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81st Annual Meeting and Research Symposium

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Virginia Academy of Science Mission Statement
The purpose of this organization shall be to establish and maintain in Virginia for scientific and educational purposes an association of persons and organizations interested in science and scientific research in all of its branches; to solicit financial and other support; to cooperate with educational institutions, industries, and state agencies in fostering an interest in scientific matters, in promoting scientific investigations and in spreading knowledge of the sciences; to provide a forum for the presentation and discussion of papers on scientific subjects and facilities for their publication; to provide opportunities for the cooperation and fellowship among its members; and generally, in doing these things, to benefit not only its own members, but to promote the civic, agricultural, academic, industrial, and commercial welfare of the people of Virginia.

Virginia Junior Academy of Science is a paper driven competition with an oral presentation to numerous judges in the field. Students' papers go through multiple judging steps. Papers are first screened by readers who are experts in their fields. The papers moving forward from the readers are sent to judges to review and score prior to the Symposium. The formal student lecture in PowerPoint format allows the judges the time to engage the student with detailed questions. There is educational value of the lecture format to the other students in the presentation room who can listen to the presentation and ask questions. The all-day event with up to 15 minutes per student gives students plenty of active time and an opportunity to learn from their peers about their projects. The value of the presentation in the current format has proven valuable for over 80 years.
The student lecture format presents an opportunity and a challenge to the student presenter to gain from the experience of standing in front of the judges and their peers and presenting a formal lecture. The structured student lecture is indeed a challenge, and it is one of the ways that VJAS is a rich educational experience. For the presenter, it is the culmination of a science process that began months earlier. The communication of the research is an integral part of the science process. The student must present their science introduction, background, hypothesis, experimental design, results, analysis, and conclusion. It requires the student to use their own judgment in deciding what content and level of detail should be presented to the judges.
The student-lecture format of VJAS is of significant educational value for fellow students attending the session. The presentation rooms are filled with fellow students who gain from witnessing the student lecture, the questions of the judges, and the answers of the student presenter. The poster format of traditional science fairs would eliminate the opportunity for fellow students to witness the processes of the contestant's research and the interaction of the judges and the presenter.
 The VJAS has a long tradition of formal research papers and lecture presentations. It is unique among the various "science fairs" in Virginia in this respect. For those who prefer the poster session format, there are other opportunities for students to participate in science fairs using the tri-fold board format. The current format of our institution is more challenging and provides opportunities such as publishing their abstracts for approximately 600 students annually.

The *2022 Proceedings* are compiled and edited by Robin W. Curtis

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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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Middle School Abstracts by Section

Animal & Human Science

First Place
Kasimir Rastogi- An Evaluation of Underlying Medical Conditions as Predictors of COVID-19 Morbidity and Mortality
Cooper Middle School

COVID-19 is a severe acute respiratory disease caused by SARS-CoV-2. In early 2020, the CDC deemed the disease a public health emergency, and the WHO deemed it a global pandemic. This study will examine the medical conditions that are correlated with COVID-19 morbidity and mortality rates using the CDC Case Surveillance Public Use Data (from February 24th, 2022), and the Behavioral Risk Factor Surveillance System (BRFSS) data on medical conditions including chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD), heart disease, diabetes, and obesity rates. This study uses multiple linear regression analysis to evaluate the statistical significance of the independent variables of BRFSS medical conditions as predictors for the dependent variables of CDC COVID-19 morbidity and mortality rates. No medical conditions (CKD, COPD, heart disease, diabetes, and obesity) were found statistically significant ($p<0.05$) for predicting COVID-19 morbidity rates. CKD, obesity, and heart disease were all significant predictors for COVID-19 mortality rate. Obesity appeared to have the strongest predictive value of COVID-19 mortality rate. COPD and diabetes were not statistically significant predictors for COVID-19 morbidity or mortality. The results of this study can be used to make efficient and appropriate public health decisions in resource allocations. The results of the study can also help clinicians make appropriate decisions for their patients.

Second Place
John Kamireddy- The Effect of Different Soil Mediums on Earthworms
George H. Moody Middle School

Earthworms are an important species in the ecosystem, as they help break down materials to create healthy and nutritious soil. They also serve as nutrition for many species, But, lately the earthworm population has been steadily decreasing as their habitats are being destroyed, and it is our responsibility to help save it. The researcher has concluded that by making artificial human - made environments, he can once again find a place for earthworms to call their home. The researcher will be conducting an experiment, to find which environment is the most healthy and preferred environment by the earthworms. In this experiment, the worms will be put into the different soil mediums,

and their movement will be recorded in inches, as worms tend to move more when they enjoy their environment. The different mediums will be loam, silt, sandy, and clay soils. The experimenter‚Äôs hypothesis for this experiment was that the most preferred soil will be the loam soil, as it is considered highly nutritious and is used for crops. His hypothesis proved to be valid, as the movement recorded for loam soil was the highest compared to the others after 10 trials, with about an average of 6 inches.

Third Place
Priya Kumar- The Effect of different concentrations of CBD oil on the heart rate of the Daphnia magna
George H. Moody Middle School

Cannabidiol, obtained from the Cannabis sativa plant, is a non-psychoactive compound that has many health benefits that have not been explored yet. For instance, the effect of Cannabidiol on the cardiovascular system has very few studies, which is why the experimenter chose to explore the topic and conduct the experiment. Cannabidiol has been linked to many health benefits, such as decreasing anxiety. Studies show that anxiety in adults and children has increased, with increased heart rate (palpitations) being one of the symptoms. It has become a topic of importance within the scientific community. The purpose of the experiment was to explore Cannabidiol‚Äôs effect on the heart rate of the Daphnia magna. If the heart rate decreased, then CBD oil could be a potential aid to those struggling with anxiety. The hypothesis of the experiment was, ‚ÄúIf the Daphnia magna is exposed to different concentrations of CBD oil, then the heart rate of the Daphnia magna will decrease.‚Äù Ten trials for each concentration were conducted. The average heart rate of Daphnia magna in spring water (control) after 10 trials was 205.2 beats/min. The average heart rate of the Daphnia magna for 1 drop of 1 mL of 10 mg/mL CBD oil, 1 drop of 1 mL of 10 mg/mL CBD oil diluted with 1 mL of spring water, 1 drop of 1 mL of 10 mg/mL CBD oil diluted with 5 mL of spring water, and 1 drop of 10 mg/mL CBD oil diluted with 10 mL of spring water were 177.2, 189.3, 201.2, and 203.6 beats/min respectively. There was a significant decrease in the heart rate of the Daphnia magna for the 1 drop of 10 mg/mL CBD oil concentration, and the heart rate kept on increasing back to normal as the dilutions increased, which supported the hypothesis. More experiments with CBD oil should be done to explore its medicinal benefits in battling anxiety and lowering heartrate.

Honorable Mention
Ishan Shah- Finding the most cost-effective alkaline water that irreversibly inactivates pepsin and aids in the treatment of laryngopharyngeal reflux (LPR)
George H. Moody Middle School

Laryngopharyngeal reflux (LPR) is a condition in which the gastric contents from the stomach travel retrogradely to the extra esophageal areas like larynx and pharynx. Pepsin, an enzyme secreted in the stomach, is detected in the larynx of patients with LPR and, along with gastric acid, has been shown to cause damage to the laryngeal epithelium

by depleting the defense mechanisms of laryngeal epithelium. Pepsin has also been shown to promote proliferation of cells and cause cancer of the laryngopharynx through changes in gene expression. Pepsin is activated at pH of 1.5 to 2 andisirreversibly inactivated at pH 8 or higher, thus making it ineffective. Therefore, in patients with LPR, drinking alkaline water with pH of 8 or higher can be veryeffective in irreversibly inactivating pepsin present in the larynx as well as in the stomach, and thus reducingthe symptoms associated with LPR.In my project, I measured pH of several brands of bottled water, to make sure that their pH was above 8, andthen compared their cost to find out the most cost-effectivebrand of bottled water that can be used in patients with LPR.My results showed that Wegmans BE U Alkaline water with electrolytes pH 9.0+ (Wegmans) with cost of $0.99/liter was the most cost-effective brand of bottled water with pH greater than 8.Thus, my project is a small step in the direction of helping patients with LPR in choosing a very important component of their treatment regimen.

Honorable Mention
Akilesh Jonnavarapu- Which Shampoo Makes Your Hair Stronger
George H. Moody Middle School

This is why Shampoo is sometimes good for you or badfor you. Hair loss is an international problem .The problem ofusing bad or wrong shampoo affects everybody. Which also results inloss of hair. I am trying to test what the most effective shampoois. Your Hair is an important part of your life . It shows yourstyle. Using bad shampoo has become a worldwide problem . Myresearch will show what shampoos are good to use and whicharen‚Äôt.My Hypothesis is: The more natural oils and vitamins thebetter the shampoo. An example of what could be solved throughthis project is hair loss and bad shampoos. I expect the outcome tobe Pantene because it has a lot of oils. I took a survey around myneighborhood to see which shampoo they used and they used eitherpantene or Head and Shoulders .

Honorable Mention
Jeev Dalawari- The Effect Of Crowding On A Cricket's Behavior
George H. Moody Middle School

While performing and thinking of this experiment, the researcher always had a set research objective and approach, to observe and collect data on the effect of crowding on a cricket‚Äôs behavior. The researcher believed that if the amount of accessories in the habitat was decreased, the cricket would in fact be more energetic. The researcher chose to use crickets as for experiments revolving around effects of crowding and population density, crickets are known to react more than other insects. The independent variable of the experiment is the amount of accessories present in the habitat contributing to the crowding, and the dependent variable of the experiment is the cricket's behavior. The experiment was conducted with a habitat, cricket, and accessories which consisted of frog moss, and twigs. The cricket would be switched out daily and the results and behaviors of it would also be recorded daily. The results of this experiment were based

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on the movement of the cricket during the time that it was in the habitat. Every 10 trials the amount of accessories would be increased. A common pattern shown in the results was that as the accessories were increased, the crickets started to ,slow down, and were stationary more often. The researcher believes that to better the experiment for future research, the amount of cricket's should also be increased alongside the amount of accessories. In addition, if the temperatures of the habitats are altered, results and reactions could also vary in the crickets.

Vansh Goel- The Effect of Different Biomes on the Behavior of Ants.
George H. Moody Middle School

The researcher believed that the ants would have very large reactions to all of the different biome. The researcher believed this because of the hypothesis which was "If the ants are put into a leafy biome, then the ants will have a higher speed and more interactions." The researcher believes that this will serve a purpose in the community because this could help with space travel due to the 33% reaction time similar to humans (Science Daily, 2010.) The experimenter had added 4-5 ants to a container containing sand, leaves, rocks, or a plant-based gel. After 1 minute the experimenter recorded the data and put it into the charts and graphs. The researcher is measuring the ants based on their speed and number of interactions. With the experiment concluded, the researcher learned that the highest speed was Gel Biome, and the highest number of interactions was the Sandy Biome. The lowest speed and interactions were the Rocky Biome. The researcher believes that this experiment will benefit society and realizes that the ants would best react to the Sandy Biome due to them being the highest amount in interactions and almost the highest amount in Speed.

Jessica Lkhagvasuren, Mallory Burton- Do People that are Closely Biologically Related Have the Same Fingerprint Pattern?
H-B Woodlawn Secondary Program

The purpose of this experiment was to study the effect of close biological relations on human fingerprint patterns. Studies performed by other people on fingerprint patterns had different results. A scholar in 1989 claimed that a child has the exact same pattern as its mother and grandmother. A more recent study said that the way people obtain their fingerprint patterns is complicated and not straightforward. Thirty humans, who were related to at least one other participant, had their fingers pressed into a black porelon ink pad and next pressed on a piece of white paper. The fingerprints were analyzed and the researchers discovered which of three patterns (loop, whorl, and arc) they were. After analyzing them completely and determining each fingerprint‚Äôs pattern, the fingerprint patterns were compared with other people the participants were related to. Twins and triplets were the most likely to have the same pattern as each other, with an 88.9% chance. Parents and children came next, with a 65.2% chance. Siblings were the least likely, with a 50% chance of having the same fingerprint pattern. In general, there was a 68% chance of biologically related people having the sam e fingerprint pattern. From this

human studies experiment, it was concluded that genetics had a significant effect on the type of fingerprint pattern a person would have. Fingerprints could have been more deeply classified into eight different patterns, which would have made our studies more specific and accurate.

Chemical Sciences – A

First Place
Anaya Kaul- Effect of *Aloe vera* on Protein Digestion
George H. Moody Middle School

Gastroesophageal reflux disease (GERD) is a chronic disease treated via allopathic medications and complementary alternative medicine such as *Aloe vera*. Allopathic medicines such as Proton Pump inhibitors and antacids are known for side effects such as food allergies caused by reduction in protein breakdown. Herbal medicines such as *Aloe vera* though useful for treating GERD need to be investigated for side effects The purpose of this study was to investigate whether Aloe Vera affects protein breakdown. Amount of protein breakdown by Aloe Vera was obtained by measuring the absorbance (Au) of a protein mixture consisting of egg white powder, Aloe Vera extract, 1% pepsin solution and 0.1M HCl. The protein breakdown by Aloe Vera was compared to the protein breakdown of the control group's protein mixture that consisted of egg white powder, 1% pepsin solution and 0.1M HCl. Results showed that the mean absorbance for the experimental group with Aloe Vera demonstrated significantly lower absorbance as compared to the control group (1.011 ¬± 0.188 vs. 1.204 ¬± 0.26, t (48), p < 0.05). Specifically, the protein breakdown was higher with Aloe Vera (experimental group) as compared to the control group, which did not have Aloe Vera. Aloe Vera had lower absorbance because it did not change the pH level necessary for pepsin activation, broke down larger number of protein peptide bonds, and Aloe Vera's composition played a role which was not quantified in this study. Further studies are required to compare protein breakdown between antacid and Aloe Vera and identifying the chemicals in Aloe Vera that may have contributed to higher protein breakdown.

Second Place
Diyaa Kirubaharan- The Effect of Different Drinks on Teeth
George H. Moody Middle School

The reason for this experiment was to point out how long a fruit can be left out until it begins to lose Vitamin C. The experimenter's hypothesis for this experiment was that if the time that the cut fruit was left out increased, then the Vitamin C concentration would decrease. In order to conduct this experiment, the steps the analyst followed to receive accurate data was to leave out lemons for different periods of time. The various times they left out ten lemons was for three hours, six hours, nine hours, then twelve hours.

When the lemon was left out for twelve hours, it had the greatest impact on the Vitamin C concentration, and when the lemons were left out for three hours, it had the lowest influence on the change of Vitamin C concentration. These results highlight the relationship between the time a cut fruit is left out and the amount of Vitamin C in that cut fruit after the period of time.

Third Place
Duchmaa Ariunbold- The Effect of Ice Melt Substances on Time to Melt Ice
Kenmore Middle School

Why is salt the most commonly used substance to melt ice? There is a plethora of other substances with more ions and atoms. I did this project to get an answer to my question, to have data to prove which substance melts ice the best. The purpose of this project was to find out which substance had the greatest effect on time to melt ice. Fifteen ice cubes were divided up into five groups of three. The groups were spread out among identical porcelain bowls. One bowl of ice had salt sprinkled on each ice cube evenly. The other substances were applied similarly. One bowl of ice was left, had no substance added, and served as the control group. Each bowl was taken out every hour and measured. The experiment ended only when all of the bowls of ice melted. Two substances were almost equally effective at melting ice. My experimental results did not support my original hypothesis. After analyzing the data, I conclude that salt is the best substance to melt ice with as it had a mean of 13.9 ml of melted ice per hour, slightly more than sugar.

Honorable Mention
Anoushka Anand- The Effect of Different Oils on the Strength of Hair
George H. Moody Middle School

Swimmers all across the globe struggle with unhealthy hair. This experiment was conducted to help this problem. The goal of this experiment was to see which oil out of Coconut Oil, Olive Oil, and Almond Oil, was the most effective when applied to hair to make it stronger. My hypothesis was, If Coconut Oil was used on hair, then the hair will be stronger. This statement was proven false. The procedure was applying 0.5 tablespoon of each oil one hour before the practice. The head was then put under a swimming cap for one and a half hours before being taken off. The strand of hair was then taken off one hour after the swim. After that the hair was tested by attaching one end of it to a pencil by duct tape and the other end to a Ziploc bag. Then, pennies were added to the Ziploc bag. The number of pennies were multiplied by 2.5, since that is the weight of pennies, and that was how much weight the strand of hair could carry in grams. The results of this experiment were unexpected. Coconut Oil was not, in fact, the strongest Oil, Almond Oil was. The average weight the hair that Coconut Oil was applied to could hold was 48.5 grams, and the average weight that the hair that Almond Oil was applied to could hold 66.5 grams. In conclusion, the Almond Oil was more effective than the Coconut Oil and Olive Oil.

Honorable Mention
Caroline South- The Effect of Over-the-Counter Medicine Coating on the Release Time in a Low pH Environment
Dorothy Hamm Middle School

Acetaminophen has different coating types, making the medicine easier to swallow and have a certain release time. This experiment tested the different dissolving times between coating types, and therefore which pill would potentially relieve pain the fastest. The hypothesis was if different kinds of over-the-counter medicines are put in a low pH environment, imitating the human stomach, then the coated tablets will release quicker, because the coated tablet doesn't have a shell around it, so less covering will have to come off to get to the medicine. Water was poured into a glass, and both pH and temperature were adjusted to mimic the stomach's conditions. The dissolving time of different types of Tylenol pills was carefully measured and compared. The data did not support the hypothesis. The results showed that the Coated Tablet took the longest to dissolve, averaging nine minutes and twenty-two seconds. The Gel cap was in the middle averaging four minutes. The Caplet dissolved the fastest averaging one minute and fourteen seconds. This experiment supports that some pill coatings take longer to release medicine than others. The best Tylenol pill to take is the Caplet, because the medicine will enter the bloodstream first.

Honorable Mention
Arinan Johri- The Effect of the Opacity of Paper on the Effectiveness of UV Light
George H. Moody Middle School

Whenever summer arrives, children are always excited to go to the beach or the pool, but one problem stands in their way: UV rays from the sun. Keeping this in mind, many children hope for partly cloudy weather to go out without the annoyance of sunscreen, but parents weren't sure if clouds reduced the UV index. The purpose of this experiment was to determine if the opacity of paper, which represented the density of a cloud, affected the effectiveness of UV light. The hypothesis was that if the paper (cloud) was opaquer, then the effectiveness of the UV light would be reduced. The experiment was conducted by placing UV-sensitive beads inside of a beaker and then placing the paper on top of the beaker. A UV flashlight was placed above the beaker, which acted as the Sun, and the beads were assigned a certain value of points based on their color after exposure to the UV light. After the experiment, the data that was collected supported the hypothesis, as the group with no paper had a mean number of points of 21.2 and the group with the opaquest paper had the least mean of 0.5. The standard deviation of each group decreased with each increase in opacity, which showed that the opaquer the paper, the more alike the results were. These results were supported by research conducted by P.N. den Outer, as their study showed that cloud cover reduced daily erythemal UV by 68%. A one-way ANOVA showed that the null hypothesis was rejected, and there was a statistically significant difference at $(f_{(3,36)} = 106.27704, p < 0.00001)$. The concepts of

density in clouds also supported the original hypothesis, as opaque, thicker clouds are denser, resulting in less UV light being able to pass through. The results and conclusion both supported the hypothesis, and the data could be used to determine the likeliness of melanoma as an extension of the research.

Aarya Mishra- The effect of Time a fruit is left out on Vitamin C Concentration
George H. Moody Middle School

The reason for this experiment was to point out how long a fruit can be left out until it begins to lose Vitamin C. The experimenter's hypothesis for this experiment was that if the time that the cut fruit was left out increased, then the Vitamin C concentration would decrease. In order to conduct this experiment, the steps the analyst followed to receive accurate data was to leave out lemons for different periods of time. The various times they left out ten lemons was for three hours, six hours, nine hours, then twelve hours. When the lemon was left out for twelve hours, it had the greatest impact on the Vitamin C concentration, and when the lemons were left out for three hours, it had the lowest influence on the change of Vitamin C concentration. These results highlight the relationship between the time a cut fruit is left out and the amount of Vitamin C in that cut fruit after the period of time.

Alex Bryner- The Effect of Different Types of Flour on the Size of Bread
George H. Moody Middle School

The experimenter chose to see if different types of flour would be worth it for bread. For the experimenters experiment the experimenter will be seeing how flour will affect the volume of bread. From the experimenter's results they have concluded that the type of flour is not super important for the type of bread, but it does change the volume. After looking at other versions of this experiment the experimenter thinks that their experiment is similar compared to experiments made by others.

Anish Aruru- The Effect of Different Ingredients in the Time it Takes to Make Jell-O
George H. Moody Middle School

Making Jell-O takes a lot of time. If there were ways to make it faster people could improve the efficiency of the process. Jell-O primarily consists of gelatin, sugar, and water. Each time you make Jell-O it can take upward to 4 hours to make it and when a person makes a bunch of it, it can waste a lot of time. My Hypothesis is that If the experimenter added honey it would form the Jell-O faster compared to the rest, and in the normal way, people do it now. 70 batches of Jell-O were divided into 7 groups with 10 each so there were 10 trials. The 7 independent variables were constant, sugar, baking soda, salt, cinnamon, chili powder, and honey. Group 1 was the Control group with the regular formula for Jell-O. Group 2 was the Jell-O with added 150 ounces of sugar. Group 3 was the Jell-O with added 150 ounces of Baking Soda. Group 4 was the Jell-O with added 150 ounces of

Cinnamon. Group 5 was the Jell-O with added 150 ounces of Chili Powder. Group 6 was the Jell-O with added 150 ounces of Salt. Group 7 was the Jell-O with added 150 ounces of Honey. Each group was measured in minutes The mean for group 1 is about 258 minutes. The mean for group 2 is 256 minutes. The mean for group 3 is 243 minutes. The mean for group 4 is 241 minutes. The mean for group 5 is 262 minutes. The mean for group 6 is 231 minutes. The mean for group 7 is 274 minutes. The mean of all of them is 252.1. The median is 256. The range is 46. The standard deviation is 13.5.

Ishaan Atturu- How Different Types of Commonly Thrown Away Substances Affect the Surface Tension of Water.
George H. Moody Middle School

The purpose of this experiment is to test on how different types of commonly thrown trash affect the surface tension of water. The researcher chose to find the surface tension since, when the trash goes into the water, it breaks though the surface tension, before harming the aquatic life below. Before starting the research, the researcher came up with a hypothesis stating that if he puts in fluids that will need stirring to absorb into the water, then the water will change the most. The researcher had to get all the materials needed which included, cups, beaker, the fluids, paper towels, and a small clear tube for measuring the surface tension. The researcher did the experiment 40 times (there were 10 trials) and recorded the data. The major findings that the researcher found and can conclude were, soap and fertilizer had the highest surface tension, and bleach and regular water (water was the control) had the lowest surface tension.

David Dong- The Effect of Different Sizes of Salt Grains on the Melting Speed of Ice
George H. Moody School

In the past century, salt has been used across the globe to melt ice on roads and the same general size of salt has been used to do it. The scientist could not find much about why this large-grained rock salt was used instead of a finer grained salt, which would dissolve faster. The scientist conducted an experiment with three sizes of salt to find a correlation between the size of the grains and the melting speed of ice. After conducting the experiment, the scientist found that contrary to what he thought, the medium grained salt had the greatest effect on the melting speed. The difference between the different salt grains, however, was hardly enough to matter, and the scientist assumed that the larger grains were chosen simply for the convenience of the user.

Henry Marshall- The effect of the Amount of concentration of salt crystals on the melting rate of ice
George H. Moody Middle School

Ice keeps our planet cool and maintains the amount of heat that gets stuck in our oceans. If our ice caps melt, the heat will get stuck in the water, and the heat won't be repealed

by the light crystals in the ice. The researcher learned that the Ice and the salt crystals became a mixture. The ice and the salt crystals were combined physically. The researcher learned that the higher the concentration of the salt crystals put on the ice, and how much diameter and the height of the ice blocks were affected.

