this process. Polymerase Chain Reaction (PCR) was then performed to amplify CB1 receptor sequences, and the presence of CB1 mRNA was confirmed using gel electrophoresis. Results: Gel electrophoresis revealed a distinct band at approximately 473 base pairs (bp) in lanes corresponding to rat stomach parietal cells, which matches the expected size for CB1 receptor

mRNA. This confirms the presence of CB1 receptor transcripts in both the fundic and antral mucosa, indicating active gene expression. Given that mRNA is a precursor for protein synthesis, these findings strongly suggest that CB1 receptors are expressed in these gastric regions. Conclusion: The confirmation of CB1 receptor expression in the stomach's fundus and antrum has significant implications for understanding the role of the ECS in gastrointestinal function. These findings provide insight into how cannabinoids, both endogenous and exogenous, influence gastric secretions, motility, and overall gut health. Further research, such as quantitative PCR or Western Blot, can be used to explore the functional consequences of CB1 receptor activation in the stomach and its potential therapeutic applications.

Third Place
Persia Martinez-Goggins *Central Virginia Governor's School for Science and Technology*
The Effect of an Altered Circadian Rhythm on the Reproductive Output of *Drosophila melanogaster*

The purpose of this study was to determine how an altered circadian rhythm affects the reproductive output of the model organism, *Drosophila melanogaster*, and thus potentially humans. WIII8 and 80903 Drosophila types were used in which the 80903 types had no circadian clock, while the WIII8 type did. All groups for both fly types included one virgin female with three males to mate with under either a 12:12 hour light: dark cycle, or a 20:4-hour light: dark cycle. They remained in plastic flasks with a petri dish at the bottom containing an agar-grape juice solution to assess egg-output using a microscope. These flasks were then placed under box-shaped darkness chambers with light bulbs inside, timed to exhibit correct light: dark ratios. Using an alpha value of .05, a two-way ANOVA test revealed significance for the light: dark cycles and the interaction within groups, but not for fly type, as the resulting p-values were 2.553x10-10, .0477, and .0741, respectively. A post-hoc Tukey test showed significance between all 20:4 and 12:12 cycles across both fly types. WIII8 and 80903 types both under the 12:12 cycle were also significant, but not those under the 20:4. These results supported the research hypothesis, which stated that both fly types under the 20:4 cycle would produce less eggs than those under the 12:12 cycle. In summation, a disrupted circadian rhythm reduced egg production, which points towards how overexposure to light can impact reproductive health.

Honorable Mention
Eshan Nath *Mills E. Godwin High School*
The Effect of Different Foods on Blood Pressure

This study investigated the effect of different foods on blood pressure, focusing on dietary interventions as a non-pharmacological approach to hypertension management. The hypothesis for this experiment was that garlic would cause the greatest decrease in blood pressure. An experiment was conducted with 25 participants, aged 14-15. This group consisted of both males and females. Participants were given one food each day, excluding Monday. Monday was when the control took place, which was a regular diet. Blood pressure measurements were taken before the food was eaten, and then they were taken again 2 hours after eating the food. Both measurements were recorded and used to find the decrease of blood pressure. Only the difference in the systolic pressure was placed into the data table since this experiment did not focus on aortic health. Results showed significant reductions in systolic blood pressure for garlic, which had a mean decrease of 14 mmHg. Walnuts, bananas, and oats showed a lower reduction of blood pressure when compared to garlic. Walnuts and bananas had an average decrease of 7mmHg, while oats had 8 mmHg. When an inferential statistics test was conducted with each experimental group against the control, it was found that all levels of the independent variable had significant data ($p<0.01$). These findings indicate that incorporating specific nutrient-rich foods into the diet can significantly lower blood pressure, providing an accessible and effective strategy for hypertension prevention and management. All of these foods were scientifically proven to reduce blood pressure, so a decrease in blood pressure was expected for all these foods.

Honorable Mention
Claire Ramsey *Central Virginia Governor's School for Science and Technology*
The Effect of Caffeine on the Inhibition of Growth of *Lactobacillus acidophilus*

The purpose of this study was to determine if the amount of caffeine given to *Lactobacillus acidophilus* has any effect on the growth rate of the bacteria. The hypothesis was if the highest caffeine concentration was cultured with *L. acidophilus*, then it would inhibit the growth of the bacteria the most. This study was conducted using aseptic technique to create bacteria cultures and serial dilutions to create caffeine

concentrations. Four concentrations were used for each trial: a control group using MRS broth with no caffeine, and MRS broth with varying amounts of caffeine, (3%, 1.5%, and 0.75%). Each bacteria culture grew for 3 days in a 37℃ incubator in MRS broth. Later, caffeine concentrations were added, and the culture grew for 3-5 additional days. A spectrophotometer was used to measure the absorbance of each group, resulting in an average absorbance of 0.32367 for the .75% concentration, 0.31067 for the 1.5% concentration, 0.24033 for the control group, and 0.19 for the 3% concentration. Higher absorbance indicates more bacteria growth. A single factor ANOVA determined the results were not statistically significant, with a p-value of .197917 and an alpha level of .05. Thus, the research hypothesis was not supported but rather the null hypothesis was retained: there is no effect of caffeine on the growth rate of *L. acidophilus*. The results show that the amount of caffeine present in a sample has no effect on the growth rate of the *Lactobacillus acidophilus*.

Honorable Mention

Benjamin Ziegler *Central Virginia Governor's School for Science and Technology*
The Effect of Sleep on Blood Pressure in Adolescents

This study investigates the effects of sleep duration and quality on systolic and diastolic blood pressure in adolescents aged 13 to 18. While sleeping's pivotal importance in physical health is well known, its specific role in cardiovascular health among adolescents remains uninvestigated. The purpose of this study was to find supporting evidence that poor sleep correlates with elevated systolic and diastolic blood pressure. The data were collected through participants recruited through school announcements, who were then asked to fill out daily self-reported surveys and the Pittsburgh Sleep Quality Index (PSQI). Blood pressure readings were self-recorded using digital monitors, and the data was analyzed to identify trends between sleep variables and blood pressure levels. While the findings in the regression tests did not reveal statistically significant relationships, since the p-values were all greater than the alpha value, 0.05, between sleep and blood pressure, the study underscores the challenges of assessing physiological impacts of sleep in adolescents and suggests directions for future research. This does not support the hypothesis of investigating how the amount of sleep and sleep quality of an adolescent effect blood pressure in the morning and at night before bed. Continued exploration with larger sample sizes and controlled experimental designs may yield deeper insights into the potential connections between sleep and cardiovascular health in this age group.

Victoria Coles *Central Virginia Governor's School for Science and Technology*
Comparing the Effects of Homeopathic Remedies and Antibiotic Vancomycin on *S. epidermidis*

The purpose of this study was to determine if homeopathic remedies could be more effective in treating *Staphylococcus epidermidis* compared to the antibiotic vancomycin. The research hypothesis of this experiment was that if honey, turmeric, apple cider vinegar, vancomycin, and a control group of distilled water were placed on an even lawn of S. epidermidis, then the group with apple cider vinegar would create the largest zone of inhibition, therefore being the most effective. This experiment was done by aseptically culturing bacteria 24 hours prior to creating spread plates, creating sterile filter disks for each solution, spreading an even lawn of bacteria on an agar plate, then measuring the diameter of the zones of inhibition 24 hours later. The average diameters for vancomycin, apple cider vinegar, honey, turmeric, and water were 22.375 mm, 12.625 mm, 2.125 mm, 0 mm, and 0 mm respectively. After running a one-way ANOVA, it was determined that the p-value was 3.813×10^{-23}. Compared to the alpha value of .05, the null hypothesis was rejected. The minimum statistically significant difference was 2.95, therefore the groups with vancomycin and apple cider vinegar had a significant difference from the control group. The results, however, did not support the research hypothesis as the group with vancomycin had the largest zone of inhibition. The results of this study indicated that apple cider vinegar could be an effective method to remedy staph infections; however, it is not as effective as the antibiotic vancomycin.

Clinton Hubbard *Central Virginia Governor's School for Science and Technology*
The Correlation of Low Heart Rate Training on VO2 Max

This research analyzed the effect of low heart rate training on athletes' VO2 max. Data were obtained from an online dataset to explore the relationship between low heart rate training and VO2 max. The low heart rate zone was calculated by taking 60% of the maximum heart rate using age-predicted heart rate max. Pearson correlation test was conducted to evaluate the relationship between low heart rate training and

VO2 max, indicating a weak relationship between the two variables. Furthermore, a t-test to determine significance resulted in a p-value of .126. The results were not statistically significant when compared to an alpha value of .05, as the p-value attained was greater than the alpha value. Consequently, the research hypothesis that training in a low heart rate zone will increase VO2 max was not supported. Although this study found little evidence of a correlation between the variables, future research with more accurate and comprehensive datasets may reveal a stronger relationship between low heart rate training and VO2 max.

Matthew Lucas Miller *Central Virginia Governor's School for Science and Technology*
The Effects of Hemp Seed Oil Ingestion on the Lifespan of AD-induced *Drosophila melanogaster*

The purpose of this study was to determine if hemp seed oil would have an effect on the symptoms of Alzheimer's Disease (AD), specifically on the lifespan. Wild-type (W118) and AD-induced (AppId) *Drosophila melanogaster* were used as model organisms, and the flies were bred in vials of molasses-based food either with or without 91.5 µL hemp seed oil mixed in. Once the offspring matured into adult flies, they were sexed under a Zeiss microscope, and the males were placed into vials for observation of their lifespans. Collected data was analyzed in Excel, and a one-way ANOVA test gave a p-value of .197, higher than the chosen alpha value of .05. The research suggested that the ingestion of hemp seed oil had no effect on the lifespan-affecting symptoms of AD, and the research hypothesis that assumed an increase in the lifespans of the flies had to be rejected. The obtained results do not point to hemp seed oil as being a possible preventative measure or treatment for the symptoms of Alzheimer's Disease or other neuroprotective diseases.

Mia Nock *Mills E. Godwin High School*
The Effect of Palm Cooling on Pushup Endurance

This study was conducted to determine the effect of different intensities of palm cooling on work volume capability in pushups. To conduct this experiment, twenty-five volunteers completed four experimental days, each testing a different intensity of cooling. Each day, participants performed two sets of pushups to failure with a three-minute rest period in between, during which they received one of four levels of cooling (two hands in cold water for two minutes, two hands for one minute, one hand for one minute, or the control of no cooling.) This control was included to determine each participant's baseline, allowing any changes in performance with palm cooling to be observed. A statistical analysis revealed that all levels of cooling were significant vs. the control ($p < 0.01$). The greatest mean of pushups completed in the second set compared to the first set was 94.5% for two hands in water for two minutes, compared to 73.2% in the control group, supporting the hypothesis that cooling two hands for two minutes would result in the greatest number of pushups completed. Prior research suggests this improvement is made possible because soaking palms in cold water circulates cooler blood around the body, reducing core temperature and allowing muscles to remain in a functional temperature range for longer. This research is valuable to anyone hoping to improve muscular strength and endurance. Additionally, as steroid use has become a prevalent problem, introducing a natural, effective method of performance enhancement could be beneficial to reducing drug use in athletes.

Stryder Parsons *Central Virginia Governor's School for Science and Technology*
Effect of Nutrients intake on Heartrate Variability

The purpose of this study was to find if there was any correlation between maximum or minimum heartrate and the amount of protein and carbs consumed. This study was conducted using a dataset found online in 2024. The hypothesis was that if someone was lacking in carbs and protein, then their heartrate may have an irregular variability. I found the amount of carbs and protein consumed for each day in the dataset and then I found each maximum and minimum heartrate for each day. I then used correlation and regression tests to see any significance between each variable. My data was not significant with a lowest p-value of .15 and an alpha of .05. Therefore, I rejected my hypothesis that stated, carbs and protein would have an effect on heartrate variability, and I retained the null that stated, there would be no effect of carbs and protein on heartrate variability. In conclusion, the amount of carbs and protein consumed does not have an effect on maximum and minimum heartrate, but nutrition still plays a vital role in keeping healthy and having energy for exercise and other daily activities.

Nalayna Stanley *Central Virginia Governor's School for Science and Technology*
Recovery Methods after a Hard Effort

The purpose of this study was to determine the best recovery method between walking, hands on head, and hands on knees, after a hard effort of running. The study was conducted at a local track using high school students who are runners with experience. Each week the participants were tasked with running a mile and performing a recovery method prescribed for that day. The researchers recorded participant heart rates before, after, and every minute for five minutes to determine how well each of the recovery methods performed. Each group before and after data points were in separate tables and a paired T-test assuming equal variance was run on each. The resulting p-values were .3586 for walking recovery; .3538 for hand-on-knee recovery; and 7.8699x〖10〗^(-5) for hands-on head recovery; resulting in the hands-on-head recovery being the only significant result due to the accepted alpha value of .05. Also, a single-factor ANOVA over all groups using the differences of before and after as data points resulted in a p-value of .1723, making the results insignificant due to the accepted alpha value of .05. These results did not support the hypothesis that said If the best recovery method is hand on your knees, then the heart rate will be lower than the walking around or putting hands on head. In summation, finding the best recovery method for one's needs can be hard, it depends on the person and how their body reacts to the method of their choice.

Rebecca Templeton *Central Virginia Governor's School for Science and Technology*
The Effects 13-cis-rentinoic Acid Has on the Egg Production in *Drosophila melanogaster*

The purpose of the research was to determine if using 13-cis-retinoic acid (Isotretinoin), affects the fertility of different sexes of Drosophila melanogaster. Within this research, each group of D. melanogaster was given .10mg of 13-cis retinoic acid (Isotretinoin). The groups consisted of females only exposed, males only exposed, both sexes exposed, and none exposed. To sex the D. melanogaster, a Zeiss Stemi 305 microscope was used. The D. melanogaster was then mated for 24 hours, and afterwards the eggs were left to develop. The number of flies that emerged each day was recorded in an Excel spreadsheet, to provide total counts of offspring produced in each of the exposure groups. To determine if the data was significant a Chi-Square Goodness of Fit test was run with the total number of flies emerging which was 34 for females, 36 for males, 34 for none, and 29 for both. The p-value after running the chi square was .17 this means the null hypothesis failed to be rejected since the alpha value of 0.05 is lower than the p-value. The Chi-Square test found that the data did not support the hypothesis of, if 13-cis-rentinoic acid is given to different sexes then there will be a significant difference in the output rate of the offspring. This conclusion was also evident after finding the total number of flies and seeing that the sums were all relatively similar. To summarize, the research data failed to reject the null hypothesis and the takeaway from this experiment is that the active ingredient in Accutane does not affect the fertility of either sex.

Ellie Tibbs *Central Virginia Governor's School for Science and Technology*
The Correlation Between Beverages Consumed and Mood within High School Students

The purpose of this study was to determine if there was a correlation between anxiety and the consumption of caffeinated drinks. Research was conducted via online survey, through a local high school. The survey consisted of questions about the number of drinks consumed with caffeine that day, as well as relating to how much anxiety a person was having, as well as their gender. The anxiety questions were from an already existing survey. The responses from this survey were used to find if there was a statistically significant difference between anxiety and drinks containing caffeine. When analyzing data, a correlational analysis and two sample t-tests were used. The correlational test analyzing drink consumption and anxiety score came back as not significant with a correlation coefficient of .03 and with a critical value of .273. Two Two-sample T-tests analyzed the significance between male and female anxiety scores and the number of drinks consumed. The test with anxiety scores came back with a t-stat of 2.81 and a T-critical of 2.01 ultimately showing significance, showing a difference between males and females. However, the drinks consumed came back with a T-stat of .13 and T-critical of 2.01, showing no significance. The correlation coefficient ultimately did not support the research hypothesis, which stated, the more drinks containing caffeine a high school student drank, the higher the anxiety level they would have. In conclusion, this study showed that the amount of caffeine consumed did not significantly affect the levels of anxiety within high school students.

Medicine & Health B (HS MDH B)

American Junior Academy of Science Alternate
First Place
Priya Kumar *Maggie L. Walker Governor's School*
Metabolic Dysfunction and Cervical Intraepithelial Neoplasia: Investigating Diabetes as a Risk Factor for High-Grade Squamous Intraepithelial Lesions

Cervical cancer remains a major public health concern, with disparities in incidence and mortality disproportionately affecting non-Latine (nL) Black women. Diabetes has been implicated in cancer progression due to its impact on immune function, inflammation, and metabolic dysregulation. However, its role in cervical intraepithelial neoplasia (CIN) progression, particularly in racially diverse populations, remains underexplored. This study examines the association between diabetes and high-grade squamous intraepithelial lesions (HSIL) and assesses racial disparities in CIN progression, with a focus on nL Black women. A retrospective cohort study was conducted using electronic health records from Virginia Commonwealth University Health System (VCUHS) between 2014 and 2021. The study included 2,189 women diagnosed with CIN, stratified by diabetes status and race. Multivariable logistic regression models assessed the association between diabetes and HSIL risk while controlling for demographic and clinical covariates. Despite the higher overall cervical cancer burden among nL Black women, a lower proportion of HSIL diagnoses was observed compared to nL White women. Diabetes was significantly associated with an increased risk of HSIL, particularly among nL Black women. The risk of HSIL was nearly sevenfold higher in Black women with diabetes compared to their counterparts without diabetes. These findings underscore the role of metabolic dysfunction in cervical cancer progression and highlight the need for integrating diabetes management into cervical cancer prevention efforts. Future research should explore targeted interventions, address social determinants of health, and foster interdisciplinary collaborations to mitigate disparities and improve outcomes.

Cancer Research Award
Second Place
Athithi Prakash *Blacksburg High School*
Novel Engineered Anticancer Biomaterial for Non-Invasive Melanoma Treatment

Skin cancer is the most commonly diagnosed cancer in the United States. Melanoma causes the majority of skin cancer related deaths. Current melanoma treatment options of surgery and immunotherapy are invasive and have low response rates. This research aims to develop a novel topical melanoma treatment by engineering temporin-1CEa, an anticancer peptide (ACP), into the C-terminal of CsgA (a nanofiber base unit) for localized drug delivery to address current treatment limitations. While temporin-1CEa is specific and highly toxic to cancer cells, its systemic administration incurs high off-target effects. Nanofibers support, protect, and prevent diffusion of the peptide, leading to localized and controlled treatment. The hypothesis tested was that the peptide-nanofiber complex would retain temporin-1CEa's anticancer activity while exhibiting cytotoxicity comparable to that of 5-fluorouracil (5-FU), the current standard topical treatment for skin cancer. This was evaluated via multiple LDH (lactate dehydrogenase) assays assessing the cytotoxicity of temporin-1CEa nanofibers against the human melanoma cell line A-375. Results indicate that the peptide-nanofiber complex maintains anticancer activity while allowing for localized treatment. Statistical analyses, including ANOVA, or Analysis of Variance, ($F(3,8) = 8.87$, $p = 0.0063$), revealed that the peptide-nanofiber complex was significantly more cytotoxic than 5-FU ($p < 0.05$) at 50 ug/uL. These findings suggest that nanofiber-based ACP delivery could serve as an effective, targeted treatment for melanoma. This project is the first to develop and test a non-synthetic nanofiber-anticancer peptide platform, reducing ACP off-target effects significantly. Given temporin-1CEa's broad spectrum activity, the biomaterial could be adapted globally to treat other skin cancers.

Third Place
Jerry Li *Mills E. Godwin High School*
Investigating the Molecular Mechanisms of Curcumin's Anticancer Activity

The scientist's previous study revealed that curcumin can potently suppress human head and neck squamous cell carcinoma (HNSCC) cells growth and proliferation. In this study, the molecular mechanisms underlying this event were explored, using culture HNSCC cell lines as the model. Western blot, RT-qPCR, and tumor sphere formation assay were adopted to examine the mechanisms by which curcumin suppresses HNSCC tumorigenesis. Statistical analysis, including t-tests supports the rejection of the null hypothesis, affirming the research hypothesis that curcumin would suppress HNSCC oncogenesis via inhibiting master regulator of HNSCC, NF-kB p65 (p65), protein level and the consequent downstream key oncogene expression directly controlled by p65. This study contributes valuable insight into the potential use of curcumin as a complementary or alternative drug in traditional cancer therapy strategies.
Keywords: tumorigenesis; proliferation; cancer therapy; herbal medication; human head and neck squamous cell carcinoma

Honorable Mention
Anandi Sarkar *Mills E. Godwin High School*
The Effect of Environment on Microplastic Abrasion Via Alkylating Agents

This experiment investigates the quantitative impact of various storage conditions on microplastic emission from polyvinyl chloride (PVC) polymer bags traditionally used in the pharmaceutical industry to store acidic chemotherapy agents. Plastics such as PVC have been shown to shed microplastics, which have been shown to be devastating to human health, creating chronic problems in the kidney, the lungs, the digestive system, and shortening life spans significantly. In this study, PVC chemotherapy bags were subjected to four storage conditions: (1) Room temperature storage in the dark for 6 hours, (2) Ambient sunlight exposure at room temperature for 6 hours, (3) Submerged in a hot water bath at 60 ˚C for 2 hours, and (4) Submerged in an ultrasonic bath at 20 kHz for 2 hours. Bags stored in a dark refrigerator at 3 ˚C served as the control condition as it represents ideal storage conditions. Microplastic emission was measured using gravimetric analysis, and it was hypothesized that deviations from the ideal storage condition would result in a statistically significant increase in microplastic abrasion. Indeed, results showed that the control sample emitted 0.02294 g of microplastics, while the emissions from Conditions 1, 2, 3, and 4 were 0.03321 g, 0.02986 g, 0.02866 g, and 0.03030 g, respectively. A statistical t-test revealed significant differences between the experimental conditions and the control in complete agreement with the hypothesis, likely because improper storage conditions lead to the degradation of the polymer structure in PVC bags, resulting in microplastic release.

Honorable Mention
Nicholas Thompson *Southwest Virginia Governor's School*
The Impact of Arm Position on Blood Pressure Measurements

Hypertension is a major problem that can possibly be over diagnosed. The possibility arises from the impact of arm position on blood pressure (BP) readings. Previous work suggests resting patients' arms on a desk at heart level is the most effective way to measure BP. Other, more common, ways of measuring BP are resting the arm in the lap or by the side of the patient. This study compared all three of these measuring procedures to investigate differences in 16-18 year olds. A 5-minute rest was required before measurements to prevent elevated BP from prior activities, and 3-minute-long rests were given between each measurement. Resting the arm on a desk at heart level resulted in significantly lower systolic BP measurements (117.55+/-3.45) when compared to the other two arm positions: By side (130.11+/-2.73; p= 0.0181) and In lap (130.83+/-3.20; p= 0.0081). Diastolic measurements were also significantly lower when measured on the desk (67.61+/-2.39) compared to by side (78.67+/-2.41; p= 0.0021) and In lap (77.44+/-1.64; p= 0.0067). The overall conclusion was that resting arms at heart level is the most accurate way of measuring BP because it resulted in a significantly lower BP measurement than by the side or in the lap; additionally, this lower measurement is more closely aligned with expected BP range for 16-18 year olds. Further investigation should be done on this topic in additional age groups in order to advocate for the proper measuring position to be implemented and the only way to accomplish it is to have the data to support or deny which way is the most effective.

Kylie Caraher *Mills E. Godwin High School*
The Effect of Different Types of Sports Drink on Heart Rate (bpm)

This research investigated the effects of different types of sports drinks on the heart rate of *Daphnia magna* The experiment focused on caffeine, sugar, and electrolytes. The study aimed to understand the impact o these drink components on heart rate, given the major concerns about their negative effects, especially drinks involving caffeine. The investigation tested Prime, Powerade, Propel, and water, with spring water as the control. *Daphnia magna* were placed in two sets of containers with different water levels of 0.5 mL and 4.5 mL, and their heart rates were recorded before and after exposure to the drinks. The results showed tha Prime had the largest impact on heart rate, causing a rapid decrease that led to the *Daphnia magna's* death which disproved the research hypothesis. Statistically significant differences were found between water and all sports drinks, and between Prime and Propel, but no significant differences were observed between Prime and Powerade, or Powerade and Propel. The findings suggested that sports drinks significantly affect hear rate, though the deaths of *Daphnia magna* may have tampered with the results due to harsh particles unsuitable water conditions, or incorrect drink ratios. Future research should focus on improving methods specifically by adjusting drink concentrations and reducing the amount of handling, to better understand the effects of sports drinks on heart rate.

Leo Chang *Central Virginia Governor's School*
Galleria mellonella as a Proxy for the Human Immune Response Allium Sativum's Effectiveness against *E. cloacae*

This study aimed to evaluate the effectiveness of garlic extract against *E. cloacae* infections. First, inhibition zones were created using lawns of *E. cloacae* and sterile disks soaked with decreasing concentrations of garlic extract. A one-way ANOVA ($\alpha = .05$, $p = 4.36x10^{-27}$) followed by a Tukey test identified 100% garlic extract as the MIC. Seven trials involved *Galleria mellonella,* which has a comparable innate immune response to that of humans, being divided into five groups: *E. cloacae* control, PBS control, garlic extract control, prophylactic treatment, and therapeutic treatment. Larvae were injected with 10µl of inocula, with bacteria and garlic extract injections separated by two hours for treatment groups. Survival was measured every 24 hours over 72 hours. A one-way ANOVA ($p = 2.41x10^{-13}$) and Tukey test revealed significant differences between therapeutic and prophylactic treatments. A two-sample t-test between prophylactic and therapeutic treatment groups ($p = .007$) confirmed the higher effectiveness of therapeutic treatment. A parallel experiment collected hemolymph from larvae every 24 hours after the last injection starting at the 2-hour mark. A one-way ANOVA ($p = 6.31x10^{-31}$) and post-hoc test highlighted significant differences between treatments, supported by a two-sample t-test ($p = 3.74x10^{-8}$), again confirming the superior efficacy of therapeutic treatment. These findings validated the H1 hypothesis but did not support the H2 and H3 hypotheses which suggested the prophylactic treatment would increase survival rate and decrease PO in hemolymph. The results suggest that while prophylactic treatment may not be effective, therapeutic treatment should be researched further.

Ekaterina Fulga *Mills E. Godwin High School*
The Effect of Different Probiotic Food on Digestion Speed

The purpose of the study was to find which popular probiotic would help digest food the fastest. The experiment included a control with no probiotics, greek yogurt, kombucha, and Olly supplements. The dependent variable was measured by measuring the rate of the surface area decreasing as the test subject was digested. The topic is important to the real world because many people suffer from indigestion-related problems which probiotics can help. The hypothesis indicated greek yogurt to digest the fastest. There was a control of no probiotics to understand the impact of the independent variables. The overall procedure was to put on protective gear, put probiotics in hydrochloric acid, dilute the left-over mixture and dispose of it. The fastest digesting probiotic food was kombucha, which had a -0.444 cm^2/min average digesting rate. The slowest rate was the control (no probiotic food) which had a -0.115 cm^2/min average digesting rate. Out of the probiotic foods, Olly supplements were the slowest to digest with a -0.152 cm^2/min average digesting rate. All independent variables were significant except for the supplements because the t-test was lower than the calculated t-test.

Varidhi Hunasgi *Mills E. Godwin High School*
The Effect of Different Drinks on Endurance in Sports

Endurance is an essential aspect of sport, and the fuel consumed beforehand is a part of that. Finding the right type of drink impacts how well the sport is performed, as this is the part in which many struggle to find one that tends to be the most convenient and effective. This experiment tests how different drinks affect endurance in sports, using humans as test subjects. There are five levels of IV (Independent Variable) and one control group, water. The hypothesis stated that if a participant drank 400mL of coconut water, then they would last the longest in comparison to the other IV levels. After each participant drank whatever beverage corresponding to the level of IV they were on, they were asked to run on a flat surface for as long as they could while being timed. The data was recorded, and the process was repeated with the other participants and levels of the IV. Once all the data was collected and tests were run, it was concluded that the data that was gathered was statistically insignificant. The T-tests for every level of the IV compared with water had a calculated T lower than the table T. These results provide us with the fact that this may have occurred as a product of a few sources of error, such as the fact that all drinks were consumed on the same day, whether or not the subjects had eaten a nutritious meal before experimentation, and the participants' gender, weight, and sizes varied greatly, making the results less accurate.

Noelle Shelton *Central Virginia Governor's School for Science and Technology*
The Effect of Varying Pseudoephedrine Concentrations on *Drosophila melanogaster* Lifespan

The purpose of this study was to determine the effect of varying concentrations of pseudoephedrine on the lifespan of *Drosophila melanogaster.* For this experiment, the effect of varying pseudoephedrine concentrations (0mg/10g, 0.0001mg/10g, and 0.0002mg/10g) on *Drosophila melanogaster* lifespan was tested. The concentrations of pseudoephedrine were mixed into the food medium, and the lifespan of the newly emerged flies was recorded daily. After completing this experiment, it was found that none of the pseudoephedrine concentrations had a statistically significant effect on the average lifespan of D. melanogaster. This insignificance was determined by running two one-way ANOVA analyses, one for the female groups and one for the male groups. The alpha value was .05, and the resulting p-values for the male and female groups were 0.342 and 0.215, respectively. The results of this study did not support the research hypothesis, as they indicated no significant differences between the average lifespan of *Drosophila melanogaster* when given food mediums containing different concentrations of pseudoephedrine. Since D. melanogaster is used as a human model, this leads to a potential connection to the effect of pseudoephedrine usage on humans.

Aditya Sunilkumar *Mills E. Godwin High School*
The Effect of Synthetic and Natural Bioadhesives on Wound Closure

The following study focuses on an analysis of bioadhesives varying from naturally derived substances to synthetically made adhesives. The experiment aimed to investigate the effectiveness of natural and synthetic bioadhesives. Bioadhesives are believed to be the next frontier of medical sciences as it is an innovative tool that can replace traditional sutures and staples, with their environmental benefits and efficacy. By comparing synthetic (PVA) and naturally derived (Microcrystalline Cellulose and Gelatin) adhesives, bioadhesives are shown to have the capability of reducing bacterial infections in wound care and the post-surgical processes. The hypothesis for this experiment is if a Polyvinyl Alcohol (PVA) bioadhesive was tested against Escherichia Coli, then it would yield the least number of bacteria passed through. The control of the experiment was no bioadhesives. This was to show how much of an effect bioadhesives had on wound closure. The experiment tested bioadhesives on synthetic skin with incisions to measure bacterial penetration of Escherichia coli across the skin medium. Bacterial colonies were observed after forty-eight hours of incubation. All safety protocols were followed, and data was collected to evaluate each bioadhesive's effectiveness. Polyvinyl alcohol yielded the least mean amount of bacterial penetration and Gelatin showed to be the least effective bioadhesive in the group. The data was significant on all counts at a level of significance of 0.01. The experiment's results came out as they are now due to the binding properties in PVA. The substance sticks well to the skin medium and prevents any bacterial leakage.

Medicine & Health C (HS MDH C)

Bethel Award

First Place

Shaankari Ravulaparthi *Mills E. Godwin High School*
A Novel Comprehensive Evaluation of Blood Thinners: Alternative Non-Cardioembolic Stroke Therapy to Minimize Gastrointestinal Bleeding

The experiment's purpose was to determine which blood thinner would most effectively treat non-cardioembolic stroke while minimizing gastrointestinal bleeding (GIB). Antiplatelets are the most common treatment for non-cardioembolic stroke. However, recent studies show that the risk for GI bleeding may increase due to ulcers and erosions in the digestive tract that antiplatelet usage induces. This research comprehensively evaluated different anticoagulants to find an alternative optimal therapy for patients. It was hypothesized that sodium citrate will have the highest comprehensive efficiency among the tested blood thinners. The independent variable levels were vitamin E, turmeric, sodium citrate, and aspirin, an antiplatelet, serving as the control. This investigation was conducted by measuring blood clot masses and internal bleeding by simulating the human body's physiological conditions using representative chemicals. AI was used to evaluate the binding affinities of each drug's target and non-target proteins. Additionally, the data were manually put through a process called score normalization to obtain percent efficiencies. T-tests were conducted on all independent variable levels. Only the data for sodium citrate showed statistical significance. Sodium citrate also exhibited the highest percent efficiency due to its property of chelating free calcium ions which activates factor X, inhibiting the coagulation cascade. The results supported the hypothesis, displaying sodium citrate's potential as a safer alternative. In conclusion, this research could lead to further studies focusing on anticoagulants' effects on gastrointestinal bleeding through proteins like fibrinogen to model coagulation more accurately. Such analyses could provide safer therapeutic options for patients at risk of embolic stroke.

Second Place

Adriana Mendez, Aysha Jafar *Osbourn Park High School*
The Effect of Microplastics on the Fertility of *Caenorhabditis elegans*

Microplastics are becoming increasingly prevalent in today's society through the prolonged use of plastic, making it more important to understand how they can affect the human body. This experiment uses C. Elegans as a basic model for the human reproductive system to find out how microplastics affect the fertility of these worms. To complete the experiment, worms were split into 2 groups of 3 OP50 E-coli seeded plates each, one group for control and one group for microplastics. They were left to mature for 3-4 days and after were inspected under a high-power light microscope to find mature or L4 stage worms. These worms were put into a bleach solution in a process called an egg retention assay to reveal how many eggs were in their uterus. Since egg retention is inversely related to fertility, more eggs retained means less eggs laid, and vice versa. When analyzing the results for the experiment, a t-test was used to see if there was a significant difference between the two groups and whether egg retention increased or decreased, and it was found that the data was statistically significant ($p<0.05$) for ($n=25$ C. Elegans per plate). Furthermore, it was found that the worms treated with microplastics had overall more egg retention than the control worms, and therefore, a decrease in fertility. Through this experiment, it was found that the ingestion of microplastics reduces fertility, and these findings can be used in further research in connection to human health.

Third Place

Shadikshya Subedi, Song Huong Pham *Osbourn Park High School*
Non-Small Cell Lung Cancer: Machine Learning Models' Ability to Predict Surgical Outcomes

This study investigates the correlation between factors such as age, gender, tumor size, location, on success rates in surgical resections for non-small cell lung cancer, known as NSCLC, patients. Utilizing a dataset containing pre-surgical information of 18,701 surgical patients, this study evaluates how those variables influence outcomes, with a focus on successfully predicting surgical survival rates. The results reveal that younger patients, smaller tumors, and favorable tumor locations heavily influence survival rates, with better outcomes. Conversely, older patients and larger tumors negatively affect surgical outcomes. It is also noted that gender had no true importance pertaining to the overall outcome of the success rates. These findings underscore the importance of considering patient variables when it comes to surgical resections for NSCLC

patients. The study also highlights the potential of machine learning models in the field of healthcare to be utilized in clinical settings as a valuable tool, helping to improve surgical resection outcomes with more accurate surgical rates.
Key Words: Non-Small Cell Lung Cancer (NSCLC), Machine Learning (ML) models, Surgical Success, Feature Importance

Honorable Mention
Ceriyah Jean *Mills E. Godwin High School*
The Effect of Antioxidants on Skin Health

This study explored how antioxidants could help keep the skin healthy. Free radicals are harmful molecules that can damage the skin, especially when exposed to environmental factors like sunlight, pollution, and smoke. This damage can lead to problems such as wrinkles, dry skin, and even skin diseases. Antioxidants are substances that can neutralize these free radicals and protect the skin. In this experiment, three different antioxidant serums were tested: Niacinamide 10% + Zinc 1%, Ascorbyl Glucoside Solution 12%, and Granactive Retinoid 2% Emulsion. These serums were compared to a control group that did not use any antioxidants. The objective was to determine how well these antioxidants could improve skin health by making it look better, feel softer, and stay hydrated. By identifying the most effective antioxidants, this study aimed to help people take better care of their skin and reduce the chances of skin problems. The results indicated that using antioxidants in a skincare routine could protect the skin from damage, maintain its youthful appearance, and improve its texture. Overall, antioxidants were shown to be important for maintaining healthy skin and preventing damage caused by free radicals.

Honorable Mention
Aditya Kore *Mills E. Godwin High School*
The Effect of pH Levels on Flintstone Vitamin D Solubility

This experiment aimed to see what effect different pH levels would have on the dissolution rate of Flintstone tablets and find the best pH level. People worldwide utilize these tablets, so many would benefit from this information as they would see results from the medicine faster. The four levels of independent variables were pH levels of 2.0, 2.5, 3.0, and 3.5. There was no control as all these pH levels fell into a possible range of pH levels of the stomach acid. The hypothesis stated that if the pH level is at 2.0, then the Flintstone vitamin D tablet will dissolve the fastest. To test this, lemon juice was poured into a cup with a pH probe to measure the pH to be 2.0. Water was added accordingly to change the pH level. Ten millimeters of this solution were placed into a separate cup where a crushed tablet was placed. The tablet dissolved with the time being recorded in seconds. This process was repeated twenty-five times with the four tested pH levels. The results showed the mean dissolution time was lowest at a pH of 2.0. All the data was significantly different according to t-tests. The collected data agreed with results found by other researchers, who stated that a pH level of 2.0 would cause vitamin D tablets to dissolve the fastest. The dissolution rate for 2.0 was the quickest, most likely due to enzymes in the tablets, which activate best in a more acidic environment.

Honorable Mention
Raya Kumareshan *Mills E. Godwin High School*
Foot Arch Variations Influence Postural Alignment

The purpose of this experiment was to examine the effects of different foot arch types on body posture. Recently, foot arch types such as flat arches, normal arches, mid arches, and high arches have been shown to influence posture and overall body alignment. The foot arch plays an important role which is distributing weight evenly throughout the body. Different foot arches like flat, high, and mid can change this leading to misalignment in the whole body. Each participant's foot arch was determined using the wet footprint test. Every participant stood with their back, head, and heels to the wall while the distance from their neck and small of their back was measured to determine their posture. The control group was participants with normal arches since the majority of people have it and they usually have the best posture compared to the other arches. It was hypothesized that participants with normal arches would have better posture than those with mid, high, or flat arches. The results showed that individuals with normal arches had the smallest distances between their neck and small of their back to the wall, which showed they had the best posture. However, participants with flat, mid, and high arches showed larger differences indicating poor posture. The statistical analysis showed the

differences between the normal arch and other arches were significant for the back to neck measures, however only the t-test for flat vs. the control was significant for the small of back to the wall measure indicating that these results were due to chance and not the independent variable.

Isha Chinthakuntla *Mills E. Godwin High School*
The Effect of Different Ingredients in Moisturizers on Skin Moisture

This investigation is driven by the critical role that skin moisture plays in maintaining the integrity of the skin barrier. The largest organ in the human body, the skin, is a protective shield. Compromised or dry skin, known as xerosis, can undermine these functions. Moisturizers, formulated with various ingredients, are most prescribed in these incidents. These ingredients (humectants, emollients, and occlusives) differ in their methods for boosting skin hydration levels. The experiment sought to evaluate the efficacy of moisturizers containing these ingredients in their ability to enhance skin moisture retention. The hypothesis argued that Cerave, a humectant-based formula with glycerin, would be the most moisturized due to glycerin's ability to attract water molecules from the environment and deeper skin layers. To investigate this, Cerave (humectant), Lubriderm (emollient), Vaseline (occlusive), and a control (no moisturizer) were applied to gelatin samples, designed to mimic human skin. Skin moisture was measured for the relative humidity near the skin's surface using a sling psychrometer. The results supported the hypothesis, with Cerave achieving the highest mean moisture content. A statistical analysis revealed that the differences between Cerave and all other groups were statistically significant, enforcing the superior benefits of humectants in maintaining skin hydration. In conclusion, this experiment affirms that humectant-based moisturizers are the most effective for optimal skin moisture levels. These results have far-reaching implications for dermatology and skin care. Future investigations should focus on examining the effects of these moisturizers under varying environmental conditions and targeting various skin types.