Jordan Haught- The Effect of Pyrethroid Pesticides on the Progression of Growth in *Lepidium sativum* (Common Garden Cress).
George H. Moody Middle School

The use of pesticides is commonly used in neighborhoods and by lawn care groups to preserve the plants' wellbeing and health to maintain the lawn's green - state. The researcher (experimenter) observed substantial changes in the growth of the plants that are taken care of by the lawn preservation companies/ groups. A chemical called DEET is used by many of the chemical source companies that provide insecticides/ pesticides for lawn care companies (Cutter, 2022). The researcher conducted an experiment to determine if the chemical (Lambda Cyhalothrin) DEET was the cause of the plant deterioration (NoMozzie, 2022). The researcher stated, If the chemical DEET was implemented in contextually adequate amounts to a group of grass - like plants (garden cress/ *Lepidium sativum*), then the plant groups would have slower growth patterns, and most will deteriorate or wilt. The researcher did find results, in which were relevant to proving the hypothesis. The researcher made careful adaptations to the environment in which the experiment was conducted to provide a nature like, environment to limit the corruption to the outcome of the experiment as much as possible. The researcher also implemented safety precautions to meet health and safety requirements provided by the state health department. In the close of the experiment, the researcher was able to conclude that the experiment had provided enough evidence to support the hypothesis and claims given. This gave more information on what the chemicals are doing to the state of homeowner's lawns and give reason to try and change the nature of pesticides to prevent this from happening more than it currently is.

Katharine Burke- The Effects of Varying Acids and Baking Soda on Tarnishing Silver
Kenmore Middle School

The purpose of this experiment was to create a new, better way to clean tarnishing silver. This experiment was based on the base and acid theory and the classic baking soda and vinegar solution (Acid-base reaction, 2021). When a base and an acid come together, they normally react to become H2O. In the case of baking soda and vinegar they are coming together to create H2O or water. This reaction is the thing that cleans the silver so if the base or in this case the acid is swapped the reaction will be different. This experiment uses acidic fruits and baking soda to test to see if they work better than the original baking soda and vinegar combination. The hypothesis turned out to be supported. This project is very important to the experimenter because of its impact on girls. In many countries it is the girls who must clean the silver. They might sit around

with a cleaning cloth working away at the tarnish for hours every day. This experiment provides an easy, do-it-from-home, effective solution to this issue.

Chemical Science – CS B

First Place
Spencer Massie- Elephant Toothpaste and Exothermic Reactions: The Effect of Changing the Amount of Catalyst
Sabot at Stony Point

In elephant toothpaste, a catalyst is added to a graduated cylinder with hydrogen peroxide and dish soap inside to make an exothermic reaction. This reaction takes the form of a foam snake, which travels out of the graduated cylinder and onto a tray. The purpose of this experiment was to find out what would happen to the reaction if more catalyst was added to the same amount of decomposition material (hydrogen peroxide).Yes, I am cool. The hypothesis was that the reaction would increase in rate (ml/s) and heat with the amount of catalyst. The project was designed to measure the rate (in seconds the foam to reach 500ml) of the reaction and the maximum heat achieved by changing the amount of catalyst introduced to a mixture of 12% hydrogen peroxide and a few squirts of dish soap. A potassium iodide solution was used as the catalyst. There were five levels of independent variable, a solution of potassium iodide and water; 2.5 milliliters of solution, 5ml, 7.5ml, 10ml and 15ml. The hypothesis was disproved because the least amount of catalyst used resulted in the hottest reaction. On average, the use of 2.5 ml of catalyst produced the hottest reaction at 42¬∞ C, but at the slowest rate (as measured by the time in seconds it took for the oxygen bubbles to reach 500ml). The original design of the experiment called for 30% hydrogen peroxide. However, the tester used 12% hydrogen peroxide because the tester couldn‚Äôt acquire 30% hydrogen peroxide. Next time, 30% hydrogen peroxide would be ordered earlier in order to get it in time.

Second Place
Rishab Kambham- The effect of different electrolytes on the voltage
George H. Moody Middle School

Battery electrolytes are a vital component of the battery, as they allow the electrical current to flow between the cathode and the anode. Volts are a unit of measurement. It measures the pressure from an electrical circuit's power source. When a battery‚Äôs electrolyte transports electricity, that itself is the voltage. A better battery requires a better electrolyte, as it determines the voltage of the battery. The best battery electrolytes have a high amount of electrolytes themselves as having more electrolytes help electrons move through the battery fluid faster. The purpose of this research was to find high quality organic electrolytes available in most homes, in order to make an organic battery. A battery electrolyte puts the chemicals needed for the reaction in contact with the cathode

and anode. If household materials are forced to behave as an electrolyte, then vinegar will conduct electricity the best. Household liquids such as soap and water, vinegar, water and baking soda, and oil, were collected. Each of these were tested by putting a copper coin (cathode) and a paperclip (anode) into each substance. The penny and paper clip each had alligator clips which connected them to a multimeter. The results indicated that vinegar was the most effective, with an average voltage of 0.796 volts. The worst electrolyte was soap and water, with a mean of 0.345 volts. The data supported the research hypothesis that if household materials are forced to behave as an electrolyte, then vinegar will conduct electricity the best.

Third Place
Meredith Lloyd- The Effect of Different Types of Soap and How Well They Clean Your Hands
George H. Moody Middle School

This project means a lot to me. For me, it is important to know that people are doing the most for their health and being safe. My hypothesis states; If I wash my hands with liquid soap, then they will be cleaner than if I use hand sanitizer. It was important for me to choose these two types because I see a lot of people substituting hand sanitizer for washing their hands. To prove my hypothesis, I came up with a procedure that would allow me to display that washing your hands with liquid soap is more effective. I used a UV-activated gel and a black light to do this. I would put the gel collection on my hands before washing them and then wash with a different type of soap. After I would use the flashlight to see how much gel was left on my hand. With the data that I had, I was able to prove my hypothesis. When I wash my hands with liquid soap, it cleans much better than the other three types of soaps. One observation I made while experimenting, is that soaps that include water in the procedure clean better than hand sanitizer. It is important to wash your hands multiple times a day to reduce the spread of germs. Germs can be very dangerous and very harmful to people. They spread exceptionally fast and also infect extremely fast. Have a visual representation of my hypothesis and it is a great example to prove that hand washing is effective.

Honorable Mention
Shrihari Kalagi- The Effect of Different Liquids on Tooth Decay
George H. Moody Middle School

Tooth decay is a detrimental health problem for many people across the globe. People who are untreated for their dental cavities and other problems are at a higher risk of getting cavities because the process becomes more rapid. The level of acidity in a liquid can affect how much the tooth dissolves. If something is lower on the pH scale, then it is more acidic and therefore more harmful to teeth. For these reasons, this project was conducted to find the best drinks for people to consume while still maintaining healthy teeth. This project was conducted with the hopes that it could also help those at home to reduce the number of cavities they get from drinking certain liquids and keeping

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themselves safe. The hypothesis made was, if orange juice is used, then the mass of the egg will decrease the most. After 24 hours, the data was recorded and assessed and the experiment was declared finished. Coca-Cola performed the worst by having the greatest average difference in mass with a mean percentage of mass increase at 2.49%. With this statistic, it was proven that the hypothesis was not supported. The findings of this experiment can be explained by the fact that the different liquids decayed the samples that had been already weakened by the liquid for some time. Since the liquids were all known for their acidic characteristics, they were able to decay the samples. A problem that could be solved would be the cracking of eggs when placed into the container. By simply placing the eggs on a spoon and slowly lowering it into the container, the problem would be solved

Honorable Mention
Manudeep Chevuru- The effect of different types of Tea on teeth enamel
George H. Moody Middle School

Tea is mainly known for being extremely healthy across the world. Although, many people do not dig deeper into the types of tea they drink. If they did, they would be able to understand that tea is not healthy in some aspects. This is the main reason that drove the expiramenter‚Äôs project. To preform this project he chose 4 different types of tea that he noticed that his parents drunk the most. They were black tea, green tea, homemade ginger tea, and sweet tea. The researcher then took half an eggshell and soaked it in the different types of tea. The researcher first planned to soak the eggshells for only an hour but then he realized that if he put it for 2 hours, the results will be more accurate. Therefore, after the eggshells were soaked for 2 hours, the experimenter took them out and measured their weight and noted the new color. According to the color scale, Black tea can make teeth look the worst in the sense of being white. On the color scale, Green Tea is the best to keep teeth white while Iced tea produces a Deep Brownish Yellow tint. Although the buildup that Homemade Ginger Tea produces on the eggshells was high. The average amount of weight that was increased was 0.8251 grams while green tea produced only 0.4138 grams. The eggshells that were soaked in Black Tea produced 0.9062 grams and the iced tea eggshells increased by an average of 0.6129. The purpose of this experiment was to figure out which type of tea helped teeth the most. When the researcher‚Äôs parents decided to go from green tea to black tea, he noticed that their teeth started to look a dark brown. He wondered if this is because of substances inside of black tea.

Honorable Mention
Myla McNair- The Effect of Types of Flour on the Hight of the Rise of Bread Dough
Williamsburg Middle School

The purpose of this experiment was to test how different types of flour, the independent variable, affect the rise of bread dough, the dependent variable. Knowing which type of flour leads to the highest rise of bread dough is important in reducing waste while making

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bread. Bread provides a good source of energy and is a low-cost food. Bread is one of the most widely eaten foods in the world and helping people know what flour to use, will help people feed their families (Britannica, 2021). The experiment tested five levels of independent variable: unbleached all-purpose flour, bleached all-purpose flour, bread flour, cake flour, and pastry flour. The experiment was conducted by making bread dough with the five different types of flour and recording the height of the rise of three portions of that dough. The doughs made with each of the five flours were given one hour to rise after being placed in the proofing containers. The hypothesis for this experiment was, If bread flour is used, then the dough will rise the highest because bread flour has the most protein, and the more protein flour has, the stronger the gluten, and the more the dough will rise (Zabik, 2021). The hypothesis was supported because the dough made using bread flour rose the highest. Bread flour produces the highest rise in bread dough. With this information people making bread can choose bread flour for a successful rise. This will lead to less waste and more people being fed.

Naman Kaushik- Effect of Different Types of Hand Sanitizer on Hardwood Flooring
George H. Moody Middle School

Hand sanitizer causes extensive damage due to its acidity and flooring cannot hold up against its acidity creating an issue where the hand sanitizer causes degradation. Hand sanitizer is very useful, and it helps us when you cannot wash your hands. New flooring has strong standards but still gets damaged. The idea is to find out how to create better hand sanitizer that won't cause as much damage and have better flooring standards so that floors don't get damaged as easily. The degradation (or damage) is the amount of change done to the flooring, and how much the type of degradation is the damage type to the floor. Will apply hand sanitizer to the floors and observe the weight change as well as the physical appearance. If we use more hand sanitizer the floors will take more damage. The flooring sustains damage, and the weight fluctuates. There is damage that can be seen by the naked eye and the hand sanitizer has left different signs of its damage. Flooring standards need to be upped and hand sanitizer is a powerful tool that helps us, but it still is extremely acidic.

Neel Joshi- The Effect of Different Temperatures of Water on Magnetic Strength
George H. Moody Middle School

A magnetic field is when the electrons create an electric current where the electrons are tiny micro magnets. Many believe that Magnetism is one of the most popular and interesting topics in physics with its real life applications, and the room to explore with it. Magnets are constantly trying to be improved, as it could hold the key to hover cars, hover trains, and many other wonders we are trying to figure out.
The purpose of the experiment was to use the different temperatures of water to change the magnetic strength and measure that. Ten trials were created, and one would gather all of the materials and start by following the methods listed. One could use a Gauss meter to measure the magnetic strength after their exposure to the selected temperature.

Next, after all of the trials were completed, the hypothesis was proved by all of the trials, and the one affected by dry ice performed the best.

Nikki Alemzadeh- The Effect of Different Smoothies on the Glucose Level
Louise Benton Middle School

Drinking smoothies are a common way to eat and stay healthy for a lot of people. Many don‚Äôt know the nutrition factors behind what they are drinking. A cause for that may be mis-advertisement for the drinks. The reason why these drinks were chosen was because they were advertised as healthy and fell in the healthy category at the specific store. The hypothesis states that if orange juice contains natural sugar, then it has a higher sugar content than store bought smoothies. This research evaluated the sugar content in different smoothies that are advertised as healthy drinks and a natural juice: The Slim N Trim Chocolate Smoothie (Smoothie King), the Apple Kiwi Kale smoothie (Smoothie King), the Pure Recharge, Mango Strawberry smoothie (Smoothie King), the Detox Island Green Smoothie (Tropical Smoothie), the Chia Banana Strawberry Smoothie (Tropical Smoothie), the Island Green Smoothie (Tropical Smoothie), and store-bought orange juice were all compared. Glucose test strips were used to measure the sugar content in each of the beverages. To validate the glucose test strips, a dilution series was used using two-fold dilutions with glucose powder and water. The results confirmed that the Slim N Trim Chocolate Smoothie had the least percentage of glucose compared to the other beverages. The results also showed that the Chia Banana Strawberry smoothie had the greatest percentage of glucose.

Sahana Muthukumar - The Effect of the Time an Apple is Soaked in Saltwater on the Time it Takes to Brown
George H. Moody Middle School

In ancient Egypt in 2000 BC, the method of salt preservation was used to preserve several artifacts of meat such as dried fish to season their food. However, because of the modern age of refrigerators and the comparatively short life of salt preservation, the method isn‚Äôt used often. But because salt preservation is still an effective method for short periods of preservation in fruits and dried meat, it can be used for the transport of jerked meat and some sliced fruits including the apple. This began the study of Osmosis, or what is better known as the process of removing water content with salt or the spontaneous passage or diffusion of water or other solvents through a semipermeable membrane. When an apple is soaked in saltwater, the saltwater has a lower concentration of water which causes water to be removed from the apple slice surface. The purpose of this project was to determine the preservation of saltwater on the browning rate of an apple slice. Four different times were set for ten trials of apple slices. The slices were soaked in the saltwater solution then placed on a tray and observed until they showed signs of browning. Each trial was tested for the time before browning using a stopwatch and observation. The results indicated that the apple slices with the longest time in the saltwater performing osmosis were the least affected by the exposure to oxygen with a

mean time of 1874.4 seconds and the apple slices with the least amount of time in the saltwater with the least time to perform osmosis weren‚Äôt able to cope with oxidation as well as the first, these apple slices had a mean of 339.4 seconds. A one-way ANOVA test was used to compare the means of the different times to the time oxidation starts to take effect. The f-ratio value is 872.174. The p-value is < .00001. The result is significant at p < .05. Because of this, the null hypothesis is rejected. Since there was a difference, Tukey's HSD test was performed, in conclusion, the results showed that all four means are different. The data supported the hypothesis that if an apple slice is soaked in saltwater for a longer period of time, then the apple slice will not be as affected by oxidation.

Sarah Coppenbarger- The Effects of Sand and Salt on Ice Melting Time
Kenmore Middle School

Studies have shown that the addition of salts and sand to ice decreases its melting time, but which one is the fastest? This project investigates the impacts of iodized salt (IS), rock salt (RS), kosher salt (KS), and sand on ice melting. Seventy-five ice cubes were placed in five same-sized bowls, over the course of five trials (three cubes/bowl). One teaspoon of IS, RS, KS, and sand were added to their respective bowls. Nothing was added to the control treatment. The bowls were placed in a refrigerator, and a stopwatch was started. Every hour, the ice cubes were observed, and after completely melting, the lap function was used to record the melting time. The hypothesis was that RS would melt the ice cubes the fastest. The experimental results were mixed‚Äìthe results showed that the average melting time for each treatment was 3.18 hours for IS, 3.405 hours for RS, 3.554 hours for KS, 9.083 hours for sand, and 10.576 hours for the control treatment. While parts of the experimental results aligned with published research as in the case of salts in general, being the best catalysts for melting ice, the initial hypothesis is not supported because RS came in second to IS, in terms of the most effective treatment. In conclusion, this experiment showed that IS could be used to melt ice faster than the other types of salt and sand.

Shaan Patel- The effect of different pH on the corrosion rate of nails
George H. Moody Middle School

The experiment which was conducted was The effect of different pH on the corrosion rate of nails. The purpose of this experiment is to find out how pH affects the corrosion rate of metal because it is very important to know to help prevent corrosion in important metal structures. The research hypothesis made prior to the experiment was that if the pH level rises, then the corrosion rate will decrease. For the procedure, the first thing that happened was 3 containers were used and labeled depending on the level of IV. 10 nails were put into each container for a total of 30 nails. Then water was poured into each container (400 ml). Then, using acid and base, the pH of the water was changed for each of the IVs (except the control). After a 7 day period, the corrosion rate was calculated. The results indicated that the pH level of 5 resulted in a higher corrosion rate than a pH

level of 7 and 9. The mean corrosion rate for the pH level of 5 was 103 mpy. As for the pH level of 7, the mean was 62.8. Finally, the pH level of 9 resulted in a mean corrosion rate of 32. The reason why this happened is that the lower the pH is, the faster the corrosion process is.

Tanvi Nareddy- The Effect of different liquid pH levels on the Corrosion of Pennies
George H. Moody Middle School

Corrosion is a dangerous and extremely costly problem. Many metals feel the effect of corrosion when many or all the atoms on the surface of metal get oxidized, which damages the whole surface of the metal and causes it to corrode. Corrosion can occur with natural events so it is important to know what causes it. One specific metal that is affected by it is zinc. Natural events and disasters happen everyday with acid rain and hail, so it is important to know how to protect specific metals from corrosion. The purpose of this experiment was to find the effect of different liquid pH levels on the corrosion of pennies. The hypothesis that is being tested for this experiment is, if a basic substance is used on a penny, then it will have a high corrosion rate. For this experiment, ¬⁰ of a cup of 5 different mixtures of different pHs were mixed. The liquids were then soaked up by a paper towel. Then pennies, which represent zinc, were weighed, and then placed inside the paper towels and covered. The paper towels were stored in a dark environment for 60 minutes. Then the ending weight of each penny was measured and recorded. The results for this experiment include, 1 tablespoon of baking soda, with a pH of around 11, exhibited the most mean weight loss (0.2808 g) compared to 1 teaspoon of baking soda, with a pH of around 10, which exhibited the least amount of mean weight loss (0.0508 g). The standard deviation for both were, 1 tablespoon of baking soda was 0.0291, while the standard deviation of 1 teaspoon of baking soda had a standard deviation 0.0178. In conclusion, a possible explanation for the results of this experiment, which supported that a higher pH level will corrode zinc the fastest, could be that the higher pH speeds up corrosion by reducing calcium carbonate solubility. To end, the hypothesis was supported in this experiment

Ecology & Earth Sciences

First Place
Nadia Lach-Hab- The Effect of the Amount of Microplastics on the Survival Rate of Daphnia magna
Dorothy Hamm Middle School

Microplastics are everywhere, from drinking water to the bottom of the oceans. The purpose of this experiment was to stimulate how microplastics can affect the survival rate of aquatic organisms. Microplastics can have detrimental effects to other organisms, so this research was created to test if the amount of microplastic would affect the survival

rate of a model invertebrate, Daphnia magna. It was hypothesized that the group of Daphnia with the most microplastic would have the lowest survival rate because microplastic can intoxicate and even kill other aquatic organisms who are exposed to microplastic. To test the hypothesis, three different ecosystems were set up: one with no microplastic, another with 0.5 ml of microplastics, and a third with 2 ml of microplastics. In each of three trials the same amount of Daphnia magna were added in each ecosystem. The survival rates of the Daphnia were monitored until all of the Daphnia magna died out. The hypothesis was supported: the group with the highest amount of Daphnia magna had the lowest survival rate. The Daphnia magna with 2 ml of microplastics all died on the first day, while the sample with 0.5 ml of microplastics all died on the second day experimenting. The trials with no microplastics had a steadily declining survival rate, all dying on the fifth day. This indicates that microplastic has a large impact on a model organism, meaning it may have a drastic effect on other organisms, including humans.

Second Place
Saket Sambaraju- The effect of the brightness of the sun on Solar Panel Efficiency.
George H. Moody Middle School

Solar panels are essential tools that can convert solar energy into electrical energy. Solar energy is also renewable, so it makes solar panels very eco-friendly. Efficiency is another key component that a solar panel must include when producing power. The brightness of the sun affects the efficiency of the solar panel. Most people conclude high brightness means high efficiency. However, to produce electricity, these electrons must be transferred to an external circuit, which is referred to as the conduction band. Electrons do not jump from the valence band to the conduction band themselves. A certain amount of energy, known as the bandgap, must be provided for them to make the transition. The purpose of this project is to test if high brightness means high efficiency. A solar panel will be placed on the driveway. A circuit will be attached and a battery will be absorbing the solar panel‚Äôs output. The original output of the battery will always be 0. Finally, the efficiency of the solar panel was tested at low, medium, and high brightness at 8 am, 10 am, and 12 pm, respectively. After taking the raw data, the results conclude that after an average mean is taken for low, medium, and high brightness, the medium brightness produced the greatest output. The data does support the research hypothesis that if medium brightness is powering a solar panel, then the solar panel will produce more energy than low or high brightness. The purpose of this experiment was to determine whether high brightness produces electricity faster than the other brightness, low and medium. The maximum output of solar cells increases with the increase of light intensity (Yang, 2021). This source suggests that when the brightness is increased, the efficiency of the solar panel cell is increased. The experiment that was done suggests that medium brightness produces more electricity than high brightness.

Third Place
Anika Parashar- Which fruit peel helps retain the most soil moisture

Hidden Valley Middle School

Dry weather and drought are becoming a common problem in many parts of the world. In 2020 around half of the continental US was under drought. Around 42% of fresh water is used for irrigation in the US. Since freshwater availability is limited and the population is increasing, development of innovative methods to help conserve water are critical. The objective of this research project was to study comparative efficacy of various fruit peels in retaining soil moisture. Naturally occurring water absorbent polymers such as pectin are present in fruit peels. The hypothesis was that if the type of fruit peel is an orange peel, then the soil moisture retained will be the most. The independent variable was the type of fruit peel (orange, banana, kiwi), the dependent variable was the soil moisture, and the control was no fruit peel. Soil moisture was measured in store bought topsoil with 60ml of water added to each of the four pots. The first pot was the control with no fruit peel and the other three pots were the boiled, dried peels of orange, banana, and kiwi. The peels were ground up with olive oil and mixed with soil. To measure soil moisture content, software was written in Java-script for a micro bit attached to two electrodes. Soil moisture levels were recorded immediately after adding water and at 24-hour intervals over a 96-hour observation period. This was repeated for five trials. At baseline, the moisture levels were relatively the same, at 24 hours the orange peel retained the most moisture and this result was sustained at 48- hour, 72 -hour, and 96- hour readings. Comparison of percent decline is soil moisture in the respective groups revealed that the hypothesis was supported, orange peels helped retain the most moisture. In conclusion, mixing fruit peels with soil is effective in preserving soil moisture, amongst the three fruit peels tested the orange peel was proven to be the most effective.

Honorable Mention
Aanya Singh- The Effect of GMO on Soil Quality and Communities of Microorganisms
George H. Moody Middle School

For many years, genetically modified agricultural technology has been widely used for commercial use, with corn, soybean, cotton, and canola crops being the most common crops. Biotechnology was used in 48% of total world plantings of these four crops in 2018. Insect resistance (GM IR) and herbicide tolerance (GM HT) are the main factors given to these crops by this technique. (Groote, 2012) These characteristics contribute to high agricultural output and are well suited to the monocropping farming practices utilized for commercial crops. Scientists noted that where GMO was used extensively, communities of microorganisms in soil became imbalanced. This sparked the study of the direct and indirect effects of transgenic crops and their management on microbially mediated nutrient transformations in soils. The disproportion is caused by differences in the amount and composition of root exudates, changes in microbial functions, and alteration in microbial populations. (Motavalli, 2004) The purpose of this experiment was to determine how genetically modified crops affect the soil quality in which they are planted in and how they affect microbial functions. The averages were 7.1 pH, 7.2 pH, 6.6 pH for the control, non-GMO crop, and GMO crop respectively. The data supported the research hypothesis that if two plants were planted at the same time (GMO and non-GMO), then the GMO

plant would make the nutrients more unbalanced. Based on the amounts of pH measured in this research, every plant reduces the pH slightly, but genetically modified plants reduce it by the greatest amount. Before it can be concluded that genetically modified plants create more of an imbalance in soil than non-GMO plants, further studies must be done at a real-life scale to ensure the accuracy of the results.

Honorable Mention
Geunyoung Chung- The Effect of Different Layers Above the Soil on the Prevention of Erosion
George H. Moody Middle School

Soil erosion occurs when water constantly washes over a particular surface, causing much of the topsoil to flood away. This leads to risks such as sinkholes and eutrophication, which is when there is an excessive amount of nutrients blocking oxygen from entering. This causes pollution of the water and harm to the creatures that inhabit it. Erosion also causes damage to the agricultural system in the United States by causing damage to farmland and increasing the loss of crops every year. In order to prevent this from happening, the researcher decided to research a suitable layer in addition to the top soil to prevent the topsoil from easily getting carried away.. When preparing for the experiment, the researcher created ten boxes for each variable and measured the appropriate heights (5 cm for the height of the soil placed in the containers and 2 cm for the height of the layers placed above the soil bedding) to ensure an equal amount of soil and layers were placed for each experiment trial. Using a funnel, the eroded sediments were then filtered through kitchen towels. For the control (soil, mulch, stones, and leaves), the average data collected was 20, 1, 1.8, and 3.4. The data validated the hypothesis that the driest material used for the layer, the greater the prevention of erosion would be. The driest layer (mulch) was found to control the most erosion because it absorbed the most water. The researcher learned from this experiment that having a layer was far more beneficial and effective than having just one. Although there were multiple trials and the controls were followed and set, the experiment would be more reliable if it were tested again using a larger environment and by setting up a real-life setting. The data could be affected since there will be a larger-scale environment rather than a smaller-scale experiment (this project) and it is actually applied to land we may live on.

Honorable Mention
Sujay Suribhotla- The effect of different types of wood on a fire's growth
George H. Moody Middle School

The purpose of this experiment is to see how much each type of wood contributes to the temperature of the fire. The fire's temperature will be recorded by an infrared thermometer and the fire will be constructed using 2 Duraflame QuickStart pieces and a lighter. If California Black Walnut is applied to a fire, then the fire will grow the hottest. A species native to California, such as Black Walnut, will produce the most change in temperature based on previous records at fire.ca.gov. The data shows that the California Black Walnut

fires had the highest average temperature of all 3 woods after the wood was added. The California Black Walnut fire also had the most temperature change from base temperature to the temperature after the wood was added. The data from this experiment supports the experimenter's hypothesis that the California Black Walnut wood would offer the most change to the fire's temperature.

Akhil Dhawan- The Effect of the *Drosera rotundifolia* on *Musca domestica*, *Armadillidium vulgare, Coccinellidae*, and *Pogonomyrmex barbatus*.
George H. Moody Middle School

The purpose of this experiment is to determine the effect of the Common Sundew on insects in its area, such as Red Harvester Ants, Houseflies, Roly Polys, and Ladybugs. My hypothesis is that if the aerial animals are not trapped or killed in a majority, then the terrestrial animals will get captured or preyed on more. The Researcher tested this by trapping subjects with the plant and seeing if the plant lures them. There were no outliers. The results disproved my hypothesis. The Researcher concluded that this experiment showed how certain environments work with certain species, and despite being similar some can be prey, while others, not.

Arhan Menta- The Effect of the Location Along the Potomac River on the Amount of Dissolved Oxygen
Williamsburg Middle School

The purpose of this experiment was to determine what location along the Potomac River on the amount of dissolved oxygen. The results of this experiment will benefit aquatic life because where these organisms are suffering and what factors reduce dissolved oxygen will be known. The hypothesis was Fletcher‚Äôs Boat House had the highest concentration of dissolved oxygen. For this experiment, Fletcher‚Äôs Boat House, Mount Vernon, Marshall Hall, and Woodrow Wilson Bridge were the locations where the amount of dissolved oxygen was tested. First, one liter of water was scooped and measured. After that was ensured, the pH of the water was measured (using a pH meter), and that had to be between 7.2 and 7.6. Once the pH was measured, the amount of dissolved oxygen was measured (using a dissolved oxygen meter). Finally, the data was recorded. The hypothesis was supported because Fletcher‚Äôs Boat House had the highest concentration of dissolved oxygen, with a mean value of 7.18 mg/L. Woodrow Wilson Bridge performed the worst with a mean value of 2.16 on mg/L. The data was reliable because the location along the Potomac River that had the highest variation (mean) only had a range of 0.2. This data suggests that the aquatic organisms living near Fletcher‚Äôs Boat House will have a higher quality of life than aquatic organisms in other locations, and the organisms in the other locations will struggle more to take in the necessary amount of dissolved oxygen.

Kristine Edassery- The Effect Of Different Kinds Of Sprouts On Soil Erosion

George H. Moody Middle School

The purpose of the experiment was to get data on which kind of sprout helps prevent erosion the most. The researcher's hypothesis was if different kinds of sprouts are planted, mustard sprouts will help prevent erosion the most. The researcher cut open the top of 2-liter bottles and planted sprouts in them with soil, then placed a cup underneath the spout of the bottle so the eroded soil would fall into there. The researcher watered the sprouts regularly. Then the researcher weighed the amount of soil in the cups. The results were that mustard sprouts had the least amount of eroded soil, and this data supports the hypothesis. In conclusion, different kinds of plants hold different amounts of soil, and the data supported the idea that ground cover plants prevent erosion. The researcher decided that for future experiments, more trials and a bigger variety of sprouts should be used.

Rashmi Adhikari- The Effect of Natural Filtration Materials on the Amount of Total Dissolved Solids of Contaminated Pond Water
George H. Moody Middle School

Nearly one billion people in the world lack access to clean water, most of whom are living in developing countries. Lack of clean water has been a problem in many places, leading to detrimental effects on health. The purpose of this experiment was to help people who do not have clean water near them and help them make clear water so they could survive. It was hypothesized that if charcoal powder, rocks, and sand were all used as different natural filtration materials, then charcoal powder would result in the smallest amount of total dissolved solids, which it did. Filtration is the method of separating solids from liquids or gasses bypassing the fluid but not the solid through a filter media. Empty water bottles with the ends cut off and cheesecloth covering the spout of the bottle was filled with sand, rocks, and activated charcoal powder. Measure 3.0 oz. of contaminated water and pour it into the filters. Then record the TDS, and do it again 6 more times, changing each bottle each trial. The means of the number of TDS were 223 ppm (Rocks), 253 ppm (Sand), 192 ppm (Charcoal Powder), 265 ppm (No Filtration Material). It was observed that utilizing activated charcoal powder resulted in the least amount of TDS (total dissolved solids) which meant it resulted in safer, more drinkable water. Activated charcoal worked because it is carbon-based and took away all the other carbon-based pollutants and the cheesecloth took the chunks of dirt away. The most important thing to improve this project would be different filtration methods and materials that could be used to take this experiment further. To conclude, the activated charcoal powder had the least amount of TDS, and supported the hypothesis, leading to the idea that activated charcoal powder can lead to safer drinking water.

Rosalind Van Reken- The Effect of Meal Acquisition on Carbon Footprint
Dorothy Hamm Middle School

This project focused one the effect of meal acquisition on carbon footprint, or, how the way a meal is acquired affects the amount of carbon dioxide that meal takes to make. In

the past decade, the environment, particularly the effect humans have on it, has been an increasing concern. As of now, it is rather simple to find information on how means of transportation, electricity usage, and how much water one uses affects the environment, but when it comes to the way we get our meals, something equally common, there is not so much information. It was hypothesized that a meal cooked at home would have a lower carbon footprint because residential appliances are lower-power compared to commercial ones. Three things were taken into account when calculating the carbon footprint, these being transportation, cooking, and reheating. Other potentially significant factors, namely storing the ingredients, were not included in the experiment for various reasons. The most prevalent being the complications in calculating how much power an appliance uses would go to the single meal in question, and what should be credited to the multitude of other items. The results supported the hypothesis, with home cooking releasing about 200 fewer grams of CO2. The biggest cause for uncertainty would be that time was not scaled for the higher heat/powered appliances used in commercial kitchens.

Sahasra Kancherla- Which natural water filter will work best on James River water
George H. Moody Middle School

Water is important, it is a necessity to living organisms. Yet too many people do not have immediate access to it and when they do a lot of the time it is not clean. Water has many components that can make it healthy, two of them are the Ph and nitrate levels. For water to be considered safe it has to be above a 7 on the Ph chart and around 5 to 10 ppm which is what is used to measure nitrate. The purpose of this project was to see which natural water filter would work the best. The experimenter specifically used water from the James river because tap water would be cleaner and it would show more progress. The experimenter hypothesized that the oysters would filter the water best, this was not correct. 32 cups of James River water were divided into 2 cups. The control was the water before any change. All of the variables were tested the same with the same amount of water from the same area of the river at the same temperature. All of the variables were tested 4 times each meaning there will be a sum of 16 trials in all. The only difference was the independent variable. The experimenter measured my data by taking in the ph and nitrate levels at the beginning of the process. At the end of the process of filtration, The experimenter did the same thing and recorded the difference in the dependent variable. The results the experimenter received were that for oysters the Ph level was 7.4 and the nitrate level was 40 ppm. The sand had Ph levels of 7.5 and in the terms of nitrate, it was 25 ppm. The wood charcoal had Ph levels of 7.1 and nitrate levels of 30 ppm. The coconut shell charcoal had Ph levels of 7.8 and nitrate levels of 40.

Zella Mantler- Testing Ventilation in a Middle School During the Era of COVID-19: The Impact of Natural Ventilation
Swanson Middle School

This study tested the effect of natural ventilation in a classroom on the average CO2 change per person over a 45 minute period in a middle school in Arlington, Virginia. The

hypothesis was that if the natural ventilation level in a classroom is higher, meaning more windows and doors are open, then there will be a lower average amount of CO2 change per person, after a 45 minute period, because there is more fresh air coming into the classroom, and that will flush out exhaled breath that would otherwise be building up in the room. The results of the study showed that the hypothesis was accurate: the average CO2 change per person, when there was maximum natural ventilation (three windows and the door were open) was a -0.72 parts per million (ppm) CO2 change per person, which meant all the CO2 being added by the people in the room was being removed. But the results were different when there was no extra natural ventilation. The average CO2 change per person, when no windows or doors were open, was 35 times higher a +24.49 ppm change per person. The results indicate that opening windows and doors increases air flow in a typical classroom and can reduce the amount of exhaled CO2 in the room. CO2 levels can be used to indicate the risk of breathing in viruses like SARS-CoV-2 in the air, so this study strengthens the evidence for opening doors and windows where possible to reduce the risk of transmission.

Zoe Schroeder- The Effect the Color of Paint Has on Insulation
Kenmore Middle School

The goal of this project was to find the effect of the color of paint or sealant on the insulation of a house. The experiment was executed by first painting asphalt shingles. The next steps consisted of using a lamp to represent the heat of the sun and recording the temperatures every fifteen minutes for an hour and a half. This showed how the house would heat up and if the temperature stayed consistent. The hypothesis was that if black paint is on the asphalt shingle, then the temperature will be the highest because black absorbs the most heat. This hypothesis was supported. The house with the shingles painted black had the highest temperature inside the house in all trials. The temperature was 24.4¬∞C. Other data from this experiment is that the highest average temperature from all houses was 22.5 degrees Celsius. The black shingled house reached that temperature and was the only house that reached 22.0¬∞C at all as an average. The coating and color on a person's roof can cost or save them money and resources. The data shows, darker coating or color on a roof of a person's house will determine the costs for heating and cooling. Darker roofs will require more cost and energy resources, while the lighter coating and color will cost less and use less energy resources. The objectives for this experiment were met, the best color to paint a house or the best sealant to use depending on what temperature someone wants the house's internal temperature to be found.

Engineering & Technology

First Place
Tess Vithoulkas- The Effect of Different Condenser Materials on the Production of Water with a Solar Still

George H. Moody Middle School

Living things need water to survive; however, many people in different places in the world have difficulty finding clean water. Most of the Earth's water is found in its oceans, but the salty solution cannot be used for drinking. Humans can purify ocean water for drinking through distillation using a solar still. The water in the still is evaporated by the sun's energy, which causes it to rise to a condenser plate and roll into a collection container as clean, drinkable water. The purpose of this experiment was to determine which condenser material produced the most water in a twelve-hour period. Based on research showing that a glass condenser had less surface adhesion and more output than plastic condensers, the hypothesis was if a single pane glass condenser is used, then the most amount of water will be distilled. Three different commercially available condenser materials were selected as the independent variable: single pane glass, acrylic, and polycarbonate. A tray filled with 200 mL of water was placed inside the solar still, and different types of condenser materials were tested. A lamp was used to simulate the sun. Five trials for each material were conducted, each lasting twelve hours. The results from the experiment indicated that glass produced the most distilled water with a mean of 41.49 g, while polycarbonate produced 23.85 g, and acrylic produced the least with 18.18 g. A one-way ANOVA test was performed on the data to test whether the means of the data were statistically different. The f-value was 6.905, the f-critical was 3.885, and the p-value was 0.010, indicating that the means were different. Following the ANOVA test, a Tukey's HSD test was performed on the data to decide which materials were different from each other. The results confirmed that the mean distilled water of the glass condenser was different from the mean distilled water of polycarbonate and acrylic. Thus, the results supported the hypothesis that glass would produce the most water.

Second Place
Aditya Sunilkumar- The Effect of Tire Surface Temperature on Tire Performance
George H. Moody Middle School

Formula One cars are high-end vehicles that go at impressive speeds. Every aspect of this racing machine allows them to drive at such speeds, one of these aspects is the tire performance. The temperature has a big impact on every factor on the F1 car, but it affects the wheels especially. Depending on the temperature, the tire's performance can increase or decrease. The research conducted was to find the optimal tire temperature for the best tire performance and to see how tire temperature affected the tires. To complete the experiment, the experimenter created a robot to see how the temperature of the tire affected the braking distance and acceleration timings, which are the main factors of a tire's performance. The robot was put on a track and was tested 90 times with various temperatures using a heat gun or a freezer. The hypothesis, if a greater temperature is applied to the surface of the tire, then the performance of the tire will increase was tested to be inconclusive. The results showed that if a greater temperature is added to a tire, the performance is indeed increased but after too much heat, the performance decreases. To conclude the research, the experimenter found that

tire temperature affects the performance of a car and that greater tire temperatures to a certain point can lead to heightened tire performance.

Third Place
Krish Gupta- Herbal Clay Based Water Filters
Swanson Middle School

Universal and equitable access to safe and affordable drinking water is a critical need to eradicate various diseases and significant suffering, especially in developing countries. Regular water filters rely on the principles of adsorption where dirt particles adhere to solid surfaces due to electrostatic charge and this in turn improves the quality of water. Through a previous project, it was demonstrated that herbal water filter were superior then regular filters in reducing common water contaminant such as nitrates. However, due to use of herbal powder the water clarity was negatively impacted. Vitrified clay has been increasingly utilized to improve the turbidity of water in developing countries as it has good adsorption qualities. In the current project the goal was to study whether locally available vitrified clay-based balls mixed with herbs can eliminate common water contaminants and also improve the turbidity of water. Two natural and widely available indigenous herbs (Azadirachta indica commonly known as 'Neem' and Ocimum tenuiflorum commonly known as 'Tulsi') were used in the experiments. Three filter groups were designed namely regular filter with no herbs as control group, herbal powder filter, and herbal clay-based filter. The results showed amongst the 3 groups herbal clay-based filtered water had the greatest reduction in levels of copper, lead, and nitrate in addition to maximum improvement in clarity of water sample likely due to unique adsorption properties and absence of loose powder particles, respectively. Also, Neem and Tulsi clay-based filters were superior to other filter types in removal of bacterial contaminants, possibly due to a slower flow rate. However, total dissolved solids (TDS) increased in this sub-type group over the control group likely due to some of the clay inadvertently dissolving in the filtered water. It was thus concluded that herbal clay-based water filters can be a viable and superior option over regular water filters to improve the quality of water in a cost-effective manner. Adequate safety precautions were taken for handling of materials and careful disposal of materials, upon completion of experiment including adult supervision.

Honorable Mention
Daniel Gabdullin- The Effect of the Size and Strength of a Magnet on its Magnetic Pull
George H. Moody Middle School

The experimenter decided to do an experiment on what affects the strength of a magnet more, they decided to do this because magnetic waste is very bad for the environment. The experimenter thinks that strength matters more. The experimenter needs to build a 1 foot track out of two pvc pipes and two pieces of wood for a frame, then place one of the magnets at one end and the marble on the other. The experimenter's hypothesis is that strength matters more than size. The experimenter found that their hypothesis was

supported by the experiment since the smaller but stronger magnet pulled it in from farther than the big but weak magnet.

Honorable Mention
Richard John- The Effect of the Height of the Bilge Keel on Time Required for a Sea Vessel to Stabilize
George H. Moody Middle School

Seakeeping is an important factor in determining the stability of fishing boats in Indonesia. The aspect of seakeeping that the project focused on was the bilge keel whether a taller bilge keel would result in better seakeeping for a sea vessel. The hypothesis was „Äú If the dimensions of the keel are the highest, then the number of seconds to stabilize will be the least.„Äù The experimenter gathered cardboard, hot glue, tape, scissors, and a box knife to construct the sea vessels. Next, the environment was prepared in a bathtub by filling it with about 64500ml of water. Then the vessels were placed on the water surface while being fasted with string and tape on two opposite sides. The tester then immediately started a stopwatch and waved four times in the vessel„Äôs front and four times at the vessel„Äôs left side of view. Once the vessel stabilized the tester immediately stopped the stopwatch and recorded the data in a notebook with a pencil. Finally, the recorded data was used to find the mean median and the standard deviation and make graphs using Microsoft Excel. The mean for the control, 1cm by 6cm by 8cm, and 1cm by 6cm by 11 cm were in descending order of 26.066, 19.7908, and 19.457 supposedly supporting the hypothesis. However, the 1 cm by 6cm by 14 cm bilge keel had a stabilization time mean of 23.456, longer than the means of the 1cm by 6cm by 8cm and the 1 cm by 6cm by 11cm. In conclusion, the data provided by the experiment does not support the hypothesis.

Honorable Mention
Shivank Murthy- Effect of external stacked magnet on the pitch that a DC motor makes
George H. Moody Middle School

One of the world's most influential and greatest modern inventions is the DC motor. It has inspired many scientists, inventors, and engineers to improve on the invention. Plus, many machines have DC motors built into them. The experimenter once watched a BrainPOP on Nikola Tesla, and it talked about DC motors and how AC motors were better and more efficient than DC motors. So it got him thinking about how DC motors work, and how you can increase the pitch. So he got a DC motor, and he attracted a magnet and the DC motor together. The frequency of the pitch of the DC motor increased. This has led the experimenter to believe that (hypothesis) if they attached 4 magnets to a DC motor, then the DC motor's noise frequency would increase the most(relative to 1, 2, & 3 stacked magnets), inducing a high pitch. The reason the tester was trying to find the change in frequency is that when something spinning and the frequency of their sound increases, it probably means it is spinning faster. So, in the experiment, the experimenter will run tests and will change the amount of stacked rare earth magnets (1-4). Factors of

the experiment that do not change are the battery type, motor type, app for measuring the frequency(audacity), type of magnet, and the area on the DC motor that magnets are attracted. Once the experimenter finished recording the frequencies, he calculated 28.75Hz as the average interval between the average frequencies for each stacked magnet number. An error that might have occurred through the testing is the battery supplying the electricity. Over time the source (battery) loses power and starts supplying less power to the load (DC motor). The research hypothesis of 4 stacked magnets increasing the frequency of the DC motor was correct because the higher the magnetic flux density the more it affected the frequency.

Abhinav Gitta- The Effect of Different Machine Learning Algorithms and Artificial Intelligence on the Accuracy of Facial Recognition Software
George H. Moody Middle School

The purpose of this experiment was to see which popular machine learning algorithm was the most accurate for facial recognition. Machine learning algorithms can be trained to identify faces using facial landmarks and measurements. Facial recognition is a field in technology that is rapidly becoming vital for everyday life. It has had the biggest impact on the sectors of law enforcement, security, and technology. In the experiment, 4 different machine learning algorithms were tested. These algorithms were DeepFace, created by Facebook, the Viola-Jones algorithm, Convolutional Neural Network (CNN), and Local Binary Pattern Histogram (LBPH). The code was written importing the respective algorithm and was tested on the same 10 images,
using a diverse range of frontal view faces. The accuracy of each algorithm was recorded and shown in a bar graph. The hypothesis was, If the Viola-Jones algorithm was used, then the accuracy of identifying faces in the frontal view would increase. There was no control variable.

Antonio Tripodi- The Effect of Different Kinds of Insulation on Temperature Inside of boxes
George H. Moody Middle School

There are many types of insulation used in houses. This study measured how well two types of insulation (Rockwool and rigid foam) hold heat. My hypothesis is that Rockwool insulation will hold heat the best because it is the most dense and it is a poor thermal conductor. The procedure of my experiment involved putting three boxes outside and taking the outdoor temperature and the box's temperature and recording what the change in temperature was for each type of insulation. Ten trials were conducted to get an accurate reading of the average change in temperature. The purpose of the experiment was to assess which was the best insulating material, Rockwool, rigid foam, or no insulation. The results were the average change in temperature for each box and the standard deviation. Both are shown in Table 1, located in the results section. All of the temperatures and averages are shown in the data Table 2 in the appendix. In conclusion, the evidence from the experiment supported the hypothesis that Rockwool would provide

the best insulation. However, the experiment may have had errors in the trials due to the temperature being taken at different times during the day.

Aryaman Rane- The Effect on Voltage from a Motor's Shaft Connected to a Generator's Shaft
George H. Moody Middle School

Motors are used so commonly around the world. The experimenter was interested in the idea of a perpetual motion design and wondered if that was possible or not or if it was possible to save energy in contrast to the modern motor design. The experimenter soon came up with the experimentation process where they attached a pulley to two motors shafts while only one is powered to and the other one is being used as a generator being spun by the spinning motor's shaft. The purpose of this experiment was to find out how much electricity is produced from connecting a motor's shaft and a generator's shaft together which will hopefully be the foundation of another experiment where if the experimenter can weld together a motor's shaft and a generator's shaft and have the motor run to produce electricity for the generator without any rotational losses. Their hypothesis was that if you were to put in X amount of electricity as an input, then you would get only 10% back as an output. They were wrong as when the experimenter tried it, at 100% RPM, the output voltage was around 50%.

Jackson George- The Effect of the Location of Weights on the Speed of a Pinewood Derby Car
George H. Moody Middle School

The purpose of this experiment was to determine the optimal placement of weights on a pinewood derby car in order to make the car as fast as possible. The hypothesis was that the center of gravity for a pinewood derby car should be approximately 2.2225 centimeters in front of the rear axle of the pinewood derby car. The procedure was to adjust the placement of the weights in three different setups on the same pinewood derby car and then time car as it was run down the track ten different times for each weight setup. The weights were shifted from a forward, middle, and back positions for the three different weight placement setups. The results proved the hypothesis to be correct, in that the weight placement that put the center of gravity closest to the rear axle yielded the shortest times down the track, with a difference of more than 22 centimeters down the 32 foot length of track between the fastest setup and the other two setups with the weights further forward and the center of gravity further from the rear axle. The conclusion was that the hypothesis was correct, and that the optimal weight placement for a pinewood derby car places the optimal center of gravity approximately 2.25 centimeters in front of the rear axle..