Ranim Elmekharam *Mills E. Godwin High School*
The Effect of Natural Antioxidants on Cancer Cell Growth Using Yeast Model

The purpose was to investigate the effects of natural antioxidants on cancer cells. The microorganism yeast was used to mimic cancer cell behavior. The natural antioxidants used included turmeric, green tea, and vitamin C. The hypothesis was that turmeric would significantly reduce yeast growth due to its potent antifungal properties. The rationale for this study was the need to find natural and effective antifungal agents, which could have implications for medical treatments. Two controls were used: positive control, consisting of a mixture of yeast culture and distilled water streaked on a plate to observe normal yeast growth, and a negative control, which was just distilled water to ensure no growth in the absence of yeast. These controls were essential for providing a comparison. The procedure involved preparing yeast cultures and treating them with different antioxidants. The petri dishes were divided into four groups: one treated with turmeric, one with green tea, one with vitamin C, and two left untreated as a control. The plates were then incubated, and yeast growth was measured by counting the number of colonies. The results confirmed the hypothesis, showing that turmeric significantly reduced yeast growth the most, followed by green tea, and then vitamin C. In conclusion, the study showed that turmeric was the most effective natural antioxidant, highlighting its potential application. The findings showed the importance of exploring natural antifungal agents and provided a foundation for further research.

Eshal Jiyas *Mills E. Godwin High School*
The Effect of Spices on Heart Rate (BPM)

The purpose of this experiment was to determine the effects of spices on heart rate. Recently, spices such as chili pepper, cinnamon, and turmeric have been used as herbal remedies to treat many diseases, including cardiovascular diseases in humans, and may have a similar effect on Daphnia Magna. Daphnia Magna, a water flea, was exposed to ¼ teaspoon (1.42 g) of chili pepper, cinnamon, and turmeric mixed with 15g of water. The Daphnia Magna was contained in the solution for 5 hours and their heart rate was measured, the control used in the experiment was no spice. It was hypothesized that Daphnia Magna exposed to chili pepper would produce more BPM than the control, cinnamon, and turmeric. The results revealed that Daphnia Magna exposed to chili pepper had on average 62 more beats per minute than the control, 53 for cinnamon, and 53 for turmeric. A t-test was done on the data, and it revealed that the data was significant for control vs chili powder, cinnamon vs chili powder, and turmeric vs chili powder, but not substantial for control vs cinnamon, control vs turmeric, and cinnamon vs turmeric. The results did support the research hypothesis. The results are believed to be due to the

capsaicin in chili peppers resulting in a faster heart rate. This research could lead to further study of how different concentrations of chili peppers affect heart rate.

Liana Poquis *Mills E. Godwin High School*
The Effect of Different Solutions on Nickel Titanium Wire Integrity

Nickel titanium wire has become a very popular orthodontic appliance over the years, but recent studies have shown that many external elements like pH have greatly affected their rate of breakage. The purpose of this experiment was to find the effects of different solutions on nickel titanium wire integrity. One hundred pieces of 0.45mL nickel titanium wire were sorted into four equal groups and submerged for twenty-four hours in solutions with varying pH's, including diet coke, lemonade, mouthwash, and water as a control. The wires were then bent at 180-degree angles consecutively until breakage occurred. It was hypothesized that diet coke would cause the lowest average bends until breakage because of its high acidity. The results revealed that diet coke had the lowest average bends until breakage (7) while mouthwash had the highest average bends until breakage (13). A t-test was conducted and showed that the data was not significant for lemonade versus mouthwash and lemonade versus water, but was significant for diet coke versus water, mouthwash versus water, lemonade versus diet coke, and diet coke versus mouthwash. The majority of the results supported the research hypothesis. It was hypothesized that the results were due to the high acidity and carbonation of the diet coke. The lemonade had a high average bends until breakage compared to the diet coke despite having a low pH, so another factor like carbonation could have affected the results. This research could lead to a further study determining the effect of carbonation on the integrity of wire.

Abel Tilahun, Minjun Oh, Zareef Said *Governor's School @ Innovation Park*
Nano-therapy A Novel Approach to Electricity Based Neurodegenerative Disease Therapeutics

Neurodegenerative diseases are driven by mass cell death in the brain. Recently, electrotherapy has shown to be able to expedite cell regeneration which could be a major combatant against neurodegenerative diseases; however, due to the blood brain barrier, these therapeutics cannot reach the brain. Carbon nanotubes are small enough to pass through this barrier and have remarkable conductive abilities. This research dives into the potential for carbon nanotubes as an apparatus for electrotherapy by analyzing their short term effects on Girardia Tigrina, or planaria, which already have regenerative capabilities. It was found that in a fume hood environment, which lowered temperatures and increased air-flow planaria tend to have higher mortality rates but electrical stimulation can counteract many of the negative effects. Electrically stimulated planaria were much healthier than non-stimulated planaria, with groups undergoing electrical stimulation with carbon nanotubes yielding the best results. This gives way to future experimentation regarding carbon nanotube based electrical stimulation as a treatment for neurodegenerative diseases, venturing into the increased biocompatibility of the material along with testing on more complex organisms and human tissues.

Asiya Shariff *Mills E. Godwin High School*
Mapping Neural Plasticity in Cognitive Rehabilitation

This experiment was conducted to predict the intensity level of cognitive rehabilitation that would lead to the biggest improvement in motor functions for a stroke patient post trauma. Stroke patients have the highest levels of post trauma paralysis which might lead to long lasting implications and an arduous road to recovery if treated incorrectly. The three intensity levels used in this experiment were mild intensity, medium intensity and high intensity. Mild intensity methods included stretching and occupational therapy. Medium intensity methods composed of electrical simulations to stimulate muscle contractions and ultrasound therapy which utilized deep heating treatment to provide relief and foster motor function. The highest intensity level was utilized in severe cases and included surgical treatments to replace damaged nerves and muscle and deep brain stimulation in which electrical signals were applied to parts of the brain in order restore mobility. Data was acquired through medical journals corresponding to stroke patients with their method of treatment and mobility immediately after the stroke and one year later. This mobility was measured using MRI (magnetic resonance imaging) and EEG (electroencephalogram) displaying brain tissue and activation in certain parts of the brain that relate to movement, specifically the cerebellum and the frontal lobe. Immediately after the stroke, patients had decreased activity in these areas which indicate a loss of fine motor skills. The data was split into two groups at random. The first data subset was used to train the Brain-Computer Interface to predict which intensity level would restore

the most mobility based on pre-therapy scans. The second data subset was used to test this interface and determine the accuracy of predictions. The interface had a 76% accuracy rate which, although not completely accurate, displays a potential path forward in predicting therapy treatments which could be built upon in the future to construct an even more accurate prediction mechanism.

Elizabeth Zhang *Blacksburg High School*
Morphological Changes to the Pelvic Floor Muscle Complex before, during, and after Pregnancy in a Murine Model

Pelvic floor disorders (PFDs) affect a quarter of women in the US, with a 20% lifetime risk of surgery. Despite this, few longitudinal studies have examined pelvic floor muscle (PFM) changes during pregnancy, limiting our understanding of PFD development. Here, I aim to fill that gap. This study provides the first in vivo longitudinal visualization and quantification of PFM morphology using MRI in a mouse model. Data were collected at five time points: nonpregnant (NP), mid-pregnancy (MP), late pregnancy (LP), 24–72 hours postpartum (PP), and 3 weeks postpartum (3WPP). 3D models of the pelvic floor muscle complex (PFMC) were generated through segmentation of the coccygeus, iliocaudalis, and pubocaudalis muscles, with volumetric and urogenital hiatus (UH) measurements. Results suggest pregnancy induces early, hormone-driven PFM adaptations, particularly in the pubocaudalis, which showed the most pronounced volumetric increases between NP and MP. A significant PFMC volume reduction occurred between LP and PP, indicating birth triggers structural remodeling. The pubocaudalis, the most affected muscle, aligns with human studies identifying the medial pubococcygeus as most susceptible to birth-related injury. Variation in postpartum muscle recovery underscores the need for further investigation on differences in recovery trajectories between individuals. The transverse UH expanded from NP to LP before stabilizing, suggesting pregnancy—not delivery—is the primary driver of UH widening, a risk factor for pelvic organ prolapse. These findings validate the mouse model for studying pelvic floor biomechanics and highlight the need for further research into postpartum recovery and PFD risk factor.

Medicine & Health D (HS MDH D)

First Place
Sofia Demchenko *Mills E. Godwin High School*
Background Reduction Methods Used on Recipient Kidney Transplant Patient Inflated MFI

HLA, short for human leukocyte antigen, is a major determinant in deciding upon solid organ histocompatibility. In the process of examining donor and recipient antibodies after flow crossmatch testing, it is important to note that these numbers may exhibit increased MFI values (mean fluorescence intensity) due to inflated background. High background may prevent a patient from being matched with a potential donor, making it more difficult to find a compatible organ. As a result, this increases the risk of transplant rejection, which is why it is crucial to determine which background reduction method is the most effective. Before testing the various background reduction methods, it was hypothesized that the addition of EDTA (ethylenediaminetetraacetic acid) to the sera would result in the lowest MFI values, and therefore most decreased background.
Five kidney patients with little to no history of pre-sensitizing events were chosen and all three background reduction methods were implemented into three separate microcentrifuge tubes of their sera before running the samples through the Luminex single-antigen test. After the tests were concluded, the data was analyzed using the software MatchIt! and sorted in an Excel spreadsheet. Since the background reducers were being compared to each other and every patient had a unique history, no control was used in this experiment.
The resulting MFI values had the expected values in coordination with the hypothesis that EDTA would decrease inflated MFI the most effectively compared to SeraClean and high-speed centrifugation, with 4 out of 5 of the patients having the lowest MFI values when EDTA was introduced to the sera. Because there was no control, fifteen t-tests were conducted for each patient's results under each background reduction method, resulting in 75 t-tests total for all five patients. The t-tests exhibited that the significance of the data varies depending on which two background reduction methods and HLA classes (I or II) are being compared, with some results of the tests being greater or less than $t=2.101$ at $a=0.05$ and $df=18$.
EDTA worked efficiently because it is a calcium and magnesium chelator. EDTA inhibits complement from binding, which prevents non-specific antibody binding and false-positive signals. Contrary to EDTA, high-speed centrifugation removes unwanted debris and proteins physically by spinning them to the bottom of the centrifuge

tube and having the clean serum transferred without disturbing the pellet at the bottom. Further contrary to EDTA and high-speed centrifugation, SeraClean reduces high MFI values by enzymatically degrading denatured proteins and aggregates which can interfere with HLA antibody detection.

Second Place
Ahana Goel *Mills E. Godwin High School*
Neuromotor Changes Associated with Ashwagandha on Caffeine-Induced *Drosophila melanogaster*

The purpose of this experiment was to find the neuromotor effects of Ashwagandha on caffeine-induced *Drosophila melanogaster*. Over 80% of people consume caffeine, and Ashwagandha is known to relieve harmful effects of coffee, which include insomnia and anxiety. In this study, flies were treated with caffeine and Ashwagandha and left with the food for two days in a contained environment. They were put in a maze and timed (in minutes) to time their completion. The control was the flies with no Ashwagandha or caffeine. The hypothesis was if 0.75 mL of Ashwagandha extract is used, then the Drosophila would go through the maze the fastest. The results revealed that 0.5 mL of caffeine caused the flies to go through the maze the fastest, but 0.75 mL of Ashwagandha caused the flies' maze time to be reduced closer to the control level time. A t-test conducted on the data revealed that the calculated t values for all but the control vs. 0.5 mL Ashwagandha, 0.5 mL Ashwagandha vs. 0.5 mL caffeine, 0.5 mL caffeine vs 1 mL Ashwagandha, and comparisons including the 0.75 mL Ashwagandha level were not significant. The results did not support the research hypothesis. It is believed that the results are due to not having enough Drosophila crossing the maze in the 0.5 and 1 mL Ashwagandha levels and the 0.25 mL Ashwagandha concentration being too weak. This research could lead to further studies investigating different ways to measure neuromotor function and longer times for the Drosophila.

Third Place
Stuti Tiwari *Mills E. Godwin High School*
The Effect of Simulated Stomach Acid on Tooth Enamel

The rationale behind the experiment was to uncover how the dental health of a gastroesophageal acid reflux disease (GERD) patient is adversely affected by their condition. GERD is a condition in which an individual's mouth is commonly exposed to gastric acid through consistent regurgitation. Hence, the purpose of the study was to determine the relationship between stomach acid and the erosion rate of tooth enamel. The experiment utilized hydrochloric acid to represent stomach acid and white eggs to model tooth enamel due to their similar chemical composition. One hundred eggs were divided into four groups and exposed to different concentrations of hydrochloric acid (0.25 M, 0.5 M, 1 M) or distilled water (0 M). The initial and final masses of the eggs (after acid exposure) were measured to calculate the erosion rate. Eggs placed in distilled water served as the control group, demonstrating an egg's typical osmotic response to a hypotonic solution without the confounding effect of acidity. It was hypothesized that higher concentrations of acid would lead to greater enamel erosion. The results conveyed that eggs exposed to 0.25 M showed a -0.05 g change in mass, those in 0.5 M showed a -0.5 g change, and those in 1 M showed a -2.05 g change, hence confirming the given research hypothesis. A t-test was performed and indicated that all the results were statistically significant. Ultimately, the findings suggested that higher acid concentrations caused more erosion, showcasing that the teeth of GERD patients likely face degradation through constant acid exposure and underscoring a concern for their oral health. Future studies that test a broader range of hydrochloric acid concentrations and document visual observations of the eggs should be conducted to better understand enamel degradation.

Honorable Mention
Aditi Nair *Maggie L. Walker Governor's School*
Sleep and Parkinson's: A novel computational approach to predict the incidence of Parkinson's Disease

Parkinson's disease (PD) is a disorder of the nervous system that gradually worsens over time. The disease is most commonly found in older patients and is caused by a drop in dopamine levels. Symptoms include tremors, slow movement, loss of balance, and disrupted sleep. Sleep is crucial for the human body because it aids in maintaining physical health. Studies have shown a correlation between the prognosis of the disease and abnormal sleep patterns. Not only is the sleep cycle for a patient with Parkinson's abnormal, but many patients also have sleep disorders such as insomnia, sleep apnea, REM sleep disorder, and more. However, making an accurate diagnosis of PD is complicated. The primary goal of my research project was to predict whether a

patient has Parkinson's disease based on their sleep patterns using a computational approach. Raw sleep signals from healthy and PD patients were pre-processed and filtered using Python. Sleep signals were scored to determine the stage of sleep at thirty-second intervals. The amplitudes of each waveform were averaged before feeding the values into a machine learning algorithm, the k-nearest neighbor algorithm, which measures the distance between the data points and a query point to make predictions based on the closeness of the data point to the query value. The k-nearest neighbor algorithm was used to predict the incidence of the disease. Interestingly, the algorithm accurately predicted whether a patient has Parkinson's Disease based on their sleep patterns 70.0% of the time, and the two patient populations proved to be significantly different from one another with a p-value of 0.0079 when z-scores were compared using a Mann-Whitney U-test at a 5% significance level. This study identifies a novel and accurate method to diagnose Parkinson's Disease to facilitate earlier detection and raise awareness before the disease worsens.

Honorable Mention
Suana Sangerpal *Mills E. Godwin High School*
The Effect of Different Acne Medications on *Escherichia coli* Culture

The purpose of this experiment was to understand the effect of different acne medications on *Escherichia coli* culture. *Acne vulgaris* has affected almost one tenth of the world; a major problem. Creams are the most common acne care products so they acted as a control, but they have been discovered containing cancer-causing chemicals, so a natural product would be more beneficial. It was hypothesized that if various acne medications are applied to *Escherichia coli,* then the copper flakes will cause the most salubrious decrease in *Escherichia coli* culture. The procedure included the collection of 10 0 petri dishes in which 150 µL of K12 *Escherichia coli* was applied by a micropipette. Sterile paper discs were dipped in the IV solutions (aloe vera gel, acne skin serum, copper flakes, and acne skin cream, each then put in a dish. Then they were all put in the incubator at 37 °C for 72 hours. After this, the dishes were collected, and their zone of inhibition was measured by a ruler in millimeters. It was found that copper had the best effect on the Escherichia coli with an average zone of inhibition of 12.8 mm, supporting the research hypothesis. The reasoning behind such results is most likely due to the strong antibacterial nature of copper which helped clear out the Escherichia coli compared to synthetic products, as supported by scientists. T-tests were calculated and 5 out of the 6 tests rejected the null hypothesis, showing that there was a slight point of human error.

Honorable Mention
Dhanvi Sheth *Deep Creek High School*
Anatomical Correlation between Ulnar Neuropathy and Triceps in Electrodiagnostic Studies

Nerve conduction studies (NCV) and electromyography (EMG) tests are a mainstay in the diagnosis of mononeuropathy and radiculopathy. Triceps denervation changes are traditionally attributed to C7 radiculopathy or radial neuropathy. Recent literature suggests the possibility of ulnar innervation of the triceps muscle, which creates ambiguity in the interpretation of EMG results, particularly in patients with ulnar neuropathy. The study aims to evaluate the prevalence of triceps denervation changes in patients with and without ulnar neuropathy. The study is a case-control study. Patients with EMG studies between January and August 2024 at Progressive Neurology and Sleep Center were recruited. The data was further analyzed using the statistical software STATA. Prevalence of triceps denervation changes were compared between patients with and without ulnar neuropathy using chi-square statistics and logistic regression. The study included 295 patients: 149 without ulnar neuropathy and 146 with ulnar neuropathy. Among the 146 with ulnar neuropathy, 41 (28%) had triceps denervation, compared to 46 (31%) among the 149 without ulnar neuropathy. There was no significant difference in triceps denervation prevalence between the two groups. A logistic regression model showed an odds ratio of 0.42 ± 3.51 for triceps denervation between the groups after adjusting for other factors, with a p-value of 0.3. There was no significant difference in the prevalence of triceps denervation between patients with and without ulnar neuropathy. The current study establishes the validity of the current practice of interpretation of triceps denervation changes

John Boles *Mills E. Godwin High School*
The Effect of Screen Time on Sleep Time and Quality.

The primary reason for investigating this topic is that most adolescents in the last few years have been using their digital screens for many hours before they sleep, leading to poor sleep quality. Sleep is a crucial factor in adolescent health, affecting cognitive function, mood, and overall well-being. The purpose of this research was to determine the optimal screen-free time before sleep for adolescents. It was hypothesized that the most reasonable amount of time that adolescents should spend without using their digital devices before bedtime is two hours, as excessive screen exposure before bed has been linked to disruptions in melatonin production and sleep cycles. This experiment involved four participants who wore identical smartwatches to monitor their sleep over four days. Each day, participants experienced a different sleeping condition, with varying amounts of no screen time allowed before bedtime. The results were gathered through sleep analysis data provided by the smartwatches and responses to online surveys completed by the participants each morning, which allowed for both objective and subjective assessments of sleep quality. The independent variable in this study was the amount of screen time spent by each participant for the four days of the experiment. The dependent variable in this study was the amount of sleep time spent by each participant and the amount of sleep time spent in a deep state of sleep for the four days of the experiment. The control variable in this study was the first day of the experiment, where all four participants spent two hours on their digital devices before their sleep time. The key findings of this research were that two hours of no screen time before sleep provided the best quality sleep for the participants. Two t-tests were done on the data, and they revealed that the data was statistically significant for all results. The results supported the research hypothesis, reinforcing the idea that reducing screen exposure before bed can have measurable benefits for sleep. The conclusion drawn from this research was that screen time affects adolescents' sleep duration and quality. It was also concluded that avoiding screen time for two hours before sleep leads to the longest sleep duration and the best sleep quality. These findings highlight the importance of promoting healthy screen habits among adolescents to improve overall sleep health and well-being.

Nisha Chandra *Mills E. Godwin High School*
The Effect of Different Probiotic Foods on Milk pH

The purpose of this study was to determine which of three common probiotic foods: yogurt, kefir, and sauerkraut, have the most active probiotics. Probiotic foods' health benefits are well-documented, and researching probiotics can teach people how to use these foods effectively. The change in pH of milk was measured as a proxy for probiotic activity. A research hypothesis was formulated that if kefir is added to the milk, then the change in pH will be the greatest. A control was implemented, milk with no probiotic, to see the change in pH solely from milk fermenting without added probiotics. To conduct this experiment, four cups of milk were poured. Each probiotic food was added to a cup and the pH was recorded of each cup. The last cup was the control. The cups fermented for 48 hours, and the pH was measured again. The change in pH was recorded. The results of this experiment showed that the type of probiotic food had an impact on milk pH as the average changes in pH were different. T-tests were conducted and showed the tests for yogurt and sauerkraut were significant and the results rejected the null hypothesis while the t-test for the kefir showed the results were likely due to chance and the null hypothesis was supported. The research hypothesis was not supported. A possible reason sauerkraut had the most activity is the solid pieces of cabbage that support the probiotic culturing. Further study can investigate more non-dairy, solid, probiotic foods.

Rebecca Ferry *Collegiate Schools*
Investigating the Correlation Between Bacteria, Student Absences due to Illness, and School Division: An Experiment

Bacteria exist in every living and nonliving organism in the world. Although many types of bacteria are essential, they can also be massively harmful. With tens of thousands of types of bacteria, less than one percent of bacteria can harm humans (Agency for Health Care, 2022). Even so, it is the reason for many illnesses today. Students spend about seven hours with one another each day, and this time acts as a catalyst for the spread of bacteria. This experiment explored bacteria concentrations in the different levels of schooling (lower: grades JK-4, middle: grades 5-8, and upper: grades 9-12), as well as the illness absences in the three subsequent divisions. In this study, samples of bacteria were taken by swabbing different locations around the three divisions of the school and streaking the swabs onto plates of agar. Once streaked, the plates were incubated in ideal conditions and allowed a growing period for the bacteria to grow and mature. About three days after incubation, the bacteria colonies were counted and collected. Each week’s samples were taken and grown from

each of the separate divisions. The sample locations within each division were altered from week to week to obtain a fair representation of the division as a whole. When analyzing the data, the Upper School was found to have the greatest number of bacteria colonies. The Middle School sample grew the least number of bacteria colonies and the Lower School grew the median number of bacteria colonies. When evaluating this data, an analysis of variance (ANOVA) test was used to determine that there were statistically significant differences between the means of the groups. Another part of this experiment was to see how student illness absences would differ based on division. The student absences due to various illnesses were collected. The absentee data did not directly correlate to the bacteria findings. When analyzed and with the use of an ANOVA, this data was also deemed significant with a P value of less than 0.05. For future experiments, a longer trial period is encouraged to get a larger representation of the entirety of each division, instead of just the places that were swabbed. This study was also limited to the equipment available in an independent school in Richmond, Virginia. Resources necessary for determining the types of bacteria were not available. In future experiments, determining the type of bacteria found would be very beneficial to determine if absences and bacteria prevalence affect one another.

Hannah Tober *Chesapeake Bay Governor's School*
Assessing Personal Care Product Usage by Teens and Identifying Gender-Specific Trends

Personal care products contain ingredients that are "generally recognized as safe (GRAS)", some have reported harmful health effects and have been linked to a variety of health problems including allergies, asthma, hormone disruption, neurodevelopment problems, infertility, and cancer. The point of this study is to research how many personal care products teenagers are using and how often they are using them, to assess their potential exposure to chemicals of concern, and to determine if gender could affect exposure. In order to participate in this study a Google Form was created that included questions asking basic demographic data, and how often participants use common personal care products. s asking basic demographic data, and how often participants use common personal care products. These products include: shampoo, conditioner, styling products, deodorant, sunscreen, facial moisturizer, body lotion, acne treatments, shaving products, body wash, eye makeup, mascara, face makeup, lipstick/lip gloss, lip treatment/balm, nail polish remover, acrylic nails, gel nails, and nail glue. Results show that females are using more personal care products overall categories; the statistical t-test yielded $p=0.003$, showing a statistical difference between male and female use of PCP. Based on the frequency data there was a mixed result, where at low and high frequencies of PCP use, females and males showed no significant difference in usage, $p>0.05$. However, at PCP moderate use frequency, females used more products than males at a statistically significant level, $p<0.05$.

Tanvi Nareddy *Mills E. Godwin High School*
Deep Learning Radiomics for Predicting Tumor Dynamics in Hepatocellular Carcinoma

Hepatocellular Carcinoma (HCC) is the most common form of liver cancer and a significant global health concern due to its frequent late-stage diagnosis. With just a five-year survival rate of 21%, early-stage diagnosis is crucial for better patient outcomes. This study aims to develop a deep-learning model to improve HCC diagnostic accuracy and predict patient-specific responses to Sorafenib and Regorafenib, two kinase inhibitors commonly used to treat HCC. The model utilizes a Convolutional Neural Network (CNN) for medical imaging analysis and a Multilayer Perceptron (MLP) model for IC50 drug response data. The medical imaging dataset was obtained from The Cancer Imaging Archive, and IC50 drug efficacy data was from The Genomics for Drug Sensitivity in Cancer. The dataset included various demographics with different genders, ages, and HCC stages, so the model could be trained on a wide range of data; additionally, all data obtained was non-identifiable patient information. The model was trained, validated, and tested using a 75/15/10 split ratio. To evaluate diagnostic and predictive accuracy, metrics such as accuracy, precision, and recall for model differentiation between HCC and non-HCC and Mean Absolute Error and R^2 Score for how far predicted IC50 values are from actual values were used. Overall, by combining deep learning with precision oncology, this study aims to improve early detection and treatment for patients with HCC, ultimately enhancing patient care.

Abigail Olihnenco *Mills E. Godwin High School*
The Effect of Exercise on Heart Rate

The purpose of this experiment was to find the effects of exercise on heart rate or beats per minute (BPM). Exercise has a significant effect on heart rate, and it is important to know how much it can affect one's health and safety. In this experiment, participants did three exercises- running, sit-ups, and squats- and then their BPM was measured. It was measured by finding the pulse and counting the beats felt in fifteen seconds and then multiplying that number by four. A control was used by measuring the BPM at a resting stage. It was hypothesized that running would cause the participants to have the highest BPM. The results revealed that running had the highest BPM while resting had the lowest. A t-test was conducted to reveal the significance of the data: control vs. running, control vs. sit-ups, control vs. squats, running vs. sit-ups, and sit-ups vs. squats were significant. In comparison, running versus squats was insignificant. Due to these results, the research hypothesis was supported. This research could lead to further studies that investigate the long-term effects of exercise on heart rate by seeing how long it takes for heart rate to return to resting after an exercise is done.

Hari Patel *Mills E. Godwin High School*
The Effect of Type of Exercise on Heart Rate

The study looked at how different kinds of exercise affect heart rate. The heart rate of 25 adults, aged between 18 and 50 years, was measured while they performed four exercises: fast walking, lifting five-pound weights, doing curl-ups, and performing jumping jacks. The goal was to find out which exercise raises heart rate the most and what this means for heart health. The resting heart rates of the participants were taken before exercising. After exercising for one minute, the heart rates were again taken five seconds later. Each activity was followed by a two-minute break with water. The results indicated that jumping jacks, an aerobic exercise involving the whole body, produced the highest increase in heart rate. It was followed by walking, curl-ups, and bicep curls. Statistical analysis showed very large differences between resting heart rate and heart rates during exercise (t-values for Jumping Jacks vs. Control = 19.603, $p < 0.01$). These findings are in line with the assumption that more intense exercises, such as jumping jacks, influence heart rate more significantly than exercises that mainly involve smaller muscle groups. This demonstrates the advantages of aerobic exercise for heart health and emphasizes the significance of exercise intensity in improving heart rate responses. The results help us understand how different exercises impact heart rate and would suggest which activities might work best for better heart fitness. Further research should look into different levels of exercise intensity, using better tools for heart rate monitoring to give more information.

Grady Smith *Mills E. Godwin High School*
The Effect of Disease Spread Prevention methods on Public Perception

The purpose of this study was to research people's opinions on partaking in different methods of reducing the spread and/or symptoms of a contagious disease. The positive effect of partaking in efforts to slow the spread of contagious diseases is very well researched. However, the effectiveness of these practices hinges on people wearing a mask in public, getting vaccinated, on them agreeing to participate. If someone finds the method that most people are willing to participate in, resources of study can be supplied to that specific method. Imagine if scientists spent billions to create a mask no one wanted to wear. The hypothesis for this experiment was if participants were asked which method they would use to slow the spread and/or symptoms, more people would be willing to social distance than any other methods of disease spread prevention. There is no control for this experiment as the CDC recommends each of these methods to prevent the spread of diseases, not only one. To perform this experiment, a group of people were instructed to take a survey asking how willing they would be to participate in 4 separate methods of slowing the spread/ symptoms of a contagious disease. (Wearing a mask, vaccinating, social distancing and avoiding public gatherings. Based on the data collected, it was concluded that participants were more willing to vaccinate than any other method and each level of IV was found to be significantly different than the expected value. The results of this experiment are believed to be the result of people knowing the effectiveness of vaccines and the aspect of each of the other levels of IV impeding one's ability to communicate with others in many ways.

Microbiology & Cell Biology A (HS MCB A)

Ann M. Hancock Microbiology and Cellular Biology
First Place

Bhoomika Kaur *Mills E. Godwin High School*

Targeting RAGE: A Novel Therapeutic Strategy Against AGE-Mediated Prostate Cancer Progression
The accumulation of advanced glycation end products (AGEs) and their interaction with the receptor for AGEs (RAGE) have been implicated in the progression of prostate cancer (PCa), the second most diagnosed cancer in men worldwide. However, therapeutic strategies targeting RAGE remain underexplored, representing a critical gap in current cancer treatment approaches. This study aimed to investigate the role of the AGE-RAGE signaling pathway in PCa progression, focusing on how RAGE inhibition affects cell migration and how RAGE knockdown influences both migration and proliferation. Methods: RAGE inhibition was achieved using TTP-488 in DU145 cells, and a migration assay assessed cell migration in response to the following treatments: no treatment (NT), the negative control; AGEs, the positive control; TTP-488; and AGEs & TTP-488. RAGE knockdown was performed via shRNA transfection in LNCaP cells, confirmed by Western Blot analysis. A Trypan Blue Proliferation assay evaluated cell growth in LNCaP shRAGE and shControl cells, while a migration assay determined migration in those cells. It was hypothesized that RAGE inhibition and knockdown would reduce PCa cell migration, with knockdown specifically reducing proliferation. Results: ANOVA and post-hoc analyses revealed that disrupting AGE-RAGE signaling via inhibition and genetic knockdown effectively mitigates cell migration, with knockdown also significantly hindering cell proliferation. These findings support the research hypothesis. Conclusion: Targeting RAGE in PCa reveals a transformative therapeutic approach to control tumor progression and metastasis, set to redefine cancer treatment globally. Future studies should explore combining RAGE disruption with conventional treatments like chemotherapy.

Second Place
Noah Allyn *Washington-Liberty High School*
Know Your Enemy: The Effect of Different DNA Repair Mechanisms (Induced via CRISPR-Cas9) on Streptomycin Resistance Acquisition in *Escherichia coli* K-12

Antibiotic resistance is currently a significant problem in healthcare. A better understanding of how bacteria can develop antibiotic resistance is needed in order to develop more effective antibiotics. This study specifically investigated how DNA repair mechanisms in E. coli K-12 contribute to antibiotic resistance development, using streptomycin as a model aminoglycoside antibiotic. When bacteria experience naturally occurring DNA breaks, they fix them using either homology-directed repair (HDR), where a DNA template is inserted to repair the break, or microhomology-mediated end joining (MMEJ), where random nucleotides are inserted into the break often creating random mutations. These two repair systems were specifically evaluated in the rpsL gene, which encodes part of the 30S ribosomal subunit protein—what streptomycin binds to kill *E. coli.* Using CRISPR-Cas9 technology, targeted double-strand breaks were induced in the rpsL gene of *E. coli*, and two distinct repair approaches were implemented: (a) template-present editing: using HDR to insert a synthetic template containing a K43T resistance-conferring mutation as a positive control, and (b) template-absent editing: forcing MMEJ to create mutations. Bacteria were then grown on streptomycin media to assess resistance development. Results: Template-present modification produced many resistant colonies, confirming the effects of the K43T mutation. The key finding was that template-absent modification produced a limited number of resistant colonies. This demonstrated that natural MMEJ-induced mutations could confer antibiotic resistance. Discussion: These findings provide insights into how bacteria can develop antibiotic resistance through DNA repair mechanisms and have major implications for developing more effective antibiotics in clinical settings.

Third Place
Kriesh Tivare *Langley High School*
Development of Device for Modulating Antibiotic Response and Bacterial Growth Using Oscillating Compound Magnetic Fields

This study investigates the repercussions of varied magnetic fields on antibiotic susceptibility and growth behaviors of Gram-negative (Escherichia coli K-12, Enterobacter aerogenes) and Gram-positive (Bacillus subtilis, Staphylococcus epidermidis) bacteria with the ultimate goal of potentially developing life-saving antibacterial non-invasive treatment options. The experimental design encompasses the modulation of bacteria using magnetic fields produced by four waveforms (15 Hz & 50 Hz) with frequency components ranging

between 15Hz-600Hz, using waveforms (Sine, Sinc, and 2 complex waveforms to comprehensively assess their effects on bacterial responses with exposure periods of 12/24 hours. Antibiotic susceptibility testing was employed to evaluate the magnetic fields' impact on the efficacy of common antibiotics: Ampicillin, Streptomycin, and Penicillin (10mcg each) against the bacterial strains influenced by the magnetic fields. Furthermore, growth behaviors were assessed to illuminate differences in the cell wall functions of Gram-positive and Gram-negative bacteria. The Sinc wave generally decreased both bacterial groups' antibiotic resistance, decreasing their resistance to Streptomycin (Gram-positive by 59.4% and Gram-negative by 8.3%). It also formidably increased S. epidermidis' susceptibility to Streptomycin (128.57%). On the other hand, the Spec1 wave made both groups more resistant to Penicillin (28.5% Gram-negative, 10.5% Gram-positive) and Ampicillin (10.5% Gram-negative, 18.4% Gram-positive). The Sine wave had the least impact, having mixed results among the different bacteria. The outcomes of this research hold promise for the advancement of life-saving antibacterial therapies, as well as the further implementation of microbial modulation strategies within industrial applications.

Honorable Mention
Taarun Ganesh *Thomas Jefferson High School for Science & Technology*
Computational design of an epitope-based vaccine for Merkel cell carcinoma with *E. coli* and lambda phage display

Merkel cell carcinoma (MCC), an aggressive neuroendocrine skin cancer caused primarily by Merkel cell polyomavirus (MCV), appears as a painless skin tumor. Currently, no approved vaccine is available for MCC. Here, we designed a multi-epitope vaccine using computational tools to elicit a strong immune response against the Merkel cell polyomavirus. Potential B and T cell epitopes were generated using the IEDB server, and 22 peptides were shortlisted based on their antigenicity, allergenicity, and toxicity properties. We fused the epitopes using linkers to express the fusion protein (molecular weight: 43.009 kDa) under the *E. coli* expression system. We performed a molecular docking analysis of the vaccine candidate with a human toll-like receptor (TLR4), where the vaccine candidate exhibited a high binding affinity. As predicted by an immune simulation study, the vaccine candidate induced a robust immune response. To achieve an optimal protein expression in the bacterial system, we optimized the codons of the vaccine candidate based on the *E. coli* codon preferences. Additionally, we demonstrate a framework for displaying these epitopes by fusion with the C-terminus of the gpD protein in λ bacteriophage, utilizing the novel BridgeRNA recombination system. We designed a 177-nucleotide bridge RNA that will bispecifically target both vaccine antigen and λ bacteriophage. Overall, this computational approach allows for the rapid generation of epitopes, which has its advantages over other traditional vaccine platforms. Nevertheless, in vitro and in vivo experiments are essential to evaluate the stability and immunogenicity of the vaccine candidate.

Honorable Mention
Deepanshi Kumar *Maggie L. Walker Governor's School*
Investigating the Overlap Between Alcohol Response Genes and Behavioral State Genes in *C. elegans* Using CRISPR-Cas9 Gene Editing and Locomotion Assays

Certain genes impact behavioral and neurological responses to alcohol consumption, the understanding of which would improve disease prevention and treatment for alcohol use disorders (AUD). The correlation between emotional states such as depression or anxiety and AUD development indicates that emotional states may regulate AUD development. Behavioral responses were studied in a nematode model, using loss-of-function (LOF) mutations in different neuropeptide receptor (NPR) genes. The LOF pdfr-1 mutation increases alcohol sensitivity and suppresses the decreased alcohol sensitivity of a peptidase gene nep-2 mutant. The pdfr-1 mutation has increased rates of dwelling (low speed, high curvature). Based on alcohol responses and behavioral exploration data, it was hypothesized that there is a link between alcohol response and roaming/dwelling adoption. Using WormLab software, frequencies of roaming and dwelling in nep-2 and NPR mutants were measured. It was found that nep-2 mutants had increased roaming rates, and the pdfr-1 mutation partially suppressed the nep-2 increased roaming phenotype, similar to its suppression of the nep-2 ethanol resistant phenotype. CRISPR-Cas9 was used to create a new pdfr-1 mutant based on a gain-of-function mutation in a related human receptor. Double mutant analyses were used to help order alcohol response genes in a biological pathway. The new mutant was found to have a similar alcohol response and dwelling phenotype as the pdfr-1 LOF, indicating that a GOF was not produced. These data support the hypothesis that some genes for alcohol response and behavioral state are connected and provide an understanding of the neurological processes behind AUD development.

Honorable Mention

Lamarra Sales *Central Virginia Governor's School for Science and Technology*
The Effect of Fluoxetine and GABA on Planaria

This study aimed to investigate the effects of fluoxetine and GABA on behavior and memory in planaria. Planaria were exposed to either fluoxetine (.001 mg/L), GABA (55 mg/L), or spring water (control), and their behavior was assessed by measuring the number of errors, turns, and time spent in a maze. Two trials were conducted after one and four weeks of exposure. A two-way ANOVA with alpha of .05 was performed for each chemical, leading to a total of three. Results showed a statistically significant difference in the number of errors ($p = .014$), with fluoxetine-exposed planaria making fewer errors than those exposed to GABA or spring water. The number of turns did not show a significant difference between groups ($p = .725$), and time spent in the maze also had no significant effect ($p = .629$). Post-hoc Tukey analysis confirmed that fluoxetine reduced errors compared to the other groups. Interaction between chemical and time had a p-value of .908, indicating no significant effect. Although GABA showed a reduction in errors compared to the control, it did not significantly impact movement or maze completion time. Therefore, the research hypothesis, which predicted that GABA would result in reduced movement and more memory issues compared to fluoxetine, was partially supported. Fluoxetine improved memory performance but did not significantly affect movement, while GABA showed some memory improvement but had no clear impact on movement. These findings suggest that fluoxetine may improve memory in planaria, while GABA's effects are less conclusive.

Andrew Camarda *Central Virginia Governor's School for Science and Technology*
The Science of Sanitation

The purpose of this study was to evaluate the effectiveness of Chlorhexidine (CHX) in reducing the bacterial viability of *Micrococcus luteus* within varying contact times in order to address the critical issue of hospital-acquired infections (HAIs). The experiment involved applying a 4.0% CHX solution to bacterial cultures for 0 and 60 seconds, followed by colony counting to assess bacterial survival. The results demonstrated that CHX significantly reduced bacterial viability, with complete eradication observed at the 60-second contact time. Statistical analysis using a two-sample t-test revealed a p-value of 1.92×10^{-11}, which is well below the alpha threshold of .05, indicating statistical significance. Descriptive statistics showed an average of 84 CFUs for the 0-second trials and 0 CFUs for the 60-second trials. The findings support the research hypothesis that longer CHX contact times lead to greater bacterial viability reduction. This study highlights the importance of sufficient disinfectant contact time in clinical disinfection protocols, offering a potential strategy to help mitigate HAIs. Future research should explore CHX's effectiveness against other multi-drug-resistant (MDR) bacteria, such as Methicillin-Resistant *Staphylococcus aureus* (MRSA) and Mycobacterium tuberculosis (TB), while addressing the limitations encountered in this study. In conclusion, this research demonstrates that CHX is a highly effective disinfectant against *M. luteus* when adequate contact time is ensured, which contributes valuable insight into infection control practices.