Kedar Kambhampaty- The Effect of Photo Size of the Accuracy of a Facial Detection Program

Williamsburg Middle School

This project explores the effect of photograph (photo) size on the accuracy of a facial detection program. In recent years, face detection and facial recognition technologies have become widely used, like in phones and cameras (Westbrook, 2020). Facial detection and recognition software can be accurate, but certain factors can lead to inaccurate results, like photo size, objects in photos, and environmental factors, to name a few (Marciniak et al., 2013). In this project, it was hypothesized that as photo size decreased, the accuracy of the facial detection program would also decrease because the program would not accurately detect faces in the smaller, less detailed photos. To conduct the experiment, a facial detection program was created and tested using the programming language. A collection of images focused on the head were
used in testing, each with copies at decreasing sizes. In testing, the program was run on the collection of photos at respective sizes, and the results showed that the accuracy of the program did not always decrease with photo size, only agreeing with the hypothesis for the middle to lower range of photo size. The lack of a clear trend indicates that a more extensive library of images may be required for testing, so that the increase in data points would potentially allow for a clear trend to emerge from testing.

Logan Krohl- The Effect of Water Filters on the Amount of Dirt Filtered
Kenmore Middle School

The purpose of this experiment is to find a way to use simple things in different ways like water filters. The goal of the project was to find the effect of water filters on the amount of dirt filtered. The way that I conducted this experiment was as follows: First add water into the big cup. Then put the dirt into the big cup and mix it together. After that pour a third of a cup into the half of the small cups. Then put 3 coffee filters over 3 small cups, 3 paper towels over 3 small cups and 3 pieces of fabric over 3 small cups. Then pour the one third cup of water that is in half the small cups into the filtered cups. Measure how much dirt the filter collected in each one. Record results. The results that I came up with after the experiments was that the fabric filtered on average 0.88 milliliters of dirt while both the paper towel and the coffee filter filtered 1.5 milliliters on average. This shows that the fabric was the worst material to use as a water filter. Paper towels and coffee filters were both the best option. I met all my objectives on this project, and this could contribute to efforts to filter water pollution.

Saicharan Valipireddy- The Effect of Different Weight Placements on the Speed of a Pinewood Derby Car
George H. Moody Middle School

Cars are designed with the sole purpose of being efficient and safe. However, the distribution of weight in cars could be adjusted for more safety and efficiency. Pinewood Derby cars are an easy way to simulate a real car. While they do not have the same functions and shape as a car, they have the same principals. The purpose of this

experiment was to test if the distribution of weight present now is the best one for the job. Is it possible that the current 50/50 distribution is slower and more unstable than having all the weight in the center of the car? The hypothesis was if the weight is in the front of the car, then it will have the fastest time. Five identical pinewood derby cars were bought, and a 1.5-meter track was bought. A three-ounce weight was placed in the front, middle, and back for each car. Two runs with each weight on each car were done totaling to 30 repeated trials. A recording was taken for each test and was timed in an editing software after. The cars with weight in the front had a mean time of 1.03 seconds. The middle ones had a mean time of 1.02 seconds, and the back ones had a mean time of 1.03 seconds. Based on the times in this experiment there is not a very significant difference in the weight placement. However, the cars with weight in the front and back did handle much worse than the ones with weight in the middle.

Yuvanth Mulpuru- The Effect of Different Types of Metallic Fabrics on the Reduction of EMF radiation
George H. Moody Middle School

EMF radiation can have harmful effects on human health, but there are many ways to decrease the quantity of the radiation (Health, 1996). If the emf radiation could be reduced many people could prosper off of the health benefits. Emf radiation creates a higher risk of cancer, and other health effects (Health, 1996). If the researcher covers the emf radiator in metallic fabric, then the amount of radiation will decrease. The experiment will be done with a cardboard box that has a circle in it. The emf radiator will be placed in the hole and the meter a few inches away from the emf radiator. Then the emf radiator will be enveloped the fabric. During the experiment the researcher observed the emf radiation going down when the metallic fabric was placed on it. The results show the dramatic decrease when the fabric is placed and the increase when it is removed. The idea of using very large metallic fabric as coating around highly radioactive materials could be viable. Elements like polonium have very high radioactivity and use something as another layer of protection against the highly radioactive material. The material can also be viable in other scenarios such as the reductions of other types of radiation such as gamma or x-rays.

Human Behavior

First Place
Sajeela Ahmad- The Effects of the Regularity of Playing Video Games on Reaction Times and Solving Simple Arithmetic Problems
Louise Benton Middle School

The objective of this research is to see if participants tested in this experiment, which met the standards as a child who plays video games regularly, had any positive change in

their reaction time (milliseconds), or in the number of correct arithmetic questions answered in 30 seconds. The hypothesis was: If an individual has played video games more regularly, then he/she will have faster reaction time, but equal arithmetic questions answered compared to those who don‚Äôt play video games regularly. Video games train an individual for fast reaction time but do not affect his/her arithmetic solving abilities. The regularity of the participant playing video games was the independent variable, and the two dependent variables were the participants' reaction time in milliseconds and the amount of correct arithmetic questions answered in 30 seconds. The planned procedure was to ask parents if their child(ren) could participate in this experiment. If the parent agreed and signed the shared consent form, they would share a suitable time for their child to take the experiment over a Zoom call. The zoom call kept the participants safe from any COVID-19 risks. The data was collected from the participants in an Excel sheet. The gamers were separated from the non-gamers by asking the participants if they played video games one or more times a week and they were assigned Group 1. If the participants played less than once a week, they would be in Group 2. Since the children participating were from a large age group (8 to 13), they were split into ages 8-10 and 11-13, making the results of the arithmetic test fair for those who had less math experience. I had hypothesized that Group 1 would have faster reaction time since the games they played would give them practice, or muscle memory. What I also hypothesized, was that Group 1 would not have any better math skills than Group 2, since video games do not teach math. A key result of the experiment was that, in both age groups (8-10 and 11-13), Group 1 (the gamers) answered more correct arithmetic questions than Group 2 (the non-gamers). Also, the video games Group 1 played improved their reaction time, causing them to have faster reaction time than Group 2.

Second Place
Sesh Sudarshan- The Effect of Social Isolation on the Popularity of Home-based Hobbies and The Effect of Those Hobbies on Depression Levels During the COVID-19 Pandemic
Swanson Middle School

The COVID-19 pandemic created economic difficulties and social isolation that led to a rise in depression levels across the United States. In this study, I attempted to determine if there was a relationship between levels of depression and the degree of social isolation experienced by a population, as represented by time spent in mandatory lockdown and by cellular mobility patterns. I also tried to determine if depression levels caused by social isolation were mitigated by developing new hobbies. It was determined that the degree of social isolation experienced by people residing in different states correlated positively with their interest in home-based hobbies. In addition, I found that people residing in more socially isolated states reported significantly increased symptoms of anxiety and depression as compared to their counterparts, but only during the initial period of the lockdown. As the pandemic progressed, people in these states significantly decreased their levels of depression over the course of one year. Importantly, this decrease in long-term depression levels was found not to be due to changes in mobility or significant change in access to mental health care. Therefore, it is proposed that, among other

things, hobbies developed early in the pandemic had a mitigating effect on depression levels caused by the COVID-19 pandemic.

Mathematics: Patterns & Relationships

First Place
William Lin- Simulating a Vaccinated Population Against COVID-19 Using Javascript
George H. Moody Middle School

COVID-19 ravaged the entire world starting in late 2019. In early 2020, the Pfizer-Biotech vaccine was first introduced on human test subjects. Later testing showed that vaccines could reduce transmission of COVID-19. The purpose of this experiment was to test which level of vaccination is most effective in saving people from being hospitalized or dying. The hypothesis was if a 100% vaccinated population is exposed to COVID-19, it will have less hospitalizations or deaths than a 0% vaccinated population. The simulation will be used by a program made specifically for this experiment. A text box allows the user to enter different vaccination levels than results will be displayed in the console. When the experiment was completed, results showed that the median of 5 trials in a 0% vaccinated population had 25,000 more deaths and 230,000 more hospitalizations than a 100% vaccinated population. The hypothesis is supported by the results. Higher vaccination rates resulted in fewer deaths and hospitalizations.

Second Place
Patrick Jiminez- The Effect of the Coronavirus Pandemic on the Financial Success of major Companies and Corporations in the U.S.
Gunston Middle School

The purpose of this experiment was to analyze the effect of the COVID-19 pandemic on the financial success of companies in the United States. The hypothesis was that since COVID-19 restrictions forced people to stay inside and avoid crowds, then goods or services that called for face to face interaction would not profit, and companies that could not find alternatives would suffer. To test this hypothesis, the researcher used the historical data in Yahoo! Finance to record the daily number of stock shares for three companies (Yum! Brands, Darden Restaurants, and The Walt Disney Company) as well as The Dow Jones Industrial Average from February 20, 2020 to January 8, 2021. The data in this experiment shows that on average, The Dow Jones Industrial Average had the highest percentage of shares over the course of the time period, with Disney close behind. Disney and Darden have the largest ranges, but whereas Darden‚Äôs high range is due to it performing extremely poorly and having the lowest mean percentage, Disney‚Äôs is due to a brief dip followed by a large increase that finished it out with the highest percentage of shares. After conducting this experiment, the researcher concluded that when faced with a pandemic environment it is best for a company to find more virtual

and contact free services to offer, as this will appeal to people‚Äôs desire for security, and make them more willing to purchase said product. This experiment could be improved by adding more companies, and therefore more variety.

Third Place
Henry Stievater- The Effect of Air Pollution on COVID-19 Spread
Swanson Middle School

The purpose of this project is to determine the effect of air pollution, specifically fine particulate matter (PM2.5) and nitrogen dioxide (NO2), on the spread of COVID-19. The independent variables are PM2.5 (Œºg/m3) and NO2 (parts-per-billion), and the dependent variable is new COVID-19 cases per 100,000 people. The hypothesis is that if air pollution concentrations are increased, new coronavirus cases will increase. The null hypothesis is that air pollution will have no effect on COVID-19 spread. To conduct this experiment, I collected air quality data from the Environmental Protection Agency (EPA) and COVID-19 data from Johns Hopkins University. I combined them in a Python program created for this purpose, and used the Python library Numpy to do statistical functions on the data. I found a positive correlation between both NO2 and PM2.5 and new COVID-19 cases per 100,000 people. Across the whole United States for all 2020 and 2021 data, the standard error was less than the magnitude of the slope for both PM2.5 and NO2, meaning that the correlation was statistically significant, so the null hypothesis is rejected. Because the correlation matches the hypothesis, the hypothesis is accepted. One explanation for the results is that air pollution causes more severe infection, via the introduction of comorbidities or by weakening the immune system. A more severe infection can then cause more spread. Another explanation is that air pollution can cause the over expression of the ACE-2 receptors in the lungs, which are what SARS-Cov-2 binds to. That means that infection could be more likely after exposure to air pollution. An extension to this project would be to look at other forms of air pollution, such as coarse particulate matter, carbon monoxide, ozone, or sulfur dioxide.

Honorable Mention
Aishwarya Kapila- The Effect of Different Water Impurities on Surface Tension
George H. Moody Middle School

Surface tension is important because it keeps the natural waters controlled. Without it, rain drops wouldn't be drops, bubbles wouldn't be formed, and insects wouldn't be able to take the breaks on the above on the surface for the water hopping around. The scientist wants to improve the properties of surface tension to unlock and understand more about water. The scientist also supposes that it would improve and construct a better life for aquatic animals and make a greater impact on outdoor life. They believe that, if higher impurities are added, then the surface tension will enhance. With a step by step process of exchanging different impurities in water and calculating the surface tension using the method PHGA divided by two, the scientist identified the greater impact of adding certain impurities to escalate the surface tension of the water. In favor of the scientist's

hypothesis, conducting the experiment showed that sugar and salt mixed with water do increase the surface tension. Though, it also showed that the overall surface tension of the soil water mixture is less than the control which is the surface tension of regular water. This is in view of the fact that the surface tension of soil water is less than that of pure water (Tschapek, 2006).

Honorable Mention
Devesh Stansbury- The Effect of Food Insecurity on High School Graduation Rates Before and During the Pandemic
Dorothy Hamm Middle School

Food insecurity is a major currently operative issue. Even though food insecurity is more prominent in third-world countries, many American citizens are also affected by food insecurity. This analysis was conducted to see if there is any correlation between food insecurity rates and high school graduation rates in 20 different states before and during the pandemic. The initial hypothesis was that if the rates of food insecurity are higher, then the high school graduation rates would be lower. This is because not having a stable food source would make it hard to study at home or stay focused during school. The data was gathered from several sources, and then the information was compiled in a spreadsheet. The data was analyzed to see if there was a correlation between food insecurity and graduation rates. These sources were the National Education Statistics and Feeding America. With the rise in unemployment due to the pandemic, the rates of food insecurity increased to over 60% from 2019 to 2021. At the same time, graduation rates stayed the same. It turned out even with these numbers, the rates of food insecurity did not affect the rates of high school graduation at all. This could be because of the expectations being significantly lower during the online setting or free lunches being provided for students regardless of their situation.

Honorable Mention
Emma Ackleson- The Game of Science
Swanson Middle School

This project was to find out if by changing a baseball's composition, would the exit velocity change. So I looked at data from two seasons of Major League Baseball. In between those two seasons they changed the baseball being played with and the home runs and overall hits went up. What I wanted to find out, and teach you all about today is the importance of density of exit velocity, specifically in baseball. How when the least dense ball gets hit, it will have a higher exit velocity, opposed to a ball that is more dense. After completing this experiment I found that for all three teams, the New York Yankees, Boston Red Sox, and the Houston Astros (MLB, nd), the exit velocity increased.

Physical Science & Astronomy - A

First Place
Essam Shah- The Effect of Different Forms of Insulation on Internal Heat Conservation
George H. Moody Middle School

Insulators resist the transfer of heat, whether the heat is escaping or entering, it will take a long time to do so. Therefore, an insulator will have a grand effect on the temperature contained within an insulated box, as without the insulator, the temperature in the box would be extremely low. The purpose of the experiment was to further investigate the mechanics of thermal energy and to reveal the optimum insulator out of four materials. It was theorized that if a cardboard box was insulated with styrofoam, the temperature within the box would change the least. For heat to pass through styrofoam, it must travel between the miniscule gaps between thousands of tiny air bubbles, which is an extremely slow process. In the experiment, the tested insulation materials, rubber, cotton, styrofoam, and polystyrene were positioned between the gap between a small and a large box. The internal temperature of the box will begin at 21.11¬∞C. The tested insulator that sustains the highest temperature when taken out has conserved the most heat. A thermometer will be inserted into the smaller box, which would be measured nine-hundred seconds following the placement of it in a freezer remaining at -17.78¬∞C for all ten trials per insulator. Following the experiment, rubber, being an electrical insulator, had achieved a mean temperature of 18.55¬∞C, polystyrene, heavier than its slightly similar material, styrofoam, had sustained a mean of 17.17¬∞C, cotton, consisting of mostly cellulose, had a mean temperature of 16.39¬∞C, and styrofoam had a mean temperature of 15.56¬∞C. The hypothesis was unsupported, as styrofoam had been outperformed. An error in the experiment was the event that the top of the box was opened to read the thermometer, causing the outside heat to swarm in, increasing the thermometer's reading. If the experiment would have been redone, the thermometer would be read from outside the freezer and the box as opposed to physically opening it.

Second Place
Nathan Yellin- Baseball Physics: The relationship between arm speed and bat mass
Sabot at Stony Point

Tampering with the bat is a form of cheating in baseball. Players usually desire a lighter bat and will sometimes illegally hollow out the center of the barrel of the bat and fill it with a lighter material, most commonly cork. It is debated whether or not corked bats actually work (Adair, 2002). Corked bats are lighter than uncorked bats, which means it will not have as much mass which decreases the force going into the swing. Some players believe that a lighter bat gives them an advantage, especially since they do not have to change the size of the bat. Some ball players attempt to illegally lighten their bat through methods like corking a bat. In this experiment the batter alternated between swinging a bat with a mass of 719 grams and swinging a bat with a mass of 703 grams, a difference

of 16 grams. During this experiment, likely due to the resin added to the bat during the corking process, the corked bat turned out to be the variable with a greater mass. An Apple Watch 3 was worn by the batter and an app called Arm Speed tracked the highest velocity of each swing. The hypothesis was that the lighter bat would have a greater average arm velocity over the 49 trials. The hypothesis was supported because the lighter bat had a greater average arm velocity. There is low confidence in this data because human error is suspected. The human error suspected is a different amount of force acted upon the bat each swing.

Third Place
Anya Mathew- The effect of distance on the level of electromagnetic radiation
George H. Moody Middle School

Cell phones have evolved into a necessity in today's world. The technology has advanced faster than the scientists' capability to determine potential long-term consequences. Cell phones emit radio frequency (RF) signals within the non-ionizing section of the electromagnetic frequency (EMF) spectrum, which has been considered harmless. However, there have been recent concerns raised about the potentially harmful effects of cell phones on humans and additional research has been advised. The purpose of this project was to determine how distance from a cell phone would affect the received EMF radiation. It was presumed that EMF values, measured in microtesla (uT), would be higher when closer to a cell phone. In this experiment, the EMF emitted by the cell phone was recorded at distances of 10 mm, 20 mm, 30 mm, and 40 mm. The control group was the distance of 0 mm from the cell phone. The results indicated that the EMF radiation in the control group of 0 mm was the highest with a mean of 8.778 uT. The furthest distance of 40 mm was associated with the lowest amount of EMF radiation with a mean of 0.245 uT. The data supported the research hypothesis that if EMF radiation values were collected at increasing distances from a cell phone, then the furthest distance from the cell phone would have the lowest values. This showed that the level of EMF radiation was inversely related to distance. Given that EMF radiation values were higher when closer to the cell phone, there would be the potential for the body to absorb higher amounts of non-ionizing radiation with closer distances. Future research should be directed towards assessing the impact of the more recent 5G technology on EMF radiation and also to determine the EMF radiation emitted from constantly-worn devices such as smartwatches along with determining methods to decrease this radiation exposure.

Honorable Mention
Alisha Kapila- The Effect of Varied Insulators on Water Temperature
George H. Moody Middle School

Everyone needs a good insulator to keep their house cool in the summertime and warm in the cold winter times. Various insulators may be used to keep the heat out however, not all of these insulators may be budget-friendly. This experiment is performed due to this problem. In this experiment, various amounts of insulating materials will be used to

test how well they can keep the heat out of a box and not affect the water‚Äôs temperature in a glass cup. The hypothesis for this experiment was: If I use spray foam as my insulator against heat, then it will keep the house temperature down the best during hot and humid days. For this experiment, four homemade materials were being tested. The 4 materials being tested were spray foam, aluminum foil, bubble wrap, and regular cardboard as the control. At the start of the experiment, a cup of cold water was measured in a glass cup so the cup wouldn‚Äôt affect the water change too much. When the temperature of the water was checked, it would be written down to ensure all the starting temperatures were the same, and then the glass was put into the cardboard box. Once it was in the box, it had to be sealed and kept next to a heater at 29.44 ¬∞C for 30 minutes. After that, the box was then opened and the temperature of the water was recorded to see the difference in temperature. When it was aluminum foil, bubble wrap, or spray foam, the inside of the box was coated with the independent variable separately. This process was repeated 5 times for each independent variable, resulting in 20 trials for all variables. The spray foam as the hypothesis suggested was most successful as it resulted in the lowest average temperature of all the variables.

Honorable Mention
Emma Cai- The Effect of the type of fabric wrapped around a Mason jar on the temperature of the water in the Mason jar after 20 minutes
Swanson Middle School

For this experiment, I tested a strip of cotton, polyester and denim fabric wrapped around a jar of hot water for twenty minutes and observed what the final temperature was. I did this so I could see which fabric would be the best thermal Insulator. The higher the ending temperature was, the better it could insulate because there was less heat loss. My hypothesis was that cotton fabric would insulate the best, because based on research, cotton could trap the most air, and would thus be the best insulator.
I had four of the same Mason jars and filled them with the same amount and temperature of water, then wrapped each fabric around one jar. I waited twenty minutes, then used a temperature probe to measure the temperatures for each jar. I had four IV levels, and did ten trials of each. After testing, I found out that cotton fabric insulated the best. Polyester fabric was the second best insulator, denim came next, and the control group of no fabric had the lowest average of ending temperatures.
I could have had more accurate data by keeping the same density and mass for each strip of fabric the same, but even when I found that the strip of cotton and polyester had a lower mass than the denim strip, it still justified my hypothesis and data, since a lower mass would most likely result in poor insulation. In conclusion, I learned that cotton fabric was the best insulator.

Honorable Mention
Kate Pietruszkiewicz- The Effect of Paper Type on Loss of Mass Experimented in the Drying Process of Wet Gloves
George H. Moody Middle School

The first drying machine was invented in 1892 by George T. Sampson as an alternative to slower techniques such as hang-drying. Efficiency is what made this ventilator-type dryer method so popular (Morris 2017). Now it is possible to dry an increased amount of clothes in a decreased amount of time. Still, when someone doesn't need a large load of clothes dried or there isn't a drying machine available, they have to turn back to alternative options. The purpose of this experiment was to determine the best material to dry out a soaked object, in this case, a glove. Three types of papers; coffee filters, newspapers, and paper towels, were tested to find the one that would absorb the most liquid. All paper materials are similar with a chemical composition of cellulose. Cellulose is simply glucose molecules linked together, and water's attraction to this organic element is what gives paper its absorbent qualities. Absorbency also depends on porosity and thickness, of which paper towels were thought to have the best combination (Purushotham 2016). The paper towel's thickness compared to the other materials combined with its extra air bubble space, led one to believe that if coffee filters, newspapers, paper towels, and no materials were used to absorb moisture from gloves, then paper towels would remove the most liquid mass and result in the driest glove. To test this hypothesis, a 10cm-by-10cm square of paper towel was cut and then rolled into a cylinder shape. After a glove was submerged to absorb the water, a rolled paper towel was inserted into each glove finger before leaving it to dry. The procedure was repeated for each of the independent variables. The mass of each glove tested was recorded before and after absorbing the water, and then again after the 12-hour drying period. These results indicated a mean mass loss of 30g when coffee filters were applied, 27g when newspaper was applied, and 26g when paper towels were applied. However, an Anova test differed, showing at 95% confidence that there was no significant difference between these discovered means. It was concluded that this insignificance was due to the tested materials's similar cellulosic makeup. This makeup gave coffee filters, newspapers, and paper towels similar permeabilities, which outweighed their significant differences in pore sizes.

Aelwen Seaver- What fruits hold the most voltage?
Swanson Middle School

Many people living in developing countries do not have access to a stable source of electricity. So, I wondered what type of citrus would give off the most electrical current, allowing these people to be able to charge their devices. When I lived in West Africa, there would be villages that had no source of electricity, but there would be lots of different fruit trees with fruit falling and rotting on the ground. I used four oranges and grapefruits, five lemons and limes, cut those up into fourths and halves, and hooked them up to copper wires, as a positive charge, and paperclips, as a negative charge. In my hypothesis, I stated that the lemons would give off the highest average amount of voltage, and my data supported that hypothesis. The lemons had an average voltage of 813.3 millivolts per lemon slice. The oranges had the least average voltage, with 785.7 millivolts per orange slice. The grapefruits had an average voltage of 796.8 millivolts per grapefruit slice, and the limes had an average voltage of 801.5 millivolts per lime slice. So the Lemon did the best on average out of the four fruits, with 813.3 millivolts per slice.