Reanna Farsin *Clover Hill High School*
The Effect of Using Saccharomyces vs. Non-Saccharomyces Yeast on the Rate at which Fermentation Occurs, Measured Using a Fermentation Tube to Determine the Amount of CO2 Produced

The purpose of this experiment was to compare Saccharomyces and non-Saccharomyces yeasts and determine which yields a higher fermentation rate based on the amount of CO2 each produced. Yeasts play a key role in fermentation processes, and their varying genera and species each display unique fermentative capacities and products. In industries that employ yeast in their operations, such as wine or bread, selecting yeast strains with higher fermentation rates can be crucial for improving productivity and efficiency. The fermentative capacities of the yeasts *Saccharomyces cerevisiae*, *Saccharomyces bayanus*, *Torulaspora delbrueckii*, and a no yeast group were tested. The hypothesis was: Saccharomyces yeasts would have a higher fermentation rate and produce more CO2 than non-Saccharomyces yeasts. The procedure consisted of dissolving a controlled amount of each yeast into warm water to create a yeast solution, piping a controlled amount of yeast solution and glucose solution into a fermentation tube, and leaving the fermentation tubes in an incubator for 1 hour. Following the incubation period, the fermentation tubes were removed from the incubator and the height of the bubbles in each tube was recorded. Fermentation rates were measured by dividing the height of the bubbles by the amount of time the tubes were left to ferment. The mean for the no yeast group, the Saccharomyces cerevisiae group, the

Saccharomyces bayanus group, and the *Torulaspora delbrueckii* group were 0, 1.148, 1.396, 0.030 (mLs of CO2/min) respectively. Out of all of the strains, the non-Saccharomyces strain yielded the lowest amount of CO2. As evident in the data, the Saccharomyces strains of yeast yielded much more CO2 than the *Torulaspora delbrueckii* group and therefore had higher fermentation rates, supporting the research hypothesis and rejecting the null hypothesis.

Hargun Tuteja *Mills E. Godwin High School*
The Effect of *Asparagus racemosus* Concentration on *Daphnia magna* Condition

The purpose of this study was to investigate the effect of *Asparagus racemosus* concentration on *Daphnia magna* condition, which is either alive and non-reproducing, dead, or alive and reproducing. This has implications for understanding phytoestrogenic properties and their potential applications in human health and ecological stability. Used in Ayurveda, *Asparagus racemosus* contains compounds structurally similar to estrogen, which may influence reproductive and physiological processes. This study explored whether these compounds could affect the condition of *Daphnia magna*, essential freshwater organisms critical to aquatic ecosystems and widely used as model organisms in research. A research hypothesis was formulated that if 2 grams/liter concentration of *Asparagus racemosus* would result in *Daphnia magna* being alive and reproducing. The control group, 0 g/L concentration, represented natural conditions for *Daphnia magna*. The procedure involved exposing Daphnia magna to four concentrations (0, 0.5, 1, and 2 grams/liter) over six days while monitoring its condition. The constants included consistency in light cycles, feeding, and environmental conditions. A chi-square was performed and showed the data for *Asparagus racemosus* having an effect on the condition of *Daphnia magna* is statistically significant ($\chi 2 > 5.991$ for 0, 1, and 2 g/L groups) with the exception of the 0.5 grams/liter concentration vs the expected ($\chi 2 < 5.991$). The conclusion suggested that higher concentrations may be toxic to *Daphnia magna*, potentially due to overstimulation or toxicity from phytoestrogenic compounds. In the future, lower concentrations of *A. racemosus* should be used, along with extended timelines to better understand this plant's impact.

Vivien Verghese *Mills E. Godwin High School*
The Effect of Cooking Methods on Vitamin C in Broccoli

The purpose of this experiment was to find the effect of different cooking methods on the vitamin C content in broccoli. Recently, home cooking has increased in popularity among the public and it's important they are aware of what ways to cook their food in order to obtain maximum nutritional benefit. Groups of 10-gram broccoli florets were either baked, boiled, steamed or raw. The raw broccoli was the control. They were then blended to a liquid consistency and tested for vitamin C levels using a titration method with an iodine starch solution. In a titration, the more mL of broccoli juice needed to turn the solution, the less vitamin C it has. It was hypothesized that if the broccoli is baked, then it will have the highest level of vitamin C. The results reveal that the baked group had the most vitamin C at 4.5 mL, followed by steamed at 5.6 mL, raw at 7.9 mL and lastly boiled at 9.7 mL. A t-test was done on the data for every level of independent variable and everyone was significant. The results do support the research hypothesis and cooking method does have an effect on vitamin C level. It is believed the results are due to vitamin C's water-soluble properties, therefore being lost in cooking mediums involving water. This research can be expanded to investigate more cooking styles or experiment on specific factors in each method, such as time or water amount.

Sean Wemyss *Tabb High School*
Can Spices Inhibit Bacterial Growth?

The purpose of this experiment was to determine whether or not certain spices display antibacterial activity, and whether the concentration of their respective antibacterial property determines the level of antibacterial activity shown. Since turmeric contains a higher concentration of its antibacterial property (curcumin), than ginger (gingerol), and cinnamon (cinnamaldehyde), then turmeric was predicted to inhibit growth the most effectively. To run the experiment, unopened versions of each powdered spice were obtained in addition to distilled water, hand sanitizer, various tools, agar plates, and the *Escherichia coli* K-12. Filtrates were created from each spice, and once each filtrate was ready, they were applied to two agar plates each with the same application. Hand-sanitizer was applied to a plate in the same manner. Once the filtrates and hand-sanitizer have been piped and spread onto their respective plates, bacterial broth (*E-coli* K-12) is added. An 8th plate with just bacteria added

was done as a control. The plates were taped and placed into the incubator for 48 hours. Afterwards, the plates were removed, and bacteria was counted on the most concentrated region in a 10mm-by-10mm zone. The data revealed that, using the hand-sanitizer control (0 bacterial colonies) and pure-bacteria control (270 colonies), each of the spices displayed a level of antibacterial activity. Turmeric (3.5) was the most effective compared to ginger (35) and cinnamon (87.5). However, the results and error bars indicated that the concentration of their respective antibacterial properties was not the sole factor in their antibacterial activity, since ginger and turmeric had a small amount of overlap on their error bars, and since cinnamon inhibited the least growth while having the second highest concentration of its antibacterial property.

Daniel Xie *Central Virginia Governor's School for Science and Technology*
Vanillin and Vanilla Extract-Infused Mouthwash in Inhibiting Quorum Sensing of *S.mutans* Dental Plaque Biofilms

This study aimed to discover effective additives in mouthwash for treating dental plaque. Aseptic techniques ensured that the working area remained sterilized throughout the research. Three solutions were prepared with varying ratios of vanillin and vanilla extract mixed with mouthwash (90.9%, 72.7%, and 54.5% Vanillin and Vanilla Extract). These solutions were dispensed into nutrient agar to measure their zones of inhibition. Two single-factor ANOVAs were used to determine that concentrations of VN were significantly different from each other (p-value =4.66x10-8, alpha = .05) as well as the concentrations of VE (p-value =1.266x10-14, alpha = .05). Additionally, significance was found comparing the equivalent concentration of VN to VE (p-value = 1.29 X 10-4, alpha = .05). with a two-factor ANOVA. Vanillin demonstrated an increase of inhibiting properties as the concentration increased (54.5%, 4.66 cm; 72.7%, 4.81 cm; and 90.9%, 5.13 cm) compared against plain mouthwash (4.48 cm). On the other hand, using vanilla extract resulted in a decreased zone of inhibition, likely due to the propylene glycol used as a sweetener. The study supported the hypothesis that if vanillin-infused mouthwash and vanilla extract-infused mouthwash were tested on the bacteria *Streptococcus mutans*, the vanillin-infused mouthwash demonstrated the greatest zone of inhibition, suggesting superior efficacy in inhibiting quorum sensing, which may enhance oral health care for individuals suffering from dental plaque.

Sanvi Yalamanchili *Mills E. Godwin High School*
The Effect of Types of Sugar on Bakers Yeast Growth

This study explored the effect of different sugar types on baker's yeast growth, aiming to address the time-consuming process of yeast preparation and offer alternatives for individuals with dietary restrictions, such as diabetes. Granulated sugar was used as the control due to its common use in baking, providing a baseline for comparison. The proposed hypothesis was, if powdered sugar is used, then the yeast will grow more in five hours. Equal amounts of water, flour, and yeast powder were mixed in 25 cups, with sugar types added, and the mixtures covered. After 45 minutes, growth was measured in centimeters. Honey produced the highest average growth (2.9 cm), followed by granulated sugar (2.6 cm), while powdered sugar showed the least growth (2.0 cm). Raw sugar (2.2 cm) and coconut sugar (2.3 cm) had moderate effects. Honey exhibited greater variability, whereas granulated sugar produced consistent results. Statistical analysis rejected the null hypothesis, indicating significant differences in yeast growth between sugar types ($p < 0.05$). Contrary to the hypothesis, powdered sugar was not optimal, showing the lowest growth. These findings suggest that honey and granulated sugar are more effective for promoting yeast growth. The results have implications for the baking industry, offering insights into more efficient yeast preparation methods and alternatives for consumers with dietary restrictions.

Lindsey Yue *Mills E. Godwin High School*
The Effect of Different Fabric on Yeast Growth Under Ultraviolet Radiation

Ultraviolet radiation in sunlight is a known carcinogen but can be protected against with several defenses, including clothing fabric. This experiment was meant to determine the effects of different fabrics on yeast growth while subjected to ultraviolet radiation. Saccharomyces cerevisiae cells were covered by either cotton, polyester, or denim fabric, and then subjected to ultraviolet light for 4 hours. The yeast was then allowed to culture for 3 days. The control in the experiment was no fabric. It was hypothesized that the denim group would provide the most colony-forming yeast units compared to cotton, polyester, and no-fabric groups. The results revealed that the yeast covered with denim fabric grew an average of 22 CFUs more than cotton, 11 CFUs more than

polyester, and 37 CFUs more than the control group. A t-test revealed that the data was significant for all levels of the independent variable. The data rejected the null hypothesis and supported the research hypothesis. It is believed that the results are due to the tighter weave pattern of the denim fabric providing less ultraviolent radiation transmission than the more porous fabrics of cotton and polyester. Additionally, the synthetic material of polyester has less space between the fibers, leading to lesser UV transmission and greater yeast colony growth. This could lead to further studies based on the different weave patterns between fabrics of the same material.

Microbiology & Cell Biology B (HS MCB B)

First Place
Joshua Osemobor *Southwest Virginia Governor's School*
Environmental Limiting Factors of the Plankton Paradox

The plankton paradox challenges the competitive exclusion principle, which suggests that species competing for the same resources cannot coexist indefinitely. Despite this, plankton communities maintain remarkable biodiversity in resource-limited environments. Many have presented possible solutions to the paradox itself, but this experiment aimed to answer a certain key part of it: What limiting environmental factors have a significant impact on the plankton's ability to coexist with other like organisms in the same ecological niche? Three key factors were investigated: light availability, nutrient concentrations, and temperature gradients. By simulating controlled aquatic cultures, the analysis focused on the equilibrium of the different plankton species living in the same space. Samples were taken from these cultures, and a hemocytometer was used to estimate the population of each type of plankton. A fluorometer was used to check each culture's health by measuring the overall fluorescence level. Results revealed temperature gradients were the most significant factor influencing species like Ulothrix, Chlamydomonas, and Pandorina. Nutrient availability and light constraints also played important roles for species like Oscillatoria. No variables were found to have a significant effect on species like Scenedesmus and Spirogyra. For Osc. temp; p-value of 0.3087, for nutrients; p-value of 0.0076, for light; p-value of 0.2397. For Scene. temp; p-value of 0.3771, for nutrients; p-value of 0.3403, for light; p-value of 0.1686. For Ulo. temp; p-value of 0.0270, for nutrients; p-value of 0.1769, for light; p-value of 0.2397. For Chl. temp; p-value of 0.0002, for nutrients; p-value of 0.1010, for light; p-value of 0.5506. For Pand. temp; p-value of 0.0152, for nutrients; p-value of 0.0654, for light; p-value of 0.5232. For Spiro. temp; p-value of 0.3985, for nutrients; p-value of 0.1573, for light; p-value of 0.2056. These findings contribute to a deeper understanding of the mechanisms underlying the plankton paradox, emphasizing the importance of sustaining environmental biodiversity in seemingly competitive ecosystems. Future experiments could build on this work by investigating the interactive effects of multiple environmental factors or begin exploring the role of predation while certain resources are limited.

Second Place
Madeline Levorson *Thomas Jefferson High School for Science and Technology*
Development and Refinement of a Novel Rapid Phage Screening Protocol to Accelerate Bacteriophage Discovery and Offer Alternatives for Antimicrobial Resistant Infections

The World Health Organization estimates by 2050, antimicrobial resistance (AMR) deaths will outnumber cancer deaths. A solution to AMR is desperately needed and bacteriophages are part of the solution. Lytic bacteriophages are bacteria-specific viruses that lyse and kill bacteria. Lytic bacteriophages, including bacteriophage cocktails, have had limited treatment roles in AMR infections since bacteriophages must perfectly match the patient's bacterial isolate and be available upon demand. Unfortunately, discovering patient-specific bacteriophages takes significant research time. In response to the need for rapid bacteriophage treatment, I sought to develop and refine a bacteriophage discovery protocol and evaluate environmental bacteriophages for cross-lytic bacteriophage activity. A novel spectrophotometric Rapid Phage Screening Protocol (RPSP) was developed, patented, and enhanced to provide a fast inexpensive method to discover lytic bacteriophages from the environment. Further refinements were made with validation of RPSP v2.0 through iterative testing of known lytic bacteriophages, phage cocktails, and environmental samples against E. coli B. Time-dependent decreases in optical density (OD) absorbance proved lytic bacteriophage activity. Additionally, this research suggests

phage cocktails may not be necessary for treatment and may have antagonistic effects. Furthermore, cross-lytic activity was displayed with all eight discovered bacteriophages against both *E. coli B* and *E. coli K12*. No lytic ativity against six other bacteria was found. RPSP v2.0, using portable laboratory equipment and protocols, allows for rapid discovery of novel lytic bacteriophages which will help ameliorate the AMR crisis by providing rapid bacteriophage discovery and personalized medical treatments to patients worldwide.

Third Place
Jasmine Chen *Chesapeake Bay Governor's School*
A Comparison of the Antifungal Properties of Different Materials Found in Hospitals for Invasive Fungal Infections

Invasive fungal infections are a significant problem in the healthcare industry. These fungal infections are easily contaminable and can spread throughout hospital patients. This study tested how various materials and textures could impair fungus growth through surface texture. Different textures, such as smooth or rough, can change their antifungal impact on fungi. In this experiment, smooth copper, textured copper, smooth steel, textured steel, and cloth were used. *Rhizopus stolonifera*, black bread mold, was chosen to demonstrate a common fungus that can be found in the modern world. This was a pilot study to measure the overall growth of *Rhizopus mycelium* when in contact with the materials used. Previous research suggests that copper exhibits stronger antifungal power compared to stainless steel. It is also hypothesized that surfaces with rougher texture will also exhibit stronger antifungal abilities. Our results suggest that stainless steel, copper, and cloth do have antifungal abilities where fungus growth can be affected, as the control had a noticeably higher mean mass of mycelium when compared to any of the other substrates. We found that the surface texture had minimal effect on the growth of the fungus. This supports the use of these materials in a hospital environment, as they have an antifungal impact. They may reduce the number of fungal infections and have implications for saving lives and money for many individuals.

Honorable Mention
Yana Dewan *Mills E. Godwin High School*
The Effect of Varying Urea 46-0-0 Concentrations on the Growth of *Chlorella vulgaris*

The purpose of this experiment was to determine the influence of varying Urea 46-0-0 concentrations on the growth of *Chlorella vulgaris*. Urea is globally utilized as a nitrogen fertilizer in pesticides and insecticides, making it easily susceptible to agricultural runoff. Because it thrives on nitrogen, *Chlorella vulgaris* is both dangerous as an algal bloom and crucial industrially. The algae were placed in a medium of mineral water and 2 concentrations of Urea: 25% and 59%. No Urea was utilized as the control. The *Chlorella vulgaris* was situated in indirect sunlight for 10 days; their growth was then measured with a SpectroVis in absorbance units. It was hypothesized that the algae treated with 25% Urea concentration would produce the greatest growth. The results affirmed that *Chlorella vulgaris* treated with a 25% concentration grew on average, 0.042 AU greater than the 59% and 0.053 AU than the control. The algal growth under 59% was less than the 25% but still greater than the control. The t-tests conducted showcased the data was statistically significant. The results supported the research hypothesis. This is likely because the nitrogen content in the 25% concentration inflated lipid production and accelerated photosynthesis within the *Chlorella vulgaris*, producing exponential growth. However, the 59% concentration likely had too much nitrogen and ammonia in its compound, causing it to become toxic to the algae instead and ultimately eliminate it. Further studies should investigate the optimum amount of Urea 46-0-0 for algae growth and how other chemical fertilizers influence it.

Honorable Mention
Krithik Poondru *Mills E. Godwin High School*
The Effect of Influenced Water on Bacterial Growth on Spinach

The purpose of this experiment was to investigate the effectiveness of turmeric- and garlic-infused water as natural alternatives to synthetic decontamination methods for reducing bacterial contamination on spinach. The significance of this research lies in its potential to address critical food safety concerns while offering sustainable,

natural solutions that align with consumer demand for environmentally friendly practices. By reducing reliance on synthetic chemicals, these natural treatments may help mitigate health risks and environmental damage. It was hypothesized that spinach treated with turmeric-infused water would exhibit the lowest Total Aerobic Microbial Count (TAMC) due to curcumin's strong antibacterial properties, followed closely by garlic-infused water, which contains allicin known to disrupt bacterial growth. To test this hypothesis, spinach samples were subjected to one of four treatments: no water (control), plain water, turmeric-infused water, or garlic-infused water. TAMC was quantified using partial serial dilutions, TSA agar plates, and incubation at 20–25°C for 24–48 hours. A control group was included to isolate the specific effects of each treatment. The results indicated significant differences among treatments, with plain water showing inconsistent effectiveness due to variability in water quality and initial contamination levels on spinach. In contrast, turmeric- and garlic-infused water produced more consistent reductions in TAMC. Statistical analysis confirmed that these natural treatments significantly impacted bacterial growth compared to the control . The consistency of turmeric and garlic treatments is attributed to their antimicrobial properties, which reduced bacterial diversity and maintained lower contamination levels compared to the more unpredictable effects of plain water.

Honorable Mention

Saanvi Sambangi *Mills E. Godwin High School*
The Effect of Different Medicinal Oils on Planaria Regeneration

The purpose of this experiment was to find the effects of different medicinal oils on the regenerative growth of planaria. Recently, essential oils have adopted a more prominent role in medicine. However, because of steam distillation, essential oils release VOCs, which are known carcinogens that cause cardiopulmonary issues, and skin irritation. To assess the effects of essential oils on skin inflammation, planaria were exposed to Tea tree oil with ethanol, Frankincense oil with ethanol, and CBD oil with ethanol. The research hypothesis was that the planaria exposed to CBD oil would grow the least. The control was planaria exposed to just ethanol. The planaria were allowed to grow for 2 weeks before the final length was subtracted from the initial length to find the amount of growth. The results revealed that the planaria exposed to CBD oil on average grew the least according to the means, which supported the hypothesis. According to the t-test conducted, all of the planaria in essential oils grew significantly less than the control, proving that medicinal oils negatively affect planarian growth. It's believed that these results are due to the effects of VOCs on lipid, protein, and mitochondrial function. Since VOCs are a kind of reactive oxygen species, or ROS, they can result in oxidative stress and lipid peroxidation as well. This experiment could lead to further research on the effects of medicinal oils and VOCs on skin cell growth and death.

Sarah Chaudhry *Central Virginia Governor's School for Science and Technology*
The Effects of Colored Lighting on CRISPR Effectiveness

The purpose of this study was to determine whether colored lighting has an effect on CRISPR effectiveness of gene editing. The study was conducted in a local high school laboratory in November and December of 2024. Blue, white, and red light was used along with a control group with no light. E. coli HB101-pBRkan was cultured and subjected to CRISPR gene editing. Following this, three groups were placed under lights with gels of each respective color while the control group was left to incubate in the dark. Successful gene editing is indicated by the presence of white colonies, as opposed to blue bacterial colonies. The average amount of plates that presented successful gene editing and turned white was 2.75 of 8 (total). The average amount of plates that presented unsuccessful gene editing and remained blue was 5.25. A chi-square test of independence resulted in a p-value of .049. When compared to an alpha value of .05, the data was significant. Therefore, the hypothesis, which stated that if red, blue, and white light were used when incubating Escherichia coli that is undergoing CRISPR gene editing, then the trial that is cultured under blue light will present the desired lacZ gene, a gene that catalyzes lactose, less effectively, was partially supported due to the red experimental group providing the same results as the blue experimental group. In conclusion, colored lighting does have a significant effect on CRISPR effectiveness.

Sydney Kelley *Mills E. Godwin High School*
The Effect of Copper Sulfate on *Daphnia*

Copper sulfate is a commonly used pesticide that can leach into groundwater and contaminate food. Pesticides can cause long lasting adverse effects on non-target organisms. The purpose of this project was to determine whether copper sulfate affects the heart rate (BPM) of *Daphnia magna*. One hundred *D.magna* were divided into four groups. They were given various doses of copper sulfate. These were 0 µg/L, 10 µg/L, 20 µg/L, and 30 µg/L, with 0 µg/L being the control. It was hypothesized that a greater amount of copper sulfate would result in an increase in BPM. The results indicated a decline in BPM for the *D.magna* exposed to copper sulfate when compared to the control. A t-test showed that the data among the independent variables (IV) and the control were significant ($p<0.05$). However, the data between the groups exposed to copper sulfate was not significant ($p>0.05$). Although, it did still show a downward trend. It was thought the decrease in BPM was the result of copper-based arterial plaques. Future studies should investigate copper metabolism as well as how those arterial deposits would impact the general health of a more mammalian species.

Vir Patel *Mills E. Godwin High School*
The Effect of Fruit Peels on Bacteria Removal in Water

The purpose of this study was to investigate the effectiveness of tangerine, lemon, and banana peels in removing bacteria from pond water. Water pollution remains a global issue, particularly in underserved communities lacking access to filtration technologies. This research aimed to identify an affordable alternative to expensive water purification methods by repurposing fruit waste. The hypothesis stated that lemon peels would be the most effective at reducing bacterial concentrations in pond water. A controlled experiment of pond water with no fruit peel was conducted to isolate the effects of fruit peels on the removal of bacteria in pond water. The procedure involved soaking equal amounts of each peel type in pond water samples for a fixed duration, measuring absorbance levels after treatment using a SpectroVIS spectrophotometer, and then comparing them with the control group. The results, analyzed using inferential statistics, demonstrated that lemon peels were most effective in reducing bacteria in pond water, with a mean light absorbance of 0.037 compared to 0.091 for orange peels, 0.325 for banana peels, and 1.306 for the control (no fruit peel). T-tests ($p < 0.05$) confirmed significant differences between experimental and controlled groups, proving that fruit peels were effective in removing bacteria in pond water. Low standard deviations indicated high precision and accuracy between the results. In conclusion, fruit peels provided an eco-friendly and inexpensive solution for costly purification methods, especially in poor and underserved communities. Variations in effectiveness were due to the unique chemical properties of each peel.

Lalantika Prabhanand *Mills E. Godwin High School*
The Effect of Different Herbs on Growth of Aerobic Bacteria

The purpose of study for this experiment was to determine the effect of different herbs on growth of aerobic bacteria. Herbs have been used for many medicinal purposes to treat diseases. A few herbs such as Tulsi, thyme, oregano, and mint have been used to treat respiratory diseases. Herbal medication could impact on our society by creating a clean, costless, and possibly healthier but still an efficient alternative for antibiotics. To determine which herb was the most effective toward the bacteria, the herbs were grinded, mixed with sterile water, dipped into disks, and placed on a petri dish with the bacteria. They were incubated for 1 week and the bacterial colonies were recorded. There was no control for this experiment because growing bacteria without herbs doesn't impact the experiment. It was hypothesized that using Tulsi the growth of bacteria will be greater than thyme, oregano, and mint. The results revealed on average, Tulsi had 18 bacterial colonies, mint had 10, oregano had 6, and thyme had 19. These results did not support the hypothesis. A t- test was performed on the data and showed that Mint vs Tulsi, Mint vs Oregano, Tulsi vs Oregano, Mint vs Thyme, and Oregano vs Thyme are significant. Tulsi vs Thyme are not significant. These results are probably due to the fact that Thyme and Tulsi have high antimicrobial properties, which sometimes help them work better with other herbs rather than with each other. This experiment could lead to further studies about medicinal herbs.

Saharsh Darsh Shetty *Mills E. Godwin High School*
The Effect of Different Decontamination Methods on Purity of Water

Access to clean drinking water is a critical issue in many countries, contributing to diseases like food poisoning and diarrhea. People in impoverished communities should have access to cheap and accessible tools to clean their water. This experiment was performed to understand how decontamination methods including Distillation,

Autoclaving, Solar Water Disinfection (SODIS), and Chlorination can reduce bacterial contamination in creek water. The researcher hypothesized that if these decontamination methods were used on creek water, the water cleaned via Chlorination would have the lowest bacterial count. Untreated water was the control which is used as a standard of comparison. Water samples were collected and distributed into PET bottles. For Distillation, the samples were boiled for one minute at boiling point. Autoclaving involves heating the water samples into an autoclave for 20 minutes, and SODIS involves exposing the samples to sunlight for 7.5 hours and to UV light for 1.5 hours. Chlorination was conducted by dropping 1 chlorine pill in each sample. Each treated sample was swabbed on one of 125 agar plates and incubated for 48 hours. Afterwards, bacterial growth was recorded on data tables and a bar graph. The results showed that Chlorination produced the least bacterial growth because chlorine can invade and destroy bacteria and had the lowest p-value compared with the other IV levels. Future improvements include distributing the length of time each sample is swabbed on agar plates and avoiding extra sunlight in SODIS samples.

Shruthi Tirunahari *Mills E. Godwin High School*
The Effect of Acne Medications on *S. Epidermidis*

The purpose of this experiment was to identify if different acne medications had an effect on the growth of *S. epidermidis.* In recent studies, acne medications have been developing immensely to stop the growth of acne for individuals suffering from it. The bacteria, *S. epidermidis*, was treated with Salicylic acid, Benzoyl Peroxide, and Adapalene. The plates were then left to incubate for five to seven days and later measured their zone of inhibition. The control in this experiment was no treatment for the bacterium in the agar plate. It was hypothesized that Benzoyl Peroxide would have the greatest zone of inhibition and prevent the growth of *S. epidermidis.* The results revealed that Benzoyl Peroxide had the largest zone of inhibition rather than Adapalene and Salicylic Acid. A t-test was done on the data, and it revealed that the data was statistically significant for Adapalene versus the control, Salicylic Acid versus the control, and Benzoyl Peroxide versus the control. The results did support the research hypothesis, and the null hypothesis was rejected. It is believed that the results are due to fact that Benzoyl Peroxide is a powerful inhibitor to gram-positive bacteria, *S. epidermidis*. This research could lead to further investigations using different bacteria such as Cutibacterium Acnes or other bacteria.

Microbiology & Cell Biology C (HS MCB C)

First Place
Saranya Manikandan *Mills E. Godwin High School*
The Effect of Spice on Bacterial Growth

The purpose of this experiment was to discover the effects of different spices on bacterial growth. Lately, natural food preservatives like spices and herbs have been utilized to improve the longevity of consumables and possibly prevent the growth of *E. coli K-12*. Turmeric, clove, or cinnamon disks were divided and placed in 100 petri dish sections with E. coli. The petri dishes were incubated for 48 hours in 37 degrees Celsius, and the inhibition zone was measured. The control group was the Petri dishes containing no spice as it would exhibit no zone of inhibition. It was hypothesized that if clove is used, then it will best inhibit bacterial growth. The results demonstrated that the petri dishes with a clove disk, on average, inhibited 1.1 millimeters more bacterial growth than turmeric, 1.13 millimeters more than cinnamon, and 1.16 millimeters more than the petri dishes with no spice. A t-test was performed on the recorded data, revealing that it was not significant for clove vs. the control, turmeric vs. the control, cinnamon vs. the control, clove vs. turmeric, clove vs. cinnamon, and turmeric vs. cinnamon. The results did not statistically support the research hypothesis. It is considered that the results are caused by an error in experimentation, possibly contamination, or the disk solutions being too diluted. This research could be inspiring for future studies evaluating which form of clove or other spices is more optimum for inhibiting bacterial growth and how clove responds to a variety of bacteria.

Second Place

Henry Amerson *Clover Hill High School*

The Effect of Adding Varying Amounts of Vitamin B12 to a Culture of *Saccharomyces cerevisiae* on the Amount of CO^2 Produced by Fermentation

The purpose of this experiment was to determine whether adding varying amounts of vitamin B12 to a culture of *Saccharomyces cerevisiae* could enhance fermentation efficiency, measured by the amount of CO^2 produced. Fermentation is a critical process for producing beverages such as beer and wine, and the improvement of its efficiency could have significant industrial benefits. The research hypothesis was: Adding vitamin B12 to a culture of *S. cerevisiae* would increase the amount of CO^2 produced by fermentation. Fermentation tubes were prepared with the same quantities of water, sucrose, and *S. cerevisiae*, while the amount of B12 varied among the experimental groups. CO^2 production was measured over a 2-hour period. The mean CO^2 production for all groups ranged narrowly from 3.51 cm^3 to 3.54 cm^3, showing minimal differences. The data indicated that adding B12 did not enhance fermentation efficiency under these conditions. The null hypothesis was not rejected by the data. The research hypothesis was not supported by the data.

Third Place

Ritvik Adusumilli *Mills E. Godwin High School*

Effectiveness of B-Lactam Antibiotics Combined with Clavulanic Acid Against *Escherichia* (Resistance)

Amid the global health crisis of antibiotic resistance (AR) which continued to claim countless lives, this study aimed to explore novel pharmaceutical approaches to address AR, an issue largely caused by the misuse of antibiotics like β-Lactams. However, other drugs such as Clavulanic Acid could be utilized to combat this resistance and potentially save lives as this problem progressed. To test this, *E. coli* was made resistant via transformation and exposed to three conditions; a disk with 50 µL of Ampicillin, a disk with 20 µL of Ampicillin and 10 µL of Clavulanic Acid, and a blank disk that acted as the negative control. After overnight growth, the inhibition zone diameters were measured in centimeters. A negative control with non-resistant *E. coli* and a blank disk was also included in which it was hypothesized that the organism would grow normally. With respect to the mutant, it was hypothesized that the combination of Ampicillin and Clavulanic Acid would yield larger zones of inhibition than the other treatments. Per the results, the antibiotics combination led to a 1.23-centimeter average, exponentially greater than the other two disks with no inhibition each. To further analyze these findings, t-tests were performed, and the data was statistically significant for all the t-tests besides the Ampicillin versus the Blank (Control). Backing up these observations, it was found that Clavulanic Acid inhibited a special enzyme called Beta-Lactamase that provided *Escherichia coli* the ability to become resistant to Ampicillin. In turn, Clavulanic Acid enabled Ampicillin to overcome resistance.

Honorable Mention

Aarush Burukunte *Mills E. Godwin High School*

The Effect of Time on Floor on Bacterial Growth

The purpose of the study was to raise awareness about the critical importance of safeguarding against nutritional contamination. Contaminants in food can originate from a variety of sources, including agricultural pesticides, toxic heavy metals, and harmful microorganisms, all of which pose significant risks to human health and wellness. Recently, there has been a heightened interest in preventing food product contamination. This increased focus is a response to several high-profile foodborne illness outbreaks that have raised public awareness about the risks associated with contaminated food. For instance, the Centers for Disease Control and Prevention (CDC) recently recalled thousands of quarter-pound burgers from McDonald's due to significant *E. coli* contamination linked to yellow onions. A research hypothesis was formulated. If the piece of cheese is exposed to the cafeteria floor for 1 second, then there will be minuscule to zero bacteria buildup. A sample of cheese that received no contamination (0 seconds) served as the control for this experiment. A petri dish experiment was conducted using 4 sets of cheese, each exposed to the cafeteria floor for varying durations of 0, 1, 5, and 10 seconds. The cheese was rubbed onto sealed Petri dishes, which were incubated for two days before being assessed for bacterial growth by a 0.01g accuracy scale. Finally, the cheese and petri dishes were sealed and disposed of in a biohazard.

Honorable Mention
Jeevan Gutta *Mills E. Godwin High School*
The Effect of Different Environments on Bacterial Growth on Toothbrushes

The purpose of this study is to explore how different environments affect bacterial growth on toothbrushes. Daily hygiene tools like toothbrushes can become breeding grounds for microbes, making proper storage essential for maintaining oral health. A research hypothesis was formulated: If toothbrushes were stored on bathroom counters, then they would have the highest levels of bacterial growth. The research examined bacterial growth under four storage conditions, using the bathroom counter as the control to represent common practice. Additional test conditions included uncovered in an open room, covered in an open room, and in a drawer. Each condition was evaluated by measuring colony-forming units. Testing demonstrated varying levels of bacterial contamination across storage environments. The results supported the initial hypothesis, with bathroom counter storage showing significantly higher bacterial growth compared to other locations. A t-test was performed and showed the data for storage location having an effect on the bacterial growth on toothbrushes is statistically significant ($\chi 2 > 2.682$ for bathroom counter, open room covered and uncovered, and the drawer groups). The high bacterial presence in bathroom storage can be attributed to humidity, moisture retention, and exposure to airborne contaminants. This research offers practical implications for both manufacturers and consumers, suggesting the need for improved storage practices and potential design modifications to enhance daily oral care hygiene.

Honorable Mention
Aaryan Tonpay *Mills E. Godwin High School*
The Effect of Different Carbohydrates on Soreness and Lactic Acid Production

This experiment was designed to view the impact of carbohydrates on soreness and lactic acid production following strenuous exercise. The researcher, including twelve volunteers, participated in this experiment. The experiment was repeated twice to ensure each independent variable group had a valid 26 trials. Carbohydrates were consumed an hour before the exercise began, which ensured that the food was digested before trials. After a swimming exercise, volunteers were asked the time when soreness or lactic acid was felt during the trial, and their responses were marked on a data table. The independent variable groups present were glucose, fiber, starch, and the control with no food. It was hypothesized that if fiber-based carbohydrates were ingested, then it would speed up the production of lactic acid. The gathered data was tested for statistical significance using a t-test. The results presented that all the t-tests were statistically significant, except for the starch vs fiber group. The data didn't provide evidence in support of the hypothesis. The control proved to be the quickest among all the groups to create fatigue. This provided information to the athletic community that consuming carbohydrates before a workout or competition can increase muscular endurance in the aspect of lactic acid production. This occurs because, when the body undergoes strenuous exercise without proper fuel, it begins breaking down fat as an alternative energy source while creating lactic acid.

Neha Beeravalli *Mills E. Godwin High School*
The Effect of Types of Protease Inhibitors on Guinea Pig Sperm Acrosomal Matrix Disassembly

This study examines the effects of the protease inhibitors Staurosporine, Aprotinin, and Leupeptin on the disassembly of the guinea pig sperm acrosomal matrix (AM), a process in fertilization. The AM breakdown, assisted by proteases such as acrosin, is important for sperm penetration of the egg but has to be regulated to ensure proper sperm function. The study hypothesized that Staurosporine, a kinase inhibitor, would induce the fastest AM disassembly due to its broad abilities compared to other protease inhibitors. A control group using a pH 11 buffer, assumed to stabilize at pH 8, was included for comparison. Disassembly times were measured under a microscope for each inhibitor. Results revealed that Leupeptin and Aprotinin each produced a mean disassembly time of 10 minutes, while the pH buffer and Staurosporine showed no disassembly. The low variance and standard deviation indicated precise data. The findings support the hypothesis that Staurosporine's inhibition of protein kinases involved in acrosome reaction signaling affects sperm function. The results show that different proteases don’t have a statistically significant effect on the sperm. The t-test results for all comparisons between the different speeds and the control revealed that the null hypothesis failed to be rejected, supporting the research hypothesis that Staurosporine disassembles the matrix the fastest in the guinea pig compared to other proteases and the control. This research helps to understand the key enzyme in the matrix that makes it disassemble, which offers insights with implications for fertility treatments or contraceptives.

Shaun George *Mills E. Godwin High School*
The Effect of Light Wavelengths on *Chlorella vulgaris* Fresh Mass

The experiment aimed to find the effects of different light wavelengths (red, yellow, blue, and white) on sp. *Chlorella vulgaris*. Recently, microalgae have been used in environmental science, biofuel production, and aquatic ecosystem maintenance. Due to the importance of biomass production, the principal objective was to see how natural and laboratory conditions such as the pigment of life affect the production, flourishing, and growth of algae cultures. In the experiment, algae cultures were grown under red, yellow, blue, and white light as the control. It was hypothesized that *C. vulgaris* grown under blue light would exhibit the highest fresh mass due to its efficient absorption by chlorophylls, as such blue light is commonly known for its higher photosynthetic rate. The experiment exposed the algae cultures to different light wavelengths for 7 days, measuring their fresh mass daily. The control was white light which was used to represent the broad spectrum of natural sunlight. The results revealed that the mass of red, yellow, and blue, on average, had a higher biomass content than white with yellow having the greatest effect followed by red and then blue. A t-test was performed on the data, revealing that the data was significant for red and yellow versus the control but not for blue versus the control. The results were shown not to support the research hypothesis. The results were believed to be due to light quality, intensity, and specific wavelengths. The cultures under the blue light could have been influenced by proximity to the other light sources causing excessive evaporation. Further research in turn could investigate longer exposure, light placement, following a day-to-night schedule, and additional environmental factors such as temperature, humidity, and oxygen levels to optimize growth conditions for the resulting biofuel and aquaculture purposes.

Alexei Lugo *Mills E. Godwin High School*
The Effect of Fertilizer and Temperature on Algae Growth

The main purpose of this study was to find the effects of fertilizer and temperature on algae growth, and understanding these effects will help also solve real world issues. Real world applications include stopping these algae blooms because algae blooms are very harmful in the environment. One of the effects that these algae blooms have is creating hypoxic (little oxygen) conditions in water which leads to aquatic life dying off. It was hypothesized that if fertilizer and temperature increase then the growth of algae will increase. The control used was 0mL of fertilizer applied and no change to the temperature. This is because it would show the growth rate of algae without any change to the environment that temperature and fertilizer would create. The process of this experiment starts with putting amounts of algae into vials and adding fertilizer based on the independent variable. For temperature change the vials were submerged in water that was heated. The algae were measured before and after using a spectrophotometer to test for growth. Results included performing a t-test that was found for all levels of independent variables except for 80 degrees temperature change. It was also found that the mean growth was the highest at 4mL fertilizer added and lowest at 72 degrees temperature change. Reasons for the results include lower temperature has a negative effect of algae growth, and higher fertilizer concentration has a positive effect. This shows how components of fertilizer such as nitrogen and phosphorus are crucial to algae growth.