Anushri Ramesh- The Effect of Heating Methods on the Temperature of an Isolated Area
George H. Moody Middle School

Recent devastations with the pandemic have touched all of our hearts and opened up our minds to new cracks in society that include race, economy, and most importantly, environmental issues. One of the biggest contributors to the depletion of our ozone and carbon emissions are the many HVAC units that people use in their homes. Thankfully, due to new technological advancements, we have had the opportunity to come up with environment friendly units. And, that is exactly what this experiment, the effect of heating methods on the temperature of an isolated area, was testing to find the most efficient method that is eco-friendly. This experiment was conducted with the use of a storage container to create an isolated area. From there, a toaster was used to replicate an electric space heater, a heated blanket represented in-floor radiant heating, and ignited coconut shells took the place of a fireplace. Now, for hydronic heating, a system was created using hot water being circulated around the box using tubes and a manual water pump. Each variable was tested for 3 minutes, and the temperature was recorded using a fahrenheit thermometer. It was originally predicted that the in-floor radiant heating would have the largest increase in temperature because heat rises, and this method targets the lower portion giving an even spread of heat. From this experiment, it was clear that the electric space heater and fireplace actually had the most significant increase in temperature. It proved that resources aside from what we think of as the only source of heat can be used just as or even more efficiently. Especially when cost plays a factor, some of the eco-friendly options may be a better fit.

Dwani Suresh- Effect of Different Materials on the Number of decibels that are received
George H. Moody Middle School

Walls have been around for thousands of years. People have used many materials to fulfill their needs when it comes to what type of wall is needed. Drywalls for normal homes, buffalo skin for prairies, wood for forests, metal for factories are just some of the many ways different materials have been used to adapt. For this project, the purpose is to find which material is best for soundproof walls. The hypothesis that was provided for this experiment was, If three-millimeter metal is used to block the sound waves then it will be the most effective. This experiment started off with three different material boxes with the material of the same width. The control in this experiment is nothing, the sound is played with nothing to block it and then it is recorded. Then a noise level meter was turned on, on one device and on another a sound of 50 dB was playing. The device that was playing the sound was then placed inside the box and every one minute the number of decibels was received was written down. Once all the data was collected, I found the average of each set of trials. Then the data was placed into a table so that it can be easily read and a graph was made to show the differences between the outcomes in a simple version. Once finished with recording the data and analyzing the experimenter came up with the

conclusion that glass is the most effective material when trying to stop sound waves from escaping and wood is not very helpful because of the molecular particles not being tightly packed.

Jaimin Ujaria- The Effect of String Length on the Sleeping Time of a Yo-Yo
George H. Moody Middle School

A yo-yo is essentially a string wrapped around an axle attached to two wheels. It works like a pulley. As the yo-yo falls, it uses two types of mechanical energy: moving and rotating. When the yo-yo drops to the lowest it can reach and stay there for a long time, it is called a "sleeping" yo-yo. The yo-yo acts like a fishing rod when sleeping when the string is in the body of water, but the pulley is still rotating. The purpose of this project was to determine what string length (70 cm, 65 cm, and 60 cm) would make a yo-yo "sleep" the longest. Three yo-yos were acquired and their strings were cut to their corresponding length. Their "sleeping" times were tested for ten trials each. The data was collected using a stopwatch and recorded onto a table and a bar graph. The bar graph contains the average of each independent variable. The results indicated that a longer string length had a higher mean (9.9) than a shorter string length (8.8 and 8.3). An ANOVA test performed revealed that the means of the groups were significantly different. A Tukey HSD test was conducted to see which means were statistically different. Only the means of the 70 cm and 60 cm string lengths were different. The data supported the hypothesis that if the length of the string increases, then the "sleeping" time of a yo-yo increases. A direct association between the string length and "sleeping" time is seen throughout this experiment. Since there is more string for the yo-yo to roll down, it will have greater kinetic energy. This will increase the rotational energy of the yo-yo. Therefore, the "sleeping" time increases.

Physical Science & Astronomy - B

First Place
Soham Mishra- The Effect of Changing the Shape of a Chladni Plate on Chladni Patterns
George H. Moody Middle School

Sound is a longitudinal energy wave that travels through the medium of transmission as compressions and rarefactions. It is difficult to visualize sound, but an experiment that made it possible has been attributed to Ernst Chladni where he observed that strange patterns appeared on a medium like salt or sand on a metallic plate when certain frequencies were applied using a violin bow and the patterns repeated on the plate for the same frequency. The purpose of this experiment was to establish that the shapes of Chladni patterns formed were dependent on the shapes of the Chladni plates, provided the frequency remained constant. Since the patterns are a result of resonance, the

hypothesis is that if Chladni plates of different shapes are used, then different patterns would be produced for the same frequency. The procedure to validate the hypothesis involved the creation of a vibration generator with a metallic spindle attached to the armature of a speaker to which one could attach Chladni plates of different shapes (square, circle, rectangle, triangle, elliptic and hexagonal) made from the same material and connected to the spindle at the center. After the trials were completed, the results showed that the documented patterns found that were produced by a sine wave of the same frequency (345 Hz), found a direct correlation between the shape of the pattern produced and the shape of the plates, supporting the original hypothesis. The respective patterns formed can be viewed in the appendix section. The plates were made from the same material and the vibration was injected at the center of the plates. As a result of this experiment, one can conclude that the shape of the pattern formed for a given frequency depends on the geometric properties(shape) of the plate given other parameters remain constant.

Second Place
Shravan Madurantakam- The Effect of Launch Angle on the Distance Travelled by a Projectile
George H. Moody Middle School

The distance traveled by a projectile is a very important topic in sports or military. One of the most important factors that determines the distance traveled is the angle of launch. For example, in sports, to pass the ball to another player; in the military when using artillery or missiles. The purpose of conducting this scientific experiment is to determine the ideal launch angle for the desired distance. The hypothesis for this experiment was that the projectile would travel the farthest when launched at an angle of 45¬∞. To conduct this experiment, we loaded foam balls into an Atomic Popper gun and launched them at increments of 15¬∞ starting from 0¬∞ and ending at 90¬∞. The balls were launched accurately with the help of Stanley I-beam. Crayola Sidewalk chalk was used to mark where the ball landed. The distance was then written on a piece of paper and was then compiled into a spreadsheet. The result of this experiment indicated that the distance increased from 0¬∞ to 30¬∞; dipped down at 45¬∞, rose at 60¬∞ and then gradually decreased all the way to 90¬∞. The results of the experiment were that the best line of fit for this set of data was a polynomial one. The conclusion of the experiment is that the launch angle impacts the distance traveled by a projectile.

Third Place
Sebastian Monroy- The Effect of Nerf Gun Angle on Dart Distance
Dorothy Hamm Middle School

The purpose of this experiment was to find the optimal angle to shoot darts that reach the furthest distance possible. This project was chosen because Nerf guns are a popular toy and players want the best shooting angle to achieve the longest distance. It was hypothesized that if the darts were shot from the Nerf gun at 45 degrees, then the darts

would travel the furthest, because the dart would be exactly between 0 and 90 degrees, achieving enough height to stay in the air long enough, and enough thrust to move the furthest.

Projectile motion is the movement of an object thrown or projected, and in this experiment, the darts were the projectiles. This experiment found where the darts hit at different angles and analyzed the results to find what the best angle was to shoot at to achieve the furthest distance. The experiment was held at a local tennis court at a size large enough that the darts wouldn‚Äôt be limited in space during the trials. The shooting apparatus was made using a car jack and the Nerf gun, using the jack handle to change the shooting angle for the darts.

After conducting this experiment, the collected data supported the hypothesis. The darts achieved a maximum distance at 45 degrees. The average distance for 45 degrees was 22.1m. Overall, the darts traveled farther the closer the shooting angle was to 45, and traveled the furthest at 45 degrees. If this experiment were to be conducted again, the test site would have been changed, since the wind increased the darts' resistance. A location without much wind would have provided more accurate results.

Honorable Mention
Neha Kurup- The Effect of Different SPF Levels of Sunscreen on Harmful UV Radiation From Sunlight
George H. Moody Middle School

UV rays can be very harmful to the skin, and wearing the correct SPF level of sunscreen can reduce the risks of these harmful rays. The hypothesis being tested was, if the sunscreen has a greater SPF level, then it will be more effective at blocking harmful UV radiation from the sun. To test which SPF level is the most effective, the experimenter compares sunscreens with different levels of SPF to test their UV index reduction using a UV index monitor. The greatest mean of UV index reduction was from 70 SPF (6.1), while 30 SPF had the lowest mean (4.1). The average amount of UV reduction for 45 SPF was 4.7, compared to 5.15 for 55 SPF. In favor of the researchers hypothesis, the sunscreen with the greatest SPF (70), had the greatest UV index reduction. To conclude, applying sunscreen with the appropriate SPF level and reapplying it as instructed can help protect the skin from skin cancer and other skin issues.

Honorable Mention
Riyaan Gopalakrishnan- The Effect of a Car Design on Impact Forces on a Passenger
George H. Moody Middle School

The invention of the car has excelled urban transportation to the next level, allowing quick and easy travel. But unfortunately, every year in the U.S an estimated 38,000 lives are lost due to car accidents. To counter this dilemma, an experiment was arranged dedicated to identifying which design of a car was the most protective. Research guided the experimenter to form the hypothesis and the best method of testing. The hypothesis concluded (based on certified articles) was as follows: if the crumple zone crumples the

full distance of the original length, then the impact force affecting upon the egg will be lower, thus making the chance of the egg's survival higher. The best way to complete this project was discovered by a previous experiment conducted by the Ardent Teacher. They tested the safety by using a ramp and crashing their cars into a wall. Using this similar idea, after building their cars, the experimenter put their track on their stairwell, allowing the cars to achieve a great velocity and a place to crash into. After every trial where a car crashed, the experimenter would record the force applied and health of the passenger (egg). The health and force applied to the passenger mainly depended on the strength of the cars, and not as much on the crumple zone. This was proven as the strongest car had an astonishing 100% survival rate and the lowest amount of average force, 175.48 Newtons. The weakest car directed an average of 249.07 Newtons and allowed two deaths (cracked eggs). This experiment identified the best design for a car in order to protect its passengers. A mixture of strength and the ability to crumple was the most ideal design. This design should be implemented into any future car to increase the chance of survival in a car crash.

Honorable Mention
Weston Montpetit- The Effect of the PSI of a Soccer Ball On the Distance Traveled When Rolled Down a Slope
Sabot at Stony Point

In the sport of soccer, players and coaches work to improve their gameplay and one method for improvement relates to the optimization of equipment such as the soccer ball. The purpose of this study was to evaluate the effect of pressure, measured in PSI, of a soccer ball on the distance it travels when rolled down a slope. The hypothesis was if a soccer ball has a higher pressure, measured in PSI, then it will travel further than a soccer ball with a lower PSI. This study applied an experimental design with one independent variable, PSI, with six levels (8.6 PSI, 7.6 PSI, 6.6 PSI, 5.6 PSI, 4.6 PSI and 3.6 PSI). The experimental conditions included releasing a soccer ball down a wood ramp at 5 degrees and rolled onto carpet indoors. The experiment was conducted 10 times per PSI level and the dependent variable was distance traveled as measured in inches. Data were averaged and analyzed for variance. These data show that 8.6 and 3.6 PSI had the farthest distance traveled and 7.6 and 6.6 had the least distance traveled of the six PSI levels. When comparing the highest and lowest average distance traveled (3.6 PSI vs. 7.6 PSI) there was a 20.95 inch difference. When comparing the average distance traveled of the highest and lowest PSI levels (8.6 PSI vs 3.6 PSI) there was a 2.65 inch difference. The hypothesis that a higher PSI level will result in a greater distance traveled was rejected. If this study was applied to soccer, a player can be quite confident that the PSI of a soccer ball likely has minimal effect on distance traveled.

Pranav Sundarrajan- The Effect of the Type of Vegetable on the Amount of Electricity Produced
George H. Moody Middle School

Fruits/vegetables surprisingly, are strongly interconnected with electricity primarily because their ionic solutions allow them to be effective sources in an electrical circuit. The positive and negative electrodes allow the fruit/vegetable to efficiently transport the electrons from the negative to the positive terminals. The experimenter conducted the below investigation to determine the vegetable that produces the most electricity. My hypothesis states, if orange is
used, then the highest voltage will be generated, as it is the juiciest fruit which would contain the most electrolytes and ionic solutions to supply electrons. This will lead to effective transport of electrons in the circuit. To conduct this investigation, the experimenter gathered five of each of the following vegetables: potato, lemon, orange, eggplant, cucumber, and onion, along with a 1.5v battery as the control group. After that, the experimenter wired the fruits & vegetables into a circuit and determined the number of vegetables required to illuminate the LED. As an extension, the experimenter also gathered a boiled, a room-temperature, and a frozen potato, and then measured the voltage to determine which of the three produced the highest voltage. While the mean value for the control group was one, the averages for the independent variables were 2, 2, 3, 3, 3, 4. Potato and lemon both generated the highest estimated voltage while onion produced the lowest estimated voltage. The data and statistical analyses did not support the hypothesis, if orange is used, then the highest voltage will be generated, as it is the juiciest fruit which would contain various ionic solutions to conduct electricity. Before the above results can be concluded, further studies in real-life scale must be investigated to validate them.

Prithvi Chakraborty- The effect of temperature on cosmological inflation
George H. Moody Middle School

The purpose of this experiment is to determine if temperature affects the cosmological inflation of footballs. The researcher's hypothesis is that If a ball is placed into a colder environment, then its pressure/inflation will decrease itself. For each temperature environment, place the football into the environment for 1 hour, measure the psi, and inflate for a total of 10 trials. The mean psi for the freezer level of the independent variable was 6.07 psi, the refrigerator level was 7.13 psi, the room temperature level was 7.94 psi, and the heating blanket level was 9.18 psi.In conclusion, through this experiment, it can be told that various temperature environments affect the PSI of footballs, proving the ideal gas law and claiming that the colder environment of the deflate-gate game caused PSI reduction of the footballs rather than human action.

Thomas Gupton- The heat absorption abilitys of Oak vs Polished Cedar
Sabot at Stony Point

Styrofoam and other common insulation materials are not biodegradable materials, wood might be the second best option. Wood has a layer of fiber that blocks heat when trees are absorbing solar energy and nutrients. This material could be used in a new method of insulation: nanowood. Nanowood is made of fibers from trees (Pate, P., 2020). What

type of wood is the best for insulation like nanowood and does the color of the wood change the light/heat absorption of the fibers? Lighter colors usually absorb less heat because they reflect the energy versus absorbing it. The more colors an object's pigment has the more photons are absorbed and not reflected, and a darker color has more colors than a lighter object. The experiment was designed to see what type of wood would absorb the most heat produced by an incandescent infrared bulb. The types of wood used were Polished cedar and Oak. The surface temperatures were collected by a surface temperature thermometer.The hypothesis of this experiment was that oak, the lighter pigmented wood, would absorb less heat overtime. The results supported the hypothesis. The oak absorbed less heat.

Plant Science & Microbiology

First Place
Deepanshi Kumar- The Effect of Ginger (*Zingiber officinale*) as Fertilizer on Bean (*Phaseolus vulgaris*) Plant Height Growth
George H. Moody Middle School

Throughout history, ginger has been used immensely in medicine, trade, and cooking. However, in today's world, ginger is constantly thrown away and wasted. Ginger is a pungent rhizome that contains more than one hundred chemicals, the most important being gingerol. This study was conducted to understand the effect of cooked and uncooked ginger on height growth in bean plants, to discover if ginger could be reused for plants. The hypothesis was 1.25 mL of cooked ginger is applied to the kidney bean plant, then it will have the greatest growth in height. The procedure began with sprouting kidney bean plants in individual pots. Then, a certain amount of cooked or uncooked ginger, the independent variable, was placed on the soil. The growth in heights of each plant over the ten day experiment period was recorded in centimeters, which was the dependent variable. The results suggested that 0.6 mL of uncooked ginger was most beneficial to the bean plant's height, with a mean growth of 22.1 cm. The level with the least height growth was the plants with 0 mL of ginger, which had a mean of 18.4 cm. The ANOVA test resulted in a p-value of 0.75, which means there was not a significant difference in the results between the amounts of cooked and uncooked ginger. However, the mean value of the control was still notably lower than the other levels, which indicates that ginger is an effective fertilizer for plants. These results occurred because of the anti-microbial and antioxidant properties in ginger, as well as cell cycle regulation benefits in the potent composition of ginger. The research acquired in this study is certainly impactful for agriculture and the environment, in addition to household families. The data and results support the potential for ginger to be reused in a beneficial and sustainable way.

Second Place
Vedica Chudiwale- The Effect of the Amount of Nutrients on Plant Growth in a
Hydroponic Environment
Dorothy Hamm Middle School

Agriculture all around the world is affected by soil depletion. The purpose of this project
was to find a simple solution for growing plants by studying hydroponics. This experiment
tested whether the amount of additional nutrients added to the plant affects the amount
of plant growth. Using the process of growing plants in water instead of soil, widely
accessible household materials including strips of towel and soda bottles were used to
easily conduct the process. Through the created hydroponic devices, three different levels
of independent variables were used, with a total of nine spinach plants. They were
monitored until leaves were visible, and then carefully extracted from the growing medium
and measured from the root up. The mean of each type of plant was then collected and
the conclusion was formed. Rejecting the initial hypothesis, the plant with the most growth
was the plant with no added nutrients, with a total of 121 millimeters of plant growth. That
was followed by the plant with the double amount of nutrients recommended (69.0ml),
which grew 108 millimeters. The plant with the recommended amount of nutrients, which
was initially hypothesized to grow the most, only grew 97.67 millimeter, and 34.5ml of
liquid nutrients were added. This may have been because the plant had enough of the
other supplements needed to grow such as sunlight and water, and so it didn‚Äôt require
as many nutrients.

Third Place
Madeleine Sicat- The Effect of Distance From a Wi-Fi Router on Pea Seed Weight and
Germination Percentage
George H. Moody Middle School

In 2013, a group of ninth grade students in Denmark conducted an experiment where
they placed a group of cress seeds in a room with Wi-Fi routers and another group of
seeds in a room without Wi-Fi routers. The cress seeds in the room with the Wi-Fi routers
died or exhibited stunted growth while the seeds in the room without the Wi-Fi router
thrived. This experiment and several others prompted the study of the negative effects of
Wi-Fi radiation. Some studies have suggested that the minimum safe distance for a
human away from a Wi-Fi router is around 4.572 m to 6.096 m. The purpose of this
experiment was to determine the effect of distance from a Wi-Fi router on pea seed weight
and germination percentage by experimenting with the following distances: 3 cm, 1 m, 2
m, 3 m, 4 m, and the control group located in a separate room far from the Wi-Fi router.
The hypothesis of this experiment was if pea seeds were germinated at different
distances from a Wi-Fi router, then the group furthest from the Wi-Fi router (Group F -
Control Group) would have the highest weight increase and highest germination
percentage. Five petri dishes with fifteen pea seeds each were placed next to each other
at each of the various distances from the Wi-Fi router and in a separate room away from
the Wi-Fi router, for a period of seven days after which the pea seed weight and
germination percentage were calculated. The experiment was conducted again for a total

of 10 samples at each distance and the control group, The results indicated all of the groups experienced a decrease in weight except for the group closest to the Wi-Fi router (Group A - 3 cm) which experienced a 1% increase and the group farthest from the Wi-Fi router (Group F - Control Group) which experienced an 18% increase. Germination percentage was fairly similar throughout all of the distances. The results of this study supported the conclusion that the Wi-Fi radiation from the Wi-Fi router caused all of the groups within four meters to experience a reduced growth rate in comparison to the control group.

Honorable Mention
Nilay Ravula- The Effect of Electromagnetic Fields on Bean Plant Growth
George H. Moody Middle School

Farming has been a prominent technique in the food industry for years in history. Scientists work everyday to improve techniques and develop technology in order to provide for optimal growth of crops. The experiment will test the specific utilization of electromagnetic fields with its effect on plant growth. The hypothesis presented in this experiment is that if the greatest strength of an electromagnetic field is developed, the level of radish plants will develop to the highest. This experiment began with the organization of 40 cups, 10 cups arranged in an oval surrounding each electromagnet. Each of the three electromagnet was created with the turning of copper wire around an iron nail, and it‚Äôs connection to a C sized battery. The strength varies depending on the copper wire‚Äôs turns around each iron nail, the levels being 10 turns, 20 turns and 30 turns. The control in the experiment was the plant group exposed to no electromagnet as a standard for comparison. After the one month period of experimentation, results were recorded using the greatest potentially accurate measurement with a ruler on the height of each plant. These results being an average of 18.75 cm for the greatest strength electromagnet, 12.85 cm for the second strongest, 8.9 cm for the last strongest and 3.95 cm for the control group. These results were calculated from measured trials and visually presented on data graphs. After analyzing results, it was concluded the plant growth increased as the strength of an electromagnetic field increased. This evidence supported the hypothesis presented. This data pattern most probably occurred due to the cryptochromes, a form of protein, in the plant body. These proteins react positively to the exposure of electricity and electromagnetic waves, therefore meaning the cryptochromes in the plants exposed to the greatest electromagnetic field were able to consume the stronger waves and create more energy for the plant.

Honorable Mention
Sara Moussavi- The Effect of Mask-wearing Duration on Bacterial Growth
Louise Benton Middle School

Face masks have been worn since the start of the COVID-19 pandemic. They have become a necessity and have become mandated in workplaces, schools, and common public areas. They are utilized to protect the spread of harmful pathogens including the

SARS-CoV-2, more commonly known as the Corona Virus. It is possible that wearing a face mask for an extended period may result in the accumulation of harmful bacteria on its surface. The purpose of this experiment was to see how much bacteria would grow on a blue surgical face mask after three to six hours. The hypothesis was that if a face mask is worn for a longer duration of time (six hours), then there will be more bacterial growth on the mask. The same surgical masks were worn at different times throughout the experiment to determine the number of bacterial colonies grown at zero hours, three hours, and six hours. A cotton applicator was used to swab the inner surface of the masks onto an agar plate. This process was repeated for a total of five trials. The results show that the longer a mask is worn, the number of bacterial colonies increases. After three hours, all the masks showed a significant growth of bacteria. By the time the mask was worn for a total of six hours, most of the masks were covered in bacterial colonies with some that were too numerous to count. In summary, because of the significant increase of bacteria on a mask over time, face masks should be changed regularly during the day to reduce bacterial growth.

Honorable Mention
Yan Angela Yu- What is the effect of sugar on active dry yeast?
George H. Moody Middle School

Yeast, a microorganism, has been used for many years because of the fermentation it produces after consuming sugar. The purpose of this experiment was to find out how much yeast reacted to certain types of sugar so that the experimenter can help others control their yeast fermentation. With the many existing uses of yeast, the experimenter hoped that this knowledge would help further the uses of yeast in our society. The hypothesis for this experiment was, If the experimenter used different types of sugar to activate yeast and then used the yeast in bread, then the yeast that was activated with maltose would produce the highest rising bread. To test out the hypothesis, the experimenter used yeast in one of its most common uses, baking, to see which type of sugar would activate the most yeast fermentation. They used the sugar and yeast to bake dinner rolls so that the experimenter would have some type of measurable results to compare the amounts of yeast fermentation. The results from each trial for every independent variable and the control group were averaged into mean, median, and mode. The mean for each independent variable was 5.3 cm (control group), 5.68 cm (glucose), 5.87 cm (fructose), 4.27 cm (sucrose), and 5.92 cm (maltose). The median for each group was 5.3 cm (control group), 5.7 cm (glucose), 5.9 cm (fructose), 4.25 cm (sucrose), and 5.95 cm (maltose). In conclusion, the research hypothesis was supported because maltose did indeed create the highest rising bread. Since carbon dioxide is what makes bread rise, the more carbon dioxide produced the higher the resulting bread. The more carbon dioxide produced means the more fermentation the yeast went through, so the higher the bread the more yeast fermentation happened. Therefore, the maltose caused the yeast to go through the most fermentation.