Sophie Moret *Washington-Liberty High School*
Temperature Variations on Mouth Digestion

This experiment was conducted to test how small modifications, like temperature, can impact a person's digestive system and the rate at which digestion occurs. The hypothesis was: If the temperature of water is at 37°C, more glucose will be released after 25 minutes. Research shows that more glucose would be released at 37°C because it is the optimal temperature of amylase. A water bath was heated to the temperature of the group being tested with 5 beakers for each group and a mixture of amylase, water, and starch in each beaker for 25 minutes. After 25 minutes, a glucometer measured the amount of glucose released into the water and results were recorded. The average amount of glucose released for group 1 was 27.2 mg/dL. Group 2 released 56.4 mg/dL. Group 3 released 57.2 mg/dL. Lastly, group 4 released 32.2 mg/dL. The results indicate that as temperature increases, the amount of glucose released will increase. This is because enzymes speed up the rate of chemical reactions. Despite there not being significance in the T-Tests as a result of too much variation within group results, the ANOVA test still rejects the null hypothesis by showing distinct differences between groups and an evident increase in the amount of glucose released as temperatures increased. This experiment is important in determining how efficient the digestion process could become by changing the environment in which digestion occurs. It could be expanded to test different types of external variables.

Aarav Nayak *Mills E. Godwin High School*
Effect of Antibacterial Soap & Generic Soap on *Rhodospirillum rubrum*

The purpose of the experiment was to evaluate whether soap labeled as antibacterial is more effective in reducing bacterial growth compared to regular soap which does not have any antibacterial properties. The implications of this research are significant, as knowing the effectiveness of antibacterial soaps could help save consumers money by preventing unnecessary purchases of these specialty products. To conduct the experiment, a control was established using generic soap, which contains no additives, allowing for a direct comparison to the antibacterial variants. The procedure involved sectioning and labeling petri dishes into four equal parts for the different soaps being tested. After introducing a bacterial sample to the agar medium, soap was applied to discs and placed in each section of the dish. The petri dishes were then incubated for a couple of days to allow for bacterial growth. Upon examining the results, it became evident that bacterial growth appeared around two of the independent variables, and this pattern was consistent across all Petri dishes. However, an important observation was made: the dyes present in the antibacterial soaps stained the agar medium, which may have misleadingly contributed to the appearance of bacterial growth. In conclusion, while the initial assumption might be that the antibacterial soap performed better, the staining could suggest that the results were not purely indicative of the soap's antibacterial effectiveness. Future experiments should consider this factor to ensure more accurate assessments of the soaps' properties and their true efficacy in combating bacterial growth.

Ayona Shah *Mills E. Godwin High School*
The Effect of Diet Composition on Yeast Growth and Activity

This study investigated the effect of diet composition on yeast growth and activity, and focused on four diets: high-protein, high-carbohydrate, high-fat, and a balanced diet. Yeast, a unicellular fungus that was used in fermentation, was chosen as a model organism to observe how different nutrients would have interacted. The independent variable was diet composition, and the dependent variable was yeast activity which was measured by carbon dioxide (CO_2) production during the fermentation. The researcher tried to show how different nutrient compositions could have affected microbial ecosystems and gave help to understanding the gut microbiome and diet impacts on human health. Previous research stated that high-carbohydrate and high-fat diets would have had the highest CO_2 production because of their easily fermentable substrates, and high-protein diets would have had lower activity because of the increase in energy demands of protein breakdown. There were 25 trials for each diet composition and CO_2 production was measured using a CO_2 sensor. The results supported the hypothesis, and the high-carbohydrate diet had the highest CO_2 production (mean: 501.24 ppm, SD: 4.47), followed by the balanced diet, high-fat diet, and high-protein diet. Paired sample t-tests showed significant differences ($p < 0.01$) between diet compositions. The researcher saw that nutrient composition significantly influenced yeast activity, which went along with previous research. This study highlighted the importance of balanced nutrient diets to best help microbial growth and provided help for future studies on dietary impacts on microbial communities, including the human gut microbiome.

Physics & Astronomy A (HS PHY A)

First Place
Anuj Dahal, Kevin DiMattina, Oguskhan Kutlan *Governor's School @ Innovation Park*
Project Icarus: A Design and Development of Rocket Nozzles for High Pressure Atmospheres

Background: Rocket nozzles, which determine the speed and shape of rocket thrust, undergo overexpansion in high-pressure atmospheres. Using hand calculations, Rocket Propulsion Analysis (RPA), CAD software, and computational fluid dynamics (CFD), we designed and compared three sets of near-optimal bell and conical rocket nozzles for their relative efficiencies in the high-pressure atmospheres of Earth, Titan, and Saturn. Methods: Thrust and isentropic flow equations, along with the Chemical Equilibrium with Applications interface (CEARUN) were used to size six rocket engines and nozzles, with engines being held constant according to

the studied celestial body. Blank nozzle contours, estimated efficiencies, and 2D geometries were then generated and meshed to ensure accuracy in CFD simulations. The exit velocities of these fluid simulations, which directly correlate with nozzle efficiency, were compared between the conical and bell nozzles using analytical and graphic methods (data tables and value contours, respectively). Results: Compared to conical rocket nozzles, bell nozzles had greater exit velocities in Earthen and Saturnian atmospheric conditions. When simulating Titan's atmosphere, the conical rocket nozzle had a higher exit velocity than that of the bell nozzle. The peak velocities of the conical nozzles were equal to their exit velocities, while the bell nozzles' peak velocities differed from their exit velocities in the atmospheric conditions of Earth and Titan. Conclusion: This study and design project showed the effectiveness of thrust and isentropic flow equations in modeling accurate rocket nozzles for high-pressure atmospheres, along with the relative efficiencies of our bell and conical designs in Earth-, Titan-, and Saturn-based CFD simulations. Due to the presence of thrust losses near our bell-nozzle exit areas, further experiments will include better-optimized bell-nozzle sizing parameters.

Second Place
Shane Bright *Central Virginia Governor's School for Science and Technology*
Exploring Continuous Wave Laser-Generated Combustion Spectroscopy: developing a cost-effective metal identification system

The greatest technological advancements on planet Earth are typically attributed to the honing of metalworking throughout history, leading to the development of modern machining, construction, and manufacturing processes. However, there are many unidentified metals that sit in heaps of unused potential. The most accurate and definitive identification methods are based on spectroscopy (identifying light). Unfortunately, they are also typically the most expensive forms of identification. This can cause one to formulate the hypothesis that if one experimentally uses a continuous wave (CW) ytterbium-doped 2000-watt 1080 nanometer (nm) laser to combust a small portion of a target material surface, one would be able to accurately identify important compositional features, such as carbon content. Hence, this research focused on creating an accurate, modular, and cost-effective system for spectra-based metal identification. This was done by combusting a portion of 56 different sample metals with a laser and analyzing the emitted spectra using various Python programs created by the researcher. Furthermore, while decreasing the cost, the system itself has a much larger number of uses over traditional methods due to the selection of laser. After testing the experimental setup, the system was demonstrated to be useful and accurate based on the data collected in the study. The hypothesis was certainly supported, with a level of accuracy surpassing initial expectations for a newly developed system. There are opportunities for improvements to the methods and procedures outlined in this study; nonetheless they have been demonstrated to be useful even in their current state.

Third Place
Bryce Barron *Central Virginia Governor's School for Science and Technology*
The Effectiveness of Eco-Friendly Materials in Sound Damping

This study aimed to evaluate the effectiveness of eco-friendly materials in sound damping and noise reduction, with the goal of reducing material waste and noise pollution to benefit the environment. Eco-friendly materials were tested by placing them in a soundproof box and exposing them to tones across a frequency range of 100 Hz to 5000 Hz. The loudness of each frequency was measured in decibels after passing through the materials. The results showed that each material significantly reduced sound levels across all frequencies tested. This was determined through the use of an ANOVA two-factor test which output a p-value of 9.62×10-279 which was compared to an alpha value of .05. This supported the research hypothesis which stated that the independent variable, various eco-friendly damping materials, would have a significant effect on the dependent variable, the loudness of sound in decibels.

Honorable Mention
Kevin Zhang *Academies of Loudoun*
From Theory to Observational Results: Baryon Acoustic Oscillations Detected at High Redshift Ranges

The current mission from several space science institutions occurring on a global scale is the search for baryon acoustic oscillation (BAO) peaks. In our work, we were able to successfully discover a BAO peak detected by the Dark Energy Spectroscopic Instrument (DESI) Early Data Release (EDR) at a higher redshift range than the current published work. In our study, we chose a selection of 60,431 quasars between redshifts ranges from 2

< z < 3. We followed the methods used by current scientists which was to compute the correlation function, revealing a peak at roughly 110 h-1 Mpc at a significance value of 4·10^(-73) compared to a correlation function associated with a pure CDM model. The detection of the BAO peak in the DESI EDR is significant as it shows the potential of DESI as a powerful tool to determine the BAO standard ruler across a wide range of redshifts, with the 2025 official DESI data release providing even more data to conduct in-depth studies on BAOs. Based on this result, future analyses can help refine the position of the BAO peak at high redshifts and uncover new values for cosmological parameters within the early universe.

Emma Biesterveld *Southwest Virginia Governor's School*
How Spin Rate Affects the Velocity of a Pitch and What Is the Main Correlation Between Them

Spin rate and velocity are two fundamental components of pitching. Understanding the correlation between the two can enhance performances of all players on the field. Even though several factors, including grip and mechanics, can affect velocity, the main components investigated is how spin rate affects velocity and how they are correlated. A sample size of 50 pitches each was thrown for the fastball, changeup, curveball, and drop ball. Each pitch was recorded, and the velocity and spin rate were found using the Physlet Tracker Video Analysis and Modeling Tool. A Linear Regression was used to determine the strength and direction of any correlation between the spin rate and velocity. All of the pitches had an r-value that fell within the 0.5-0.8 limits, indicating there was a moderate positive correlation, and the p-value for each pitch was less than 0.0001, which makes the results statistically significant. Each pitch was able to reject the null and support that there is enough evidence to reach the conclusion that spin rate and velocity are correlated. The Magnus Effect explains the correlation between spin rate and velocity since the differences in pressure along the sides of the ball that create lateral and vertical movement and give each pitch its break also affects the actual and perceived velocity of each pitch. The increase in the velocity of a pitch also strengthens the Magnus Effect. Knowing the correlation between spin and velocity will enable pitchers to further develop each pitch in a way that makes it most effective. Ultimately, the synergy revealed between spin rate and velocity displays the importance of not just focusing on one aspect alone, but both together.

Landon May *Central Virginia Governor's School for Science and Technology*
How Soccer Headgear Affects Impact Forces

The purpose of this study was to examine how the angles of impact compared across several different soccer helmets affected the resulting impact force on a dummy head. The hypothesis was that if one used expensive headgear, then it would protect the person from receiving a concussion. Two types of headgear were used for this experiment, along with a control, having no protection. These were then tested on five different impact locations: the forehead, back, right side, left side, and top of the head. Each impact location per headgear was measured upon impact against a wall in acceleration m/s2. Afterward, a two-factor ANOVA determined significance in the interaction effect, with p-values of .29, .15, .02, compared to an alpha value of .05. A post-hoc Tukey test then determined between which groups the significance was held, with a Dmin value of 13.04. The difference was shown to lie between the interaction between the no headgear front and Full 90 headgear left side impacts (with a difference of 15.15), and this supported the original hypothesis, that using expensive headgear could protect one from receiving a concussion at a close distance. The results suggested that using more expensive headgear provides more protective capabilities compared to using no head protection.

Addison Mecom *Southwest Virginia Governor's School*
Effect of Temperature and Humidity on Road Traffic Noise

Road traffic noise greater than 55 A-weighted decibels (dBA) during the day and 40 dBA at night can have adverse public health effects. One study showed that absolute humidity, temperature, temperature gradient, wind velocity, wind velocity gradient, and relative wind direction all affect air traffic noise. Another study found that car noise from the side of the road increased with lower temperatures and greater humidity. The project aimed to find how temperature and humidity affect levels of road traffic noise at a distance from the source of the noise. The null hypothesis is that temperature and humidity will have no effect on road traffic noise. The alternate hypothesis is that lower temperatures and higher humidity levels will increase road traffic noise. A weather station was set up approximately one kilometer north of Interstate 81. On weekdays, data were collected between 5:30 p.m. and 7:00 p.m., when traffic is heaviest. Noise was measured five times each day, every five

minutes. Temperature, humidity, and wind data were recorded with the first and last noise measurements of the day. Averages of each measurement were calculated daily. Data were recorded as many days as possible, amounting to fifteen data points. Multiple linear regression implies a correlation between road traffic noise and temperature ($p=0.0021$), and no correlation between road traffic noise and humidity ($p=0.9677$) or wind speed ($p=0.6457$). The experiment should be performed again with more data and more diverse weather conditions. Areas near highways with frequently elevated temperatures should consider noise barriers to keep the population safe from unsafe levels of road traffic noise.

Physics & Astronomy B (HS PHY B)

Physics and Astronomy Award, Catesby-Jones/Ellett Award
First Place
Minh Nguyen *Blacksburg High School*
Optimizing Meta-Atoms for Large Scale Metalenses

Metalenses, promising new lightweight and customizable optical technology, are challenging to implement in practical situations. This is due to the difficulties of constructing precise, subwavelength-sized structures necessary for these lenses to function. Currently, metalenses are fabricated using methods such as e-beam lithography, which is too costly and time-consuming to apply on a large scale. Photolithography is a promising alternative method for efficient manufacturing; however, photolithography also has a lower resolution than current predominant fabrication technologies and depends on significantly larger meta-atom structures. This study addresses this issue by simulating several potential dielectric propagation phase-based metalenses using meta-atom structures optimized for their transmission intensity and maximal size. Four nanopillar shapes- circle, hexagon, triangle, and square- were investigated, and the resulting phase shift and transmission data were used to produce full phase coverage and incomplete phase coverage lenses. The study found that incomplete phase coverage lenses with small periodicity yielded greater focusing efficiencies while having larger minimum nanopillar radii. Additionally, hexagon meta-atoms typically produced the best-performing meta-lenses out of the four shapes.

Second Place
Joseph Legutko *Collegiate Schools*
The Effect of Satellite Trails on Astrophotos

The production and release of satellites is vastly increasing, leading to the rise of nervousness and fear in the astronomical scientific community. The effect of individual satellite trails on the stacking set of short-medium length exposure astrophotos was measured. Using a small deep sky telescope, satellites were tracked and imaged. Using ten subs with no satellite contamination, ten subs with one sub contaminated, and nine subs with no trail subs, 3 stacked frames were created. 8 sets of this were replicated in a similar manner. Their histograms were then analyzed, and the mean and standard deviation of the pixel values were recorded. From this, the SNR values could be determined for all three frames in all 8 sets. The resultant ANOVA p-values were calculated for the mean, standard deviation, and SNR, all of which came out to be insignificant when p is < 0.05. These results suggest that the effect of the satellites was essentially negligible, and when either the trail frame or rejected frame somewhat differed from the control frame, it was never repeated in the same way between sets. Thus, it would appear that, at least to the limitations of this study, single satellite trails have little to no negative impact on a stacked image.

Third Place
Tre Booth *Chesapeake Bay Governor's School*
Safety and Performance When Comparing Natural Grass and Artificial Turf While Performing Various Athletic Movements

Playing surface and surface type in the NFL and other professional outdoor sport leagues has been a hot topic recently. Out of the 30 stadiums that fly an NFL flag, 15 of them have natural grass fields and the other 15 possess artificial turf fields. Ninety two percent of league's players prefer natural grass and say that it is softer,

and therefore safer than artificial turf. Numerous studies have compared injury rate to the type of turf, but only a few have studied the physics of the two surfaces. This study compared natural grass (Bermuda) and a common artificial turf found in professional stadiums (FieldTurf) to examine which surface type was best for safety and performance. Using a force plate, the peak force (N) was measured when performing two athletic movements to compare the safety of the surfaces. To depict which surface was best for performance, the time of the curve (s) was obtained when performing the athletic movements. It was found that the average peak force was less when the surface type was natural grass. Conversely, artificial turf was found to have a lesser average time of impact, therefore meaning it was better for performance due to it having less give, which decreases the time the player is on the surface. Moreover, it was found that natural grass has a significantly less cost of installation, however natural grass requires more maintenance and has a longer life span. The results of this experiment offer further knowledge to future owners of facilities on what surface is the best to buy and maintain, while factoring in the environment and most importantly, player safety.

Honorable Mention
Lessa Bowers *Clover Hill High School*
The Effect of Passing Electricity Through Various Types of Insulators, Using a Van de Graaff Generator, on the Height and Width of the Resultant Lichtenberg Figures, as Well as the Number of Individual Branches

The purpose of this experiment was to explore the differences in the way that electricity moves through insulative surfaces, and to see which insulator was least effective. This was studied by observing the formation of Lichtenberg figures on polyethylene and acrylic. The electrical charge was built on a Van de Graaff generator and discharged through a nail into the insulative surface, and the size of the resultant figure was measured using the ImageJ app. The research hypothesis was that the Lichtenberg figure formed on polyethylene would be the largest and have the most branches. The mean areas of polyethylene and acrylic figures were 18.63 cm2 and 67.06 cm2 respectively, and the mean numbers of branches were 174 and 102 respectively. The research hypothesis was supported, and the null hypothesis was partially rejected. The data regarding the number of branches was significant, while the data regarding the area of the figures was not.

Honorable Mention
Minnah Khan *Clover Hill High School*
The Effect of Various Surfaces on the Amount of Force in Newtons Required to Slide a Pine Wood Block Across Each Surface

The purpose of this experiment was to determine whether pine wood, turf, porcelain tile, or play sand generates the most friction. Friction plays a crucial role in sports, as surfaces like turf, pine wood, sand, and porcelain tile are commonly used for gymnasiums and sports facilities. Identifying which surface creates the most friction can improve athletes' performance and reduce the risk of injuries by improving the design of sports facilities. The hypothesis was that compared to pine wood, porcelain tile, and play sand, turf would require more force in Newtons to slide a pine wood block across it using a spring scale. A pine wood block was slid across each surface using a spring scale to measure the applied force in Newtons, with 30 trials conducted per surface. The mean amount of force required for the pine wood, turf, porcelain tile, and play sand were 0.425 N, 0.673 N, 0.405 N, and 0.658 N, respectively. The results demonstrated that turf required the highest amount of force, while porcelain tile required the least. The null hypothesis was rejected, and the data supported the research hypothesis confirming that turf creates more friction than pine wood, play sand, and porcelain tile.

Honorable Mention
Collin Pounds *Clover Hill High School*
The Effect of Elevation Above Sea Level on Distance a Football Travels, When Launched

On December 8, 2013, Broncos kicker Matt Prater made a deep field goal to set the NFL record for the longest field goal made at the time. While Prater's success can still be attributed to his own talent, the high altitude at the game in Denver allowed for the ball to travel farther due to less density in the air. The purpose of this experiment was to further develop this physical concept, determining at which elevations in the Virginia Commonwealth a launched American football would be most affected in terms of distance: Virginia Beach (0 m), Midlothian (110 m), Roanoke (520 m), Smyth County (940 m) and Smyth County (1640 m). The hypothesis of this experiment was that the football would travel farthest at 1640 m above sea level. The American football was

launched using a Heavy Duty Football Potato Launcher, with the attached poles being spaced apart by 2 meters, before the football being launched 3 meters back from the midpoint. The pressure inside the football was kept constant, with the ball being blown up to 69 kPa of pressure. The distance that football traveled was determined by measuring tape, which began at the launcher's midpoint. The mean distance traveled for Virginia Beach (0 m) was 7.579 meters, 7.614 m for Midlothian (110 m), 85.424 m for Roanoke (520 m), 8.432 m for Smyth County (940 m), and 8.902 m for Smyth County (1640 m). The results of this experiment suggested that the distance that a football travels increases as the elevation above sea level increases, with the data for this experiment being deemed as significant.

Dylan Armstrong *Clover Hill High School*
The Effect of Roller Coaster Carts of Varying Heights/Centers of Gravity on Roller Coaster Speed and Distance Traveled

The purpose of this experiment was to determine which pair of handmade roller coaster carts with varying heights/centers of gravity would result in the greatest speed and distance traveled. There were four different pairs of carts, those being the 5 cm tall cart pair (the control), the 3.5 cm tall cart pair, the 2.5 cm tall cart pair, and the 1 cm tall cart pair. The location of the center of gravity on vehicles, especially amusement park rides like roller coasters, contributes to the speed at which the vehicle and the passengers inside move at. The hypothesis was: When the height/center of gravity of roller coaster carts was decreased, the carts would not travel as fast or as far. The 72-piece track which the pairs of carts traveled on was assembled. After the track was assembled, the different pairs of carts were built, and quarters were glued inside each individual cart to maintain a constant weight. Each pair of carts then traveled down the track one hundred times per cart pair with the speed being calculated and distance being recorded each time. The time was measured using a digital stopwatch and the distance was measured using string that had been marked at 1 cm increments by a ruler and then taped around the track. The speed each cart pair traveled at was calculated by dividing the distance the carts traveled by the time the carts took to travel. The 5 cm tall carts (control pair) had a mean speed of 84.4 cm/s. The 3.5 cm tall carts had a mean speed of 81.7 cm/s. The 2.5 cm tall carts had a mean speed of 83.4 cm/s. The 1 cm tall carts had a mean speed of 88.0 cm/s. When in comparison with each of the other height cart pairs, the 1 cm tall cart pair yielded the highest mean speed. The null hypothesis of the experiment was rejected although the research hypothesis was partially supported. The two lower height cart pairs, both the 3.5 cm tall and 2.5 cm tall cart pairs, displayed lower mean speeds than the control pair did. However, the 1 cm tall cart pair showed a higher mean speed than the control pair did.

Cara Barker *Clover Hill High School*
The Effect of Dropping Various Brands of Volleyballs, All Inflated to the Same Pressure (kPa), on the Bounce Height of Each Brand

The purpose of this experiment was to determine which brand of volleyball would yield the highest bounce: Mikasa, a brand originally from Thailand but popularized in the United States and recognized at the Olympic level, Molten, a Japanese brand, Tachikara, another Japanese brand that was easily recognizable through its softer textured leather, and Wilson, an American brand and manufacturer known for its affordable prices. While many of these brands are known by volleyball players everywhere, the variety of balls distributed between leagues are yet to have a consistent ball that everyone may use. At the collegiate level, Molten balls with a paneled exterior are the standard for both the men and the women. Yet, at the Olympic level, a specific type of Mikasa ball that is infamous for its mixture of small dimples across the surface of the ball and the significant number of panels in a non-traditional orientation is the standard for the men's national teams. The hypothesis was: if all the balls were inflated to the same pressure, the Mikasa volleyball would bounce the highest. Each brand of volleyball, Molten, Wilson, Tachikara, and Mikasa, had the classic 6 panel orientation, and were inflated to the same pressure. The balls were dropped off of a ladder, which was roughly the same height as a men's volleyball net, using a simple machine ramp. The Bounce Test was a volleyball was placed at the top of the simple machine ramp and using a slow-motion camera, the height of the bounce was documented and recorded. The mean bounce height for the Mikasa, Molten, Tachikara, and Wilson balls were 107.82, 111.56, 106.78, and 126.05 cm, respectively. The null hypothesis was rejected, and it became evident that the balls that were composed of harder leather components yielded the highest bounce results. The softer the leather of the volleyball, the lower the bounce height, which was realized as the Wilson volleyball had the hardest leather and the Mikasa volleyball was crafted with a softer, yet firm material.

James Nigriny *Clover Hill High School*
The Effect of Amount of Scuffing of a Baseball on Speed of the Ball and Percentage of Pitched Balls that are Found Within the Strike Zone

The purpose of this experiment was to determine if scuffing baseballs with various sandpaper grits had an effect on the speed of the ball and the percentage of pitched balls found within the strike zone. The results of physically altering baseballs are widely unknown in baseball physics causing a gray area in the understanding of how a baseball moves and how the outside factors interact with the flight path of a baseball. By using different sandpaper grits to scuff a baseball, research can be conducted to study how physically altered baseballs affect the variability of a baseball pitch. The hypothesis of this experiment was, the 60 grit sandpaper would lower the speed and lower the percentage of strikes of the baseball the most. The sandpaper grits, 60, 100, 150, 220, and control, were each assigned a baseball and scuffed the exact same way. After the sanding process was complete, the baseballs were taken to a baseball training facility to conduct testing. The testing was conducted using a pitching machine to simulate a baseball pitch that was constant for every trial. The speed of the baseball was measured using a radar gun and the percentage of strikes was measured using a reinforced strike zone. The mean speed for the control baseball was 113.4 km/h, 113.5 km/h for 60 grit, 113.1 km/h for 100 grit, 115.1 km/h for 150 grit, and 114.6 km/h for 220 grit. Furthermore, the percentages of pitched balls found within the strike zone for the 0, 60, 100, 150, and 220 grit baseballs were 65%, 13%, 19%, 0%, and 6% respectively. The null hypothesis of the experiment was accepted. Additionally, the hypothesis was not supported by the data because the 60 grit sandpaper ball did not lower the speed of the ball the most and did not have the lowest percentage of pitched balls found within the strike zone.

Psychology A (HS PSY A)

Psychology Award
First Place
Molly Morris *Southwest Virginia Governor's School*
The Correlation Between Milk Packaging Types and Human Perception of Quality and Price

The packaging of milk plays a crucial role in consumer perception, influencing both the perceived quality of the product and its price value. Therefore, this study aims to determine why and how milk packaging types affect the perception of quality and price. To conduct this study the researcher created a six-question survey using pictures of milk with different packaging (white plastic, yellow plastic, and glass). For the first through third questions, participants were asked to use the Likert scale to determine how much they agreed or disagreed with the statement "The milk below is high quality." For the fourth through sixth questions, participants were asked to choose a price range (less than $0.99, $1.00-$1.99, $2.00-$2.99, …, Greater than $6.00) to determine what they perceived the price of the milk that was pictured below. The statement "The average price of a gallon of milk in the New River Valley is $3.66. Using this information, how much do you assume this milk costs?" The sample size for this study was 36 participants; however, having more participants would not affect the methodology of

this project. Results of the survey were statistically analyzed by the use of two Chi-Squared tests. This test suggested that the question of “How can milk packaging color affect perception of quality and price?” was that color can affect a person’s conception of price and quality. The yellow plastic picture was the most likely to be considered the lowest quality and price while the glass was considered the highest quality and price. By gaining a better understanding of color expectations, researchers and producers could recognize the importance of color/material cues when making decisions about the products that consumers will purchase

Second Place
Lorelei Maas *Central Virginia Governor’s School for Science and Technology*
Relationships Between Collegiate Cheerleading, Eating Habits, and Self-Esteem

The purpose of this study was to determine if there was a significant relationship between collegiate cheerleading, eating disorders, and self-esteem. Collegiate cheerleading coaches were contacted inquiring about participation in this study. If allowed, athletes took a survey that included questions from the EAT-26 test and Rosenberg Self-Esteem Scale (RSES), along with proper grouping questions. These results were separated according to stunt position, and t-tests were performed to determine if there was statistical significance between flyers and bases within each test (EAT-26 and RSES). A regression analysis was conducted based on the data to determine a correlation between EAT-26 and RSES. The t-tests revealed no statistically significant data, while the regression analysis did. The EAT-26 and RSES t-tests resulted in p-values of .16 and .26 respectively. The regression analysis provided a p-value of .045, which showed a significant relationship between the two. Throughout all the tests, an alpha value of .05 was compared to the p-values. Some important things of note were the average EAT-26 and RSES scores for the combined groups, being 15.06 and 17.94 respectively. The research hypothesis, if a female individual participates in collegiate cheerleading and is a top-girl/flyer, then she is more likely to develop an eating disorder and have lower self-esteem than her base counterparts, was partially supported. This study was limited in participant size, but still displayed evidence significant enough to spread awareness on the issues relating to body image in sports that are heavily influenced by appearance.

Third Place
Jillian Jurkow *Central Virginia Governor’s School for Science and Technology*
Impact of Type One Diabetes on Caretakers' Wellbeing

The purpose of this study was to determine whether a diabetic child's A1C has negative effects on their caretaker’s mental wellbeing. This study was conducted using a Google Form which was sent to local support groups and shared on the internet. During the survey, participants were instructed to answer all questions regarding their child’s diabetes, and their own mental health. Once submitted, each participant’s answers were replaced with numbers and added together to give an overview of the participants mental wellbeing. These participants were split into six total A1C groups, each having a mean mental wellbeing score as follows: 33.27 for the 5-5.9 A1C group, 33.92 for the 6-6.9 group, 35.3 for the 7-7.9 group, 36.89 for the 8 and above group, 37.54 for caretakers with multiple T1D (type one diabetic) children, and 36.73 for caretakers who did not know the A1C of their child. Running a single factor ANOVA revealed a p-value of .07 which was negligible compared to the alpha value of .05, denoting that the data was not significant. My research hypothesis which states that if a child has a higher most recent A1C, then the parent/caretaker will have higher levels of anxiety and depression, was not supported. In conclusion, the A1C of a caretaker’s type one diabetic child did not have a significant impact on the parent/caretaker’s mental wellbeing in this study.

Honorable Mention
John-Paul Mancier *Central Virginia Governor’s School for Science and Technology*
The Relationship Between Music Tempo and Shopping Behavior

The purpose of this study was to determine whether the tempo of background music in stores affected the purchasing behavior of consumers, intending to help create a comfortable in-store environment and optimal conditions for small businesses. This study was conducted at three local stores between late November and early December. Store owners were visited and provided with information and a consent form, and emails containing instructions were sent to those who agreed to participate. Three playlists were tested, each containing a different range of tempo: 70-95 beats per minute, 96-129 BPM, and 130-175 BPM. After the music was played, sales data regarding the number of customers and total earnings for the period the music was played was

returned. The data was used to calculate the average expenditure per customer, which was then converted to a percentage of the total average expenditure per store. The data was then analyzed using a one-way ANOVA test to determine differences in average consumer expenditures between tempo groups. This test yielded a p-value of .076 compared to an alpha-value of .05. The research hypothesis that the slowest tempo would result in the highest expenditure per customer was not supported. In conclusion, music tempo has either small or very complicated effects on sales.

Honorable Mention

Anna McCloskey *Central Virginia Governor's School for Science and Technology*
The Influence of Age on the Cognitive Processes Related to Retention

The purpose of this study was to determine if age groups (4th, 7th, and 11th grade) affect how someone retains information and the efficiency of their recall. Each age group was given age-appropriate passages and divided into three groups: Reading, Listening, and Reading & Listening combined. Afterwards, these students took a brief follow-up test on the information in the passage and scored on correctness. The highest mean test score was in the Middle School's combined Reading & Listening group. The lowest mean test score was the High School's Listening group. With an alpha level of .05, a one-way ANOVA for the Different Methods of Retention, revealed a p-value of .00516; and, another one-way ANOVA for the Elementary School's Scores, revealed a p-value of .001521. Both one-way ANOVAs found that the Listening groups retained and recalled less than the rest of the groups and does not support the research hypothesis: If the recall from retention is tested among different age groups, then recall efficiency will vary based on the retention methods used. Younger children are more likely to recall information when it is listened to, while older children are more likely to recall information when it is read. All ages, however, will struggle with recalling information, if methods of Listening and Reading are combined in use of retention, due to brain overload. In summation, this study supported the idea that the age of a person significantly affected the best way to retain and recall information.

Anna Apkarian *Central Virginia Governor's School for Science and Technology*
The Correlation Between Religious Involvement and Self-Esteem

The purpose of this study was to evaluate potential correlation between an individual's involvement in their religious community and their self-esteem. This topic was chosen to better understand an individual's wellbeing. The data was collected by anonymous Google Form online surveys, which were distributed to a set of students at local high schools in Virginia and adults in the community. Participation was requested via e-mail and in-person recruitment. The sample size of 32 participants were asked about their religious environment and self-esteem: the self-esteem questions being modeled upon the Rosenberg Self-Esteem scale. The responses showed very low correlation and regression, revealing an almost non-existent relationship between religious involvement and self-esteem. This was determined by performing tests of correlation and regression between the scores, and with a degree of freedom value of 30 and r-critical value of .349 being more extreme than the correlation value between the scores, -.0436, this did not support my hypothesis that those with more involved have higher self-esteem. Furthermore, there was insufficient regression between scores because the p-value of .813 was larger than the chosen alpha value of .05. Ultimately, my study emphasized that we should not label ourselves or others of different religions as unhappy or miserable, or as having more interesting lifestyles. My findings aid in the rebuking of harmful stereotypes, and in better understanding an individual's wellbeing and realizing that religiosity is not a monofactorial cause for positive or negative aspects of their health.

Mohammed Khan *Mills E. Godwin High School*
The Effect of Age Groups on the Development of Lying

Interrogations are usually conducted on people that can be of different ages, they are used to obtaining information from a suspect. Lying during an interrogation can potentially mislead an investigation. The project was conducted to observe if any age group exhibits the highest frequency of lying. The study consisted of 25 high schoolers (14-18 year-olds), 25 college students (19-22 year-olds), 25 adults (23-50 years-olds), and 25 senior (+50 year-olds) that were selected. There is no control group due to there being no established standard in age. They were then asked to fill out a Google form consisting of 5 questions one of which was "On a scale of (1-5), How often do I lie in general?" which was the main focal point of this study. It was hypothesized that the youngest age group (high schoolers) would admit to the highest frequency of lying.

It was found later that high schoolers would admit to lying the most and seniors would admit to lying the least. A chi-square test was performed to see if it was significant, the test showed the data for the college students and seniors to be significant, but the adults and high schoolers were not significant. High schoolers lie the most because their brains undergo less cognitive functions and they have less mental maturity and reasoning behind their choices compared to the other groups. Further studies being conducted can contribute to helping people understand the nature of lying by understanding whether other variables such as gender or intellect might play a role.

Abhinav Padala *Mills E. Godwin High School*
The Effect of Running on Cognitive Abilities

The purpose of this study was to investigate the immediate impact of different sprint distances on students' cognitive performance. Recent studies showed that cardiovascular exercise has a significant effect on a student's academic performance. Furthermore, the driving cause for this is the endocannabinoid system which releases enzymes called endocannabinoids into the bloodstream during physical activity. Also, the endocannabinoids that were released can break through the blood-brain barrier which causes 'runner high'. The runner's high is a euphoric feeling that occurs at the end of a run. Additionally, there are numerous benefits from exercise such as human memory, cognitive skills, and faster reaction times. Before performing the experiment, a hypothesis was formulated which stated if a person sprints 200 meters, then he or she will be able to perform the best on the test. In addition, a no-exercise control group was created, to be directly compared to the other running distances. Twenty-one participants completed a cognitive assessment after running 4 different distances: 0, 100, 200, and 400 meters. Once the participants finished, the assessments were graded, and a t-test was conducted. The t-tests compared the control group to the other running distances. The t-tests were conducted at the significance level of 0.01, and the t-test showed that the data collected was insignificant. The results were caused due to human error, difficulty of assessments, potential fatigue effects. Another source of error was the participant's availability, which caused the testing to be done over the course of three days, which caused insignificant data.

Aiden Sexton *Central Virginia Governor's School for Science and Technology*
The Correlation Between Academic Burnout and High School Students' Academic Performance

The purpose of this study was to determine whether or not academic burnout had any negative effects on high school student's academic performance. This study was conducted using an online survey given to participants at a local high school. Students from 9th, 10th, and 11th grade were asked questions that evaluated their levels of burnout. Based on these answers, they received a score on a 100-point scale to further determine their burnout level. This score was then compared to several dependent variables such as GPA, class grade, and test scores. The data was analyzed by using several linear regression tests. The mean burnout score was 65.2. Multiple regression tests, with an alpha value of .05, revealed several p-values greater than .05. However, the regression test comparing burnout scores to the number of rigorous courses, which yielded a p-value of .0367, was the only test that displayed significance. Overall, the values showed that the data was not significant. Therefore, the research hypothesis, which stated that if students overwork themselves to the point where they experience burnout, then this stress will hinder their academic performance, was not supported. In conclusion, academic burnout had no significant effect on a high school student's academic performance as it was measured in this study.

Psychology B (HS PSY B)

First Place
Kendra Nguyen *Southwest Virginia Governor's School*
The Effect of Music and Background Noise on Handwriting Speed

Handwriting remains an important tool of learning, even in the rise of technology, but it and studeying in general can often be gruieling. Music and background noise are one possible tool for rectifying this issue. However, research about their benefits and detriments on studying is controversial, and studies directly examining their effects on handwriting are lacking. Thus, could music and background noise affect or improve handwriting speed? The null hypothesis was Ho: μ1=μ2=μ3=μ4 , and the alternative hypothesis was Ha: μi≠μj for the same pair, and μ was the mean speed of each group. All the audio stimuli were hypothesized to improve speed. Four groups of five people were assembled to test handwriting: silence, instrumental music, rain noise, and white noise. Participants were assigned to a group, asked to fill out a survey, and copied down two passages, one an excerpt from Ulysses and the other Vietnamese, while audio was playing. The surveys, which asked about a participant's familiarity to a certain topic, were used to determine whether any group would have an advantage over another group. Speed was determined by counting the number of characters written in the participants' copied passages, and it is also referred to as cpm (characters per minute). An ANOVA test and a Tukey HSD follow-up test was used to determine which groups were significant. No group had an advantage over another group. The null hypothesis was partially rejected; one group, the rain noise group, did achieve statistical difference in the Ulysses excerpt (p-value: 0.0164) with a speed of 80.98 cpm. It is possible that the range of difficulty in the task was too broad to determine a relationship. Future research could more closely align the difficulty level among the tasks, use a larger sample size, and a wider variety of background noise to clarify this relationship.

Second Place
Olivia Wilborn *Southwest Virginia Governor's School*
The Relationship Between a Guardian's Level of Preparation for Change and the Career Goals Their Dependent Holds

Understanding the parental influence on childhood development, particularly concerning their perspectives on a functioning world, is integral to navigating the process of upbringing. Prevalent notions hold that a child's cognitive and social development is heavily influenced by their interactions with guardian/role-model figures. This study was created and performed with the intention of further exploring how a guardian's attitude, particularly on unexpected change, was reflected in the dependent's career goals. The 42 participants, aged 16 to 18, were asked to complete a survey consisting of 19 prompts designed to determine the parental unit's level of preparedness for unexpected change and their tendency toward spontaneity, and how this was reflected within the respondent's career goals. Of the 13 questions determining career goals, significant correlation with parental profiles were found in two; in those, a relationship between external influence– specifically attitudes toward spontaneity– and a dependent's career goals can be suggested. However, a holistic perspective of the results of this experiment aligns with sentiments respected in the psychological and sociological community: childhood development is reliant on more factors than simply parental influence. Further research into specific parental influences on a child's attitudes toward their future lives would be suggested. A larger sample size more representative of the general public would be ideal.

Third Place
Bisan Rai *Southwest Virginia Governor's School*
The Correlation Between Nicotine Patch Usage to Episodic Future Thinking and Contingency Management within a Research Environment

Substance Use Disorder is a mental disorder that causes a person to lose their ability to control their use of substances. One of the most accessible substances causing unnecessary death is tobacco and other smoking products. Many psychologists have used varying methodologies to combat this growing issue. One prevalent strategy of treatment is Nicotine Replacement Therapy (NRT). NRT offers a controlled way to reduce nicotine dependence by using nicotine patches. This experiment examined if NRT can potentially augment other methods of addiction recovery such as Contingency Management (CM) and Episodic Future Thinking (EFT). Contingency Management is a recovery method that provides participants with an incentive,

such as money or other rewards, to promote reduced substance use. Episodic Future Thinking is a psychological method with the goal to make the participants view their future more in a positive way. The experiment was conducted using data from a study using veterans with smoking addiction that inclu1d49ed all of the methodologies listed above. The experiment contained two research questions, “Is there a positive correlation between nicotine patch usage and engagement in Episodic Future Thinking (EFT) cues in a larger study?” and “Is there a negative correlation between nicotine patch usage with the average ppm from carbon dioxide monitors and cigarettes smoked per day?” The experiment used a linear regression model to compare variables of the methodologies to see if there was a significant correlation. The results indicated that there was significant evidence for a weak positive relationship between NRT and EFT and there was not significant evidence for any correlation between NRT and CM. One possible explanation is that the NRT and CM variables were self-reported. Further research should obtain data more specifically for testing the effectiveness of NRT with CM and EFT in mind to better understand their relationship.

Honorable Mention
Kailey Eagle *Central Virginia Governor’s School for Science and Technology*
The Connection between Trauma and Addiction

The purpose of this study was to explore the relationship between trauma exposure, the age at which trauma exposure takes place, and the presence of addiction habits. In order to explore this relationship, a previously collected dataset was used and the data was manipulated to be able to address this research question. Counts of different combinations of the variables were tallied and three separate chi-square tests of independence were conducted in order to test the significance of the relationships. When the tests were conducted, an alpha value of .05 was used and p-values of .33 (sorted by addiction), .97 (sorted by trauma), and .92 (based on age) were produced, meaning that there was no significant relationship found between the addiction, trauma, and age of trauma. The research hypothesis, which stated that a child that experiences sexual and/or physical abuse at a younger age will be more likely to experience a heavy addiction behavior towards stronger drugs, such as cocaine or methamphetamine, was not supported by this research study.

Honorable Mention
Elana Ordower *Central Virginia Governor’s School for Science and Technology*
The Correlation Between Font Color and Perception of the Underlying Meaning of the Text

The purpose of this study was to determine if there was a significant correlation between the color of typed text and the perceived tone of the sentence. The data of this study was collected using Google Forms to survey participants in which they were shown seven neutral sentences: two in red, two in yellow, two in blue, and one in black to serve as a control grouping. By running a Chi Squared Test for Independence, followed by four separate ANOVAs and their subsequent Tukey tests the null hypothesis, that there would be no significant difference between color and a caused emotional response, was rejected and significance was concluded. Red held significance with the emotional response of anger as the dominant emotional response with a p-value of .024, lower than the chosen alpha value of .05. Sadness was found to be the dominant emotional response for blue, as predicted, with a p-value of .02. Significance was found in regard to yellow with both joy and surprise, with a p-value of .001. These results support the research hypothesis that red will have a high rating of anger, blue will invoke strong feelings of sadness, and yellow will spark a joyous undertone. In conclusion, color is an underutilized tool for communication with clear ties to innate emotional responses when studying primary colors alone that appear to be mostly uniform across all participants surveyed in this research.

Honorable Mention
Smyan Sajish *Mills E. Godwin High School*
The Effect of Different Ways of Receiving Information on Retention

The purpose of this experiment was to find the effects of different ways of receiving information on retention. After the pandemic, more digital resources are being used, which is leading to new ways of presenting information to students. Participants, 13–15-year-olds, were given 2 minutes to receive information about a topic, then tested on it using a 10-question test. The 3 styles of receiving information were Auditory, Visual, and Reading. There was no control since there is no typical way of presenting information in the classroom. It was hypothesized that if the participants were exposed to the visual information for 2 minutes, then they would retain the most information. The results revealed that the visual information score

was around 19% higher than the score on the Reading test, and 23% higher than the score on the Auditory test. A t-test was done on the data, and it revealed that the data was significant for Visual vs Auditory, as well as Visual vs Reading, while the data was not significant for Auditory vs Reading. The results supported the research hypothesis. It is believed that the results are due to Visual information helping relate images to words, which in turn converts information from working memory to long term memory faster. This research could lead to further studies using other learning styles, like kinesthetic, which is a learning style which uses hands-on methods.

Tanusiya Debnath *Mills E. Godwin High School*
A Comparative Study of Psychosocial, Socioeconomic, and Lifestyle Determinants on Recovery Capital in Addiction Rehabilitation

As rates of overdose and the misuse of prescription drugs increase rapidly, it is imperative that new treatment and addiction therapy methods are discussed and developed. Recovery Capital is the measurement of resources that enhance the chances of long-term recovery from drug addiction. Recovery capital can be divided into three groups: personal, social, and community capital. It was hypothesized that certain demographic groups may have lower recovery capital due to systemic barriers and that individuals who live healthier lifestyles have higher recovery capital. When statistically analyzing demographic groups, there was no control because all groups were assumed to be equal before analysis – however, when analyzing other groups, the control was zero or the absence of that variable. Participants in an addiction recovery residence were surveyed about their personal, social, and community capital using three to eight questions per section to gauge their wellness in each sector. Each question was given a weightage, and individuals were given a composite score for their cumulative responses in each section. It was found that Black/African American individuals had statistically lower social capital and community capital than White/Caucasian individuals, but there was no significant difference between personal capital. These results may be a result of lingering systemic and socio-economic barriers. Along with this, individuals who got more sleep on average had statistically higher personal and community capital. This was expected because sleep has been proven to have beneficial effects on personal and community development. Future expansions could include analyzing cultural capital and barriers to recovery.

Iyla Ferguson *Central Virginia Governor's School for Science and Technology*
The Correlation of App Usage and Adolescent Anxiety

The purpose of this research project is to find a way to help lower adolescent anxiety and improve mental health. Increases in screen time by adolescents has raised the question of there is a relationship between phone time and anxiety. Teenage participants were asked to fill out nightly Google forms in a ten-day sequence. This included questions pertaining to screen time, their top used apps, and the GAD-7 anxiety survey. All participants were within the age range of 13-18 and were recruited from local high schools. In total, five correlations were run to check each group tested, social media, gaming/recreational, messaging, miscellaneous, and total time. The result from this study shows that gaming/recreational apps have a positive correlation with anxiety, along with general screen time. The correlation statistic was .226 for total time, and .189 for gaming/recreational apps in relation to the Pearson correlation critical value of .180 (alpha .05). The research hypothesis that stated if Teenagers spend most of their screen time on social media app group such as Facebook, Instagram, TikTok, X, YouTube, and Snapchat, then they will have higher anxiety levels than those who spend most of their screen time gaming/recreational apps and on messaging apps was not supported by the data, as the only significant correlation was with total screen time and anxiety. This study provides more data and perspective on the effect of cell phones on teenagers' mental health.

Esmarie Henry *Mills E. Godwin High School*
The Effect of Different Noise on Ability to Focus

The purpose of this study was to find the effect of different sounds on focus, as measured by the number of math problems a subject could complete in an allotted time. This has implications for society because everyone needs to be able to focus for extended periods of time. If a new strategy is found to improve focus or a common strategy is proven ineffective, it can improve work efficiency for students and professionals. The hypothesis for this experiment was that listening to binaural beats would improve focus and would have a greater positive effect on focus than music (both with and without words). The procedure was to have subjects' complete math problems in four different trials, each with a duration of three minutes. Subjects listened through headphones to a different sound during each three-minute period: (one) no sound, (two) and

stating that listening to binaural beats had a positive effect on concentration. Further study should test other ranges of binaural beats, randomize the order of the sounds and holiday song, (three) classical music, and (four) binaural beats. The control was to have no sound during the first three-minute period. The results showed that subjects listening to Christmas music had the highest mean number of math problems completed. Yet none of the sound types were found to have a statistically significant impact on focus. The data collected contradicted results found in other research stating that listening to binaural beats had a positive effect on concentration. Further study should test other ranges of binaural beats, randomize the order of the sounds, and separate trials by longer periods of time to eliminate subjects' mental fatigue as a possible factor impacting the level of focus.

Psychology C (HS PSY C)

Roscoe Hughes Genetics Award, Virginia Academy of Science Honorary Membership
First Place
Rania Lateef *Governor's School @ Innovation Park*
Scents and Sensibility

Olfaction or the sense of smell plays a fundamental role in the animal kingdom's survival and interaction with the environment. However, its role as a marker for human disease and problems, including mental disorders, is poorly understood. The main study objectives are: 1) To examine the age and sex specific patterns of olfactory function; 2) To evaluate heritability of olfactory function; 3) To ascertain whether olfactory function is associated with anxiety, depression, and migraine 4) To examine the association between olfactory function with smoking, alcohol use and drug use. The current study sample is a subset of participants from the National Institute of Mental Health (NIMH) Family Study of Affective Spectrum Disorders, which is a community-based family study focused on probands with mood disorders. The study utilized the NIMH Family Study Diagnostic Interview for Affective Spectrum Disorders (DIAS) to diagnose lifetime and current mood disorders and substance use. Olfactory function tests were administered during an in-person clinical visit and included the University of Pennsylvania Smell Identification Test (UPSIT). The analytic sample included 451 participants who completed the UPSIT test. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA). Rates of mood, anxiety, and substance use diagnoses by sex were tested using Chi-square test. Means of UPSIT variables by diagnosis were evaluated using T-Test. Mixed effects linear regression models, which included both fixed and random effects, were used to evaluate the familial aggregation of the olfactory tests. Female subjects had better olfactory function (p-value 0.0489), compared to males, however no significant trends were seen by age. Smell scores of Bipolar I subjects were significantly lower than controls (p-value 0.0175) and the data also showed familial aggregation among probands and relatives (p-value 0.0286). Odor identification is a familial trait and maybe a marker for mood disorders such as Bipolar Disorder I.

Second Place
Paris Bacon *Chesapeake Bay Governor's School*
How A Student's Academic Ability and Age Affects their Likelihood of Conformity

Conformity is a type of social influence that plays a key role in an one's social and psychological development, especially in formative years. This study analyzed the likelihood of conformity in middle and high school students of two different academic abilities: average and gifted. It was performed to determine if a student's academic ability and age played a role in whether or not they conformed. Participants, with parental consent, completed a survey on school-issued computers in a classroom setting. The study included a total of 304 students divided equally by grade and academic ability. Using a Google form, participants answered a questionnaire consisting of ten multiple choice questions twice, once before knowing their peers' responses and once afterwards. An Anova Two- Factor test was used to compare how both independent variables affected the change in answers from pretest to posttest and corresponding graphs were made. All average students conformed more than their gifted counterparts and conformity increased with age from 5th to 9th grade; participants in the 12/11 grade age group conformed more than those in the 10/9 and 8/7 grade age group. An ANOVA Two-Factor test yielded a p-value of 0.07 that trended towards significance; the alternative hypothesis for academic ability failed to be supported. Findings for age were similar; average conformity decreased with age, excluding 12/11 grade participants. An ANOVA Two-Factor test yielded a p-value of 0.02 which was significant and supported the alternative hypothesis for age while rejecting the null. These findings suggest that while conformity and age have a significant correlation to one another, conformity and academic

mental fatigue. A chi-square was performed on the collected data with all the tests being proven significant, and it was found that the results did support the research hypothesis. It is believed that the results are due to the many implications of mental fatigue increasing too high including depression, anxiety, burn out, and much more.

Crawford Craig *Collegiate Schools*
Effects of High School Student Athletic Participation on Academic Stress

Academic pressure is an issue that impacts students and student-athletes alike, causing severe stress in their lives. Student-athletes are believed to experience more stress than they admit to, which can cause even more stress (Ward et al, 2023). Although this appears to be a widespread problem for student-athletes, there is a noticeable lack of research on this topic. There has, however, been extensive research on the relationship between playing a sport and academic performance, highlighting the fact that a student's grades are often valued more than a student's mental health. The goal of this study was to discover whether participating in a sport increases academic stress, and what systems can be implemented to mitigate it, if it does. In this study, both students and student-athletes received a survey that assessed their stress level in relation to their sports and academic involvement. The participants in this experiment filled out this form weekly, and the results were later analyzed. Inside the survey, the participants were asked about their daily time spent on sports, their daily time spent on homework, their perceived academic stress level for that week on a scale from 1-5, and how much they believed playing a sport affected their academic stress. The findings of this study showed negligible differences between the academic stress levels of student-athletes versus non-student-athletes, with a difference of only .32 on a scale of 1-5. A t-test was run to get the p-value which was 322, therefore failing to reject the null hypothesis. Interestingly, among the student-athlete group, those who spent more time playing a sport reported experiencing less stress. While surprising, there was also reason to believe that playing a sport does indeed increase academic stress levels. There was an extreme outlier in the student-athlete group who played sports many hours per night but experienced very low academic stress levels. This anomaly drastically changed the results of the experiment and may not accurately represent the average student-athlete. Another possibility for error is in the students' care for the experiment. The students in the experiment may not have given their full effort into giving real and accurate results. The sample size of this experiment was also fairly small, particularly with the non-student athletes, and a bigger sample size may have given a more accurate representation of the community as a whole. Although this experiment found no statistically significant difference in academic stress levels between student-athletes and non-athletes, several key observations and conclusions were drawn.

Rojin Kim *Mills E. Godwin High School*
The Effect of Noises on a Person's Cognitive Ability

The purpose of this study was to find which type of background noise affects human cognitive ability the most. This was done for research and development of hearing aids so they can be improved for people with hearing loss. Out of the four different types of noise that represented an independent variable, it was decided that if the type of background noise used was distracting noise, then it would affect human cognitive ability the most. While there are four independent variables that all are different types of noise, they needed to be compared to a control. The control in the case of this experiment was no background noise, which was just the signal. The participants were told to listen to five different videos that each had a questionnaire that corresponded with each and to do one every day for five days. As well as being located in a quiet environment and at 20 percent of their maximum volume. All of the independent variables were compared to the control, which gave four different t-test values. These were then compared to the table t-value, which was 2.429, based on the degrees of freedom of 38 and the level of significance of 0.01. The results showed that the data for three out of the four independent variables were insignificant and due to chance. Except for loud noise, which was significant. This data doesn't support the research hypothesis and was most likely due to some participants not correctly following orders.

Meredithe Nourse *Mills E. Godwin High School*
The Effect of Exercise on Test Taking Decisions

This experiment aimed to find the effect of different exercise amounts on test-taking decisions. Decisions are essential to daily life, with each person making over 30,000 a day. Understanding when people can't

make those accurate decisions as a result of their brains being fatigued is important because their inaccurate choices may harm others or even themselves. The research hypothesis was that if a 15-minute workout was performed, then the test score accuracy would decrease. Participants were asked to work out for durations of 0, 1, 5, 10, and 15 minutes and then take an 80-question, simple multiplication test graded on accuracy. They would rest for 10 minutes in between workouts, then begin the next exercise duration. The control was the 0-minute workout as no exercise was being performed before the test so this acts as the baseline. Although the mean of inaccurate choices increased as the exercise durations got longer, a t-test revealed the results were not statistically significant and the research hypothesis was not supported. Meaning, that these results were due to chance and most likely not the independent variable. These may have resulted from human error as this experiment focused on humans. Efforts of participants with varying math levels may have been a reason for these results. Test length may have also played a role, as the test contained 80 questions. If this experiment were to be conducted again, participants of equivalent skill levels and a shorter test would likely reduce the variability in the results.

Kareem Mukhtar *Mills E. Godwin High School*
The Effect of Different Audio Based Environmental Stimuli on Cognitive Function

Five different audio based environmental stimuli (ABES) were tested to find out whether they positively or negatively affect memory and reaction time. These ABES being Thunderstorm sounds, Traffic, Conversation, Yoga Music, and No Sound serving as a control. The first three ABES mentioned are heard in most people's lives. Yoga music is being monitored because this type of music specifically is said to help focus and if this is true could help many people. It's believed that traffic sounds will produce the weakest memory and slowest reaction time. The participants are given a sequence of 10 numbers to memorize and are exposed to the ABES for 11 minutes, the first minute being for memorization. At the end, they are asked to do the Human Benchmark reaction time test and recite the 10-digit code. The Human Benchmark score and the percentage of the number of numbers they correctly answered are recorded. These tests showed that No Sound and Yoga Music have the most positive impact on memory. Their data is significant compared to the ones worse for memory, Conversation & Traffic. The rest of the data was not significant. For the reaction time tests, none of the data is significant and Yoga music was shown to be the best for reaction time. The research hypothesis was not supported by the data. The results for memory are due to the intensity and fluidity of the sound and the reaction time results are due to reaction time not being affected much by ABES.

Samantha Scott *Mills E. Godwin High School*
The Effect of Different Scents on Human Efficiency

The purpose of this experiment was to determine which scent had the best effect on human efficiency when solving a puzzle. In this study, 25 high school students, ranging in age from 14 to 15 years old solved 16-piece jigsaw puzzles while exposed to different scents. Participants were exposed to cinnamon, fish sauce, garlic, and lavender throughout the experiment and asked to solve puzzles while their solving time was recorded for each scent using digital stopwatches. Participants smelled coffee beans in between trials to prevent the next trial being impacted by the scent before. The control of the experiment was no scent. It was hypothesized that participants exposed to lavender would have the fastest solving time. The results revealed that trials conducted with garlic-scented masks yielded the fastest solving times at an average of 73.16 seconds, followed by lavender at 78.87 seconds, fish sauce at 84.73 seconds, cinnamon at 85.68 seconds, and without scent at 90.95 seconds. A t-test was used to determine the significance of the data and revealed that the data was insignificant for all levels of the independent variable, and therefore the results were likely due to chance and not the independent variable. The results did not support the research hypothesis. This research could lead to studies that further investigate the effects of scent on human productivity and experiment with a larger range of scents to determine which fragrance is best to implement into the work environment to encourage efficiency.

Alina Zagorodnyuk *Mills E. Godwin High School*
The effects of Equine-assisted therapy on BAI scores

The purpose of this experiment is to investigate the effects of equine-assisted therapy on Beck Anxiety Inventory (BAI) scores, by exploring the potential benefits of equine therapy on BAI scores and examining how different duration of time impacts BAI. A hypothesis was stated that if participants engage in longer durations of equine-assisted therapy, then their BAI scores will significantly decrease. The following experiment was conducted to compare the effectiveness of three different durations of time - 30 min, 60 min and a control of 0 min - on reducing stress and anxiety ultimately decreasing BAI scores. A sign-up application was created to recruit female participants aged fourteen to sixteen, as limiting the sample to females helped control for gender-specific factors that could potentially influence the results. The participants engaged in a 30-minute equine session followed by an BAI test after providing informed consent. This was conducted once for each independent variable group with the use of twenty-five participants at a peaceful barn located in Hanover. The results revealed that there is a positive correlation between equine assisted therapy and BAI scores, meaning that there was positive intake from various time frames between the control. A t-test was also conducted to reveal the significance of the data; 60 min vs. control were significant while 30 min vs. control and 30 min vs. 60 min were not. This investigation was drawn to the conclusion that equine assisted therapy does have a positive effect on BIA scores due to the increase of mindfulness and focus and the reduction of stress and anxiety.

Statistical Analysis & Inferences (HS SAI)

Carpenter Statistics Award
First Place
Lyra Piche *Blacksburg High School*
English Placenames and Viking Activity

The time period 795-1066AD contained an abundance of Viking incursions and raids into Britain. These incursions had a large effect on the developing country of England, in a cultural, linguistic, and genetic manner. The linguistic effect is most present in placenames; many place-names in England have Old Norse elements, most of which are thought to derive from Viking invasions. If the correlation between Old Norse-element placenames and Viking activity is strong enough to merit accurate identification of Viking archaeological sites, it can simplify the search for sites of battles or Viking activity whose locations are presently unknown. This study seeks to discover whether Viking-element placenames are correlated strongly enough with sites of proven Viking activity to allow for accurate or near accurate identification of Viking sites for future archaeological research prior to any actual archaeological research. The data collected from the Gazetteer of British Placenames, the Key to English Place Names, the Anglo-Saxon Chronicle, and Archi Maps UK appears to prove that this correlation is not strong enough to merit use. 18 of 31, or 58%, of the historic counties with Old Norse-element placenames had no Viking sites within 10 kilometers of any of the Old Norse-element sites, and of the 39 historic counties examined in this study, only two had percentages of names with both Old Norse elements and Viking activity over 50%.

Second Place
Gabriel Frias *Central Virginia Governor's School for Science and Technology*
Comparative Analysis of Television, Radio, and Newspaper Advertising on Consumer Behavior

This study investigates the relationship between advertising budgets across television, radio, and newspaper channels and the resulting sales revenue in USD to identify the channel with the strongest correlation. The dataset used includes advertising budgets and sales revenue, which were verified for consistency to ensure uniform currency values and the absence of outliers or missing data. The Pearson correlation coefficient was employed to measure the strength of the relationship between each channel's budget and sales revenue. Regression analysis was performed to predict sales based on advertising expenditures, with all monetary values scaled to thousands of dollars for advertising budgets and millions of dollars for sales revenue. The results demonstrated that television advertising had the strongest positive correlation with sales revenue (r = 0.78), followed by radio (r = 0.58) and newspaper (r = 0.22) compared to an r value of no correlation (r = 0), and an r value of high correlation (r = 1). Regression analysis further confirmed that television advertising investments provided the highest predictive value for sales revenue, with a p value of 1.47 x 10-47 compared to an alpha level of 0.05, supporting the hypothesis that television is the most effective advertising channel. These findings emphasize the importance of targeted advertising strategies and suggest that television is the most impactful channel for generating sales revenue among the three analyzed.

Third Place

Tyler Chen *Princess Anne High School*

A Statistical Study of Potential Economic Impact of Virginia Demographic Change

Demographic change due to the shifts in birthrate and death rate can have significant implications for societies. This paper draws on historical data to explore employing a log-linear multiple regression model to gain quantifiable insights into the potential economic impact, measured by GDP growth per capita, of such demographic change in Virginia. The null hypotheses are rejected based on p values indicating that birthrate and morality rate are both statistically significant explanatory variables. The model results suggest the model explains statistically significant amount of variation in economy growth. The standardized coefficients of the model suggest that birthrate has a negative influence while mortality has a positive influence on economy output. The unstandardized coefficients of the model suggest birthrate and death rate influence economy output with different magnitudes in original unit scale.

Parker Stanbery *Central Virginia Governor's School for Science and Technology*

Nutrition and Inequality: How Demographics Effect Dietary Supplement Use

This study examined the relationship between demographic factors (gender, race, education, income, height, weight, BMI, and age) and the use of dietary supplements. A chi-square test was used to investigate the significant association-driven analysis of data from public datasets. Supplement use was defined as the consumption of vitamins and minerals. The results showed significant associations between supplement use and gender, education, race, income, and age, but not with height, weight, or BMI. Men and women had different supplement intake rates ($\chi 2 = 1.26\times10E\text{-}9$). Higher education levels ($\chi 2 = 3.67\times10E\text{-}58$) and higher income ($\chi 2 = 1.06\times10E\text{-}31$) were linked to more frequent supplement use. However, no significant relationship was found between supplement use and height, weight, or BMI, as their p-values were above my alpha value of .05. The findings partially supported the hypothesis, revealing that not all demographic variables influence dietary supplement use. Economic disparities were identified as a key factor influencing supplement use, highlighting the need for targeted public health initiatives to address inequities among underprivileged populations. These actions could enhance fairness in nutrition and public health sections of actions. Further research is needed to clarify how demographic factors shape dietary supplement use. These findings can inform future public health initiatives to reduce nutritional inequities.

Kyle Stephens *Southwest Virginia Governor's School*

Change in Throwing Performance Throughout the History of the Olympics

Understanding the historical context behind the throwing events is key to understanding their future. This study analyzed the change in performance over time in the throwing events of the Olympic Games. The exact events analyzed are as follows: Men's Shot Put, Men's Discus, Men's Javelin, Men's Hammer Throw, Women's Shot Put, Women's Discus, Women's Javelin, and Women's Hammer Throw. Viable data from each Olympic Games was split into three categories; Farthest/Winning distance, Mean-Medaling Distance, and Mean Non-Medaling Distance. Data was organized using Excel. Each event had a separate data containment subunit that contained the raw data for each Olympic Games. A Regression Analysis was

performed to establish a correlation between distance thrown and years. The x-axis in these Regressions was the year and the y-axis was the distance thrown. A level of significance of 0.05 was used. These analyses showed that the data categories for every event, excluding the Farthest/Winning Distance for Women's Hammer, had a statistically significant positive correlation with years. Most Men's events had strong positive correlations between years, and distance thrown. This trend was not reflected in the Women's events as they mostly had moderate positive correlations with a few showing weak positive correlations. All p-values for the Men's events were less than 0.001 while the Women's events, especially the Hammer Throw, tended to be above that. The more personal explanation for this phenomenon is the advancement of sports science. This includes strength training, nutrition, and specific technical models used in the throws. As strength training and nutrition evolve athletes can produce more force and better maintain the physiological benefits from training. The better technique allows more efficient use of force. The more statistically relevant portion is the large amount of data. Women's Hammer Throw demonstrates this best as it had the highest p-values and the least amount of data.

Zoology A (HS ZOO A)

First Place
Lilly Riffe *Chesapeake Bay Governor's School*
Utilizing Micro Artificial Reefs to Improve Biodiversity in the Chesapeake Bay

Artificial methods of oyster restoration have become much more common, with different substrates being tested to determine which is the best solution. This study seeks to determine if a constructed micro-artificial reef (MAR) can attract oyster reef species to colonize it and improve species biodiversity and abundance in shallow water environments in the lower Chesapeake Bay. Location sites were the York River in Gloucester, VA for MAR 1 and 2; Stutts Creek in Mathews, VA for MAR 2 and 3; and Mobjack Bay in Gloucester, VA where MAR 5 and 6 were deployed. MARs were examined every 2-3 weeks and data were collected each visit. All values were $p>0.05$, showing that there was no significant difference between locations ($p=0.14$ between the York River and Stutts Creek, $p=0.20$ between Stutts Creek and Mobjack Bay,$p=0.12$ between Mobjack Bay and York River). This data demonstrates that the MARs all provided a similar quality habitat across the sites. The York River MAR had the highest species richness, the Mobjack Bay MAR was in the middle, and Stutts Creek had the lowest species richness. After referring to statistical tests, the null hypothesis that "providing a micro-artificial reef MAR substrate for settlement will not attract estuarine organisms to colonize it as a habitat" was rejected. The second null hypothesis stating that "providing a micro-artificial reef settlement substrate will not significantly increase biodiversity" was also able to be rejected.

Second Place
Justin Kim, Nishka Shah *Thomas Jefferson High School for Science and Technology*
The Impact of Storm-Driven Hypo Salinity Cycles on Coral Thermotolerance in Warming Oceans

We present novel evidence to explain how recent increases in tropical cyclone intensity caused by climate change affect coral reefs, a crucial marine habitat. We determined the impact of hypo salinity fluctuations due to heavy freshwater precipitation and runoff from tropical cyclones on coral health, expression of a heat shock

protein (Hsp70), and tolerance to rising ocean temperatures. Using the sea anemone *Exaiptasia pallida* as a model organism, we subjected anemones to different levels of hypo salinity fluctuations and subsequently conducted a heat stress assay. We found that the algal symbiont (Symbiodinium) density, growth, and thermotolerance peaked at moderate (25 ppt) hypo salinity fluctuations, likely due to increased expression of Hsp70, a stress response mechanism that protects proteins from denaturation under thermal stress. However, at severe (20 ppt) fluctuations past a hypo salinity threshold, the negative effects of hypoosmotic stress appeared to overwhelm the Hsp70 response, resulting in increased bleaching and decreased health. Additionally, the frequent fluctuation group showed decreased Symbiodinium density and increased bleaching, suggesting that higher frequencies of freshwater influx can further worsen the health of coral reefs. Overall, these results demonstrate that hypo salinity fluctuations past a threshold of 10-15 ppt below normal conditions can further compromise coral reefs' resilience to warming oceans, emphasizing the urgency of mitigating climate change and restoring these ecosystems.

Third Place

Priya Kumar *Maggie L. Walker Governor's School*

The Effect of Different Concentrations of Liquid Berberine on the Heart Rate of the *Daphnia magna*

Berberine ("nature's Ozempic/semaglutide) is a chemical known for its antibacterial and anti-inflammatory effects. It is significant in ancient Ayurvedic medicine and Traditional Chinese Medicine and has been linked to several health benefits. However, not many modern studies have studied its effect on the human body, especially the cardiovascular system. With berberine becoming a popular aid to treat type 2 diabetes and weight loss, understanding its benefits and impacts is crucial. The purpose of the experiment was to explore berberine's effect on the heart rate of the *Daphnia magna.* If the heart rate decreased, then it may have a positive cardioprotective effect. The hypothesis of the experiment was, "If the *Daphnia magna* is exposed to different concentrations of liquid berberine, then the heart rate of the *Daphnia magna* will decrease." Ten trials for each concentration were conducted. The average heart rate of *Daphnia magna* in spring water (control) after 10 trials was 218 beats/min. The average heart rate of the *Daphnia magna* for 1 drop of 1 mL of berberine, 1 drop of a 1:1 dilution, 1 drop of a 1:5 berberine dilution, and a 1:10 dilution was 152, 178.2, 204, and 208 beats/min respectively. There was a significant decrease in the heart rate of the *Daphnia magna* for the 1 drop of pure berberine concentration, and the heart rate kept on increasing back to normal as the dilutions increased, which supported the hypothesis. Statistical analyses showed that the data collected from the experiment was significant, as the p-values were < 0.05. Berberine may be a safe and prospective natural supplement for those diagnosed with T2DM and associated morbidities, such as hypertension and cardiovascular disease. Future studies should be done to explore its full benefits and safety.

Honorable Mention

Ethan Easter *Southwest Virginia Governor's School*

Determination of the Effects of Light Pollution and Subsequent Circadian Disruption on *Palaemonetes paludosus* Algal Consumption Rates

Palaemonetes paludosus is a species of nocturnal freshwater shrimp, commonly known as the ghost or glass shrimp. This particular species is considered to be a keystone species of freshwater bodies in the Southeastern United States for regulating algae and oxygen content in their habitat, yet little research is available on them. As light pollution is a growing threat to multiple ecosystems, particularly aquatic habitats, it was chosen as the condition by which the shrimp were tested. 20 glass shrimp were held in a glass tank and placed in a dark room. The shrimp were given 10 milliliters of phytoplankton 5 times to consume, with the final reading of the container being recorded. These results were gathered under four lighting conditions: a 12:12 cycle with 12 hours of dark and light acting as a control, a full light cycle, a full dark cycle, and another 12:12 that used LED lights at night to stimulate light pollution. An ANOVA test was conducted on the collected data. The average of each lighting setting was 3.40 +/- 0.42, 2.59 +/- 0.25, 5.58 +/- 0.36, and 4.73 +/- 0.30 for the 12:12, dark, light and LED conditions, respectively. The ANOVA test returned a p-value of less than 0.0001, indicating that consumption was significantly different between lighting conditions. A follow-up Tukey HSD Test was performed and reported that the light setting was significantly different from the dark and 12:12 setting at p-values of less than 0.0001 and 0.00007, respectively. The 12:12 LED was also significantly different from the dark setting at 0.00008. This indicates that settings with extra light cause difficulties for *P. paludosus* to properly eat algae, particularly at

night. More research could be done on varying levels of light impacting the shrimp or other types of pollution on their functions as a keystone species.

Honorable Mention
Ayaan Mohammed *Mills E. Godwin High School*
The Effect of pH, Serotonin, and Electricity on the Regeneration of Planaria (mm)

The purpose of this experiment was to find the effectiveness of serotonin and electricity at stopping the inhibiting effects on the regeneration of planaria. Regeneration is one of the most untamed fields in science, and planaria can help provide a greater insight on how we can use various kinds of treatments to help our cells, given to the similarity of how planaria neoblasts and human adult stem cells act. There were 4 different IV groups with 25 planaria fragments, each exposed to a different kind of treatment, electricity or serotonin, with an inhibiting environment, being either an acidic or basic environment. The length of each planarian was measured in millimeters after 14 days. There was no control used for this experiment, because I had already had data of what happens when planaria have no treatment and finding that out is not the main idea of the experiment. The hypothesis of the experiment stated that planaria exposed to a basic environment and treated with electricity would regenerate the most. Observations have shown that planaria that were exposed to electricity generally had more growth than those treated with serotonin. This suggests that electricity is more efficient at creating stem cells than serotonin. A t-test was performed showing that all the data was statistically significant, proving the research hypothesis. It is believed that the results are due to the field strength of the electricity, which allowed stem cells to be able to migrate better and faster to wounded areas. This research could lead to further studies that could investigate different ways to increase stem cell proliferation.

Subhransu Das *Mills E. Godwin High School*
The Effect of Various Vitamins on Planaria Growth and Regeneration

This study investigated how Vitamin A, Vitamin B12, Vitamin C, and no vitamins affected the growth and regeneration of planaria, small flatworms that can regenerate lost body parts using stem cells called neoblasts. It was hypothesized that planaria treated with Vitamin C would show the most growth and regeneration compared to the control group and those treated with other vitamins. The goal was to show whether vitamins could promote regeneration, providing insights into how they help improve tissue repair and healing. The experiment involved cutting planaria into two parts, the head and the tail, and dividing them into four groups: a control group with no vitamins and three experimental groups treated with Vitamin A, Vitamin B12, and Vitamin C. Their growth and regeneration were tracked for two weeks, and their initial and final lengths were measured. Conditions like water quality and vitamin drops were kept constant across all groups. The results showed that vitamins did not significantly improve planaria growth or regeneration. Statistical tests showed differences between Vitamin B12 and Vitamin C versus the control, but these did not lead to real growth. Vitamin A had a small effect on growth, but it was not significant compared to the control group. These results show that vitamins, in this experiment, do not help planaria regenerate better.

Ngo TanAn Nguyen *Mills E. Godwin High School*
The Effect of Obstacles on Slime Mold Navigation Abilities

Slime molds are single-cell organisms. (It is important to note that Slime molds are not true fungi and are not mold. They are single celled multi nuclei amoeba. There was no mold involved in this experiment). However, the way they navigate to find the most optimal pathway towards their food source astonishes scientists. Multiple studies have been conducted to better understand this navigation ability and apply it to real life in multiple fields such as transportation. In 2010, a study researching slime molds tested the efficiency of slime molds by comparing the Tokyo railway system and the system slime molds built. At the end of the experiment, the system built by many highly skilled engineers was found to be like the system the single-celled slime molds built. In the future, slime mold algorithms will be used to take a person from point A to point B, and so on. However, walls or other obstacles can change the time it takes for slime molds to reach their food source. This can lead to a variety of outcomes, such as never reaching the goal of expending a longer amount of time to reach the goal than without obstacles. Therefore, this study's purpose was to test the hypothesis that obstacles would hinder the growth of slime molds.

Jaiden Opoku *Mills E. Godwin High School*
The Effect of Honey on Planaria Survival

The purpose of this experiment was to determine the effects of varying amounts of honey on planaria survival. It was expected that the planaria would have the best survival in the 10% honey solution. Antimicrobial resistance is rising; honey may serve as an effective wound-healing accelerator. Brown Planaria were cut into two parts (head and tail) and then divided into five groups: four experimental groups 1%, 2.5%, 5%, and 10% of honey concentrations and a control group with no honey. The planaria survival after 14 days as living or dead was observed. The results revealed that planarian in solution not treated with honey had a better chance of survival compared to the planaria in honey solution where all planaria died. A chi-square was performed, and it was revealed that the data was significant for Expected vs 1%, 2.5%, 5%, and 10% but did not have a significant difference for Expected vs 0%. Due to these results, the research hypothesis was not supported but showed that honey had a negative effect on planarian survival. The results indicated the possibility of honey in solution causing the cells to lyse. These results suggested that honey, in this experiment, does not help planaria survive better. This research has the potential to lead to further studies on how honey might have affected tissue regeneration and how it could have impacted other organisms.

Noah Poovathukaran *Mills E. Godwin High School*
The Effect of Fat-Soluble Vitamins on Planaria Regeneration

The experiment was conducted to determine the effect of fat-soluble vitamins on the regenerative rate of planaria. Neurodegenerative diseases, such as Alzheimer's, affect millions around the world and lead to life-threatening problems. Neurodegenerative disease is caused by reduced neurogenesis, a process which creates new neurons based on stem cell activity. Planaria regenerate their amputated body parts using stem cells, which makes it an ideal model for studying neurogenesis. Although neurogenesis declines with age, there are external factors that can enhance the process. Vitamins, a micronutrient found in many foods, include properties that benefit different regions of the body including the brain. Therefore, it was hypothesized that if planaria were exposed to Vitamin A, Vitamin D, and Vitamin K, then the planaria would regenerate the fastest in a solution containing Vitamin D. In the experiment, a control of spring water was used to compare regeneration rates between solutions. Solutions were created using liquid extracts of Vitamin A, Vitamin D, and Vitamin K respectively, and these were divided into groups of twenty-five petri dishes. After creating the solutions, planarians were amputated and placed into each petri dish; and the regeneration rate was recorded in the number of days. The descriptive statistics test showed that the planaria regenerated the fastest in the Vitamin D solution. Furthermore, the inferential statistics test determined all independent variable groups were significant except for the Vitamin A group. A reason for the results may have been that the vitamins had mixed effects on the stem cell activity.

Zoology B (HS ZOO B)

Virginia Association of Biology Educators Award
First Place
Emily Paul *Southwest Virginia Governor's School*
The Effects of Heavy Metal Contaminants on Negative Phototropism Behaviors in *Ephemeroptera* Species

The Radford Army Ammunitions Plant (RAAP) is a supplier of propellants and explosives that is located on the New River, a significant water source and recreational area in Montgomery County, VA. Environmental monitoring of the RAAP measured several heavy metal contaminants in soil that exceeded established regulation, which can run off into the New River and accumulate. Freshwater macroinvertebrates at low trophic levels, such as Ephemeroptera (mayflies), are sensitive to environmental changes due to their variety of feeding habits, rapid metabolism, and hemimetabolous life cycles. This study investigated *Heptageniidae*, a common mayfly scraper, that feeds on algae where contaminants may have accumulated from upstream (Radford, VA, n = 20) and downstream (Parrott, VA, n = 42) locations of the RAAP. Water samples (n = 6) were collected and analyzed for metal ion content using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), revealing significantly increased concentrations of magnesium, calcium, sulfur, and strontium

downstream (p-value < 0.001 to 0.04) that were within the United States Environmental Protection Agency's regulatory limits. Negative phototropism was then tested on collected mayflies by using green light and measuring net distance traveled along the light intensity gradient in shallow water where sampling location was not a significant factor (p-value = 0.066). The length and mass of the mayflies were measured and showed that mayflies from upstream were significantly (p-value < 0.001) less massive per length and power series regression constants were found. The study failed to reject some parts of the alternative hypothesis due to significant p-values, but showed significant disturbance to the biomass, which can reasonably be correlated to increased metals downstream of RAAP.

Second Place
Ngo TanAn Nguyen *Mills E. Godwin High School*
The Effect of Black Coffee and Tylenol on Planarian Regeneration

Using coffee and painkillers is common in the US and around the world. Pregnant women also take these substances. However, it is not fully understood if these substances can affect the development of fetuses. Animal models like planarians can be used to better understand the impact of these substances. Planarians are worms which when cut, produce a copy of themselves. In 2 - 3 weeks, planarians are able to multiply their numbers through asexual reproduction. As their relation to pregnant women, usage of planarians as an animal model elicits pregnancy in women during planarian regeneration. One application of this animal model is in women who may overuse coffee and painkillers as they are more receptive to them during pregnancy. Consequently, this may result in an environment unsuitable for fetus development. Here, this study was aimed to investigate the effects of Tylenol and black coffee on planarian regeneration rates and was achieved by exposing them to different concentrations of these substances for 15 days. During these days, the survival rate and behavior were recorded. Important results were observed. Any concentration of black coffee had no significant effect on the regeneration rate. However, planarians in any concentration of Tylenol were significantly affected (p-value < 0.05 after 2 days). These findings suggest that Tylenol can have a negative impact on the regeneration rate of planarians while black coffee has no impact. These results have important implications for studies of high doses in pregnant women and the development of their fetuses in such conditions.