Aahana Sikka- The Effect of Temperature on Fruit Decomposition
George H. Moody Middle School

245 million metric tons of fruit is bought every year. Meaning, 245 million metric tons of fruit is stored every year. (Statista, 25 Feb. 2022.) Although, if stored in the wrong temperature, the fruit tends to decay, or rot. To figure out which temperatures are the best to keep produce in, the researcher used equipment that helped maintain temperatures. It was predicted that the colder the temperature, the longer it'll take for the fruit to rot. To test this, the researcher recorded how long it takes for a strawberry to rot at a certain temperature. After the ten trials of different temperatures, the researcher came to the conclusion that when the temperatures were lower, the strawberries decomposed slower.

Alice Torrico- The effect of the drying time of hand sanitizer in a school setting
George H. Moody Middle School

The drying time of hand sanitizer is extremely important as it ensures whether or not the sanitizer has had enough time to kill the bacteria on one's hands. This data is supported by an experiment done by Hamilton Health Sciences, where they tested the effectiveness of washing hands. It showed that well washed but undried hands still have bacteria growth on them while on the other hand, well washed and dried hands show little to no bacteria growth. The purpose of this project was to see which drying time can most effectively kill germs on hands after coming into contact with commonly touched surfaces in a school setting. The hypothesis was if the hand sanitizer was dried for 60 seconds, then the most bacteria would be killed. The procedure of this experiment was gathering 10 participants to touch the same commonly touched surfaces in a school. The hands would then be swabbed and placed into a bag to be streaked onto a Petri dish later. Then, hand sanitizer was applied to the hands and was distributed on the gloves evenly for a total of 5 seconds. After 5 seconds, the hands would lay flat and wait for the drying time to pass. Once the drying time was reached, the hands were immediately swabbed and placed into a bag to be streaked onto a Petri dish. Once all 10 hands were swabbed, the swabs were taken to a lab and were streaked onto Petri dishes. The results showed that 120 seconds of drying time was the most successful in the killing of germs on the hands. 120 seconds of drying time had an average of 54 colonies killed, while 30 seconds showed an average of -68 colonies killed. 60 seconds showed an average of -180 colonies killed while 90 seconds showed an average of 28 colonies killed. This data does not support the hypothesis that 60 seconds of drying time of hand sanitizer would most effectively and efficiently kill bacteria. This experiment revealed how important drying time is in relation to hand sanitizer and the killing of germs.

Ameen Rahman- The Effect of Carbohydrate Structure on the Rate of Respiration in S. cerevisiae
Elizabeth Davis Middle School

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The purpose of the study was to examine how the respiration rate of S. cerevisiae varies depending on the type of carbohydrate available for metabolism. The independent variable of this study was the carbohydrate types, and the dependent variable was the rate of respiration in the S. cerevisiae, as measured by the volume of bubbles produced. The hypothesis formed was that maltose would have the highest rate of respiration due to its disaccharide structure. Three solutions of glucose, maltose and cellulose were prepared at a 5% concentration. The S. cerevisiae were added to 100ml of each solution and the volume of bubbles was measured over a 60-minute period. The control was not given a carbohydrate source, and there were three trials completed for every level of the independent variable and control group. The results of the study found that the rate of respiration for the glucose group was higher than the maltose group, and that the hypothesis was not supported. There was no significant difference between the cellulose group and the control. The findings of the study indicate that larger carbohydrates take more time to break down and utilize, resulting in a lower rate of respiration. A more thorough version of this study could have also included a larger variety of carbohydrates such as fructose or lactose. This study is significant because it provides insight about carbohydrate metabolism in eukaryotic cells and can be used to better understand cellular respiration in human cells.

Anshi Chowdhory- The Effect of Layering Versus Mixing on Composting Banana Peels
George H. Moody Middle School

Composting is a natural process of recycling organic materials or waste. Decomposition is the process of breaking down plants, animals, and insects when they die. That being out of all 30 trials and 3 subjects, layered, mixed and both, the best way to support the hypothesis would be that the method of layering compost effectively works best.

Bhama Unnithan- The Effect of Various Sound Waves on the Growth and Development of Plants
George H. Moody Middle School

The experiment was designed about the effects of varying degrees of sound on the growth of plants. The experimenter chose 3 levels of hertz to test out on the plants. There were 3 trials in total, for each of the 3 plants. 3 trials were chosen for a higher level of accuracy in determining the outlying factors. The project helped the experimenter to figure out the level of changes sound could make to the environment. The clear plastic containers helped contain the testing sounds and kept out any other outside sounds. The supplies used in the experiment were 9 pots, 9 seeds, water, soil, 3 plastic containers, and an electronic device. The experimenter used the electronic device to emit the required hertz. The experiment was spanned over a 3-week period and was measured over a one-week period. After the plants had reached a specific height, the measurements were taken to average. They hypothesis introduced was, if different levels of sound are conveyed upon a controlled environment, then the impact should be greater as the hertz level increases. The independent variable was the 3 different hertz levels, and the dependent variable

was the height of the plants after the experimentation. After the experimentation the results received were then averaged and submitted.   In conclusion, the hypothesis was correct, there was greater effect to the plants which were experimented on with higher sounds.   The plants exposed to lower, quieter sounds grew at a normal rate whereas the ones with the higher sounds grew slower and wilted much quicker.

Esperanza Piechowski- The Effect of Coffee Concentration on Lima Bean Plant Growth
Dorothy Hamm Middle School

This study measured the effect of coffee concentration in soil on plant growth. The purpose of this experiment was to see if coffee stunts or promotes the growth of plants. The original hypothesis was that the coffee concentration would stunt the plant growth because it interferes with the production of ATP in the plants, which affects their metabolism. French press coffee and Lima bean plants were used for this experiment. The levels of the independent variable were 0% coffee concentration (control, 10 ml water, 0 ml coffee), 25% (7.4 ml water, 2.6 ml coffee), 50% (5 ml water, 5 ml coffee), 75% (2.5 ml water, 7.5 tsps coffee), and 100% (0 ml water, 10 ml coffee). The plants were watered every day for a total period of 3 weeks, as growth was measured over 1 week for 3 trials. By the end of the experiment, plants did not grow according to the hypothesis, as plants with lesser percentages, and in the case of 100% coffee concentration, a larger concentration, did not grow as much. These results led the hypothesis to be rejected, as plants that were watered with a 75% coffee concentration ended up growing the most.

Eshwar Bejugam- The Effect of Water on Seed Germination
George H. Moody Middle School

Seed germination is a crucial element of growing plants and crops. Germinated seeds have already started growing and are able to easily transition into growing in a field or pot. However, the amount of water given to seeds needs to be precise and accurate as too much water will harm the seed and too little water will not allow the seed to germinate. As a result, gardeners needed to know how much water their seeds should be given to properly germinate without being harmed. This was the purpose of this experiment, finding the proper amount of water in which seeds can easily germinate without drowning. In the experiment, three levels of water were tested on a group of ten seeds, two tablespoons, three tablespoons, and four tablespoons of water, with no water being used as a control. A group of ten pinto bean seeds were placed in each water level and were left for a week to see which bowl would have the most germinated saplings. Through the experiment, the bowls were placed near a window to provide light, and a heater was turned on with gentle heat to keep the seeds warm as the experiment was conducted during winter. The hypothesis of the experiment predicted that the group with four tablespoons of water would yield the most germinated plants and was supported by the results of the experiment. At the conclusion of the experiment, the bowl with four tablespoons of water produced the most germinated seeds which also, after being observed, appeared to be healthier and stronger than the other groups. Although it may

seem like it, the amount of water is not directly in proportion to the number of seeds germinated as the two tablespoon group produced ten germinated seeds whereas the 3 tablespoon group yielded nine germinated seeds. Seed germination is affected by heat, light, and spacing of the seeds which may have affected the overall outcome of the experiment.

Nikolai Bukin- The Effect of Different types of water on the speed of growth of Cucumbers
George H. Moody Middle School

The reason for this experiment was to investigate a way to collect water safely and measure the impact of different water sources to the plant. By measuring plant growth, the researcher investigated how capable the water is in transporting these nutrients. Freshwater resources on planet Earth are severely limited. Today, rainwater is essential to sustain a healthy ecosystem. The project was researching the effects of three types of water sources including rain, pond, and tap water on plant growth over a short period of time and forming a hypothesis based on the results gathered from the experiment to better understand the effects of water sources in agriculture in the area.The hypothesis in this experiment is that the rainwater will prove to be the most efficient for the growth of healthy plants. The dependent variable in this experiment is growth of plants. The independent variable is the type of water used to water plants. The experiment included collecting materials, testing water sources, planting seeds, watering seeds, collecting data over time, and analyzing data. At the start of the experiment, the chemical analysis did not show any significant differences between the three water sources. The seeds that thrive off of rainwater, had sprouted the most, supporting the researchers hypothesis. The result of the experiment, collected after 31 days, has been summarized in several different charts. The average height of a plant watered by rainwater, resulted in being the tallest compared to the plants watered with tap and lake water, supporting the researchers hypothesis. In the research, the data showed that the rainwater proves to be most effective on the number of plants successfully sprouted. The researcher observed that the rainwater plants had the highest average sprouting rate and average height of the plant.

Sanika Kumar- The Effect Of Different Rising Agents On Non-Risen Dough
George H. Moody Middle School

In the introduction, the experimenter talked about how bread had been a key food in society and which rising agents could potentially work as well as yeast to see if there is any cheaper alternative for yeast that society can use to their advantage. The experimenter's hypothesis was that if the experimenter puts different rising agents into non-risen dough, yeast will make the dough rise the most. In the methods and materials, the experimenter showed how to conduct the experiment and measure the un-risen and risen dough. In the results, the experimenter talked about how yeast rose (on average) the most, with baking soda in second, baking powder in third, and the control (no rising

agent) in fourth. In the conclusion, the experimenter talked about how the results supported the experimenter's hypothesis and how someone could conduct the experiment again with more success.

High School Abstracts by Section

Botany - A

First Place
Mackenzie Cauthorn- Does Using the Sidedressing Method Increase the Growth and Yield of Corn?
Chesapeake Bay Governor's School

This experiment was aimed to investigate the effect of the sidedress method has on the growth and yield of corn. The sidedress method, is fertilizer application used by some farmers, where fertilizer is a liquid place in between the rows of the crop. In most cases it is spread by using a broadcaster which is a tractor that sprays it down, but in this study it was done with a hand pump spray. Fertilizers that contain Nitrogen, Phosphorus, and Potassium are commonly used to promote the growth of plants and increase the crop yield. However, doing the sidedress method can be costly and take a lot of labor in order for a small chance to the crop to reach a significant difference in yield compared to not sidedressing. In this study, there were a comparison of two different amounts of fertilizer, 60% and 30% along with the control of no application of sidedress fertilizer. There were nine total plots, each group having three plots. The corn was planted in March and data was collected from April to October. However, in result there was no significant difference with the yield since it had a p-value of 0.26. For growth it can be determined that the growth for both 60% and 30% was greater than the no application of sidedress fertilizer. The importance of this study is to inform agriculturist and farmers about the possible benefits from using the sidedress method. While the yield was no significant there are many factors like rain which can influence the corn of reaching its highest potential. The regular application of fertilizer before planting cost of $92.16 per acre. While the cost of sidedressing, 60% fertilizer cost $17.63 per acre while the 30% fertilizer costed $8.12 per acre. The corn was then sold at $5.25 bushels per acre.

Second Place
Katherine Cross, Sophia Schumaecker- Transient Genetic Transformation of *Cuscuta campestris* Using Arginine-functionalized Nanohydroxyapatites as a Plasmid Delivery Vector
Roanoke Valley Governor's School

Successful genetic silencing within certain varieties of parasitic plants has the potential to limit their destructive tendencies, doubling crop yields in certain sectors of the

agricultural industry. *Cuscuta campestris*, a holoparasite that has been observed to exchange mRNAs with other organisms via haustorial connections with its hosts, is notoriously difficult to genetically modify due to its robust cell walls. This study attempted to overcome this phenomenon by designing nanomaterials as gene transport vectors to bypass through such barriers. It was hypothesized that infiltration of arginine-functionalized nanohydroxyapatites appended to a reporter gene into C. campestris tissue would promote biocompatible transient transformation. During the experiment, transformation was attempted through the use of in-house synthesized nanohydroxyapatite rods (nHAs) with the reporter plasmid pMAS:GFP-35S:GUS appended through functionalization by positively charged arginine to create plasmid conjugate nHAs. Treatments used were plasmid nHA conjugates, plasmid without nanorods to test the efficacy of nHAs bypassing cellular barriers, agroinfiltration with the plasmid as a positive control, and 0.5% carboxylmethylcellouse solution utilized as a negative control. Using vacuum infiltration at -0.7 MPa, solutions were infiltrated into six-day old, germinated C. campestris seedlings, and were left to transform in a dark controlled environment for six days prior to GUS staining. During this period, plants were monitored for GFP expression, which was observed in the treatment group but in neither the positive nor negative control groups. GUS assays performed demonstrated minimal but still present GUS expression in the treatment group, suggesting its success with altered methods in future applications.

Third Place
Isla Wearmouth- The Effect of Aquaponic Farming, in Comparison to Irrigation and Hydroponic Farming, on the Height of Lettuce Seeds
Washington-Liberty High School

This experiment was designed to test the effectiveness of aquaponic farming on the height of lettuce seeds in comparison to irrigation and hydroponic methods. The increasing water scarcity in parts of the U.S. as well as globally is an important issue in agriculture, and aquaponics could potentially provide a solution. The hypothesis was: If the aquaponic farming method is used, then it will produce lettuce plants the same height as plants grown using irrigation or hydroponic methods because of the nitrates produced from ammonia in the fish water. Three separate agricultural experiments (aquaponics, hydroponics, irrigation (control)) were conducted and observed for 4 weeks. Lettuce plant growth was recorded. Hydroponics had the highest mean growth with an average height of 4.5cm compared to aquaponics with 2.5cm and irrigation with 0.8cm. The hypothesis was not supported because the lettuce plants grown using the hydroponic method grew significantly taller than the aquaponic group with a p-value of 0.03. However, the null hypothesis can be rejected because although the aquaponic method was less effective than the hydroponic method, it was significantly more effective than the irrigation (control) method with a p-value of 0.02. The t-test results between the hydroponic and irrigation (control) groups had an extremely significant p-value of 0.000004. A lack of germination in many of the seeds largely affected the data, and overall, the results of this experiment produced too much variation to draw a definitive conclusion. Nevertheless, this topic shows enough potential for future research.

Honorable Mention
Alba Edsall- The Effect of pH Level of Simulated Acid Rainwater on the Shoot Length of Soybeans
Washington-Liberty High School

The purpose of this experiment was to study the effect of pH level of simulated acid rainwater on the shoot length of soybeans (in cm) over a 10-day germination period. The hypothesis of this experiment was; if soybean plants are treated with simulated acid rainwater that have different pH levels, then those treated with rainwater that has a pH level of 6.0 over a ten-day-period will have the greatest average growth in shoot length because water having a pH range of 6.0-7.0 maximizes the nutrient availability and nitrogen fixation for the growth of soybeans. The hypothesis was not fully supported by the data because although the group of pH 6 had the highest average growth of 2.3, there was no statistical difference between the groups of pH 6 and pH 5. A t-test between pH 6 and pH 5 calculated a p value of 0.3667 which is greater than the critical value of 0.05. Additionally, an ANOVA test was calculated, and the p value was 9.021-21. The ANOVA test showed that the data was statistically significant, and the null hypothesis was rejected. The null hypothesis stated, if the soybean plants are treated with simulated acid rainwater that have different pH levels, there will be no difference in shoot length of the soybean plants between groups. The data showed that the groups of pH 5.0 and 6.0 had greater growth rates than the groups of 3.0 and 4.0. Further experimentation could include the effects of simulated acid rain on the yield of soybean seeds over a longer time period. This study is significant because many countries that are major soybean exporters such as Brazil have increased acid rain due to rapid industrialization and acid rain could potentially harm the agricultural economy. In order to prevent the negative effects of acid rain on plant growth, measures will have to be taken to decrease air pollution rates and consequences of industrialization.

Honorable Mention
Ciara Nauful- Comparing Effects of Auditory Environment on *Helianthus annuus*
Central Virginia Governor's School

The purpose of this research was to observe the effects of sound pollution related to urbanization on the growth of plants in order to identify proper environmental conditions. Two groups of plants were exposed to different types of environmental noise, traffic and nature, over a period of 22 days, receiving 25 mL of tap water every other weekday. Audio was played for eight hours a day, and data was collected twice a week during each trial period. Plant height was measured in centimeters, and seven data collections were done for both the experimental and control groups. Data was analyzed with two sample t-tests, a single factor ANOVA test, and a post-hoc Tukey test. The two sample t-tests allowed for the control groups accompanying both experiments to be combined, verifying that there was no significant difference between them. With a set .05 alpha value, the ANOVA test of all the groups revealed a p-value of .0225. A post-hoc Tukey test was used to

locate the difference within the data, with a significant difference being found between the traffic-exposed (10.913 cm) and nature-exposed (13.400 cm) groups as well as the traffic-exposed and combined control (12.457 cm) groups. These results supported the research hypothesis, which predicted greater growth in the nature-exposed group over the traffic-exposed group. Data collected within this experiment advises against exposing plants to an aggressive, high-traffic urban environment, suggesting that a quieter, natural environment is a more ideal habitat for plants.

Honorable Mention
Emma Hemsch- The Effect of Water Stress on the Rate of Transpiration of Pisum sativum
Washington-Liberty High School

The purpose of this experiment was to determine the effect of the frequency of watering on the rate of transpiration of a common North American garden plant as a model for increased drought-like conditions as a result of climate change. It was hypothesized that if groups of sugar snap peas (Pisum sativum) were given 30 mL of water every 3, 4, 5, and 7 days, then the plants watered every 3 days would have the highest rate of transpiration, because the plants not under water stress would have developed fewer adaptive features meant to slow the rate of transpiration. Some examples might be a thicker cuticle, less open stomata, and fewer aquaporin proteins in the root cells. The plants were grown from seeds for 10 days before their frequencies of watering were changed. After one month, the rates of transpiration were measured using potometers. The group of plants watered every 4 days had the highest rate of transpiration, at 0.084 cm/hour, and the group watered every 5 days had the lowest, at 0.015 cm/hour. These results did not support the research hypothesis. An ANOVA test showed that the results between groups were not significantly different, so the null hypothesis was accepted. The results of the experiment were inconclusive; however, the experimental design could be repurposed for further studies, with some changes such as increasing the days between watering and number of trials per group in order to achieve statistical significance.

Aayush Kulkarni- The Effect of Different Inorganic Nanoparticles on the Chlorophyll Content of Spinacia oleracea
Mills E. Godwin High School

Nutrient deficiency with plant production is a problem that can cause negative impacts on the health of consumers. Many areas around the world are unable to provide the necessary nutrients to plants, and inorganic nanoparticles are a potential solution to this issue. Inorganic nanoparticles are non-toxic, hydrophilic, biocompatible, and highly stable. The purpose of this experiment was to determine which inorganic nanoparticle was the most effective as a means in improving overall plant health. It was hypothesized that if the Zinc Oxide nanoparticles were applied to Spinacia oleracea (Spinach), then those plants would have the highest chlorophyll content. To measure the effectiveness of different inorganic nanoparticles, the spinach seeds were treated with four different types

of nanoparticles: no nanoparticles (control), Zinc Oxide nanoparticles, Titanium Dioxide nanoparticles, and Copper Oxide nanoparticles. After 4 weeks, a chlorophyll meter was used to measure the chlorophyll content (SPAD). It was found that the Zinc Oxide nanoparticles were most effective at increasing the chlorophyll content of the plants. An apron, goggles, and gloves were worn for safety and the experiment was completed in a controlled environment. All equipment was washed and disposed properly. The differences between the means of each group were statistically significant at a 0.001 level of significance. The effectiveness of the Zinc Oxide nanoparticles is likely due to its ability to biosynthesize the hormone auxin. A further study could be conducted to determine how the different sizes of the same type of nanoparticles can have varying effects on the plant's health.

Alexandra Nguyen- The Effect of Watering and Chemicals on Mint Health
Mills E. Godwin High School

The purpose of the experiment was to determine what watering and chemical conditions generate the healthiest mint. Uncovering the environment that promotes mint growth can benefit the mint industry, water use efficiency, marketability, and human health. The hypothesis that the mint under the tubing system and phosphorus condition would grow mint with the most stamina was rejected. Mints that received no chemicals through the pouring system were classified as the control. Twenty-five leaves from sixteen pots of mint, all grown in varying conditions, were harvested. The leaves were set out for three days in Ziploc bags then were observed on their health with the following rating scale: 1 as unhealthy, 2 as moderately healthy, and 3 as healthy. Additionally, the median ranking of each experimental group was recorded. Mint watered with phosphorus using the double pot system grew the healthiest mint, as its frequency distribution for rank 3 was 24. Chi-square tests were used, and when compared to expected distribution, five out of sixteen groups had a chi-square value greater than the table chi-square. This indicated that the data was not statistically significant and was most likely due to chance. The study of fertilizer and irrigation methods on plant growth is widely known and continuously studied. Possible errors during experimentation include the experiment timeframe and the amount of fertilizer the plants received. To further extend the research, the mint plant's dry weight could be measured to determine if mint development conditions affect other aspects of mint growth.

Ayush Pal- The Effect of Tactile Stimulation on the Chlorophyll Concentration of Morning Glories
Mills E. Godwin High School

The purpose of this experiment was to determine a significant relationship between tactile stimulation, and how healthy a morning glory vine is, which can be determined by its chlorophyll concentration. Results from the experiment could prove to be useful in finding optimal growing conditions for vines. A research hypothesis was derived that if the vine spends more time in contact with an object, its chlorophyll concentration will be greater,

signifying that it is healthier. Two groups of 25 morning glory vines were planted, with group A experiencing no contact, and group B in full contact, with group A being the control. The plants were observed for 30 days before having their leaves measured for their chlorophyll concentration. The measurements collected showed a significant difference between the two groups, with group B having an average concentration 0.0242 mg/cm^2 greater than group A. A t-test that was performed on the data confirmed the significance of the results to a degree of certainty greater than 99.99%, which supports the hypothesis. Future experiments based on how tactile stimulation affects other attributes of a plant could be performed based on inspiration from this one.

Daisy Maxwell- The Effect of Sunscreen on *Elodea canadensis*
Washington-Liberty High School

The following experiment investigated the effect of sunscreen on *Elodea canadensis*, an aquatic plant that supports many marine ecosystems. Sunscreen often ends up in waterways, and knowing whether that has detrimental impacts is an important step in preserving the environment. To conduct this experiment, 96 Elodea plants were placed into individual test tubes and separated into four groups: chemical sunscreen, natural sunscreen, bleach, and nothing. The hypothesis was that the group with chemical sunscreen would be of the least length after 8 days. It was expected that the ingredients in the chemical sunscreen, specifically oxybenzone and octocrylene, would prevent necessary processes from occurring within the plants, stunting their growth. The t-tests taken on the collected data signified inaccuracy in the natural sunscreen and bleach groups, so those measurements were discarded. The inaccuracy most likely stems from deviation between the Elodea; those cut from the ends of plants were thinner and less healthy than the ones taken from the tips. However, the hypothesis was supported, since the mean data shows that the chemical sunscreen caused the plants to be of less length than when nothing was added. This information is significant because it offers a fairly easy way in which humans can adapt to treat the environment better.