Honorable Mention
Sajeela Ahmad *Osbourn Park High School*
The Effect of Atrazine on the Heart Rate of *Daphnia magna*

The objective of this research was to observe the effects of atrazine on the metabolism of *Daphnia magna*, measured through heart rate. It was hypothesized that if *D. magna* are exposed to a growing amount of atrazine for 5 days, their heart rate will decrease by 10 bpm on average. In order to achieve this objective, five *D. magna* were each placed in one experimental and one control tank. Their baseline heart rate was measured through a microscope. The water temperature and pH were measured every day for safety of the animals, and 1 mL of atrazine-water solution was dropped in the experimental tank daily for 5 days. On the last day, the heart rate was again measured in the same way as in the beginning, and 1 mL bleach was dropped into the tanks to properly dispose of the *D. magna*. At the beginning, the heart rates of both experimental and control were not significantly different. The results showed that the experimental group's heart rate significantly increased after exposure to atrazine. They also showed that the experimental group and the control group's heart rates were not significantly different at the end of the experiment. Importantly, there was one deceased *D. magna* and one outlier in the experimental group. This shows the importance of having a large sample size as this could have prevented any confusion in the results. In conclusion, the results did not support my hypothesis and show proof both for and against the dangers of atrazine and other pollutants in the environment. Higher-quality research is needed to achieve clarity on this topic.

Honorable Mention
Xavier Gitre *Blacksburg High School*
Interspecific Social Networks of Parulidae Warblers in Active Migratory Passage

As songbirds in active migratory passage have proven frustratingly enigmatic, almost no literature has investigated the sociobiology of nocturnal migrants, despite strong evidence from radar and acoustic

observations suggesting they frequently interact in flight. Studying these interactions will provide insight into the social structures of nocturnal migrants, how they facilitate information exchange, and, crucially, if social factors influence poorly understood variables linked to population declines (chiefly window collision rates). Advances in flight call recording have opened an exciting window into the interspecific ecology of species in active migratory passage. Here, I utilize this technology to investigate the sociobiology of an abundant and diverse lineage of nocturnally migrating songbirds, Parulidae warblers, using social network analysis. I test the hypotheses that 1) their social interactions are structured by a nonrandom and ecologically relevant social network that resembles an ecological community, 2) variables relevant to nocturnal migration underlie that structure, and 3) migrants' social behavior is associated with their risk of window collisions. I find strong support for the first and third hypotheses, while the second is partially supported but remains somewhat ambiguous. These results merit further investigation into interactions between migrating songbirds on larger taxonomic and spatiotemporal scales and their implications for window collision rates.

Honorable Mention

Elena Milsted *Chesapeake Bay Governor's School*

The Effects of Differing Macronutrient Ratio Consumption on the Canine Oral Microbiome

This study examined the impact altering canine diet macronutrient ratios have on their oral health by noting the impacts of consuming high carbohydrate diets (kibble), high protein and fat diets (canned food), and balanced macronutrient diets (kibble and canned food mixture) in canine oral microbiomes. Bacterial abundance and diversity, salivary pH, and plaque buildup levels were assessed after participants were introduced to these three diets, where their original diet served as a control. Since high bacterial concentrations, plaque buildup levels, and acidic salivary pH's are commonly associated with poor oral health and periodontal disease, it was hypothesized that these recordings would be exhibited in dogs consuming high protein and fat diets. Saliva samples were collected to measure salivary pH, bacterial abundance, and bacterial diversity and oral cavity pictures revealed plaque buildup levels. This process was repeated two weeks following dietary changes to high carbohydrate and balanced diets and one week following changes to a high protein and fat diet. While salivary pH and plaque buildup levels displayed relatively stable, insignificant trends, trends observed in bacterial biodiversity, although non-significant, peaked among dogs consuming the high carbohydrate diet. Bacterial abundance was the only measurement to exhibit significant changes as it gradually decreased after exposure to the high carbohydrate diet. Although inconclusive, these findings indicate benefits to consuming high protein and fat diets in canines. However, more intensive studies are needed to sufficiently determine optimal canine macronutrient ratios and further the understanding of canine dietary needs with respect to their oral health.

Bryce Croxford *Mills E. Godwin High School*

The Effect of Microplastic Concentration on Food Preference in Planaria

Microplastics are a growing concern amongst U.S. citizens, being present in tap water, freshwater, and the oceans. A microplastic is described as any particle of plastic that is <5mm. Microplastics have been found to have an adverse effect on the regeneration of Planaria through inhibition, and the project was performed to determine if Planaria can detect the presence of microplastics. A hypothesis was developed that there would be no difference in food preference in planaria when exposed to microplastics. 100 *Dugesia tigrina* were separated into four petri dishes and fed egg yolk with varying concentrations of microplastics weekly. The concentrations were determined to be 1000 ppL, 500 ppL, and 250 ppL. The control in this experiment was egg yolk without any added microplastics. The number of Planaria observed consuming the egg yolk throughout the 30-minute feeding time was recorded. The results indicate that the difference between each IV except for 1000 vs. 500 is significant, however, the difference between the mean of each group was less than 1. The results indicated that the difference was significant, however, this is due to the low variance inflating the calculated t-values. Due to the minimal difference between each group, Planaria likely cannot detect MP presence in food and will consume it unknowingly.

Hannah Fryer *Central Virginia Governor's School for Science and Technology*

The Effect of Titanium Dioxide Nanoparticles on the Reaction Time of *Dugesia dorotocephala* upon Exposure to Light

Titanium dioxide nanoparticles are utilized in many industries as a whitening pigment in photo catalysts, antibacterial coating, paint, cosmetics, sunscreens, and food products. However, despite their vast application, the effects of TiO_2 nanoparticles on the environment as well as human health has not been considered. Furthermore, studies have shown when these products are disposed of, TiO_2 can enter waterways, leading to harmful effects on aquatic ecosystems and human health, raising concerns about its potential neurotoxicity. Indicator organisms such as planaria can provide insight into neurotoxicity due to their heightened sensitivity to environmental pollution and complex nervous systems. Based on these findings, I sought to determine the impact of TiO_2 nanoparticles on the reaction time of *Dugesia dorotocephala* when exposed to light, to ascertain whether TiO_2 nanoparticles inflict neurological repercussions. This study aims to explore the broader biological effects of TiO_2 exposure, particularly in relation to its potential neurological and ecological consequence

Elle Garnett *Collegiate Schools*
Effects of Microplastic Consumption on Dark Wing Beetle Larvae Growth and Development

Plastics are all around the world all the time. They are used in almost everything humans interact with- at restaurants, at schools, at grocery stores, at home, and more. They are so popular due to their easy accessibility and cheap prices. However, unfortunately, some are single use which makes them often not recyclable or reusable. This trash can commonly be found all around our outside world on roads, in bodies of water, and more. However, even when thrown in the trash, plastic develops and breaks down into Microplastics. Microplastics are tiny pieces of plastic that can be easily missed due to their microscopic size. These tiny particles can severely impact aspects of our living planet through the air, water, or consumption. Due to the fact that these microplastics are so small, animals often accidentally inhale them or consume them either directly by thinking they are food or through their prey that has consumed them first. In this study, I experimented with the impact of microplastics when consumed by a species known as Darkling Beetles, also known as “Mealworms”. I wanted to see if this had a major impact on how they function over time. Through my research, I found contradicting sources. While two of the studies saw no results between the consumption of microplastics and animals, 3 others did find results. This made me curious about what my results would yield and which conclusion the results would take. I studied the beetles during the 3 stages of life. These include larvae, pupae, and adult/ beetle. There were two aspects of my experiment to test how they would respond to the microplastics. These included growth and development over time. To see the growth, I took masses of 2 sets of 5 groups of 10 Mealworms. One group of 5 was fed microplastics, while the second group was not. To measure the development, I kept count of how many mealworms were at each stage of life in each growth and recorded it. Due to my background knowledge on how plastic impacts species, I drew the hypothesis that the consumption of microplastics will negatively impact Darkling Beetle Larvae growth and development. However, through the findings of my experiment, I have determined that the consumption of microplastics has no impact on Darkling Beetle Larvae growth and development. To determine these results, I ran the mass through a t-test and the counts through a Chi-squared test. Both p-values were greater than 0.05. Therefore, I failed to reject my null hypothesis. For future studies, changing the type of insect, plastic, or amount of time to conduct the experiment, could be beneficial in order to see results that succeed in rejecting the null hypothesis.

Vertika Manoj Kumar *Mills E. Godwin High School*
The Effect of Various Spices on the Regeneration Rate of Planaria

This project was designed to understand the regeneration rates of Planaria when various spices are applied. Previously, ayurvedic spices such as Turmeric, Ginger, and Cumin have proven useful when healing minor cuts and burns. Additionally, household spices such as the ones stated above are considered more affordable and exhibit less side effects, making it a more reliable option. In order to test the efficacy of these spices, solutions were made out of powdered ginger, cumin, and turmeric and distributed evenly into petri dishes. Regular water with no added spices also was distributed into petri dishes since it was used as the control for the experiment. Planarians were cut and placed into these dishes for 8 days. During this time period, the growth rate of the planarians was observed and recorded before humanely disposing of them. It was hypothesized that if cumin was applied to planaria, then it would produce the most accelerated reproduction rate When analyzed, it was concluded that Cumin and Turmeric had equivalent mean regeneration rates, while Powdered Ginger was 2 mm less. However, all the spices had a smaller mean

regeneration rate than the control, Water. Six t-tests were conducted, comparing each IV level to each other. It was determined that all the t-tests were insignificant and less than the table value. These results were due to the lack of time in experimentation. The planaria were not starved for 14 days before experimentation and were only allowed to grow for 8 days.

Barathi Saravanan *Mills E. Godwin High School*
The Effect of Endocrine Disruptors on Reproduction of *Drosophila melanogaster*

EDCs (endocrine disrupting chemicals) are natural or synthetic substances which can cause changes in the hormonal/homeostatic systems of the organisms exposed to their action (Ercan, 2022). The independent variables of this experiment are phthalates, PFAs, Red Dye No. 3, & soy isoflavone. The control is no EDC since the effect of the chemicals can be compared to the normal behavior of the flies. If *Drosophila melanogaster* are exposed to food containing phthalates, then there will be a lower reproductive rate. *Drosophila melanogaster*, also known as the common fruit fly, shares 60% of the same DNA as humans. Since they breed in around 2 days, they are ideal candidates for reproductive studies. A culture of flies were grown until adults (6 days) and then separated into male and females. Once fully developed at 6 days, one male and female fly were placed in a separate dish with the media with 10 grams of a 10% concentration of a common food with an EDC. The flies were left to reproduce and the dependent variables (the number of offspring, overall health, reproductive) were observed for each independent variable. Twenty - five trials were conducted for each variable to ensure precision and accuracy. The results showed that out of all of the chemicals, Red Dye No. 3 resulted in the lowest number of offspring. When a t-test was performed, the data for Red Dye No. 3 and phthalates was significant. The other data being insignificant may be due to sources of error such as incorrect counting and temperature fluctuation. These possible errors could be avoided by performing the experiment in a laboratory with controlled conditions. Further exploration into the realm of the effect of endocrine disrupting chemicals include using different test animals and chemicals. While there have been studies on the effects of EDCs on animals, the effect of these chemicals on human health needs to be further explored. On January 16, 2025 (after the experiment's completion), the UFDA officially banned Red Dye No.3 since it was a carcinogenic substance.

Kyla Williams *Clover Hill High School*
The Effect of Using Dead Leaves vs. Green Leaves, in a Pill bug Habitat, on Pill bug Choice

The purpose of this experiment was to determine if pill bugs prefer green leaves or dead leaves when given the choice between the two. Pill bugs have a diet containing green leaves, but they are also detritivores. The hypothesis was: More of the pill bugs would choose dead leaves over living leaves. The control had two empty sides of a choice chamber, one level had green leaves and an empty side of the choice chamber, another level had dead leaves and an empty side of the choice chamber, and another level had a side of the choice chamber with green leaves while the other side of the choice chamber had dead leaves. After the pill bugs were placed in a side of the choice chamber, one of the level tests were conducted. A level test consisted of setting a one-minute timer and recording the number of pill bugs on each side. The one-minute timer was set a total of ten times to complete a trial. The mean for each side of the control were 5.04 and 0.96, 3.71 for the green leaves and 2.30 for the empty side of the level with a side with green leaves and an empty side, 5.32 for the brown leaves and 0.68 for the empty side in the level with a side with brown leaves and an empty side, and 4.20 for the green leaves and 1.80 for the side with brown leaves in the level with green leaves and brown leaves. The pill bugs only preferred the brown leaves when there were no other options for leaves available. The null hypothesis was not rejected. The data did not support the research hypothesis.

American Junior Academy of Science

The following papers were selected as representative and alternates for the Virginia Junior Academy of Science at the American Junior Academy of Science in February 11-14 of 2026.

#1 Hrishi Desai & Raghav Kasi *Thomas Jefferson High School for Science and Technology*
Sponsor; James Crockett ***Dean Decker AJAS Sponsor Award***

Calcium-Doped Biochar for Optimized Glyphosate Removal in Aqueous Media

Raghav Kasi and Hrishi Desai

Abstract

Glyphosate is an herbicide that is found ubiquitously in aquatic environments, which has been shown to be adsorbed by biochar. This study aimed to optimize the glyphosate adsorption capabilities of biochar in aqueous media. Biochar was prepared by using recycled aluminum cans to create a TLUD (top-lit updraft) gasifier, and dried wheat straw was used as a substrate for further modification. Two biochar variants were created: one solely consisting of wheat straw (BC), and the second soaked in a calcium acetate solution derived from acetic acid and egg shells prior to pyrolysis (CaBC). UV/Vis spectrophotometry revealed that BC and CaBC removed 81% and 93% of glyphosate, respectively. Kinetic models for CaBC fit both a pseudo-second order and pseudo-second order profile, suggesting a complex adsorption mechanism dependent on both chemisorption and physisorption. However, when data for BC was mapped to the same kinetic models, BC had a significantly lower correlation coefficient towards the pseudo-second order model, indicating limited chemisorption. Moreover, CaBC isotherm studies exhibited high correlation coefficients for both Langmuir and Freundlich models, further suggesting a mixed adsorption mechanism. FTIR characterization for CaBC yielded peaks at 721 cm^{-1}, indicative of Ca-O bonds. Additionally, these peaks were not visible post-adsorption, suggesting that the Ca-O bonds were replaced with interactions between Ca^{2+} ions, OH^-, and glyphosate. This research demonstrates the viability of biowaste for water remediation, and highlights the novel potential for calcium amendments.

Introduction

Glyphosate (N-(Phosphonomethyl)glycine) is a non-selective, broad-spectrum herbicide. Due to its efficiency and accessibility, it is the most commonly used herbicide across the world used to manage weeds in agricultural settings, present in 60% of commercially available formulations (Costas-Ferreira, 2022). After being taken up by the leaves, it works through inhibiting an essential biosynthetic pathway. While it has been presumed that glyphosate is

largely absorbed by soil, desorption can be promoted by factors such as rainfall, organic matter, metallic oxides, and soil pH, facilitating its transport to subsurface groundwater (Vereecken, 2005). Moreover, United States Geological Survey data showed that glyphosate was present in at least 80% of samples at half of the collection sites (USGS, 2020). While the quantities found did not exceed accepted regulatory levels, chronic low-level exposure to glyphosate, in combination with other agricultural waste chemicals and co-formulants such as surfactants, can be detrimental to aquatic biota. According to the EPA, glyphosate is likely to kill or injure 93% of species protected by Endangered Species Act. The increasing usage of glyphosate and its potential to disrupt several ecosystems requires the need for an efficient and effective solution.

Biochar is a highly porous, carbon-rich material that is produced through the pyrolysis of biomaterial under limited oxygen exposure. The resulting compound has been shown to be effective for the adsorption of various compounds due to its excellent physical adsorption capabilities (Wang et al., 2024). Due to its surface functional groups and porous structure, it has been shown to adsorb through several mechanisms, including but not limited to: pore-filling, electrostatic interactions, and pi-stacking. Currently, the leading methods of glyphosate removal from water include activated carbon and reverse osmosis which have proven to be expensive and energy-intensive (Alhashimi et al., 2017). Therefore, biochar serves as a suitable candidate for glyphosate removal applications. To date, few studies have been done involving the chemical modification of biochar for glyphosate removal with high removal efficiencies. However, the use of several chemicals can increase cost, energy intake, and create further aquatic contamination (Xu et al., 2022). We sought to create biochar with a high glyphosate adsorption capacity while retaining its inherent benefits.

For this study, we chose to create a calcium-doped biochar using wheat straw as a carbon source and eggshells as a calcium source. Wheat straw was selected for its renewability and abundance as agricultural waste. Eggshells, containing over 90% calcium carbonate, were selected as another agricultural and consumer byproduct. While unmodified biochar has excellent physical adsorption properties, it may have limited chemical interactions with glyphosate. We hypothesized that through the addition of positively charge-dense metallic ions, glyphosate interactions with biochar would be strengthened and adsorption capacity would increase.

Materials and Methods

Biochar Production

Biochar was created using a low-cost Top-Lift Updraft (TLUD) reactor made from recycled aluminum cans. Biomass was ignited at the top, initiating a descending pyrolysis front where low oxygen levels beneath the pyrolysis zone (due to primary airflow) prevented combustion. To ensure proper primary airflow, approximately 15 holes (0.5 cm each) were drilled into the base of the primary chamber. An aluminum crown was installed to facilitate secondary airflow, and a final chimney flue, constructed from small cans, was assembled on top to direct syngas emissions. Two types of biochar were prepared: calcium-doped biochar (CaBC) and unmodified biochar (BC). CaBC was produced by soaking wheat straw in a calcium acetate solution for 24 hours before drying and pyrolyzing. The calcium acetate solution was created by dissolving eggshells in white vinegar. Unmodified BC was prepared by pyrolyzing wheat straw without any chemical modification.

Sample Preparation

A commercial herbicide containing 18% glyphosate (RoundUp Concentrate Plus) was used as the glyphosate source. A stock solution of 900.0 mg/L glyphosate was prepared and diluted to a final volume of 200 mL using deionized water. Dilutions were performed to obtain a range of glyphosate concentrations (60 mg/L, 30 mg/L, 20 mg/L, 10 mg/L, 5 mg/L) for the adsorption studies. To determine adsorption isotherms, a range of initial glyphosate concentrations was used, and the adsorption process was modeled using Langmuir (Equation 1) and Freundlich (Equation 2) isotherm models:

$$\frac{1}{q_e} = \frac{1}{K_L q_{max}} \cdot \frac{1}{C_e} + \frac{1}{q_{max}} \quad (1)$$

$$log(q_e) = log(K_f) + \frac{1}{n} log(C_e) \quad (2)$$

Where q_e represents the equilibrium adsorption capacity (mg/g), C_e represents the equilibrium concentration of glyphosate (mg/L), q_{max} represents the maximum adsorption capacity (mg/g), K_L represents the langmuir constant, and K_f represents the freundlich constant. Removal efficiencies of glyphosate were also calculated per equation 3:

$$R = \frac{C_0 - C_e}{C_0} \cdot 100\% \quad (3)$$

Where C_0 and C_e represent the initial and equilibrium glyphosate concentrations (mg/L), respectively. Moreover, the free energy of adsorption was calculated using equation 4.

$$\Delta G_{ads} = - RTln(K_L) \quad (4)$$

Where ΔG represents free energy of binding. Additionally, kinetic adsorption studies were conducted using an initial concentration of 60 mg/L glyphosate, with samples collected at 0, 1, 2, 3, 4, 6, and 12 hours. Adsorption kinetics were analyzed by fitting the data to pseudo-first-order and pseudo-second-order kinetic models, shown in equation 5 and 6, respectively.

$$ln(q_e - q_t) = ln(q_e) - k_1 t \quad (5)$$

$$\frac{t}{q_e} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} \quad (6)$$

Glyphosate Quantification

Adsorbed glyphosate was quantified using a ninhydrin-based colorimetric assay (Bhaskara et al., 2006). The assay relied on a reaction between glyphosate and 5% ninhydrin in the presence of a sodium molybdate catalyst (Thermo Fisher Scientific) and heat, leading to the formation of a tertiary amine, which was subsequently dehydrated to generate an enamine. This reaction produced Ruhemann's purple, which was detected at 570 nm using UV/Vis spectrophotometry. The procedure involved the addition of 5% ninhydrin and 5% sodium molybdate to the collected glyphosate samples, followed by reaction in a boiling water bath (100°C) for 12 minutes to facilitate the condensation reaction. The reaction mixtures were then aliquoted and transferred into cuvettes for spectrophotometric analysis, and absorbance was measured at 570 nm to determine the glyphosate concentration based on a standard curve. Post-adsorption glyphosate concentrations were calculated using the established standard curve, which was constructed using Beer's Law (equation 7).

$$A = \varepsilon bc \quad (7)$$

Where A represents absorbance, ε is the molar absorptivity constant, b is path length, and c is concentration.

Surface Characterization

Biochar characterization was performed using Fourier Transform Infrared Spectroscopy (FTIR) to analyze functional groups on the biochar surface before and after glyphosate

adsorption. The analysis was conducted for calcium-modified biochar (CaBC) and untreated biochar (BC), both pre-adsorption and post-adsorption. For FTIR analysis, biochar samples were placed on the FTIR crystal for spectral acquisition. The obtained spectra were processed using analytical software, and percent transmittance was plotted against wavenumber to identify functional groups involved in glyphosate adsorption.

Results

Kinetic Studies

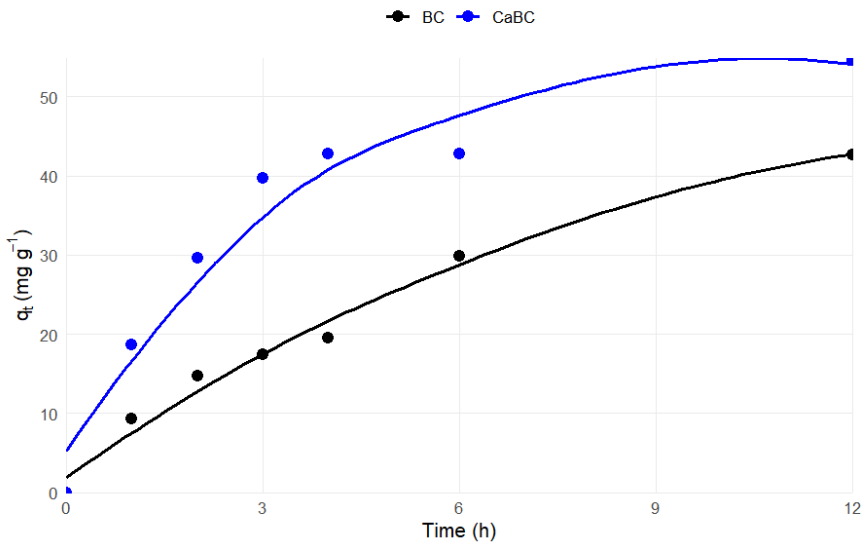


Fig. 1. Comparison of adsorption capacity at various times (q_t) across CaBC and BC

The kinetic adsorption experiments revealed distinct performance differences between BC and CaBC materials. CaBC demonstrated consistently higher adsorption capacity (qt) compared to BC across all time points from 0 to 12 hours (Figure 1). Statistical analysis using a paired t-test confirmed a significant difference between the two materials ($t(6) = 4.52$, $p = 0.004$). CaBC showed a mean improvement in adsorption capacity of 13.52 mg/g over BC, with a 95% confidence interval of [6.20, 20.85] mg/g. Both materials exhibited typical adsorption kinetics with rapid initial uptake followed by a gradual approach to equilibrium. CaBC reached a maximum q_t of 54.61 mg/g at 12 hours, while BC achieved 42.69 mg/g at the same time point.

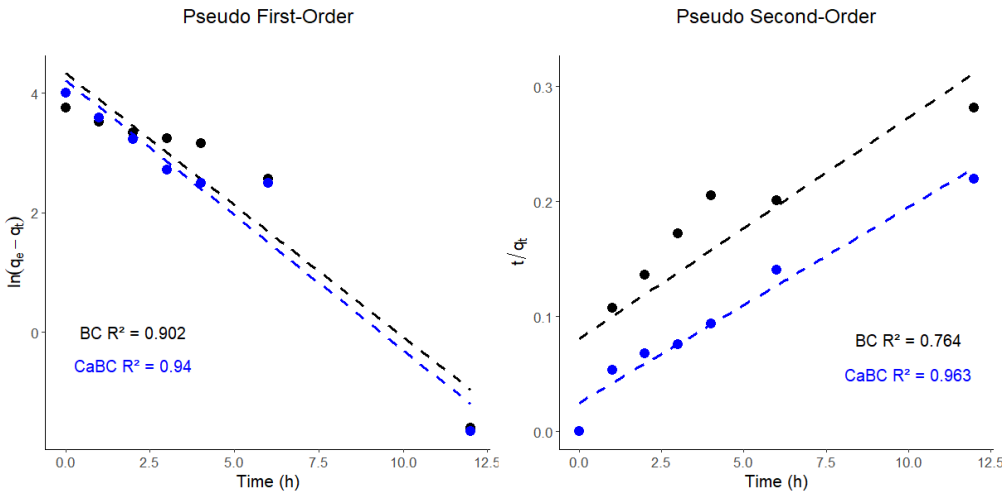


Fig. 2. Pseudo-First and Pseudo-Second Order Models

	Pseudo-First Order			*Pseudo-Second Order*		
	k_1 (h^{-1})	**q_e** (mg/g)	**R^2**	**k_2** ($gmg^{-1}h^{-1}$)	**q_e** (mg/g)	**R^2**
CaBC	0.038	67.4	0.940	0.012	58.82	0.963
BC	0.038	75.9	0.902	0.34	12.4	0.764

Table 1. Summary Statistics for Kinetic Models

To better understand the adsorption mechanisms, both pseudo-first-order and pseudo-second-order kinetic models were applied to the kinetic data. The pseudo-second order model showed superior fit for CaBC compared to the pseudo-first order model, with R^2 values of 0.963 for PSO and 0.940 for PFO. On the other hand, the pseudo-first-order model had a better fit for the unmodified BC, with R^2 values of 0.902 compared to 0.764 for PSO. The pseudo-second order rate constant (k_2) for CaBC was determined to be 0.012 g/(mg·h), while BC exhibited a higher rate constant of 0.34 g/(mg·h). The theoretical equilibrium adsorption capacity (q_e) calculated from the pseudo-second-order model was 58.82 mg/g for CaBC and 12.4 mg/g for BC, aligning well with the experimental observations.

Isotherm Results

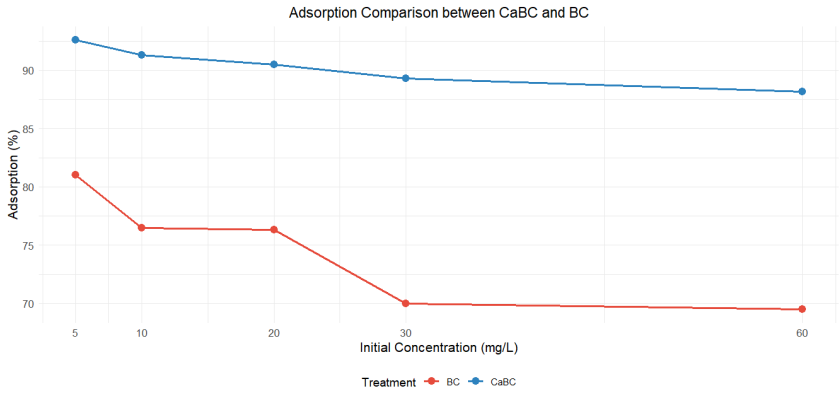


Fig. 3. Comparison of glyphosate removal rate across CaBC and BC with initial glyphosate concentrations of 5, 10, 20, 30, and 60 mg/L

Isothermal data was used to plot percent absorbance as a function of initial concentrations. Figure 3 illustrates the comparative removal efficiencies of CaBC and BC across varying initial glyphosate concentrations (5-60 mg/L). Statistical analysis through a paired t-test ($p = 0.0001316$) confirmed statistically significant differences between the two materials' performance. CaBC exhibited consistently superior removal rates, with a mean improvement of 17.70% compared to BC. A 95% confidence interval of 14.57% to 20.83% was computed. While both materials showed a gradual decrease in removal efficiency with increasing initial concentration, CaBC maintained notably higher performance throughout the range, achieving 92.6% removal at 5 mg/L and 88.17% at 60 mg/L. In contrast, BC demonstrated lower removal efficiencies, ranging from 81% to 70.67% across the same concentration range.

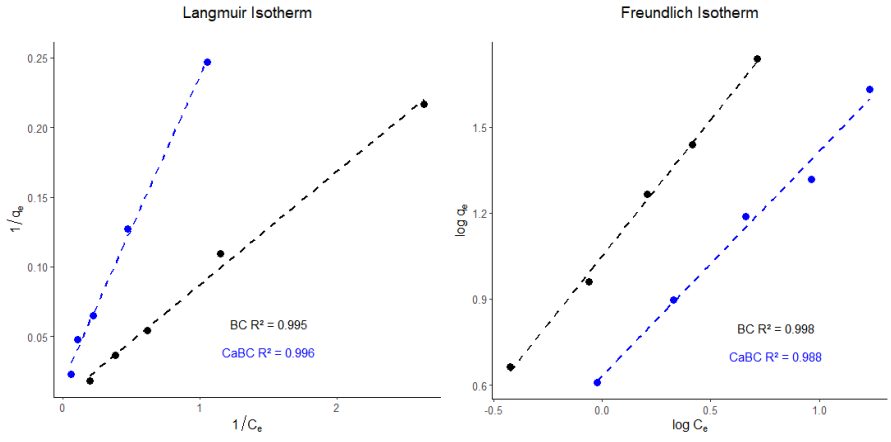


Fig. 4. Langmuir and Freundlich Isotherm Model Regression

Adsorption mechanics were analyzed using both Langmuir and Freundlich isotherm models. Langmuir isotherms assume monolayer adsorption with minimal adsorbate-adsorbate interactions, while the Freundlich model assumes multilayer adsorption. The Langmuir isotherm analysis revealed improved adsorption characteristics for CaBC, with a maximum adsorption capacity (q_{max}) of 102 mg/g and K_L = 0.126 L/mg (R^2 = 0.993). BC showed comparatively lower values with q_{max} = 47.6 mg/g and K_L = 0.095 L/mg (R^2 = 0.987). The Freundlich model similarly demonstrated favorable adsorption behavior, with CaBC showing a K_f = 10.96 $(mg/g)(L/mg)^{1/n}$ and n = 1.10 (R^2 = 0.986), while BC exhibited K_F = 4.08 $(mg/g)(L/mg)^{1/n}$ and n = 1.25 (R^2 = 0.991). The high R^2 values (>0.98) for both models indicate good fit to the experimental data, suggesting complex adsorption mechanisms involving both monolayer and multilayer adsorption processes. The linear regression plots for both Langmuir and Freundlich isotherms (Figure 2) further validate the superior performance of CaBC. The steeper slope observed in the CaBC Langmuir plot indicates a higher adsorption rate, while the Freundlich plots demonstrate more favorable adsorption intensity for CaBC compared to BC.

Fourier Transform Infrared Spectroscopy (FTIR)

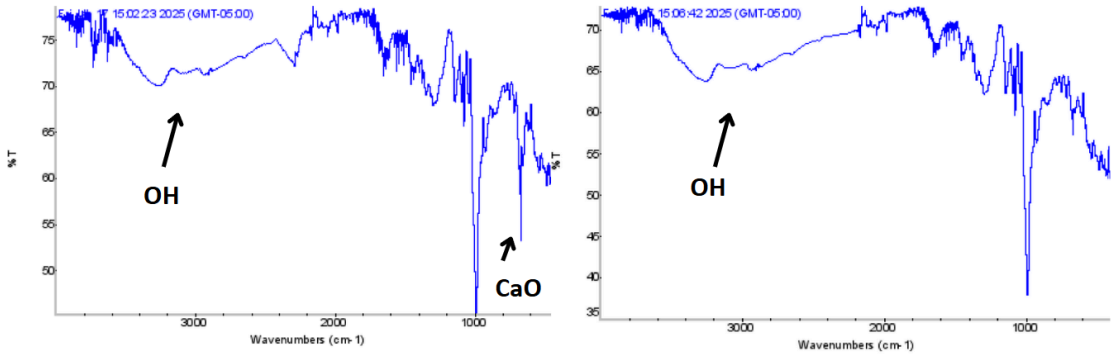


Fig. 5. CaBC pre-adsorption (Left) and post-adsorption (Right) FTIR spectra

Both samples of CaBC demonstrated a hydroxyl group stretch at 3300 cm^{-1}. However, only the samples pre-adsorption demonstrated a significant peak at 721 cm^{-1}, which is close to the previous literature values of Ca-O bonds (Jellali et al., 2020).

Discussion and Conclusions

Kinetic Studies

Pseudo-order kinetic models are used when one reactant is in heavy excess. In our studies, the adsorbent (biochar) was in excess in relation to the glyphosate. The PFO model assumes the rate-limiting step of adsorption is diffusion onto the biochar surface, whereas the PSO model assumes the rate-limiting step is chemical sorption. CaBC displayed better fitting to the PSO model, than the PFO model, suggesting primarily chemisorption. However, it fit both models highly, revealing that CaBC adsorption was through a combination of physical and chemical mechanisms. Moreover, the rate constant k_2 for CaBC was lower than k_1, suggesting a slower adsorption process due to the formation of chemical bonds instead of simple diffusion, further validating second-order adsorption. BC fit the PFO model well and the PSO model poorly. Therefore, the BC adsorption mechanism was likely primarily physisorption. Furthermore, rate constants k_1 for both biochars were equal, demonstrating that the details of physisorption was similar between the two, likely due to the use of the same wheat straw carbon source.

Isotherm Studies

Removal percentages at isothermal conditions were initially analyzed to gain preliminary information on adsorption capacities. CaBC had a maximum removal efficiency of 92.6%, while BC had a maximum removal efficiency of 81.0%. Moreover, removal efficiencies decreased as initial concentration increased, likely due to a constant concentration of adsorbent and complex association equilibria. Lita et al. (2023) achieved a removal efficiency of 99.6% with the use of chemical modification and low pH not characteristic of environmental conditions. Zaparoli et al. (2023) achieved a removal efficiency of 87.9% with no chemical modification. Therefore, our study reveals that eggshell CaBC outperforms chemically unmodified biochars but underperforms chemically modified biochar.

CaBC better fit the langmuir isotherm model, but still showed strong correlation for the freundlich model. These results demonstrate that CaBC exhibited both physisorption and chemisorption but favored the latter. Contrarily, BC better fit the freundlich isotherm model, but still showed strong correlation for the langmuir model. These conclusions are consistent with the kinetic data. The langmuir model was used to calculate q_{max} values for both biochars. CaBC showed over double the q_{max} value than BC, showing that calcium doping significantly increased the amount of glyphosate adsorbed per gram of biochar.

Energetics

The thermodynamic parameter, free energy of binding, was calculated using the langmuir constant according to equation 4. A more negative free energy translates to a more thermodynamically favorable and product-favored adsorption equilibrium. Since the calculated value of ΔG_{ads} was negative and of large magnitude, this suggests that interactions between glyphosate molecules and the biochar surface lowered the overall system energy. While other thermodynamic parameters, such as enthalpy and entropy were not calculated, it can be hypothesized that intermolecular interactions, precipitate formation, and hydration shell displacement contributed to an exergonic adsorption process.

Spectroscopic Characterization and Adsorption Mechanisms

FTIR analysis revealed that all CaBC showed a peak at 721 cm pre-adsorption, representative of a Ca-O bond stretch. After absorption, this peak disappeared in CaBC. This suggests that Ca-O bonds formed during biochar pyrolysis were replaced with acid-base interactions with phosphate. Hard-soft acid-base theory categorizes acids and bases on their polarizability and charge density, where acids and bases with similar hardness have more favorable interactions. We chose calcium ions to dope the biochar because its hardness as an acid is similar to the phosphate group's hardness as a base, leading to increased adsorbent/adsorbate interactions.

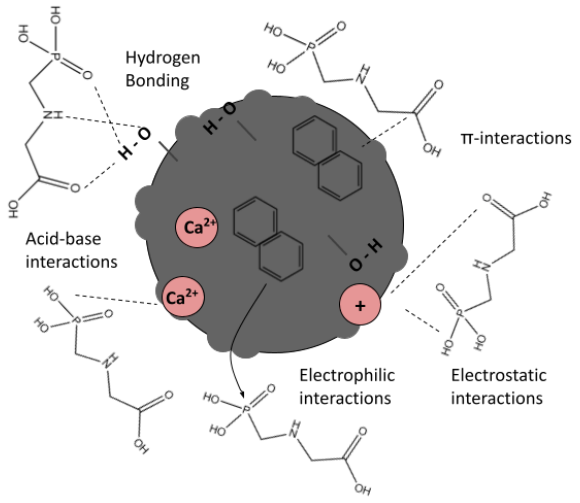


Fig. 6. Biochar Adsorption Mechanisms

However, a small peak was still present, suggesting the retention of some Ca-O bonds. This was likely due to the formation of small amounts of a modified hydroxyapatite, which would

precipitate in a slightly basic environment (Xu et al., 2022). The phosphate group on the glyphosate molecule may react to form a modified crystal structure, leading to surface precipitation. This is shown in equation 8, where (gly) represents the phosphate group on glyphosate.

$$3(gly) + 5Ca^{2+} + OH^{-} \rightarrow Ca_5(gly)_3(OH) \quad (8)$$

Conclusions and Future Work

Our study demonstrated that ultimately, CaBC increased biochar-glyphosate interactions and improved removal efficiency, affirming our hypothesis. Adsorption mechanisms were proposed through the use of kinetic and isotherm studies, suggesting a mix of physisorption and chemisorption in CaBC and solely physisorption in BC. Moreover, CaBC outperformed previous studies that did not use synthetic doping chemicals and achieved a maximum adsorption capacity 2.1 times normal BC, suggesting promising work for future optimization. However, our study was restricted by a small sample size, so further work must be done to validate our findings. Moreover, our study only tested one formulation of glyphosate (RoundUp) and did not use a range of pHs, calling upon the need for future studies regarding the interference of inactive ingredients and protonation of different groups on glyphosate. Further work regarding surface morphology and testing ecological interactions with aquatic organisms must be done to further elucidate adsorption chemistry and ensure that the administration of biochar for aquatic management does not have off-target effects.

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Computational Design of Novel CD117-Specific RNA Aptamers for Targeted Therapy of Glioblastoma Multiforme (GBM)

ABSTRACT

Glioblastoma multiforme (GBM) is a high-mortality brain cancer that causes 50% of all brain tumors and has an average survival rate of 12-15 months. CD117 is a transmembrane glycoprotein that is largely overexpressed in GBM cells. Its cytoplasmic kinase domain contains an ATP binding site, a promising druggable target. Aptamers are short single-stranded nucleic acids that serve as effective cancer therapeutics due to their selective targeting of tumor cells and minimum toxicity. This investigation aimed to computationally evaluate parent (already-existing) RNA aptamers: V15, W3, V5, and H5/V36 as ATP-site specific CD117 inhibitors and design novel GBM drugs by mutating the best-performing parent aptamer. Molecular docking was performed to determine each parent aptamers' binding strength towards CD117's ATP site. Five mutants of the best parent aptamer were created via in-silico mutagenesis and subjected to molecular docking again. The V15 aptamer had the highest binding strength due to its low binding energy (-300.65 kcal/mol), but mutants M1 (-304.99 kcal/mol) and M3 (-355.96 kcal/mol) of V15 displayed stronger binding to the ATP site, particularly M3. The parent aptamers were further assessed for structural motifs, shared nucleotide sequences across the aptamers that enhance binding to the ATP site. The analysis revealed a statistically significant motif ($E < 0.05$) AGUGUCNA that enhances aptamer binding to the ATP site. Molecular dynamics (MD) were performed with the M3 and M1 aptamers due to their superior performance in molecular docking. Variations in RMSD and Rg values were quantified to determine the aptamers' stability over a dynamic timeframe when bound to CD117. The MD simulations revealed that the M3 aptamer was the most stable due to its lower RMSD and Rg variation throughout the simulation's timeframe. The M3 aptamer was further analyzed through molecular docking with blood brain barrier (BBB) receptors: transferrin receptor and leptin receptor as well as RNase T2. A high binding strength towards BBB receptors was determined, suggesting strong brain permeability, yet strong binding to RNase T2 was also observed, implying high risks for degradation. Hence, structural modifications are required to optimize M3's design and lower degradation susceptibility. In conclusion, this research designed a novel aptamer, M3, for GBM therapy which can potentially be tested with GBM cell lines and live patients.

INTRODUCTION

Glioblastoma multiforme (GBM) is the deadliest form of brain cancer, occurring from excessive growth of astrocytes, the most prevalent cell types in the central nervous system (CNS). Glioblastomas account for over 50% of all malignant CNS tumors and has a median survival of 12-15 months. Only 17% of patients survive 2 years after diagnosis and only 6% survive 5 years post-diagnosis. Even though GBM tumors primarily localize within the cerebral cortex and do not usually spread to distant organs, they induce various neurological impairments like seizures, speech disorders, intracranial hypertension, and motor/cognitive issues (Grech et al. 2020; Hanif et al. 2017). Current chemotherapy is highly ineffective as they deal considerable damage to healthy brain cells and induces numerous toxic side effects. Surgical removal is also non-viable as GBM spreads throughout the entire brain. In addition, the tumor cannot be completely withdrawn without removing healthy brain tissue, often leading to adverse impacts on brain function. Lastly, radiotherapy is also ineffective as GBM tumors & microenvironments tend to acquire radioresistance mechanisms. Clinical studies have reported that GBM recurrence rates are at a staggering 80-90% even after a combination of chemotherapy, surgery, and radiation (Petrecca al., 2013). As standard treatment options are not viable, it is vital to develop novel, effective GBM therapeutics.

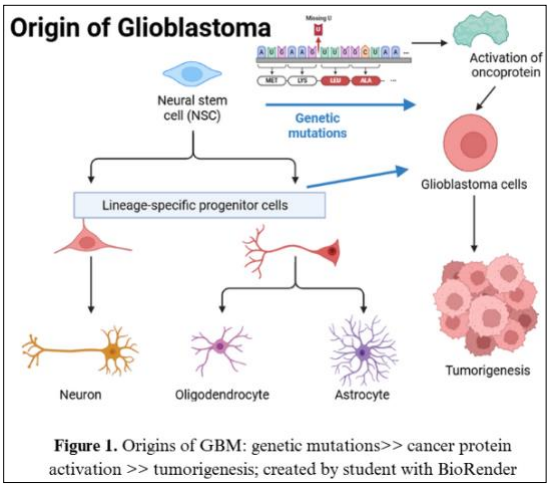


Figure 1. Origins of GBM: genetic mutations>> cancer protein activation >> tumorigenesis; created by student with BioRender

CD117 is a membrane glycoprotein lining brain cells whose overexpression is implicated in CNS tumors, mainly GBM (~76% cases) (Mitrofanova et al., 2020). CD117 contains an extracellular (EC) domain, a transmembrane (TM) helix, and an intracellular (IC) kinase domain. Its intracellular kinase domain (endodomain) has two subdomains: tyrosine kinase 1 (TK1) and tyrosine kinase 2 (TK2), that assist in the activation of secondary cellular proteins responsible for cancer-causative signaling pathways like such as JAK/STAT, Ras/MAPK, and PI3K/Akt/mTOR. Overexpression of these pathways leads to excessive cell proliferation and resistance to apoptosis that induces tumor formation. The TK1 subdomain, which is particularly important, contains an

ATP-binding site where ATP binds and activates tumor-inducing secondary messenger proteins like adaptor proteins (SHC, GRB2), transcription factors (STAT), and phospholipases (Sheikh et al., 2022; Pearson & Regad, 2017). Though class III RTK inhibitors like Lenvatinib have reduced CD117+ GBM progression in clinical testing, these compounds pose toxicity risks and cause side effects like nausea, hypertension, proteinuria, fatigue, and constipation (Li et al., 2017).

Aptamers are short, single-stranded DNA/RNA molecules with unique 3D structures that bind to receptor targets at a high strength and specificity. Current chemotherapy drugs often utilize non-specific inhibitory mechanisms that lead to high recurrence rates and toxicity risks. On the contrary, aptamers directly bind to cancer-causative biomarkers. As healthy cells do not overexpress cancer proteins, aptamers mainly localize to tumor cells and avoid healthy cells, eliminating the many toxic side effects that occur in chemotherapeutic agents. In addition, they can also be bound to chemotherapy drugs for their precise delivery into cancer cells (Mahmoudian et al., 2024). The blood brain barrier (BBB) is a complex network of endothelial cells that separates the blood and the brain. Since the BBB blocks the entry of brain-related drugs, crossing this layer is one of the largest issues in developing brain cancer therapeutics. However, aptamers can be enclosed by nanoparticle (NP) carriers like lipid NPs and polymeric NPs that increase permeability into the brain via transport across the BBB. Additionally, they can also bind to receptors located on endothelial cells forming the BBB like transferrin receptors (TfRs), albumin receptors (GP60/SPARC), and leptin receptors. Binding

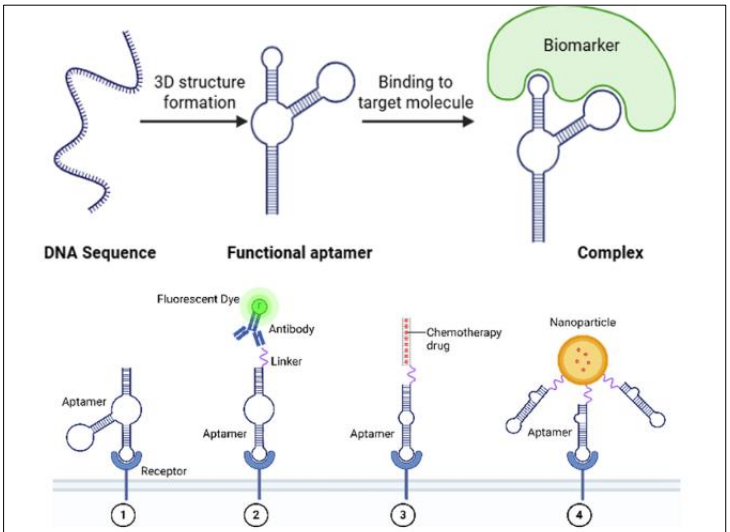


Figure 2. Binding of aptamers to biomarkers, chemotherapy drugs, nanoparticle carriers, and cancer-detecting fluorescent dyes; made by student with BioRender.

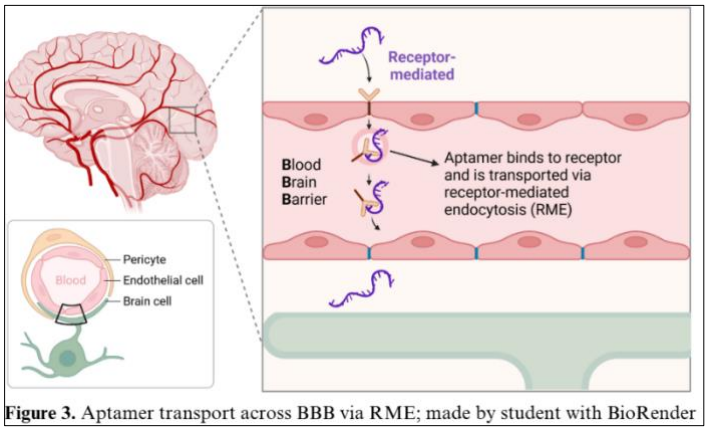


Figure 3. Aptamer transport across BBB via RME; made by student with BioRender

of drugs like aptamers to these proteins into the brain via receptor-mediated endocytosis (RME) which would then eliminate BBB-causative drug permeability issues (Bukari et al., 2020).

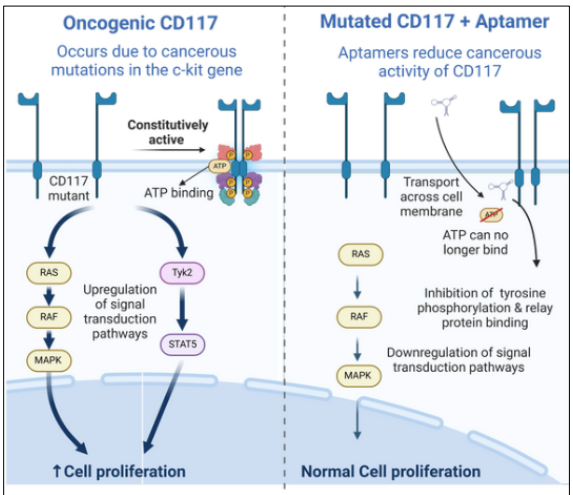


Figure 4. Visual representation of CD117 function under oncogenic and aptamer-mediated conditions; aptamer binding to the ATP site inactivates tyrosine phosphorylation and secondary messengers; made by student using BioRender

The ATP-binding site, present in CD117's TK1 lobe, has been a crucial target for reducing aberrant activity of the CD117 receptor and cancerous signaling pathways. ATP site-specific tyrosine kinase inhibitors directed towards CD117 inactivate secondary messengers by preventing tyrosine phosphorylation, which leads to downregulation of signal transduction pathways and anti-cancer effects. Although a few researchers like Shraim et al., have reported inhibition of CD117 and class III RTKs by aptamers like V15, V5, H5/V36, and W3, this area of research is highly limited and requires further analysis to comprehend the viability of aptamer-based therapies as GBM therapeutics (Shraim et al., 2019).

Current drug discovery processes are unbelievably expensive, time-consuming, and susceptible to failure. It takes nearly 10-15 years to design a drug and costs a staggering $2.6 billion USD. In addition, 90% of drugs entering clinical trials fails to gain FDA approval. More importantly, 75% of the failures are from inaccuracies and inefficacies in experimental and clinical procedures (Sun et al., 2022). Computer-aided drug discovery (CADD) is a growing field in biomedicine that uses computational modeling to identify and design optimal drugs. CADD technologies can screen hundreds of drugs like aptamers at an extraordinary speed and narrow down the top-performing ones that require experimental/clinical validation. By reducing the amount of manual testing required, CADD techniques offer a much more efficient and cost-effective alternative that speeds up traditional drug discovery. CADD technologies also provide effective visualizations of the molecular interactions between drugs and target proteins and gives

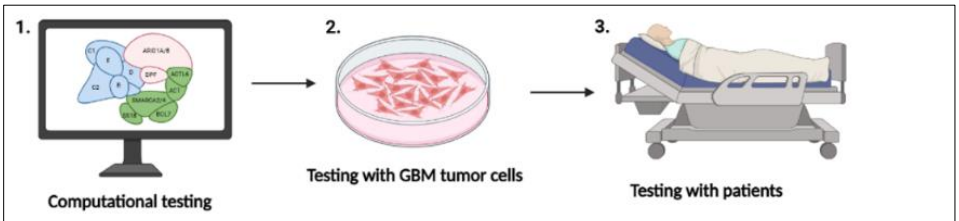


Figure 5. Phases of computer aided drug discovery (CADD): computer testing >> cells >> live patient testing; created by student using BioRender

a clear understanding of how adding different functional groups to drug-like molecules enhances their binding to proteins. For example, a recent study used CADD to demonstrate that adding a triphenylphosphine group to pyridazinone makes it an effective proteosome inhibitor for the treatment of white blood cell cancer. In addition, CADD can be performed on a standard computer, offering an accessible, simpler alternative to traditional wet lab research (Leelananda et al., 2016).

This research aimed to computationally develop novel RNA aptamers for ATP-site specific CD117 inhibition. First, the binding strength of already-existing (parent) aptamers V15, W3, H5/V36, and V5 towards CD117's ATP site was quantified. Next, shared nucleotide sequences across the parent aptamers enhancing binding to CD117 & the ATP site was identified. This study then designed optimized mutants of the highest-affinity aptamer to develop novel, superior inhibitors that can gain clinical applications. The two top-performing mutant aptamers exhibiting stronger binding to CD117 than the best parent aptamer underwent further analysis to determine their stability over a dynamic timescale. The best-performing aptamer overall was assessed for binding strength to transferrin receptor and leptin receptor to quantify BBB-permeability as well as RNase T2 to quantify susceptibility to degradation. Low degradation susceptibility is optimum since that indicates the aptamers will not break down before interacting with the target protein (CD117). It was hypothesized that the aptamers will demonstrate high affinity towards CD117's ATP site, a strong potential for BBB permeability and low susceptibility to RNase T2 degradation.

METHODS AND MATERIALS:

Protein Structure Visualization: The BLAST sequence of the human CD117 receptor was submitted to the AlphaFold 3 software for 3D structure prediction. The 3D structure was then uploaded to the YASARA software to remove all but the endodomain (IC kinase domain), which is amino acids 581-676. The endodomain was further input into the Chimera X software to visualize the ribbon 3D structure and electrostatic surface potential (surface charges). The presence of more positively charged regions on the endodomain allows for stronger binding of the negatively charged aptamers by facilitating electrostatic interactions (those involving opposite charges) between the two macromolecules. The GrASP software, that uses graph neural networks (GNNs), was used to find the specific location of the ATP binding site within the kinase domain.

Aptamer Generation and Sequence Analysis: The FASTA (base pair) sequences of each parent aptamer: V15, W3, H5/V36, and V5 were entered into the UNAfold software as linear RNA and

subjected to 2D structure prediction under physiological conditions of 37°C, 1 mM of NaCl, and no divalent ions. The 2D structures were further input into Vfold3D software to develop the 3D structure of the aptamers. The FASTA sequence of each aptamer was then input into the MEME software for multiple sequence analysis to identify motifs within the aptamers. Motifs are recurring sequences within the aptamers that enhance binding to the target region (ATP site). E values for each motif were analyzed for significance. Values lower than 0.05 indicate the motifs are statistically significant and biologically relevant, which in this case is enhancing binding to the endodomain. Values higher than 0.05 indicates the motifs are not statistically significant and simply predicted from random chance, meaning it has no biological significance.

Molecular docking to endodomain & in-silico mutagenesis: Molecular docking was performed to determine binding orientation of each aptamer to the endodomain and quantify binding strength. The 3D structure files of the endodomain and parent aptamers (W3, V5, H5/V36, V15) files were uploaded into the HDOCK server, and molecular docking simulations for each parent aptamer were initiated Binding energy, in kcal/mol, of each output complex (aptamer + endodomain bound together) was determined. Lower binding energy values indicate higher binding affinity to the endodomain and a higher effectiveness of aptamers. For each aptamer-receptor docking, a list of ten binding poses were generated, ordered from highest to lowest binding energy. The complex with the lowest binding energy where the aptamer specifically binds to the ATP site was selected. Additionally, the type and number of intermolecular interactions between each of the aptamers and the endodomain were determined with the PLIP server. In addition, five mutants (M1, M2, M3, M4, M5) of the best parent aptamer were created through in-silico mutagenesis and subjected to 3D structure prediction and molecular docking. The top two best mutant aptamers, whose performance surpassed that of the best parent aptamer, was subjected to molecular dynamics.

Molecular dynamics (MD) Simulations: Molecular dynamics simulations use computational modeling to determine the molecular movements of biomolecules like proteins and aptamers within a dynamic timeframe and analyze parameters like stability and dynamic interactions over time (Aghajani & Farnia, 2022). The GROMACS software was utilized to perform MD in an A100 GPU, which includes two steps: (1) preparation run and (2) production run. In the preparation run, the AMBER ff14sb force field was utilized, and the complex was surrounded by TIP3P water molecules to mimic biological systems. To mimic the physiological ion concentration, the system

was neutralized with 0.154 M Na^+ and Cl^- ions. The system was then energy minimized to remove unfavorable atomic clashes and equilibrated to stabilize temperature and pressure. Next, the production run (final MD run) was performed for 20 ns at 2 fs timesteps. Once finished, the root mean square deviation (RMSD), radius of gyration (Rg), and hydrogen bond counts over the 20 ns timeframe were obtained and plotted into a line graph. RMSD and Rg variation throughout the simulation were determined by calculating the standard deviation of each. Lower RMSD and Rg fluctuations suggest the aptamer-CD117 complexes are stable and at a low energy orientation, suggesting optimum aptamer performance.

Molecular docking with BBB receptors & RNase T2: The best-performing aptamer from MD was subjected to molecular docking with BBB receptor proteins: transferrin and leptin receptor to quantify BBB permeability via RME. High binding affinity (binding energy < -200 kcal/mol) indicates a potential for strong binding to these proteins and therefore, effective entry into the brain to then target the CD117+ GBM cells inside the brain. The aptamer was also docked to RNase T2, an enzyme that breaks down RNA molecules like aptamers, to determine susceptibility to degradation. Low affinity (binding energy > -200 kcal/mol) to RNase T2 is optimum as it suggests minimum risks of being degraded before it can effectively bind to the endodomain.

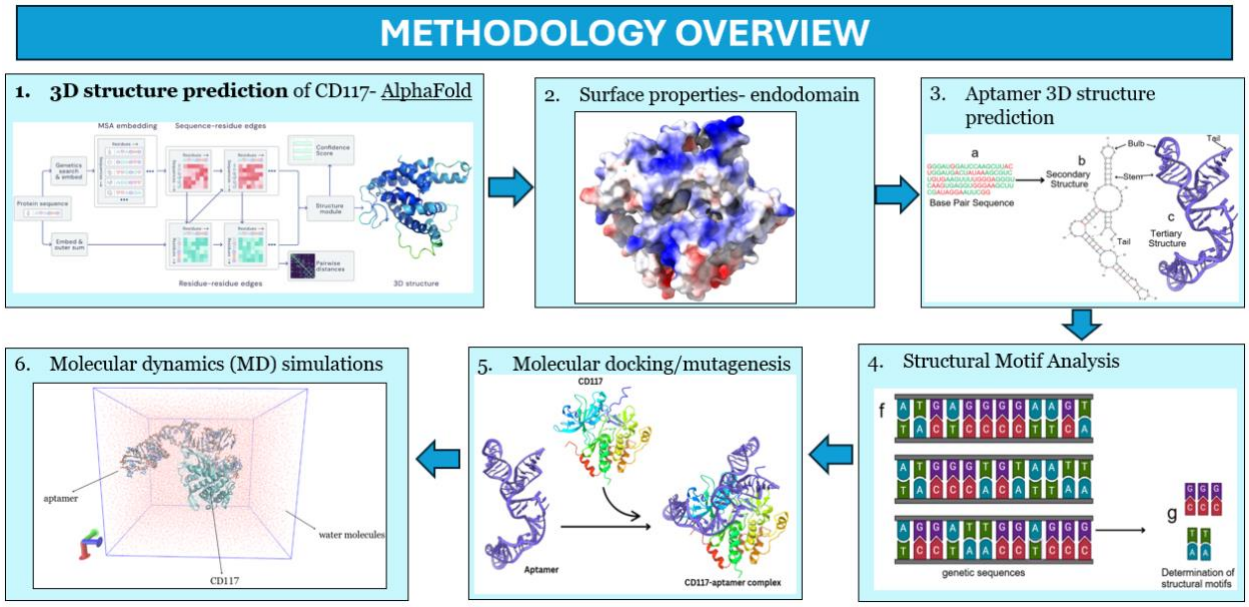


Figure 6. Methodology overview; image 1 was sourced from Jumper et al., 2021 & rest were created by student; docking with BBB-receptors and RNase T2 was excluded for brevity.

RESULTS

Surface Properties of CD117's endodomain: Druggable site prediction of the endodomain was performed using the GrASP server to determine the location of the ATP site. In addition, UCSF Chimera X was also utilized to visualize the 3D ribbon structure and electrostatic surface potential: the surface distribution of electric charges across the receptor. It was revealed that the endodomain contained many positively charged regions (blue areas), including at the ATP site, allowing for electrostatic interactions and strong binding of the negatively charged aptamers. This was further confirmed when visualizing the aptamer-endodomain complexes where all aptamers except for M2 effectively bound to the kinase domain and most importantly, the ATP binding site.

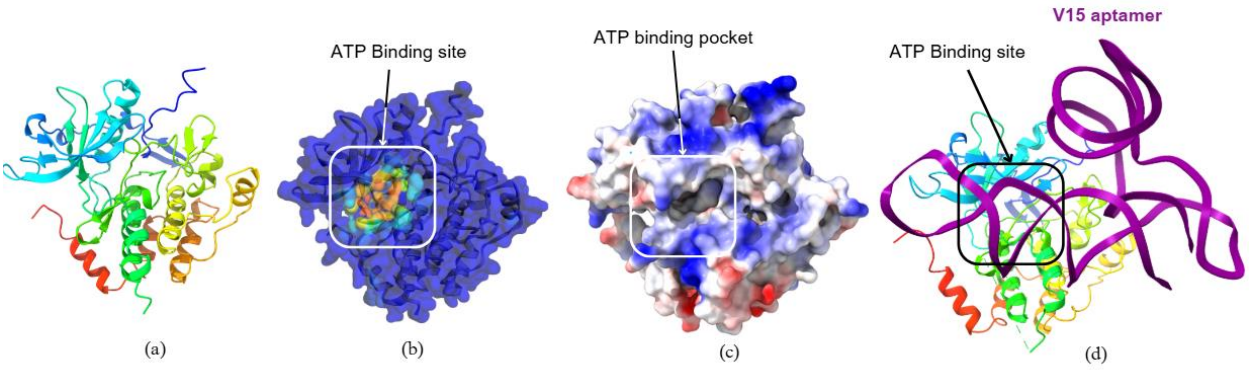


Figure 7. 3D Structures of CD117 endodomain. (a) ribbon structure; (b) Druggable binding site—orange and red regions indicate areas of strong binding affinity; (c) Electrostatic surface potential—blue represents positively-charged regions, and red represents negatively-charged regions; (d) V15 aptamer bound to CD117's endodomain & ATP site.

Motif	GACMARUUCUC	AGUGUCNA	CAACKR
E-value	1.2 × 10^1	2.9 × 10^-2	1.4 × 10^2

Table 1. Motif prediction and analysis of candidate aptamers & tabulated E-values. A, U, C, G represent standard nucleobase letters; the letters M, R, K, N indicate a presence of either A or C, G or A, U or G, or any nucleobase respectively, for the aptamers.

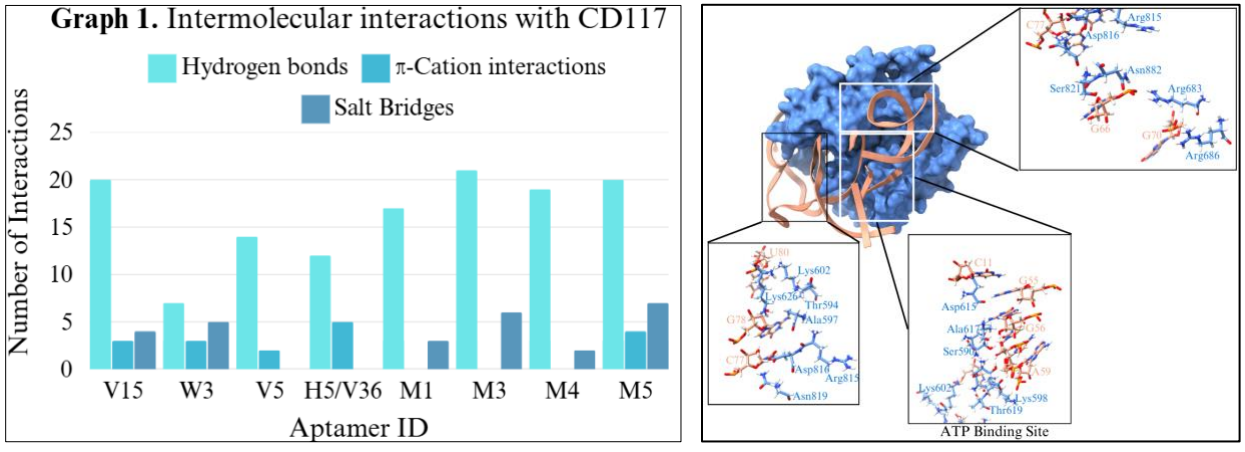
Analysis of motifs: Structural motifs were also analyzed for all parent aptamers to determine conserved nucleotide sequences within the aptamers that enhance binding to the ATP site. Two of the motifs: "GACMARUUCUC" and "CAACKR" were insignificant ($E > 0.05$), suggesting it was predicted by random chance and carries no biological significance. However, the motif: "AGUGUCNA" was statistically significant ($E < 0.05$), implying it carries biological significance and is critical for the aptamers' effective binding to the endodomain and the ATP binding site.

Molecular Docking Simulations: Molecular docking was performed to quantify binding strength between the endodomain and each parent/mutant aptamer. Aptamer V15 had the highest binding affinity towards the kinase domain since it possessed the lowest binding energy of 300.65

kcal/mol, compared to the other three aptamers: W3 (-262.42 kcal/mol), V5 (-277.73 kcal/mol), H5/V36 (-282.89 kcal/mol). Due to its optimum performance, in-silico mutagenesis was used to create five mutants of V15, and these mutants were subjected to molecular docking. The M3 (-355.96 kcal/mol) and M1 aptamers (-304.99 kcal/mol), both mutants of V15, demonstrated even higher binding affinities to V15, implying even stronger potential as GBM therapeutics. M2 was excluded from further analysis as it did not bind to the ATP binding site, meaning it would be an ineffective CD117 inhibitor. M1 and M3 complexes were further examined with MD simulations.

Aptamer	H-bonds	π-cation interactions	Salt Bridges	Binding Energy (kcal/mol)
V15	20	3	4	-300.65
W3	7	3	5	-262.42
V5	14	2	0	-277.73
H5/V36	12	5	0	-282.89
M1	17	0	3	-304.99
M3	21	0	6	-355.96
M4	19	0	2	-290.00
M5	20	4	7	-299.80

Table 2. Binding energy (kcal/mol) values and intermolecular interactions for aptamer-endodomain complexes

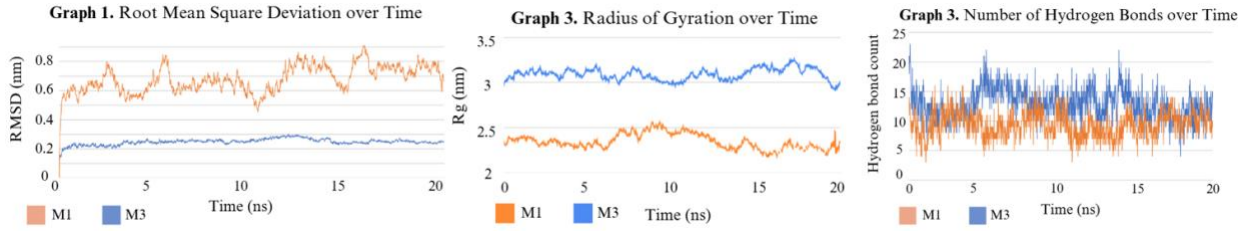


(a) (b)

Figure 8. (a) Graph of intermolecular interactions between aptamer-CD117 complexes; (b) specific interactions between the M3 aptamer and CD117 where blue = interacting amino acids, salmon = interacting nucleotides.

In addition to binding affinity calculations, intermolecular attractions between each aptamer and the endodomain were also determined. An abundance of electrostatic interactions was observed, including hydrogen bonds, π-cation interactions, and salt bridges. Electrostatic interactions are a lot stronger than neutral interactions like hydrophobic interactions and London dispersion forces (LDFs); thus, their abundance indicates strong affinity towards the ATP site. In addition, a direct correlation was determined between binding strength and number of intermolecular interactions. Aptamers with higher affinities like V15, M1, and M3 had a lot more total interactions: 21, 27, 27, respectively, than low-affinity aptamers like W3, H5/V36, V5: 16, 17, 16, respectively.

Molecular Dynamics Simulations: Due to the superior performance of M3 and M1 in the docking phase, molecular dynamics were performed for the M3 & M1-endodomain complex. Average RMSD and Rg values were calculated and the SD of each was calculated to quantify fluctuations. Hydrogen bond fluctuations were also analyzed, as shown above. The average RMSD values were 0.248 ± 0.0004 nm and 0.679 + 0.0021 nm, and the SD values were 0.0211 and 0.092 nm for M3 and M1, respectively. The average Rg values were 3.089 ± 0.002 nm and 2.346 ± 0.003 nm, and the SD values were 0.064 and 0.081 nm, for M3 and M1, respectively. The number of hydrogen bonds were primarily within the 10-20 range for M3 and the 5-15 range for M1. M3 had comparatively lower RMSD and Rg fluctuation values (SD values) than M1, implying that the M3-complex is even more stable. Based on these results and its low binding energy values from docking, M3 is the optimum aptamer for ATP-site specific CD117 inhibition.



(a) (b) (c)

Figure 9. (a) RMSD plot over time, (b) Rg plot over time, (c) hydrogen bond plot over time.

Aptamer	RMSD variation (SD)	Rg variation (SD)	Average RMSD	Average Rg
M3	0.021 nm	0.092 nm	0.248 ± 0.0004 nm	3.089 ± 0.002 nm
M1	0.064 nm	0.081 nm	0.679 + 0.0021 nm	2.346 ± 0.003 nm

Table 3. RMSD and Rg variation & averages for M1 and M3 aptamers

Molecular docking with BBB receptors and RNase T2: As M3 was the most stable aptamer in MD, it was further subjected to molecular docking with BBB receptors: transferrin and leptin receptor to analyze BBB permeability via RME as well as RNase T2 to quantify degradation susceptibility. M3 possessed a high affinity (kcal/mol < -200) for both transferrin (-374.23) and leptin-receptor (-203.17), suggesting that it strongly binds to these receptors and can effectively be transported into the brain to then target the CD117+ GBM cells. However, M3 possessed a high affinity for RNase T2 (-317.27), showing it is highly susceptible to degradation.

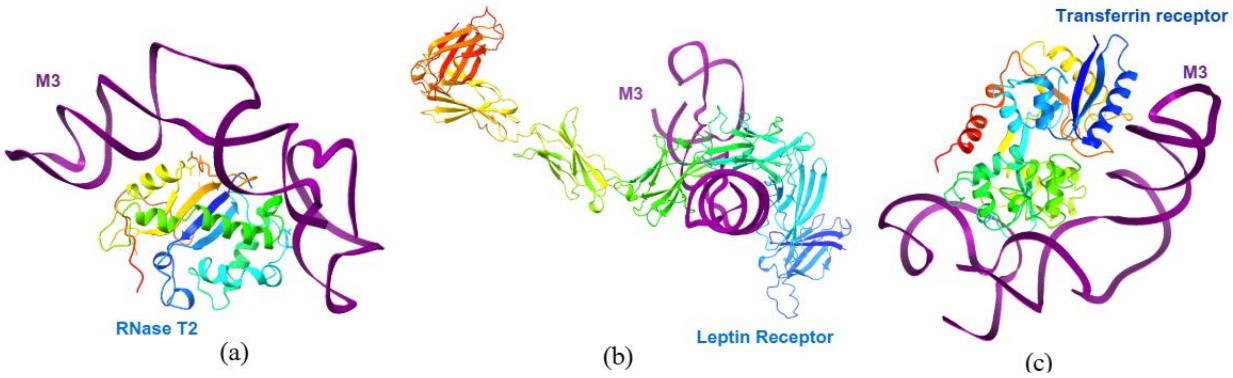


Figure 10. binding of the M3 aptamer to (a) RNase T2 and BBB receptors: (b) leptin receptor & (c) transferrin; purple represents the phosphate backbone of the aptamers and rainbow represents the receptor.

Parent Aptamer	Leptin receptor	Transferrin	RNase T2
Binding energy	-203.17	-374.23	-317.27

Table 4. Binding energy (kcal/mol) values for parent aptamer-BBB receptor and aptamer-RNase complexes

DISCUSSION/CONCLUSION:

The primary goal of this study was to examine the effectiveness of existing ATP-site specific CD117 aptamers: V15, V5, H5/V36, and W3 for GBM modulation and to develop novel, superior mutant aptamers that could gain applications in therapeutics. V15 was identified as the best parent aptamer via molecular docking, but mutants M1 and M3 of V15 possessed even higher affinity to the endodomain and ATP site, demonstrating stronger potential for GBM therapy. Further analysis yielded AGUGUCNA as a significant motif across the parent aptamers that enhancing binding to the ATP binding site. M3 was the most stable when bound to CD117, as confirmed by MD simulations. Further analysis with molecular docking revealed M3 possessed a strong affinity for BBB receptors, implying high brain permeability, but also a high affinity for RNase T2, suggesting high risks for degradation and the need for further structural optimization.

Although research on CD117-specific aptamers has been limited, numerous researchers have developed numerous aptamer-based therapeutics for other proteins implicated in GBM pathology. For example, Tan et al. utilized human glioma U87 cell line models to discover DNA aptamers targeting the EGFRvIII receptor, another highly overexpressed RTK in glioblastomas. They reported that many of these aptamers remained localized to U87 cells and showed no binding to the non-cancerous HEK293 cell lines. Additionally, the top two aptamers bound to the EGFRvIII protein with a K_d values as low as 0.62±0.04 nM and 4.40±0.27 nM (<100 nM = high binding affinity), clearly demonstrating their outstanding potential as EGFRvIII inhibitors (Tan et al., 2013). Similarly, Camorani et al synthesized novel aptamers for targeted PDGFRβ binding in human glioma U87MG cells and reported that the Gint4.T aptamer bound to the receptor's ectodomain with a K_d value of 9.6 nM (Camorani et al., 2014). CADD technology can be integrated into these forms of research to enhance efficacy, minimize costs, and conserve resources.

Despite the robust findings of this research, the study still presents limitations that need to be addressed. First, many computational simulations and 3D structure prediction softwares rely on constant temperature and ion concentration. However, they often fluctuate under physiological settings, thereby introducing potential errors. Additionally, the above results are heavily based on built-in algorithms and models used; inaccurate models may lead to false positives. Due to these limitations, computational testing is only a baseline for drug design and not a replacement for clinical testing. For continued study, in-vitro binding assays like SPR can be conducted with GBM cell lines to validate binding strength to the ATP site. Machine learning models involving variational autoencoders can further be implemented to further optimize aptamer sequences (Wang et al., 2024). Lastly, aptamers like M3 can be subjected to 2'-O methylation (addition of CH_3 groups) to reduce risks of RNase degradation and enhance their performance (Abula et al., 2021).

Glioblastoma is one of the most malignant CNS tumors, and despite advancements in treatment modalities, these cancers remain largely uncured. As a result of numerous biological obstacles like low blood-brain-barrier permeability for drugs, weakening of immune cells, and rapid invasion of nearby brain tissue, GBM is incredibly difficult to treat (Bukari et al., 2020). Aptamers are unique, high-affinity therapeutics that demonstrate strong potential for GBM modulation due to their specificity to cancer cells, low toxicity, RME-enhanced BBB permeability, and high heat stability (Bukari et al., 2020). The above research not only analyzed the efficacy of

existing aptamers but developed a novel aptamer: M3 that has an even higher affinity for the ATP binding site. This aptamer can be synthesized using biochemistry techniques like SELEX and experimentally validated with live GBM cell lines and potentially current patients.

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#3 Priya Kumar *Maggie L. Walker Governor's School*
Mentor; Dr. Katherine Y. Tossas. Sponsor; Shashi Prabhakar

Metabolic Dysfunction and Cervical Intraepithelial Neoplasia: Investigating Diabetes as a Risk Factor for High-Grade Squamous Intraepithelial Lesions

Abstract

Cervical cancer remains a major public health concern, with disparities in incidence and mortality disproportionately affecting non-Latine (nL) Black women. Diabetes has been implicated in cancer progression due to its impact on immune function, inflammation, and metabolic dysregulation. However, its role in cervical intraepithelial neoplasia (CIN) progression, particularly in racially diverse populations, remains underexplored. This study examines the association between diabetes and high-grade squamous intraepithelial lesions (HSIL) and assesses racial disparities in CIN progression, with a focus on nL Black women. A retrospective cohort study was conducted using electronic health records from Virginia Commonwealth University Health System (VCUHS) between 2014 and 2021. The study included 2,189 women diagnosed with CIN, stratified by diabetes status and race. Multivariable logistic regression models assessed the association between diabetes and HSIL risk while controlling for demographic and clinical covariates. Despite the higher overall cervical cancer burden among nL Black women, a lower proportion of HSIL diagnoses was observed compared to nL White women. Diabetes was significantly associated with an increased risk of HSIL, particularly among nL Black women. The risk of HSIL was nearly sevenfold higher in Black women with diabetes compared to their counterparts without diabetes. These findings underscore the role of metabolic dysfunction in cervical cancer progression and highlight the need for integrating diabetes management into cervical cancer prevention efforts. Future research should explore targeted interventions, address social determinants of health, and foster interdisciplinary collaborations to mitigate disparities and improve outcomes.

Metabolic Dysfunction and Cervical Intraepithelial Neoplasia: Investigating Diabetes as a Risk Factor for High-Grade Squamous Intraepithelial Lesions

Introduction

Cervical cancer (CCa) remains a significant global health concern, ranking as the fourth most common cancer among women worldwide (World Health Organization, 2024). In the United States alone, an estimated 13,960 new cases were diagnosed in 2023, with approximately 4,310 deaths occurring that year due to the disease (*Cervical Cancer Statistics*, 2025). However, cervical cancer is highly preventable and treatable, particularly when detected early through regular screening. The disease develops slowly, often taking up to 20 years before symptoms manifest, making preventive strategies such as routine Pap testing critical for reducing incidence and mortality (*Cervical Cancer Causes, Risk Factors, and Prevention*, 2024).

Screening has played a pivotal role in lowering cervical cancer rates. Regular Pap testing can detect abnormal cervical cells, or precancerous lesions, before they progress to invasive cancer. Evidence suggests that routine cervical cancer screening can decrease incidence and mortality by at least 80% (*Cervical Cancer Screening (PDQ®)*, 2024). Despite the effectiveness of screening, disparities persist, disproportionately affecting non-Latine (nL) Black women. In 2021, only 72.4% of eligible women were up to date with their cervical cancer screening, highlighting gaps in preventive care that may contribute to racial disparities in cervical cancer outcomes (*Cervical Cancer Screening*, 2021). Additionally, nL Black women are nearly twice as likely as nL White women to be diagnosed with late-stage cervical cancer, contributing to a five-year survival rate disparity of 56% versus 66%, respectively (Siegel et al., 2021).

Cervical cancer incidence and mortality disparities extend beyond screening. In Virginia, cervical cancer incidence is lower than the national average (5.9 vs. 7.5 cases per 100,000

women), yet certain counties—particularly urban areas such as Roanoke City (11.1 per 100,000) and Norfolk City (8.7 per 100,000)—exhibit significantly higher rates. Racial disparities persist as well, with nL Black women in Virginia experiencing an incidence rate of 6.1 per 100,000 compared to 5.5 per 100,000 among nL White women. Mortality rates follow a similar trend, with nL Black women facing higher cervical cancer-related deaths (2.2 per 100,000) compared to nL White women (1.8 per 100,000) (*State Cancer Profiles,* 2025). Understanding these disparities requires a closer examination of contributing factors, including the role of chronic diseases such as diabetes mellitus.