Daniella Jeyasingh- The Effect of Natural Insecticides on Army Worm infested Grass
Mills E. Godwin High School

The purpose of this experiment was to find an affective natural insecticide on the growth of army worm infested grass. This study used the bio-pesticides Spinosad and Bacillus Thuringiensis to show the effectiveness in natural insecticides compared to the control which is water. Army worms were added to grass pots to form an outbreak. After the grass achieved the height of three centimeters, the insecticides were sprayed three times on their respective pots. The three groups of grass pots were measured from the center blade of grass. It was hypothesized that the grass pots that were treated with Bacillus Thuringiensis would grow to be the tallest. In the results, it showed that the grass with the Bacillus Thuringiensis grew taller than the grass treated with Spinosad and water.

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Emma Matos- The Effect of Differing Intensities of Acid Rain Neutralizer on Plant Growth
Mills E. Godwin High School

The purpose of this experiment was to find the effects of differing amounts of sodium carbonate, an acid rain neutralizer, on plant growth. As pollution continues to cause the chemical reactions that produce acid rain, plant and animal life are the ones who are negatively affected by it the most. This project could open eyes to a new way of neutralizing the growing issue of plants being stripped of indispensable nutrients and minerals. Bean plants were germinated then separated into cells with soil, each group of 25 combined with either 0 g, 1 g, 2 g, or 3 g of sodium carbonate. The cells were then subjecting to acid rain trials over a two-week period before their height was measured. The control that was used in this experiment was the cells containing only regular soil. It was hypothesized that bean plants subjected to 1 gram of sodium carbonate would grow the tallest. The results of this experiment revealed that plants given 1 g of neutralizer exhibited increased progress in growth over 0 g, 2 g, and 3 g. A t-test was performed on the data, revealing that the data was significant for 1 gram versus the control and 3 grams versus the control. The data was not significant for 2 grams versus the control, 1 gram versus 2 grams, 2 grams versus 3 grams, and 1 gram versus 3 grams. The results supported the research hypothesis. It is believed the results of the experiment are due to the fact that less sodium carbonate wasn‚Äôt as detrimental to the plant, causing increased plant growth. This research could stem further studies involving differing concentrations, or even another neutralizer entirely, to better aid in plant growth.

Gabriella Venezia- The Effect of pH on Bean Germination
Washington-Liberty High School

The pH of soil can change the solubility of nutrients, which can affect plant growth. When a soil is too alkaline, it causes issues with phosphate, manganese, and iron deficiency. In terms of acidic soils, often there are toxic levels of aluminum and manganese that defect plant growth and overall plant health. Nutrients such as nitrogen, phosphorus, potassium, sulfur, calcium, and magnesium are insufficient in acidic soils. In order to form a better understanding on how soil pH affects the solubility of nutrients and therefore plant growth, lima beans and bush beans were germinated in various petri dishes with pH levels of 4, 7, and 10. Based on preceding knowledge, a hypothesis for this experiment was created stating: if lima beans and bush beans are germinated in petri dishes with extreme pH levels, it will be shown that lima beans are hardier because they require only little amounts of nitrogen and moderate amounts of phosphorus and potassium, as these nutrients are all deficient in extreme pH levels. Furthermore, the null hypothesis for this experiment follows: if lima beans and bush beans are germinated in petri dishes with extreme pH levels, there will be no difference in hardiness. The data collected supported the hypothesis and rather showed that lima beans are hardier than bush beans in extreme pH levels. The null hypothesis was rejected based off results from the petri dishes.

Jacob Coleman- The Effect of Acid Rain on the Germination of Different Types of Bean Seeds
Washington-Liberty High School

The purpose of this experiment was to determine which type of bean seed would germinate best when given acid rain instead of distilled water to germinate, with the goal being to find out for people who live in areas where acid rain is prevalent, but would like to grow bean seeds, which type of bean seed would grow best when exposed to it The hypothesis for this experiment was that more fava bean seeds would germinate than pinto or lima bean seeds and the null hypothesis was that there would be no difference in the amount of each type of bean seeds that germinated. For this experiment 30 bean seeds of each type (lima, fava and pinto) were put in a petri dish and given an acidic solution with a similar pH to acid rain (4) to germinate. Another group with 10 seeds of each type was given distilled water to germinate and acted as the control group. Each day at 4PM, the number of seeds that had germinated per group were recorded. After the experiment had concluded, it was found that more pinto bean seeds had germinated than the other two types of beans (26/30(86.66%) compared to 19/30(63.33%) for the lima bean seeds and only 8/30(26.66%) for the fava bean seeds). Also, for every type of bean seed it was found that a higher percent of each type of seed germinated in the control group than the experimental group, with 9/10(90%) of the lima and pinto bean seeds germinating and 10/10(100%) of the fava bean seeds germinating. Since in the experimental groups a higher percentage of pinto bean seeds germinated than either other bean, that means that pinto bean seeds would be the best type of bean seed to grow if you lived in an area where acid rain is common. Also, the fact that a higher percent of seeds in the control group germinated than the experimental group means that the acid solution had an effect. So, while it is not possible to officially declare this experiment statistically relevant it is likely that it is. In conclusion, if you want to grow bean seeds in an area where acid rain is common, pinto bean seeds would be the way to go.

Jerin Jose- The Effect of Added NPK Nutrients on Radish Root Mass
Mills E. Godwin High School

This experiment was conducted to determine how different nutrients in the NPK ratio affected the root mass of *Raphanus raphanistrum* sub. sativus. The data from this experiment could help societies such as China, in which radish species are majorly grown. It was hypothesized that if nitrogen was added to soil, then the root mass of Raphanus raphanistrum sub. sativus would increase the most. One hundred twenty-five seeds of *Raphanus raphanistrum* sub. sativus were germinated in a tray filled with Miracle-Grow germination soil in direct sunlight for seven days. Then, 100 pots were filled with one kilogram of topsoil. In 25 pots, 2.77g of urea was added. In 25 pots, 2.77g of phosphate was added. In another 25 pots, 1.67g of potash was added. Twenty-five pots were left unaltered for the control. In each of the pots, one seedling was placed into the soil. For the next thirty days, 200mL of water was given to each plant. Then, the root mass of the plants was measured with an electronic scale and recorded. The mean for control, nitrogen, phosphorus, and potassium groups were 11, 25, 14, and 17 grams, respectfully.

The analysis of the data supported the hypothesis. The results of the t-tests showed that all the data was significant, and the mean shows that nitrogen has the greatest effect on root mass. Nitrogen performed the best because it boosted the intake of other nutrients in the soil and was a significant nutrient needed to build plant structure.

Madison Mussatt- Effect of Homemade Fertilizers on *Lobularia maritima* Growth
Mills E. Godwin High School

The purpose of this experiment was to determine the effects of different fertilizer subsititues on *Lobularia maritima* growth. Nitrogen based fertilizer has many negative effects on the environment. Therefore, the experiment was conducted to determine if there were any fertilizer substitutes that had similar growth results with less negative environmental impacts. *Lobularia maritima* plants were treated with a solution of 10 mL of the different variables in separate containers with 946 mL of water. The plants were given six weeks to grow. Each week the plants were measured using the cm side of the ruler and then watered on the same day. The control used was the nitrogen-based fertilizer. The remaing variables were vegetable juice, root beer, and club soda. It was hypothesized that the *Lobularia maritima* treated with the nitrogen-based fertilizer would produce the most growth in comparison to the remaining independent variables. The results revealed that plants treated with nitrogen-based fertilizer produced the best growing plants. A t-test was performed on the data, and it revealed that the data was not significant for any level of the independent variables. However, the results did support the research hypothesis. It is believed that the results are due to the fact that nitrogen-based fertilizer had the adequate nutrients plants and soil needed, whereas the other independent variables lacked the nutrients that aid in plant growth and soil health. This research could lead to further studies on the reduced nutrients in different fertilizers effect and its on plant growth and health.

Botany - B

First Place
William McGee- The Effects of Broadcast Seeding on Secale cereal Growth and Abundance
Chesapeake Bay Governor's School

The Chesapeake Bay watershed has seen a decline in health over the past 50 years, primarily due to excessive nutrient loading. A leading cause of this trend is stormwater runoff carrying inorganic fertilizers used across 7.8 million acres of land across Virginia. The primary means of combating the adverse effects from such runoff is the planting of cover crops in between the rotation of cash crops. Three sites were chosen based on their method of planting Rye, either being disked, broadcasted, or broadcasted into straw. Five randomly generated plots were created at each field to obtain a random sample. Data was then collected over a two-and-a-half-month period that measured the growth of the Rye plants. This did not present any significant findings. At the conclusion of the

testing window, abundance data was then collected for each of the five plots in each field. The Rye which was Disked had double the abundance than that which was broadcasted. The broadcasted with straw group showed even less abundance, with one of the 1m plots containing only 4 Rye plants total. The abundance data did prove to be significant with a P-value of 3.00 x10-7. With this result, the abundance null hypothesis was rejected, and the alternate hypothesis could be supported. Traditional planting methods provide the most abundant crops which in turn will help to absorb the most excess fertilizer and provide better sediment stabilization. While broadcast planting methods enable farmers to plant cover crops more efficiently and at a lower cost, doing so could jeopardize the health of the cover crops planted, and consequently the Bay.

Second Place
Tanvi Ganti- The Effect of Trace Elements on the Growth of Excessively Nitrogen Fertilized *Antirrhinum majus* Sprouts
Mills E. Godwin High School

The purpose of this experiment was to determine the effect of trace elements on the growth of plants suffering from nitrogen pollution. As nitrogen pollution has become an increasing concern in the agricultural industry and for the environment, scientists have started to research the effects of exposing plants to trace elements that have been proven to play a vital role in a plant's defense system: zinc and iron, both of which display similar effects in relation to reinforcing a plant's growth and enhancing photosynthesis and metabolism. *Antirrhinum majus* sprouts (snapdragons) were exposed to excessive amounts of nitrogen fertilizer for five days; they were then divided into equal groups and received respective treatments of plain water (control), iron supplements, and zinc supplements. After two weeks, the sprouts had their heights measured (cm). It was hypothesized that sprouts treated with zinc would demonstrate the most growth out of the three treatments. The results accordingly showed that zinc-treated sprouts grew, on average, 0.49cm more than iron and 1.48cm more than plain water. A t-test was conducted and revealed that the data was significant for both iron versus the control and zinc versus the control. Based on this data, the results did support the hypothesis and it is believed that zinc caused a greater impact on the plant growth because nitrogen pollution more directly affects a plant's structure, which zinc directly contributes to in a plant. This research could lead to further studies on how external trace elements affect earthworm productivity in soil and how trace elements affect soil quality.

Third Place
Quynh Nguyen- The Effect of *Bacillus subtilis* CU1 on Root Growth in Mung Beans under Drought Stress
Mills E. Godwin High School

The following work was conducted to evaluate the effect of *Bacillus subtilis* CU1 on root growth in mung beans under drought-stressed conditions. Various Bacillus species are major rhizobacteria with many applications in crop production of leguminous and non-

leguminous plants by improving soil fertility, increasing crop yield, and potentially enhancing drought tolerance in crops. A four-week experiment was performed on 100 mung bean seeds grown under water-deficit and water-abundance conditions. Half of the seeds were placed in soil inoculated with B. subtilis CU1. Mung beans planted in uninoculated soil with adequate watering were used as the experiment‚Äôs control. The t-test results indicated significant data for root length comparisons between mung beans grown in soil treated with *B. subtilis* CU1 versus mung bean grown in untreated soil. However, the data was insignificant when comparing plant samples developed under similar soil treatments, suggesting the poor influence of environmental factors on mung beans development during experimenting. Overall, soil inoculation with *Bacillus subtilis* CU1 demonstrated beneficial effects on root development in mung beans under drought-stressed and non-stressed states. This effect is suggestively associated with the bacterium's ability to promote plant growth and increase water retention in inoculated plants through biofilm formation.

Keywords: *Bacillus subtilis* CU1, mung beans, drought stress, drought tolerance, biofilm

Honorable Mention
Radhika Bharambe- The Effect of Temperature Abuse on Vitamin C Content in Spinach
Mills E. Godwin High School

This experiment was performed with the purpose to see if extreme temperature changes or temperature abuse affected the vitamin C content in vegetables, specifically spinach. Recently, freezing has become a common method of preserving fruits and vegetables, and heating or thawing comes with this. However, exposing vegetables to these processes could decrease their nutritional quantity. This research was conducted to understand temperature abuse, see if it affects ascorbic acid content in spinach, and if domestic and industrial practices affect the nutritional value of food. To test this, an iodine titration was performed to find the vitamin C content of three independent variable levels: fresh, unfrozen, frozen spinach, and freeze, thaw, freeze, thaw spinach. The control is the fresh, unfrozen spinach as it has been unaffected by temperature abuse and was chosen to be able to compare results of temperature abuse vs non-temperature abuse. The research hypothesis created before experimentation was that if the spinach was froze, thawed, froze, and thawed, then the vitamin C content would be the lowest. The results showed that frozen spinach held the most ascorbic acid whereas the freeze, thaw, freeze, thaw spinach held the least. For the most part, t-tests indicated that temperature abuse did have an impact on vitamin C content in spinach and the data sets were due to this, not chance or error. From this experiment, it is believed that extreme temperature changes can affect the nutritional quality of vegetables, particularly leafy greens, because of their structure and that ascorbic acid is affected by this process because of its vulnerability to heat and oxygen. Further research recommendations include looking into physical attributes and other vegetables.

Honorable Mention
Seth Richards- The Effect of the AtUNC-93 Gene on Abiotic Stress Response in
Arabidopsis thaliana

Roanoke Valley Governor's School

Abiotic stress continues to be a prevalent problem in the agriculture industry across the world; however, an effective solution has not yet been discovered. The model organism, *Arabidopsis thaliana*, was chosen because of the low maintenance required for effective growth since only air, water, and minerals are needed. In this study, the ability to resist abiotic stress, induced by drought and levels of NaCl, was tested in a AtUNC-93 gene mutant line of *A. thaliana* and a wild-type Columbia line of *A. thaliana*. In order to test drought resistance, the *A. thaliana* plants were exposed to up to sixteen days of drought. In addition, salt-based stress was tested on separate seedlings, which were planted in MS Medium agar supplemented with 0.25 and 0.125 grams of NaCl. Results for drought stress showed that the wild-type *A. thaliana* plants had a higher growth rate, at 0.00127 cm/hr, compared to the mutant plants, at 9.58×10^{-4} cm/hr, but the wild-type plants experienced a leaf death rate of 0.00103 leaves/hr in comparison to 8.42×10^{-4} leaves/hr for the mutant. The control wild-type *A. thaliana* also had more efficient growth, but less efficient flowering, than the AtUNC-93 control as the wild-type plants maintained an average length of 25.13 cm and 18 flowers over a 44-day compared to an average of 24.6 cm and 22 flowers over the same time frame. In salt-based trials, the wild-type control produced large leaves, flowering shoots, and overall green plants while the AtUNC-93 mutant severely withered and produced small and unhealthy plants. There were no useful results from plants exposed to salt since the majority were overcome with mold. The sole conclusion is the AtUNC-93 mutant of *A. thaliana* grows far less effectively than the wild-type strain in MS medium agar.

Honorable Mention
Steven Appiah-Yeboah- The Effect of Trimming Various Lengths Below a Terminal Bud on the Resultant Lengths and Number of Lateral Branches
Clover Hill High School

The purpose of this experiment was to determine the effect of trimming various lengths below a terminal bud on the resultant lengths and number of lateral branches. 40 basil plants were placed outside and were given equal sunlight and water. The plants were randomly split into four different groups and trimmed 0 cm, 0.3 cm, 0.6 cm, and 0.9 cm respectively. The growth of the basil was recorded for a 5 week period. The control group grew a mean number of 37.3 lateral branches with the longest lateral branch being an average of 9.13 cm. The 0.3 cm group grew a mean number of 42.6 lateral branches with the longest lateral branch being an average of 8.44 cm. The 0.6 cm group grew a mean number of 37.6 lateral branches with the longest lateral branch being an average of 8.22 cm. Lastly, the 0.9 cm group grew a mean number of 34.9 lateral branches with the longest lateral branch being an average of 7.97 cm. To find whether or not the data was significantly different, two ANOVA tests were conducted. The outcome of the tests showed that both p values were less than 0.05, meaning that the data is statistically significant. Therefore, because of the statistically significant difference, the null hypothesis was rejected. The experimental hypothesis stated that the more the terminal

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bud would be trimmed, the longer the lateral branches would be and the more lateral branches there would be. This hypothesis was not supported.

Meribel Pan,Sharmila Balaji- The Allelopathic Effect of Butternut Squash on
Germination and Growth of Morning Glory and Sweet Corn
Roanoke Valley Governor's School

Morning glory weeds are known to decrease corn yields, but counteracting the weeds with synthetic herbicides has been shown to be difficult as the weeds have developed a tolerance for herbicides, and synthetic herbicides can cause environmental damage. Squash, an allelopathic plant, could be a useful natural herbicide if shown to be effective at morning glory inhibition in corn farming. The purpose of the experiment was to determine the allelopathic effect of butternut squash on the germination and shoot length of sweet corn and morning glory seeds. The butternut squash skin was freeze-dried, ground, and used to make filtrates at 1%, 3%, and 5% concentrations (m/v), which were then added to 80 MS10 agar-filled petri dishes. Morning glory seeds and sweet corn seeds were added to the petri dishes and were monitored for two weeks. The butternut squash filtrate had a neutral effect on the sweet corn germination (Chi-Square p-value, 0.071) and shoot length (ANOVA p-value, 0.245). Conclusive data could not be recorded for the morning glory seeds due to an overall lack of germination. However, a Chi-Square test run on the seed part emergence of the morning glory seeds indicated a nonsignificant effect (Chi-Square p-value of 0.363) of the squash on germination, and qualitative observations of germination suggested negative effects from the squash. The experiment indicated that butternut squash does not have a significant effect on corn growth, and further studies need to be conducted to find whether squash has a definitive effect on morning glory.

Mia Pisacane- The Effect of Different Watering Levels on the Germination Rate and
Root Length of Lettuce Seedlings
Washington-Liberty High School

The purpose of this experiment was to determine the effect of different watering levels on the germination rate and root length of lettuce seeds. The levels were 1 mL, 3 mL, and 6 mL, and the constant was 3 mL. The hypothesis was: if lettuce seeds were given different amounts of water, the plants given 3 mL of water would have the highest germination rate because they were getting the recommended amount of water. However, the plants given 1 mL of water would have the longest roots, as they would adapt to less water by producing longer root systems. The germination rate was 72%, 75% and 90% for the plants given 1mL, 3mL and 6 mL respectively. The mean root length after 11 days was 1.5 cm for the first group, 2.7 cm for the second group, and 4.1 cm for the third group.   The results of this experiment were all significant except for the comparison between the first and second groups, which allowed for the null hypothesis to be rejected. The research hypothesis was rejected as the seeds given 6 mL of water had the highest germination rate and root length. The results suggest that while plants

given high amounts of water have much higher germination rates and root lengths, there is no significant difference between under-watered plants and plants given moderate amounts of water.

Nihita Korrapati- The Effect of Soaking Cabbage Seeds in Various Chemicals on Germination
Mills E. Godwin High School

Plants are necessary for life on Earth. They assist to lower CO2 levels in the atmosphere by providing oxygen and absorbing pollutants. By studying the how various chemicals influence seed germination, people can plant more seeds in a shorter length of time, therefore improving the environment and preventing many environmental disasters in the future. The purpose of this experiment is to identify which chemical used as a pre-sowing seed treatment method would increase the number Brassica oleracea seeds germinated. Brassica Oleracea seeds were treated with either hydrogen peroxide, hydrochloric acid, isopropyl alcohol, or water. The seeds were allowed to germinate for one week and then the data was collected to see if the seeds have germinated or not. The control in this experiment is water since seeds are normally germinated using water. It was hypothesized that if Brassica Oleracea seeds are soaked in hydrogen peroxide, then the greatest number of seeds will germinate. The results revealed that the seeds soaked in hydrogen peroxide had the greatest number of seeds germinated. A chi-square test was performed on the results, and it showed that all the data was significant. The results did support the research hypothesis. It is believed that the results are because Hydrogen peroxide allows the seed to take in more oxygen by breaking down the seed coat, which increases seed germination. This research could lead to further studies that investigate the optimum concentration of hydrogen peroxide for seed germination, and how hydrogen peroxide effects various types of seeds.

Roseanna Saunders- The Effect of Varying Numbers of Orbeez, Added to Soil, on Plant Growth (cm)
Clover Hill High School

The purpose of this experiment was to determine the effect of varying numbers of Orbeez, added to the soil, on plant growth. Keeping plants hydrated during drought season without wasting the limited stored water. The hypothesis was that if Orbeez were added to a marigold's pot, the marigold would grow taller. The independent variable in this experiment was the number of Orbeez in each pot. The level of the independent variable was the number orbeez in steps of 10. The dependent variable was the height of the marigolds in centimeters. The control group was the ten pots with no Orbeez. There were ten trials per level, 10 pots with 10 Orbeez per pot, 10 pots with 20 Orbeez per pot, 10 pots with 30 Orbeez per pot, and 10 pots with 40 Orbeez per pot. The heights were measured and any plants that died were removed from the means recorded. The mean height cm was 6.84 for the control, 4.92 for 10 Orbeez, 5.27 for 20 Orbeez, 5.57 for 30 Orbeez, and 5.84 for 40 Orbeez. After the data was collected, an ANOVA test was

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conducted to test if the data was statistically significant. The results concluded that the data was not significant. The null hypothesis, which stated that the number of Orbeez would not have an effect on the plant growth of marigolds, was not rejected. The research hypothesis was not supported.

Samuel Laneve- The Effect of Different Water Types on the Growth of *Tagetes erecta*
Central Virginia Governor's School

The purpose of this research was to determine whether or not different types of water influence the growth of *Tagetes erecta*. The experiment consisted of 10 samples each for the four water types present, which included spring, bottled, tap, and lake water. Each sample received 15 mL of the respective water type every other day over the course of 4 weeks. After the 4 weeks had concluded, the *Tagetes erecta* were cut in half and the biomasses of the shoots and roots were taken and then the means of each group were calculated. Single factor ANOVA tests determined whether the data held any statistical significance. With an alpha value of .05, the shoot height data was shown to not be significant with a p-value of .054; whereas the root and shoot biomass data were shown to be significant with a p-value of .003. Despite this, the research hypothesis which stated that, if *Tagetes erecta* samples are given lake water, tap water, bottled water, and spring water during the duration of the period of growth exhibited by the plant, then the sample given bottled water would experience the most growth compared to the other samples of *Tagetes erecta*, was not supported by the data. Despite the research hypothesis not being supported by the data, it was still shown that the difference in water types had an impact on the overall biomass of the *Tagetes erecta*, with the *Tagetes erecta* given tap water having the largest biomass average in comparison to the other groups.

Shreel Golwala- The Synthesis of Effects of Agricultural Pesticides on Filamentous Algae
Mills E. Godwin High School

The objective of this experiment was to determine the effects of commonly used agricultural pesticides on Cyanobacteria blooms, such as filamentous algae. In the last decades, pesticide and chemical dumping has drastically increased and has started to contaminate bodies of clean water. These chemicals are harmful to the marine ecosystem as they carry nutrients that excessively boost the process of eutrophication which has a whole another cascade of atrocities ranging from massive aquatic die outs to even potential poisonings in humans. So, the purpose behind this experiment was to fully understand how these chemicals affect algae and spread awareness about rising eutrophication problems and chemical dumping. In the aspect of the experiment, 100 Cyanobacteria clusters were placed in four different groups of 25 Petri dishes. Out of the four groups, three contained agricultural pesticides such as an herbicide, fungicides, and insecticides. The last group served as the control group thus only consisting of normal water. The organisms were in the experimentation period for 5 days and data was recorded every 24 hours. It was hypothesized that the pesticides will cause an increase

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in algae growth. The average bloom sizes of herbicide, fungicide, insecticide, and control were 2.9, 2.8, 2.3, and 2.3 cm respectively. A set of t-tests were also performed; fungicide versus insecticide (2.752), herbicide versus insecticide (4.317), fungicide versus control (2.736), and herbicide versus control (4.273) were all significant ruling that the research hypothesis was supported. The results of this experiment yielded the fact that pesticides do boost eutrophication.