Chronic diseases, defined as conditions lasting over a year and requiring ongoing medical attention, disproportionately impact marginalized populations (Shadmi, 2013). Diabetes mellitus, a prevalent metabolic disorder, is one such chronic disease that disproportionately affects nL Black individuals in the U.S., with 12.5% of Black women diagnosed compared to 6.1% of White women (*Diabetes and Black/African Americans*, 2024). Diabetes alters immune system function through chronic inflammation and immune suppression, increasing susceptibility to infections and reducing the body's ability to clear precancerous lesions naturally (Berbudi et al., 2019). Many women with cervical intraepithelial neoplasia (CIN) lesions clear the infection spontaneously (*Cervical Dysplasia: Causes, Symptoms, Diagnosis & Treatment*, 2023); however, those with weakened immune responses, such as individuals with diabetes, may be at an increased risk of lesion persistence and progression to cervical cancer.

Studies suggest that diabetes is associated with an elevated risk for various cancers, including liver (2.5-fold increase), pancreas (1.8-fold increase), breast (1.2-fold increase), and bladder (1.3-fold increase) cancer, largely due to its impact on immune function (Pliszka & Szablewski, 2024). Hyperglycemia induces oxidative stress, impairs white blood cell function,

and alters the effectiveness of infection-fighting proteins (González et al., 2023), weakening the immune system's ability to control HPV infections and associated cervical lesions. Given this connection, it is crucial to investigate the relationship between diabetes and the development of high-grade squamous intraepithelial lesions (HSIL), a precursor to invasive cervical cancer. By examining this association within a racial health disparities framework, this study seeks to identify whether diabetes contributes to increased cervical cancer risk among marginalized populations.

Understanding the intersection of diabetes and cervical cancer progression provides an opportunity for early intervention and targeted prevention strategies. If diabetes is indeed a contributing factor to lesion persistence and progression, integrating diabetes management into cervical cancer prevention efforts could improve patient outcomes. Furthermore, these findings may have broader implications for other metabolic disorders and their role in cancer progression, ultimately contributing to more equitable cancer prevention and management strategies. This study aims to provide a clearer understanding of the association between diabetes and high-grade cervical lesions, setting the stage for subsequent analysis and discussion on its public health implications.

Methods and Materials

Study Design and Data Source. This retrospective cohort study analyzed hospital and physician billing claims data from the Virginia Commonwealth University Health System (VCUHS), covering the period from January 1, 2014, to December 4, 2021. The billing claims data were used to identify diagnoses of cervical intraepithelial neoplasia (CIN) and to extract associated clinical and sociodemographic information at the time of diagnosis. The study cohort included

women diagnosed with CIN grades 0, 1, 2, or 3 within this timeframe. Data were obtained from electronic medical records, including International Classification of Diseases (ICD-9/10) codes, Current Procedural Terminology (CPT) codes, and electronic health record (EHR) documentation.

Participant Selection. Eligible participants were adults aged 18 or older, assigned female at birth, who attended routine wellness visits and underwent cervical cancer screening at VCUHS between January 1, 2014, and December 4, 2021. Inclusion required having a hospital account or documented medical history in hospital records, as indicated by billing codes linked to CIN on hospital accounts or physician invoices. A total of 2,761 eligible women were identified. Exclusion criteria included pregnancy (n=141) due to potential hormonal changes affecting cervical cells, and HIV-positive status (n=79) due to immunocompromised status, as per prior literature (Shen et al., 2023). To center the analysis on potential disparities between Black and White populations, 352 patients who did not identify with either racial group were also excluded. The final analytical cohort included 2,189 women diagnosed with CIN grades 0-3.

Definitions of SIL Status. The primary outcome of interest was the risk of HSIL, defined as CIN grades 2 and 3. Within the billing data, CIN 0 was classified as undetermined dysplasia of the cervix uteri, CIN 1 as mild cervical dysplasia, CIN 2 as moderate cervical dysplasia, and CIN 3 as carcinoma in situ of the cervix. For analysis purposes, CIN 2 and CIN 3 were grouped as HSIL, while CIN 0 and CIN 1 were categorized as low-grade squamous intraepithelial lesions (LSIL), in accordance with established literature (Mwangi et al., 2024).

Covariables of SIL Risk. We evaluated self-reported and clinically documented characteristics for their potential association with HSIL risk, including demographic factors (e.g., age, marital status, religion, insurance type, race), HPV status, bacterial vaginosis/sexually transmitted infections (STIs), HPV vaccination status, birth control use, smoking, alcohol use, and personal cancer history. Data were self-reported during clinical encounters or documented by physicians in electronic health records and subsequently abstracted into ICD-9/10 codes for analysis. Demographic data were extracted from VCUHS billing claims at the time of CIN diagnosis. Chronic conditions, including diabetes, documented at any time before CIN diagnosis and up to 30 days afterward (to account for updates and ensure complete medical histories), were extracted from hospital accounts and physician invoices.

Statistical Analysis. Two-sample unpaired t-tests were used to assess mean differences in age by SIL status (HSIL vs. LSIL) and by race (Black vs. White). Stepwise logistic regression with entry and retention criteria of alpha 0.2 and 0.1, respectively, was applied for multivariable analysis. First, we examined the additive effects of race on HSIL risk, controlling for confounders. Then, we explored potential interactions between race and diabetes to investigate their effects on HSIL risk. The final regression models included significant predictors and interaction terms that met statistical significance thresholds. Results were reported as adjusted odds ratios (AOR) with 95% confidence intervals (CI).

Results

Of the 2,189 women**,** 541 (25%) were diagnosed with HSIL with an average age of 39.2 years. Most were Black (51%), unmarried (75%, single, divorced, widowed, or separated),

Christian (64%), English-speaking (99%), and privately insured (47%). Despite no statistically significant age differences by race (p=0.23), Black women were more likely to be single (69% vs. 44%, p<0.0001), Christian (70% vs. 57%, p<0.0001), non-English speakers (2% vs. 1% p=0.03), and publicly insured or uninsured (p<0.0001) compared to White women. Black women were less likely to have an HSIL diagnosis compared to White women (21% vs. 28%, p=0.0002). Most women were never smokers (58%), and although smoking behaviors did not vary by race (p=0.13), those with HSIL were more likely to report current smoking than those with LSIL (28% vs. 21%, p=0.003). The majority reported alcohol consumption (57%), with Black women less likely to report it compared to White women (p<0.0001).

After adjusting for covariables, the risk of HSIL was slightly higher for White women compared to Black women (OR=1.23, 95% CI: 1.01, 1.52). Among women with diabetes, the risk of HSIL was 6.7 times that of their counterparts that did not have diabetes (OR=6.7, 95% CI: 1.84, 24.4). When stratified by race, there was differential risk for Black women (p=0.02), but not White women (p=0.08). The risk of HSIL among Black women with diabetes was nearly seven times their racial counterparts without diabetes (OR=7.10, 95% CI: 1.29, 39.19).

Discussion and Conclusion

This study examined the association between diabetes and high-grade squamous intraepithelial lesions (HSIL) while assessing racial disparities in cervical intraepithelial neoplasia (CIN) progression. Our findings indicate that diabetes is significantly associated with an increased risk of HSIL, particularly among non-Latine (nL) Black women. These results highlight the potential role of metabolic disorders in cervical cancer progression and emphasize the need for integrated chronic disease management in cervical cancer prevention efforts.

This study contributes to the biological sciences by providing further insight into how metabolic dysfunction, specifically hyperglycemia and insulin resistance, may act as catalysts for cancer progression at the cellular level. The association between diabetes and cancer extends beyond simple correlation; mechanistically, diabetes fosters an environment that promotes cellular proliferation, inhibits apoptosis, and facilitates chronic inflammation, all of which are fundamental drivers of tumorigenesis. Diabetes is not a "bystander" to cancer but may actively contribute to its formation and progression. Research has shown that hyperglycemia, a key indicator of type 2 diabetes mellitus (T2DM), can increase cancer risk by promoting the accumulation of carcinogenic compounds, altering DNA, and fostering an environment conducive to tumor growth (Yue et al., 2022). Additionally, cancer cells exhibit a heightened ability to utilize glucose, further fueling rapid tumor proliferation in individuals with uncontrolled diabetes. Insulin resistance, another hallmark of T2DM, has also been implicated in cancer development by promoting cell survival and proliferation (Sullivan & Hopcroft, 2023), thereby increasing the likelihood of tumor formation and progression.

For cervical cancer specifically, previous studies have reported that patients with diabetes have higher odds of HPV infection, cervicitis, and malignant or premalignant lesions, with a particular emphasis on persistent HPV infection and lesion progression (Yue et al., 2022). Given the global burden of diabetes, with over 199 million women currently living with the disease—a number projected to rise to 313 million by 2041 (Kapur & Seshiah, 2017) —understanding its role in cervical cancer risk is critical for shaping future prevention strategies. The findings in this study highlight the need for interdisciplinary collaboration between metabolic disease researchers and oncologists to explore novel interventions that address both diabetes management and cancer prevention holistically.

Despite the overall higher cervical cancer burden among nL Black women, our study found a lower proportion of HSIL diagnoses in this group compared to nL White women. This finding contrasts with broader epidemiological trends that demonstrate higher incidence and mortality rates for cervical cancer among Black women (Boitano et al., 2022). One possible explanation is differential access to and utilization of healthcare services, which may lead to earlier detection and treatment of precancerous lesions, reducing progression to HSIL. Additionally, differences in biological susceptibility or screening behaviors may have influenced these findings, warranting further investigation.

The stronger association between diabetes and HSIL among nL Black women emphasizes the intersection of chronic disease burden and cancer disparities. Higher diabetes prevalence in this population, coupled with structural barriers to healthcare access, may contribute to a compounding effect that increases cervical cancer risk. These findings suggest that diabetes management should be incorporated into cervical cancer prevention strategies, with a focus on early intervention in populations at higher risk.

These findings have important clinical and public health implications. Routine diabetes management should be integrated into cervical cancer prevention efforts, particularly in populations disproportionately affected by both conditions. Clinicians should consider metabolic health as a potential risk factor for cervical lesion persistence and progression. Public health initiatives should also prioritize improving cervical cancer screening uptake and preventive care among women with chronic diseases, ensuring that high-risk populations receive timely and appropriate interventions. Addressing social drivers of health, including healthcare access and insurance disparities, is critical to reducing racial disparities in cervical cancer outcomes.

Several limitations should be considered. Reliance on electronic health records and billing data may introduce misclassification bias, as diabetes and HSIL cases could be underreported. The cross-sectional nature of the study limits the ability to establish causality between diabetes and HSIL development. Future longitudinal studies are needed to clarify the temporal relationship between metabolic dysfunction and cervical cancer progression. Additionally, the exclusion of individuals from racial and ethnic groups outside of Black and White limits the generalizability of these findings. Further research should explore the role of diabetes in cervical lesion progression across diverse populations.

This study highlights the need to integrate metabolic health management into cervical cancer prevention efforts, particularly among Black women who experience a disproportionate burden of both conditions. Addressing these disparities requires a multifaceted approach, including improved healthcare access, targeted community interventions, and interdisciplinary collaboration between oncology and endocrinology specialists. Future research should continue investigating the biological and structural mechanisms underlying these disparities to inform more equitable cancer prevention and management strategies.

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#4 Bhoomika Kaur *Mills E. Godwin High School*
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Targeting RAGE: A Novel Therapeutic Strategy Against AGE-Mediated Prostate Cancer Progression

Abstract:

Purpose: The accumulation of advanced glycation end products (AGEs) and their interaction with the receptor for AGEs (RAGE) have been implicated in the progression of prostate cancer (PCa), the second most diagnosed cancer in men worldwide. However, therapeutic strategies targeting RAGE remain underexplored, representing a critical gap in current cancer treatment approaches. This study aimed to investigate the role of the AGE-RAGE signaling pathway in PCa progression, focusing on how RAGE inhibition affects cell migration and how RAGE knockdown influences both migration and proliferation. **Methods:** RAGE inhibition was achieved using TTP-488 in DU145 cells, and a migration assay assessed cell migration in response to the following treatments: no treatment (NT), the negative control; AGEs, the positive control; TTP-488; and AGEs & TTP-488. RAGE knockdown was performed via shRNA transfection in LNCaP cells, confirmed by Western Blot analysis. A Trypan Blue Proliferation assay evaluated cell growth in LNCaP shRAGE and shControl cells, while a migration assay determined migration in those cells. It was hypothesized that RAGE inhibition and knockdown would reduce PCa cell migration, with knockdown specifically reducing proliferation. **Results:** ANOVA and post-hoc analyses revealed that disrupting AGE-RAGE signaling via inhibition and genetic knockdown effectively mitigates cell migration, with knockdown also significantly hindering cell proliferation. These findings support the research hypothesis. **Conclusion:** Targeting RAGE in PCa reveals a transformative therapeutic approach to control tumor progression and metastasis, set to redefine cancer treatment globally. Future studies should explore combining RAGE disruption with conventional treatments like chemotherapy.

Introduction:

Prostate cancer (PCa) is the second most diagnosed cancer among men in the United States, with a significant impact on health outcomes. Despite advances in detection and therapy, understanding the complex molecular mechanisms driving this disease is essential for improving treatment strategies (Maekawa et al., 2024). Among the most intriguing areas of research is the role of advanced glycation end products (AGEs) and their receptor, the receptor for advanced

glycation end products (RAGE). This signaling pathway, when disrupted, can trigger inflammation, promote cell growth, and activate signals that contribute to cancer development. The AGE-RAGE interaction has emerged as a significant contributor to PCa pathogenesis, offering potential new targets for therapeutic intervention (Tobon-Velasco et al., 2023; Yumnam et al., 2020).

AGEs represent a heterogeneous group of irreversible reactive metabolites formed through non-enzymatic glycoxidation. This process involves the spontaneous reaction between carbonyl groups (C=O), often derived from reducing sugars or metabolic intermediates, and free amine groups on biomolecules. AGEs are produced during normal metabolic processes and, under normal physiological conditions, at manageable rates. However, in pathological states like hyperglycemia, their accumulation increases. Additionally, lifestyle factors such as poor dietary habits and lack of exercise aggravate the AGE burden. It is noteworthy that AGE accumulation has been linked to increasing oxidative stress, inflammation, and cancer severity (Turner, 2015).

In PCa, AGE accumulation in the tumor microenvironment (TME) enhances cellular dysfunction and supports tumor progression. AGEs promote DNA damage, protein misfolding, and activate pro-inflammatory pathways. This leads to increased oxidative stress, which further damages tissues and exacerbates tumorigenic conditions. AGE exposure also promotes the transformation of normal fibroblasts into cancer-associated fibroblasts (CAFs), which support tumor growth by enhancing angiogenesis, cell migration, and ECM remodeling (Krisanits et al., 2022)

RAGE is a transmembrane receptor that mediates cellular responses to AGEs, and it plays a pivotal role in cancer progression. The receptor activates various pro-tumorigenic signaling pathways that contribute to inflammation, survival, and metastasis. Aberrant RAGE activation in cancer cells leads to a positive feedback loop that exacerbates AGE accumulation and accelerates tumor progression (Krisanits et al., 2022; Krisanits et al., 2024).

This study investigates the impact of AGE-RAGE signaling in PCa, exploring two potential therapeutic strategies targeting this pathway: RAGE inhibition and RAGE knockdown. This dual approach provides deeper insights into how different levels of RAGE modulation impact tumor progression, as well as into RAGE's influence in both cancer cells and the tumor stroma, helping to better understand RAGE biology. These strategies offer potential for novel therapeutic interventions in PCa.

Procedure and Materials:

For all procedures employed in this research, safety was implemented. Gloves, a lab coat, and tight-fit clothing were worn for safety. Additionally, materials were discarded appropriately in biohazard bins, and the hands were immediately washed after handling materials.

RAGE Inhibition Phase - Migration Assay

Day 1A - Cell Culture Well Base: Inserts (8.0 microns) were transferred from a Transwell well plate to a new standard well plate, and the latter was set aside. Then, WPMY1 fibroblasts were trypsinized and collected in 10mL serum media. The media was spun for 5 minutes at 1000 rpm and the supernatant was subsequently aspirated and quantified using a Cellometer as per manufacturer's instructions. The cell pellet was resuspended at an appropriate volume of serum media. Next, in a 24-well plate, 25,000 WPMY1 cells were added in 0.6mL media per well and left to attach overnight in a 37 degree incubator with 5% CO2.

Day 1B - Fibronectin Insert Preparation: The well plate containing the inserts was unpackaged and 10µg/mL of fibronectin solution was prepared. Then, avoiding bubble formation, 200µL of the diluted fibronectin was added to each insert. The well plate was left overnight in a 37 degree incubator with 5% CO2.

Day 2A - Cancer Cell Labeling and Seeding: DU145 cells were labeled with 10µL of 5 mM CellTracker™ Green CMFDA and incubated in a 37 degree incubator with 5% CO2 for 30 minutes. Labeling was confirmed by fluorescence microscopy. Then, cells were trypsinized, collected in 10mL serum media, immediately spun for 5 minutes at 1000 rpm, and promptly aspirated. The cells were counted with a Cellometer and appropriate dilutions were made in serum-free media in 15mL conical tubes. After, 25,000 DU145 cells were added in 0.5mL media to each insert.

Day 2B - Fibroblasts Compartment Treatment: At this time, appropriate fibroblast compartments were treated with the presence or absence of BSA-AGE solution (10µg/ml) and TTP-488, as required. For wells that required BSA-AGE solution, 1.5µL was added per well to achieve a final volume of 0.6mL suspension. After performing a PBS rinse, the fibronectin-coated inserts from “Day 1B” were then carefully placed into the original Transwell plate from “Day 1A” containing the WPMY1 fibroblasts. The plate was then incubated at 37°C for 4 hours.

Day 2C - Fixation and Imaging: Following the 4-hour incubation, the media from the inserts and wells were aspirated, and the inside of each insert was cleaned 4 times with Q-tips® cotton swabs that were wetted in media (once with each end of the swab). Immediately after, the inserts were fixed in 10% formalin for 15 minutes, followed by washing with PBS. The inserts were stored in PBS at 4°C. Imaging was performed using a fluorescence microscope at 488nm, and the number of migrating (stained) cells were then counted in 10 microscopic fields based on the images captured.

RAGE Knockdown Phase - Transfection Assay

Cells were seeded at 70-80% confluence 24 hours prior to transfection. On transfection day, an shRNA construct targeting RAGE was diluted in Opti-MEM and mixed with Lipofectamine RNAiMax, according to the manufacturer's instructions. After a 10-20 minute incubation, the mixture was added to cells for 4-6 hours, after which the medium was replaced with fresh growth media. Knockdown efficiency was assessed 24-48 hours later via Western blotting. A scrambled shRNA control vector was used to confirm knockdown specificity.

RAGE Knockdown Phase - Western Blot Assay

Cell Lysis: A lysis mixture was prepared with 970µL of 1x RIPA buffer, 10µL of 100x PMSF, 10µL of protease inhibitor, and 10µL of Na3VO4. Cells were harvested from -80°C, washed with PBS, and lysed on ice. Samples were centrifuged at 12,000rpm for 15 minutes at 4°C to separate cellular debris from the lysate.

Protein Concentration with BCA Assay: Protein concentration was determined using a BCA assay. For this, a series of dilutions were prepared using 48µL of PBS and 12µL of the supernatant for each sample in each new Eppendorf tube. Additionally, a 2 mg/mL BSA standard was used to create a standard curve. Samples were thoroughly centrifuged, a BSA standard curve was prepared, and absorbance was measured at 562nm using a plate reader.

Western Blotting: Protein samples were mixed with 2X Laemmli buffer and boiled. The gel was run at 80V for 20 minutes and 120V until the dye front reached the bottom. After electrophoresis, the gel was equilibrated in transfer buffer, and proteins were transferred to a nitrocellulose membrane at 100V for 60 minutes on ice. The membrane was blocked in 5% milk in TBST for 1 hour and washed. The membrane was incubated with anti-RAGE antibody overnight at 4°C, along with alpha-actin (employed as the loading control), followed by secondary antibody incubation for 1 hour at room temperature. The blot was developed with

enhanced chemiluminescence (ECL), captured with imaging software, and reprobed with housekeeping antibodies.

RAGE Knockdown Phase - Proliferation Assay

LNCaP shRAGE and shControl cells were cultured in appropriate growth medium and seeded into a 24-well plate to reach 70-80% confluence within 24 hours. Following incubation, cells were trypsinized and mixed with equal volume of 0.4% Trypan Blue solution. The mixture was loaded onto a hemocytometer, where live (unstained) and dead (blue) cells were counted to quantify cell proliferation.

RAGE Knockdown Phase - Migration Assay

The migration assay was modified from the initial procedure by omitting treatments, with LNCaP shRAGE and shControl cells being added to the inserts, and WPMY1 fibroblasts seeded into the wells. The rest of the procedure, including fibronectin coating, cell labeling, insert rinsing, and fixation, remained the same as in the original migration assay.

Analysis of Results:

The therapeutic potential of RAGE inhibition and knockdown on PCa cell progression was investigated.

RAGE Inhibition Phase

For the migration assay, the results of the statistical analysis are presented in Tables 1, 2, and 3, and Graph 1. A research hypothesis was formulated that when WPMY1 fibroblasts are exposed to pre-formed AGEs and are treated with TTP-488 (i.e. AGEs & TTP-488), DU145 cell migration would be mitigated more than observed for AGEs. The mean was determined for each of the levels of the independent variable. The comparisons between NT (4.556 cells), AGEs (8.333 cells), TTP-488 (4.333 cells), and AGEs & TTP-488 (5.000 cells) imply that RAGE inhibition does have an effect on AGE-mediated cell migration. In this case, the results support the hypothesis, as AGEs & TTP-488 showed significant inhibition of cell migration when compared to AGEs. The variance and standard deviation were calculated for each of the levels of the independent variable. The standard deviation was low for all of the levels of the independent variable. This implies that those data sets were tight and precise. One of the data points for the "TTP-488" level of the independent variable was outside the 2 SD range, implying that it was an

outlier. However, none of the other data points were outside the range, indicating that there was only one outlier overall.

A single factor analysis of variance (ANOVA) test was performed on the data at a level of significance of 0.05. The null hypothesis was that there would be no significant difference in the migration of DU145 cells between the different treatment conditions. The calculated F-value for the comparison between the levels of the independent variable was 10.494. This value was greater than the critical F-value of 2.901 (for df = 3, 32), indicating that there is a significant difference between the groups.

To further investigate the differences between groups, a post-hoc analysis using Tukey's HSD test was conducted with a threshold of 2.214.

The absolute mean differences between NT and TTP-488 (0.222), NT and AGEs & TTP-488 (0.444), as well as TTP-488 and AGEs & TTP-488 (0.667) were all less than the threshold of 2.214. This implies that the null hypothesis should not be rejected and there is no significant difference between the previously stated comparisons. The probability of the results being due to chance is greater than 0.05, implying that the results of this part of the experiment were most likely not due to the independent variable.

The absolute mean differences between NT and AGEs (3.778), AGEs and TTP-488 (4.000), as well as AGEs and AGEs & TTP-488 (3.333) were all greater than the threshold of 2.214. This implies that the null hypothesis should be rejected and there is a significant difference between the aforementioned comparisons. The probability of the results being due to chance is less than 0.05, implying that the results of this part of the experiment were most likely due to the independent variable. Overall, the data showed that NT vs AGEs, AGEs vs TTP-488, and AGEs vs AGEs & TTP-488 exhibited significant differences in comparison. NT vs TTP-488, NT vs AGEs & TTP-488, and TTP-488 vs AGEs & TTP-488 did not show significant differences.

RAGE Knockdown Phase

For the Western Blot assay, the results are presented in Figure 1 and reveal a visual reduction in RAGE expression in LNCaP shRAGE cells when compared to LNCaP shControl cells. Additionally, the levels of α-Actinin, the loading control, were comparable and confirmed equal protein loading across all samples. While a statistical analysis was not conducted due to the qualitative nature of the data, the visual inspection of the bands supports the conclusion that

RAGE knockdown was achieved in LNCaP cells.

For the proliferation assay, the results of the statistical analysis are presented in Tables 4, 5, and 6, and Graph 2. A research hypothesis was formulated that when RAGE expression is reduced in LNCaP cells through genetic knockdown, their growth would be mitigated more than observed for their respective control. The mean was determined for each of the levels of the independent variable. The comparisons between LNCaP shRAGE (1.823 cells) and LNCaP shControl (5.135 cells) imply that RAGE knockdown does have an effect on cell proliferation. In this case, the results do support the hypothesis, as LNCaP cells transfected with the shRAGE vector experienced less growth when compared to their control. The variance and standard deviation were calculated for each of the levels of the independent variable. The standard deviation was low for all of the levels of the independent variable. This implies that those data sets were tight and precise. Furthermore, none of the data points for the "LNCaP shRAGE" and "LNCaP shControl" categories were outside the 2 SD range, indicating that there were no outliers overall.

A single factor analysis of variance (ANOVA) test was performed on the data at a level of significance of 0.05. The null hypothesis was that there would be no significant difference in the proliferation of LNCaP cells between the different conditions. The calculated F-value for the comparison between the levels of the independent variable was 20.543. This value was greater than the critical F-value of 4.965 (for df = 1, 10), indicating that there is a significant difference between the groups.

To further investigate the differences between groups, a post-hoc analysis using Tukey's HSD test was conducted with a threshold of 3.150.

The absolute mean difference between shControl and shRAGE (3.312) was greater than the threshold of 3.150. This implies that the null hypothesis should be rejected and there is a significant difference between the comparison. The probability of the results being due to chance is less than 0.05, implying that the results of this part of the experiment were most likely due to the independent variable. Overall, the data showed that shControl vs shRAGE exhibited significant differences in comparison.

For the migration assay, the results of the statistical analysis are presented in Tables 7, 8, and 9, and Graph 3. A research hypothesis was formulated that when RAGE expression in LNCaP cells is reduced via genetic knockdown (i.e. LNCaP shRAGE), the migration of LNCaP

cells would be reduced more than observed for their control group (i.e. LNCaP shControl). The mean was determined for each of the levels of the independent variable. The comparison between LNCaP shRAGE (19.667 cells) and LNCaP shControl (41.000 cells) imply that RAGE inhibition does have an effect on cell migration. In this case, the results do support the hypothesis, as LNCaP shRAGE cells experienced less migration when compared to LNCaP shControl cells. The variance and standard deviation were calculated for each of the levels of the independent variable. The standard deviation was found to be relatively high, implying that the data set was more spread out and less precise. Furthermore, one of the data points for the "LNCaP shControl" level of the independent variable was outside the 2 SD range, implying that it was an outlier. However, none of the other data points were outside the range, indicating that there was only one outlier overall.

A single factor analysis of variance (ANOVA) test was performed on the data at a level of significance of 0.05. The null hypothesis was that there would be no significant difference in the migration of LNCaP cells between the different conditions. The calculated F-value for the comparison between the levels of the independent variable was 47.644. This value was greater than the critical F-value of 4.414 (for df = 1, 18), indicating that there is a significant difference between the groups.

To further investigate the differences between groups, a post-hoc analysis using Tukey's HSD tests was conducted with a threshold of 6.450. For the pairwise comparison.

The absolute mean difference between shControl and shRAGE (21.200) was greater than the threshold of 6.450. This implies that the null hypothesis should be rejected and there is a significant difference between the comparison. The probability of the results being due to chance is less than 0.05, implying that the results of this part of the experiment were most likely due to the independent variable. Overall, the data showed that shControl vs shRAGE exhibited significant differences in comparison.

Table 1. Descriptive Statistics for The Effect of RAGE Inhibition on DU145 Cell Migration	**Table 2. One-Way ANOVA Statistical Test for The Effect of RAGE Inhibition on DU145 Cell Migration**	**Table 3. Post-Hoc Tukey's HSD Test for The Effect of RAGE Inhibition on DU145 Cell Migration**

Descriptive Information	Type of Treatment			
	NT	AGEs	TTP-488	AGEs & TTP-488
Mean	4.556 cells	8.333 cells	4.333 cells	5.000 cells
Range	5.000 cells	3.000 cells	7.000 cells	6.000 cells
Maximum	7.000 cells	10.000 cells	9.000 cells	8.000 cells
Minimum	2.000 cells	7.000 cells	2.000 cells	2.000 cells
Variance	2.778	1.500	4.750	3.000
Standard Deviation	1.667	1.225	2.179	1.732
1SD	2.889-6.222	7.109-9.558	2.154-6.513	3.268-6.732
2SD	1.222-7.889	5.884-10.783	0-8.692	1.536-8.464
3SD	0-13.667	0-24.326	0-13.462	0-15.804
Number	9	9	9	9

Table 4. Descriptive Statistics for The Effect of RAGE Knockdown on LNCaP Cell Proliferation

Source of Variation	SS	Df	MS	F	P-Value	F-critical value (α=0.05)
Between Groups	94.667	3	31.556	10.494	5.82×10^{-5}	2.901
Within Groups	96.222	32	3.007			
Total	190.889	35				

Table 5. One-Way ANOVA Statistical Test for The Effect of RAGE Knockdown on LNCaP Cell Proliferation

Group	Mean Difference	SE	Q	Threshold	Mean Difference > Threshold ?
NT vs AGEs	3.778	0.578	3.83	2.214	Yes
NT vs TTP-488	0.222	0.578	3.83	2.214	No
NT vs AGEs & TTP-488	0.444	0.578	3.83	2.214	No
AGEs vs TTP-488	4.000	0.578	3.83	2.214	Yes
AGEs vs AGEs & TTP-488	3.333	0.578	3.83	2.214	Yes
TTP-488 vs AGEs & TTP-488	0.667	0.578	3.83	2.214	No

Table 6. Post-Hoc Tukey's HSD Test for The Effect of RAGE Knockdown on LNCaP Cell Proliferation

Descriptive Information	Presence of RAGE Knockdown	
	shControl	shRAGE
Mean	5.135 cells	1.823 cells
Range	1.320 cells	3.940 cells
Maximum	5.760 cells	3.700 cells
Minimum	4.440 cells	-0.240 cells
Variance	0.312	2.891
Standard Deviation	0.559	1.700
1SD	4.576-5.694	0.123-3.524
2SD	4.018-6.252	0-5.224
3SD	3.459-6.811	0-6.924
Number	6	6

Table 7. Descriptive Statistics for The Effect of RAGE Knockdown on LNCaP Cell Migration

Source of Variation	SS	Df	MS	F	P-Value	F-critical value (α=0.05)
Between Groups	32.901	1	32.901	20.543	1.09×10^{-3}	4.965
Within Groups	16.016	10	1.602			
Total	48.917	11				

Table 8. One-Way ANOVA Statistical Test for The Effect of RAGE Knockdown on LNCaP Cell Migration

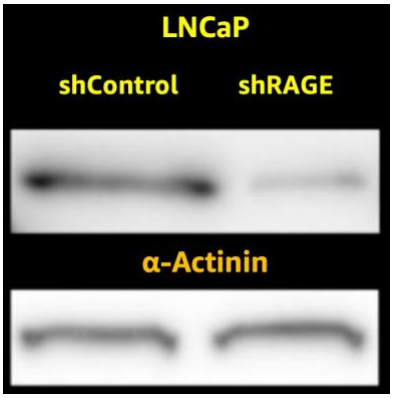
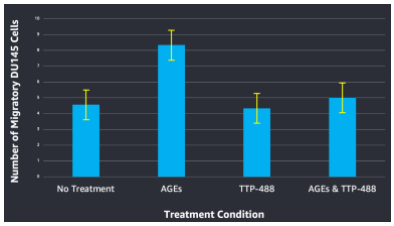
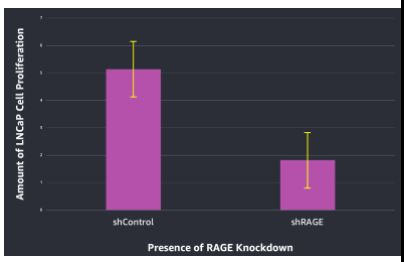
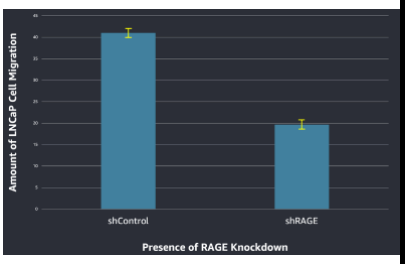
Group	Mean Difference	SE	Q	Threshold	Mean Difference > Threshold ?
shControl vs shRAGE	3.312	0.517	2.96	3.150	Yes

Table 9. Post-Hoc Tukey's HSD Test for The Effect of RAGE Knockdown on LNCaP Cell Migration

Descriptive Information	Presence of RAGE Knockdown	
	shControl	shRAGE
Mean	41.000 cells	19.667 cells
Range	25.000 cells	14.000 cells
Maximum	57.000 cells	26.000 cells
Minimum	32.000 cells	12.000 cells
Variance	57.000	25.000
Standard Deviation	7.923	5.618
1SD	33.077-48.923	14.048-25.285
2SD	25.155-56.845	8.430-30.904
3SD	17.232-64.768	2.811-36.522
Number	10	10

Source of Variation	SS	Df	MS	F	P-Value	F-critical value (α=0.05)
Between Groups	2247.200	1	2247.200	47.644	1.87×10^{-6}	4.414
Within Groups	849.000	18	47.167			
Total	3096.2	19				

Group	Mean Difference	SE	Q	Threshold	Mean Difference > Threshold ?
shControl vs shRAGE	21.200	2.172	2.97	6.450	Yes

Figure 1. Western Blot Results Verifying RAGE Knockdown in LNCaP shRAGE Cells When Compared to LNCaP shControl Cells	Graph 1. The Effect of RAGE Inhibition on DU145 Cell Migration	Graph 2. The Effect of RAGE Knockdown on LNCaP Cell Proliferation
		
Graph 3. The Effect of RAGE Knockdown on LNCaP Cell Migration		
		

Discussions and Conclusion:

The purpose of this experiment was to investigate the role of the AGE-RAGE signaling pathway in PCa progression, specifically exploring the therapeutic potential of RAGE inhibition on DU145 cell migration and RAGE knockdown on LNCaP proliferation and migration.

RAGE Inhibition Phase

The effect of RAGE inhibition on PCa progression was quantified using a migration assay, which explored the effects of four solutions (NT, AGEs, TTP-488, and AGEs & TTP-488) on DU145 cell migration. The hypothesis that inhibiting RAGE with TTP-488 would significantly decrease cell migration was supported.

An ANOVA and post-hoc analysis was performed on the data, which determined that the data is both statistically significant and insignificant. The outcomes for NT vs TTP-488, NT vs AGEs & TTP-488, and TTP-488 vs AGEs & TTP-488 imply that the data was not statistically significant. However, the data for NT vs AGEs, AGEs vs TTP-488, and AGEs vs AGEs & TTP-488 implies that the data was statistically significant and the results were due to the independent variable, demonstrating that RAGE inhibition does indeed affect the AGE-RAGE signaling pathway.

Previous research has observed that cancer cells typically exhibit RAGE overexpression, with one study demonstrating that RAGE inhibition suppressed cell migration in other cancer types, including breast cancer (Faruqui et al., 2022). Similarly, another study showed that RAGE inhibition mitigated AGE-induced inflammation and fibrosis (i.e. the buildup of stiff, fibrous tissue, leading to a TME that promotes cancer progression) in PCa models (Liu et al., 2023).

The assay results suggest that RAGE inhibition with TTP-488 significantly reduced PCa cell migration compared to the AGEs solution. AGE treatment increased migration, highlighting AGEs' role in promoting cell motility. The reduction in DU145 migration upon TTP-488 treatment indicates that RAGE inhibition interferes with AGE-driven signaling pathways. This may prevent epithelial-mesenchymal transition (EMT), a key process in cancer progression, by inhibiting downstream pathways that promote migration. Additionally, TTP-488 likely prevents AGE-induced CAF transformation and the secretion of chemoattractants, impeding the TME. These results underscore the therapeutic potential of RAGE inhibition, as TTP-488 restores tissue integrity, reduces oxidative stress, and limits inflammatory mediators, highlighting the importance of targeting the AGE-RAGE axis in prostate cancer therapy.

RAGE Knockdown Phase

RAGE knockdown was confirmed via Western Blot, and its impact on PCa cell progression was assessed through migration and proliferation assays in LNCaP cells. This therapeutic strategy explored the effects of RAGE knockdown presence (i.e. shControl and

shRAGE cells). The hypothesis that RAGE knockdown would significantly reduce migration and proliferation was supported.

An ANOVA and post-hoc analysis was performed on the data, which determined that the data is statistically significant. For both the cell migration and proliferation assays, the data for LNCaP shControl vs LNCaP shRAGE implies that the data was statistically significant. Consequently, the results from the migration and proliferation assay were due to the independent variable, demonstrating that RAGE knockdown significantly altered migration and proliferation compared to control groups.

Studies have demonstrated that RAGE knockdown can suppress cancer cell migration and invasion in other cancer models. For instance, RAGE knockdown has been linked to decreased invasion in colorectal cancer, aligning with findings from the present study, where RAGE silencing reduced LNCaP cell migration. Additionally, the knockdown of RAGE in prostate cancer models has been shown to mitigate AGE-induced inflammation, reducing the associated fibrosis and ECM modifications that contribute to TME (Liang et al., 2011).

The study suggests that RAGE knockdown via shRNA reduced LNCaP cell migration and growth, indicating RAGE's role in tumor cell motility and proliferation. This reduction may emerge from the inhibition of key signaling pathways that promote migration and proliferation, as well as decreased AGE-induced oxidative stress and inflammation. These findings support RAGE as a critical mediator of AGE-driven migration and proliferation in prostate cancer. RAGE knockdown not only limits cancer cell motility but may also restore tissue integrity by preventing fibroblast transformation into CAFs, highlighting its potential as a therapeutic target in prostate cancer.

Limitations & Recommendations for Further Research

This study provides valuable insights into the AGE-RAGE pathway in prostate cancer but has limitations. While it demonstrated the effects of RAGE inhibition and knockdown on cell migration and proliferation, the specific downstream molecular mechanisms remain unclear. Future research should explore the intracellular signaling cascades involved. Additionally, the use of two-dimensional *in vitro* models limits the complexity of the TME, so three-dimensional models should be considered for more accurate tumor representation. *In vivo* studies, such as murine models, are needed to assess the relevance of RAGE targeting in prostate cancer progression.

Findings from this study have significant implications for the development of novel therapeutic strategies targeting the AGE-RAGE signaling axis in PCa. Given the established role of RAGE in cancer progression, inflammation, and metastasis, the results suggest that targeting RAGE–either through pharmacological inhibition or genetic knockdown–could serve as promising therapeutic strategies for mitigating prostate cancer aggressiveness. The observed decrease in cancer cell migration and proliferation following RAGE inhibition and knockdown highlights the potential of anti-RAGE therapies in reducing metastatic potential and improving patient outcomes. Beyond prostate cancer, these findings could be relevant to other pathologies where RAGE plays a pivotal role, such as diabetes mellitus, cardiovascular disease, neurodegenerative disorders, and other forms of cancer. Overall, this study presents a novel approach to targeting prostate cancer by focusing on the inhibition of the AGE-RAGE axis, an underexplored yet critical pathway. By demonstrating that disrupting RAGE function significantly impairs tumor cell migration and proliferation, this research paves the way for innovative treatment strategies.

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