Siddarth Siddabattula- The Effect of Pruning Length on Branch Growth (cm)
Mills E. Godwin High School

The purpose of this study was to find the optimal pruning length to achieve maximum branch growth in rose plants. Pruning is a common plant-growing technique that is used to stimulate growth in specific areas. However, there is no single optimal pruning length that is widely known; the rationale of this experiment was to find this. It was hypothesized that pruning at 3cm will result in the most plant growth. Four rose plants were pruned, 25 times each, at lengths of 1cm, 2cm, 3cm, and 4cm. There was no control group because there is no ‚Äúnormal‚Äù pruning length, and not pruning entirely was not used as a control because it is already known that pruning positively affects plant growth. The growth was measured after 25 days and was recorded. The group that grew the most was 2cm (average 1.44cm) and the group that grew the least was 1cm (0.84cm). T-tests were performed on the data and they showed that the data was not statistically significant. Apart from the 2cm group, the 4cm group grew the most because there were still auxins in the branch due to the length of the cut, and these auxins allowed apical dominance to occur. Apical dominance is when the dominant branches are favored and there is less competition, allowing there to be more growth. This was also apparent in the 1cm group when there was no apical dominance because of most of the auxins being removed in the cut.

Varun Yeri- Neutralization of Acid Rain Effects on Radish Crop
Mills E. Godwin High School

This experiment was conducted in order to understand the optimum lime concentration to use in order to counteract the effects of acid rain on radish crops. The swift progression of climate change has become a greater issue in the agriculture sector than ever before. Emissions from motor vehicles and factories are causing great problems, and the ones bearing the bulk of the impact are farmers. Understanding the effects of different concentrations of lime would show how to maximize crop yields and minimize economic losses. 100 radishes were grown in 5 separate sections of a container and were watered daily, once with acidic water to simulate acid rain, and once with different concentrations of lime (the IV). The different concentrations tested were 0%, 10%, 30%, 50%, and 70%. Based on project research, it was hypothesized that the 30% group would show the most growth. However, the experiment revealed that 10% concentration was actually most effective. The observed behavior most likely occurred because it is the right balance of negating the acidified rain‚Äôs effects and keeping unnecessary compounds to a

minimum. The effects of this experiment may be felt across the agriculture sector; it may help create an elaborate algorithm which with simple inputs, such as type of soil and amount of acid rain, would output the optimum concentration of lime. This could maximize annual crop yields and minimize economic losses

Vi Chau- The Effect of Varying Ratios of Nitrogen, Phosphorus, Potassium, and Calcium, in Homemade Fertilizer, on Plant Growth of *Poa pratensis* in centimeters.
Clover Hill High School

The purpose of this experiment was to determine the effect of varying ratios of typical food wastes, such as coffee grounds, bone meal, banana peels, and eggshells on the plant growth of *Poa pratensis*. A recommended substitution to highly-processed and manufactured fertilizers was food waste because of the present nutrients such as Nitrogen(N), Phosphorus(P), Potassium(K), and Calcium(Ca). The hypothesis stated that equal amounts of coffee grounds, bone meal, banana peels, and eggshells, in homemade fertilizer, allowed the greatest growth on Poa pratensis compared to other varying ratios of fertilizers. During the preparation of the experiment, the coffee grounds, banana peels, and eggshells were sundried. Afterwards, the banana peels were turned into ash and the eggshells were crushed until fine powder. Lastly, the fertilizer components were rationed into the designated ratio levels for the growth of Poa pratensis. There were six ratios of N:P:K:Ca fertilizer which consisted of 0:0:0:0 (control), 12:6:6:6, 6:12:6:6, 6:6:12:6, 6:6:6:12, and 12:12:12:12. The control level received no fertilizer. Each ratio received 30 trials for a total of 180 trials. Over the course of four weeks, the plant growth was measured based on the plant height in centimeters and the number of grass stalks. The mean height for levels 0:0:0:0, 12:6:6:6, 6:12:6:6, 6:6:12:6, 6:6:6:12, and 12:12:12:12 were 7.523, 7.892, 8.586, 8.305, 9.561, and 6.846 cm respectively. The median level of grass stalks for levels 0:0:0:0, 12:6:6:6, 6:12:6:6, 6:6:12:6, 6:6:6:12, and 12:12:12:12 were 9.0, 6.5, 7.5, 8.0, 8.0, and 4.0 respectively. The null hypothesis was rejected, and the experimental hypothesis was not supported through the ANOVA test. The alternative hypothesis was supported because level 6:6:6:12 produced the greatest overall plant growth compared to the level of 12:12:12:12.

Zahra Akbar- The Effect of Different Preservatives on the Lifespan of Roses
Mills E. Godwin High School

The purpose of this study was to determine the effectiveness of different preservative solutions on roses. Roses are often deprived of nutrients once they are torn from the soil. The lack of nutrients these flowers receive often cause them to wilt and die quickly, therefore it is important to find ways to keep them fresh longer to benefit the floriculture industry. The hypothesis stated that if sugar and vinegar solution was added to the vase, then the roses would last the longest. The control had no preservative solutions added. The roses were separated into 4 groups of 25 flowers each and had a different preservative solution added to each group except the control group. After experimentation, the results showed that the group with sugar added lasted the longest,

with a mean of 16.5 days. The group with aspirin added lasted the shortest, with a mean of 9.60 days. A t-test was conducted at a df of 48 and a significance of 0.05. The calculated t of the control vs aspirin was 5.329, the control vs sugar was 4.412, and the control vs. sugar & vinegar was 2.460. All calculations had a greater value than the t from the table (2.012), therefore they were found to be statistically significant. In conclusion, sugar had the greatest effect on elongating the lifespan of the roses as it acted as food for the flower. To build on the investigation, other potential combinations of preservative solutions can be tested.

Chemistry - A

First Place
Arjun Modi- The Effect of Starches on Digestion Time Utilizing Salivary Amylase
Mills Godwin High School

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 corn starch, potato starch, tapioca starch, wheat starch, and rice 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 it contains the least amount of amylose. 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 rice starch was digested the quickest by salivary amylase and wheat 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.

Second Place
Arianna Hellman- The Effect of the Type of Sugar or Sugar Substitute on the Height of a Cupcake
Washington-Liberty

This experiment was designed to observe how easily different kinds of sugars and sugar substitutes could be replaced for granulated sugar in baking, as desserts commonly contain large amounts of sugar. This poses a health challenge for many people, especially diabetics, and greatly increases someone‚Äôs caloric intake. The experiment observed the texture and measured the height of cupcakes using different sugars and

sugar substitutes to determine how much the variety of sugar impacts baking, namely in a cupcake. The research hypothesis for this experiment was if cupcakes are made with granulated sugar, then they will rise more than if they were made with any other type of sugar as the granulated sugar assists in beating the right amount of air into the cupcake batter. To conduct the experiment, the following independent variables were tested: coarse sugar, dark brown sugar, stevia, and xylitol. The control was granulated sugar. After 5 trials, the average height of the cupcakes was found to be 3.988 cm with granulated sugar, 3.636 cm for dark brown sugar, 3.579 cm for coarse sugar, 3.579 cm for stevia, and 3.614 cm for xylitol. Therefore, granulated sugar performed the best as it produced the tallest cupcakes. Xylitol is a better sugar substitute in baking than stevia because it achieves a similar effect to standard sugar. However, there is more to factor than just the height and resulting texture of a cupcake when deciding what works best individually. Whether just out of granulated sugar and unable to go to the store, or wanting to cut back on the sugar for health reasons such as diabetes-related issues, the results of this experiment can be widely used to enable people to make educated and well-informed decisions for themselves based on their own personal and dietary needs.

Third Place
Jodilee Irby- Influence of Fiber Reactive Dyes on the Ultraviolet Protection Factor of Cotton and Linen Fabrics
Central Virginia Governor's School

The purpose of this study was to determine the effects of fabric type and fiber-reactive dye color on the Ultraviolet Protective Factor (UPF) of fabrics. One hundred percent cotton and one hundred percent linen fabric samples were dyed with either red, yellow, green, blue, violet, or black fiber-reactive dye. The control group consisted of undyed fabrics. Transmittance percentage values for fabrics were measured using a spectrophotometer, and UPF values were calculated by using recorded transmission values in a ratio with wavelength step, relative erythemal spectral effectiveness, and solar spectral irradiance. Mean UPFs for each group were used in a two-factor ANOVA test with an alpha set at .05. This revealed a sample p-value of 7.8123×10^{-15}, column p-value of 1.5018×10^{-10}, and interaction p-value of .0017. A post-hoc Tukey test with a calculated dmin value of 3.8037 was then used to compare the difference in mean UPF values of each group of fabrics to determine statistical significance. The research hypothesis that blue linen fabric would have the greatest UPF was not supported. Experimental results suggested that red linen fabric had the highest UPF. Comparing fabric types, linen fabrics had higher UPF values than cotton fabrics of the same color. Among the six different colors, red fabrics stood out with the greatest UPF but the colors with lower UPFs varied between cotton and linen samples.

Honorable Mention
Anna Freeman- The Effect of the Amount of Heavy Cream on the Density of Caramels
Washington-Liberty

The purpose of this experiment was to discern whether the density of caramels was affected by the amount of heavy cream in the caramels. There were five levels of the independent variable: 60 mL, 125 mL, 250 mL (the control group), 375 mL, and 435 mL. The hypothesis for this experiment was that if 375 mL of heavy cream was added to the caramels, then the caramel will be less dense, because the protein in the cream reacts with the sugar to start the Maillard Reaction. An ANOVA test conducted showed that there was no significant difference between the levels of the independent variable, with a p value of approximately 0.055. The null hypothesis for this experiment was that the amount of heavy cream in the caramels would have no significant effect on the density of the caramels. Because the ANOVA test showed no significant difference between levels of the independent variable, the null hypothesis can be accepted.

Honorable Mention
Carter Neuman- The Effect of Biowaste Type on Biogas Production
Mills Godwin High School

Limited fuel and expense are struggles when camping; therefore, testing the effect of biowaste type on biogas production has valuable potential. It was hypothesized, if grass is used in the biogas production process, then the most biogas would be produced. The rationale of this experiment pertains to the global push towards zero emission. A container suitable to host a biogas reaction was set up. For each 25 trials per independent variable, either 250 grams of fallen leaves, grass, or corn husks, and 250 grams of an even cow dung and water mixture were added to the reaction container. The biogas pressure produced was measure and entered into a data table. There was no control in this experimental design because the reaction used does not have a specific composition of biowaste recommended. Based on the results, the average biogas pressure produced by grass and corn husks were significantly more than that of fallen leaves. On average grass produced around 17 kPa more biogas pressure that corn husks. A t-test revealed that the data was significant for fallen leaves versus corn husks and grass versus corn husks but not for fallen leaves versus grass. The research hypothesis was supported by the results. It is believed that the results are due to grass being more susceptible to decomposition than corn husks and that fallen leaves have already released most of their biomass. This research could be further studied with an investigation on the ideal ratio between grass, cow dung, and water.

Honorable Mention
Gabrielle Cordero- The Effect of Detergent Products Containing Sodium Percarbonate on Luminol Efficacy
Washington-Liberty High School

The purpose of this experiment was to test the effect of Sodium Percarbonate's (also known as Active Oxygen) effect on luminol efficiency. Luminol is a reagent used to detect microscopic traces of iron found in blood. Luminol is a popular tool used by forensic scientists to indicate the presence of blood using a process called chemiluminescence.

The increasing use of active oxygen could potentially erase blood affecting crime reconstruction. To test this theory, myoglobin was used as a blood alternative and applied on strips of 100% cotton fabric. It was hypothesized that if clothing fabric was soaked in myoglobin and thoroughly washed with liquid laundry detergent containing Sodium Percarbonate, then there would be a negative luminol test because Sodium Percarbonate is a bleaching and oxidizing agent strong enough to remove microscopic traces of iron that would normally render a positive luminol test. The control group for this experiment used natural detergent that did not contain Sodium Percarbonate. However, no change was observed between the controlled and experimental group, therefore the null hypothesis could not be rejected. A series of tests were then performed to find an explanation for this result. The reason remained unknown. Consequently, this experiment suggests that Sodium Percarbonate has no significant effect on luminol efficiency.

Addison Rosen- What is the Effect of Various Leavening Agents on the Density (gms) of Baked Bread?
Washington-Liberty

The purpose of this experiment was to see if the effect on the type of leavening agent on the density of baked bread. More specifically, the hypothesis being tested stated that the source of leavening agent will influence the density of the product during the making of bread. This is assumed because the presence of a leavening agent induces bubbles to be formed hence resulting in a lower density. The leaving agents studied were active dry yeast, a mixture of lemon juice and baking soda, a sourdough starter, these were compared with no leaving agent as a control. Ten induvial loafs of bread were baked using each of the four variables. When the baked bread was finished the weight and the volume of each loaf was measured. Through these observations, the density was computed by dividing weight by volume. After comparing each of the densities, the store-bought yeast produced the less dense bread (see figure 5). This is followed by the sour dough (figure 7) started that produce a density that had a 33% increase than the active dry yeast. The density of the bread that used lemon juice and baking soda (figure 6) as its leavening agent was comparable to the control bread (figure 4), having no leavening agent.

Anna Pritchard- The Effect of Types of Stain Removal Substances on Cotton Fabric Treated with Soy Sauce
Washington-Liberty

The purpose of this experiment was to determine which stain removal substance would be most effective in removing soy sauce stains from cotton fabric. Four stain removal substances were tested: (1) OxiClean Max Force stain remover; (2) Tide stain removal stick; (3) homemade stain remover; and (4) Puracy All Natural stain remover. The hypothesis of this experiment was that if the four stain removal substances are applied to the cotton fabric treated with soy sauce, then the OxiClean Max Force stain remover will be most effective, because it has a combination of washing soda and dry hydrogen

peroxide as its main ingredients. The results of the experiment showed that the hypothesis was supported. The mean Likert scale number for the OxiClean Max Force stain remover was lower (lighter) than all of the other experimental groups, meaning that it was most successful in removing the soy sauce stain from the cotton fabric. The OxiClean Max Force stain remover experimental group fabrics being the lightest, the other stain removal substances‚Äô fabrics varied in color. The homemade stain remover was the second lightest, Puracy All Natural stain remover was the third lightest, and Tide stain removal stick was the darkest and least effective in removing the soy sauce stain from the cotton fabric. The results of the experiment had a statistically significant difference for all of the means of the experimental groups. The results of the experiment were likely affected by the blue dye in the Dawn dish soap used to make the homemade stain remover. This experiment could be expanded by both using a non-dye dish soap in the homemade stain remover and by using a wider variety of stain inducing substances, rather than just soy sauce. The Dawn dish soap‚Äôs blue dye may have affected the experiment's results by making that experimental group fabrics a darker color than they would have been if a non-dye soap had been used.

Autumn Will- The Most Accurate Method of Maintaining Fingerprint Integrity
Central Virginia Governor's School

The purpose of this study was to determine the most accurate fingerprint technique on two commonly used surfaces. This study was conducted at a local high school in December of 2021. Ten fingerprints were analyzed using powder, fluorescent dye, and cyanoacrylate methods on both a porous unfinished treated wood and a non-porous glass surface. After pulling each fingerprint off the surface with tape, each fingerprint was analyzed under a microscope to count the fingerprint ridges to declare fingerprint integrity. A two-way ANOVA with the alpha-value set a .05, revealed a p-value of 2 x 10-6 which displayed a statistical significance. Given a Dmin value of 4.13 from the Tukey post-hoc test, all of the fluorescent dye methods on the porous unfinished wood values were above the Dmin and all of the fingerprint techniques on the non-porous glass surface were all around the same value which led to no method being better than the other on the non-porous glass surface. Therefore, the data did not support the research hypothesis; if the glass is non-porous, then the powder method will work best on the glass and the fluorescent dye method will work best on the porous wood. All in all, the data supports not using fluorescent dye fingerprint technique on the porous wood surface. However, all of the fingerprint techniques on the non-porous glass surface work equally well. Knowing which fingerprint techniques aren't compatible will help forensic scientists narrow down which one to use to help solve crimes.

Carson Gilmore- Comparing Disintegration Rates of Maltodextrin and Hypromellose
Blacksburg High School

Disintegrants are excipients used in solid oral dosage formulated medications with the purpose of helping to release the active ingredient. This research is set up to compare

the disintegration rates of maltodextrin, and hypromellose. The research was conducted by running tablets containing these disintegrants through a simulated gastric disintegration machine, using simulated gastric fluid. Results in the form of time were measured and recorded. Two different formulas, both with hypromellose took 93:30.00 minutes and 89:08.16 minutes to fully disintegrate. The maltodextrin tablet took 56:58.20 minutes to disintegrate. These results show that - 1. The tablet formulation does not affect the efficiency of disintegrant in the two tablets containing hypromellose, and 2. Maltodextrin is a more efficient disintegrant that hypromellose. Knowing this information is useful when formulating a tablet to target a specific goal regarding disintegration time.

Evelyn Ortuno- Average Mass(g) of Beef Liver Dissolved in Different pH Levels
Washington-Liberty

The overall purpose of the study was to find out which pH level best dissolved the beef liver. Three pH levels that were tested are vinegar with a pH of 2.5, bleach with a pH of 13 and water(control) with a pH level of 7. Studies have indicated that, vinegar has the potential to dissolve food. In addition, vinegar is shown to have a similar pH level as stomach acid (Whelan, 2019). The hypothesis was if the beef liver is placed in vinegar, then the beef liver will have the least amount of mass left. 10 trials were done for each pH level. The study comprised of 30 dixie cups with 5 grams of beef liver in each cup and a tablespoon of each liquid. The major findings or trends found are the 2 lower pH levels dissolved the most meat. However, the analysis is the vinegar and water had no statistical difference. The acidic and neutral solutions dissolved more meat than the basic solution.

Haley Baasansukh- The Effect of Different Solvents on the Retention Factor of Photosynthetic Plant Pigments
Washington-Liberty High School

The purpose of this experiment was to test if various solvents would influence the separation of several pigments found in spinach leaves through the measurement of the retention factor. Retention factor is measured through the distance travelled by a pigment over the distance the solvent travelled. Chromatography is used to aid in the separation of substances. Solvents would aid in the separation of plant pigments, where capillary action would allow the pigments to be carried along the paper. It was hypothesized that if the isopropyl alcohol is tested, that level will be the most effective in the separation of pigments, due to chlorophyll and carotenoids being insoluble in water, with the isopropyl alcohol having the lowest water content. The null hypothesis for this experiment is that if different solvents were tested, then there is no effect of the separation or the measurement the retention factor of the spinach leaves' pigments. Four levels were tested: water, saltwater, isopropyl alcohol, and hydrogen peroxide. The hypothesis was tested using ten chromatographs per level, where strips of chromatography paper were left to sit in a spinach leaf and isopropyl alcohol solution. From the data collected, it was concluded that the isopropyl alcohol was most effective in the separation of various pigments extracted from spinach leaves, with mean retention factor values of 0.132 for

chlorophyll A, 0.452 for chlorophyll B, and 0.725 for carotene. The data supports the hypothesis that was tested. Statistical tests were done to determine the statistical significance of the data, with both an analysis of variance (ANOVA) test and three T-tests on all experiment groups, yielding p-values of less than the critical value of 0.05.

John Jurgens- The Effect of Different Materials of Cathodes on the Voltage Output of a Salt Battery
Clover Hill High School

The purpose of this experiment was to determine the cathode material best suited for the conduction of electricity in an aqueous electrolyte battery. As renewable energy has become more prevalent in the world, secondary conductors other than zinc may be beneficial to determine. The research hypothesis was that if graphite, aluminum, and iron electrodes were used as cathodes in an aqueous electrolyte battery, aluminum would provide the highest voltage. The control material was zinc, a common material already used in various battery types. Four Solo cups were used to hold the electrolyte solution, as well as copper, graphite, iron, aluminum, and zinc electrodes to conduct the electricity. Two electrodes, one copper, and another of the varying cathode types were placed into the cup filled with a mixed solution of distilled water and iodized salt. A voltmeter was used to measure the voltage generated through each trial. Each cathode was tested thirty separate times in order to ensure consistency. When testing concluded, the average voltages of the zinc, aluminum, iron, and graphite cathodes were 0.8078V, 0.5159V, 0.3138V, and 0.2608V, respectively. Zinc, the control, surpassed all other material types to have the highest average voltage, therefore the research hypothesis was not supported. The null hypothesis was also not supported, since the results showed variation, as well as an ANOVA test that indicated that the results were significant.

Kaitlin Ervine- Effectiveness of Rust Removers
Southwest Virginia Governor's School

Rust is a chemical that is formed when ferrous metal is exposed to the moisture and oxygen in the atmosphere. It causes metals to become weaker and not function properly, which can be detrimental for metal buildings and cars. Research shows that when removing rust consumers should use industrial grade rust removers in order to remove the most rust. This research experiment tested to see if there is a homemade rust removing solution that removes rust more effectively than an industrial grade rust remover. If there is a homemade solution that works better than an industrial one, then the consumer will be able to make a rust removing solution at home for a fraction of the cost. In this experiment there were four homemade rust removing solutions and one industrial grade rust remover. Each group had six pieces of steel which were weighed before being put into the solutions for twelve hours. After twelve hours they were rinsed off, dried, and weighed again. The analysis showed a p-value of 0.0001 which means there was a difference in the groups means. The results of this experiment was that the industrial grade rust remover removed the most rust, but there was a homemade solution

that works almost as well. This shows that industrial grade rust removers are the best at removing rust, but there are some homemade solutions that work but may take multiple attempts to completely remove the rust.

Lauren Kwak- The Degradation of Epinephrine Concentration When Exposed to Extreme Temperatures
Southwest Virginia Governor's School

Epinephrine is a hormone secreted by the adrenal glands in times of stress. As a part of the body‚Äôs natural fight-or-flight response, epinephrine and norepinephrine work together to increase a body‚Äôs heart rate and constrict the blood vessels. These effects reverse the symptoms of anaphylaxis. Epinephrine is a lifesaving medicine that most people concerned about severe allergies carry with them via an epinephrine autoinjector, also known as an EpiPen. Although the suggested temperature for EpiPens is around room temperature (25-30¬∞C), it is likely they are put in back-packs, cars, or even refrigerators. The objective of this project was to analyze how extreme temperatures affect epinephrine concentration. Eight temperature groups were made (including -4¬∞C, 20¬∞C, 30¬∞C, 40¬∞C, 50¬∞C, 60¬∞C, and 70¬∞C) with three samples in each group. After the epinephrine was exposed to these temperatures for one hour, the concentration levels were detected using gas-chromatography-mass-spectrometry. The Analysis of Variance test performed on the data produced a p-value of <0.0001, implying a significant difference in concentration levels after exposure. The Tukey test performed on the data produced seven p-values less than 0.05, meaning seven pairs showed a significant difference. All seven of these pairs included either the -20¬∞C group or the 4¬∞C group. After freezing the epinephrine at -20¬∞C, the average concentration remaining was 0.055, meaning it lost 45% of its original concentration, whereas the average concentration left after being exposed to 70¬∞C was 0.11. These results suggest that epinephrine concentration degrades more in lower temperatures than it does in higher temperatures. In future work, a larger sample size would be ideal for more accurate results.

Meyyammai Subramanian Periyakaruppan- Effect of Air Pollution on Hair
Mills Godwin High School

Air pollution, a prevalent issue in the 21 century, affects nine out of ten people because it appears as miniscule antigens instead of a large avoidable pathogen. In the experiment, hair strands were exposed to no air pollution, one hour of pollution, or exposed to two hours of air pollution. After the hair was exposed to different intervals of air pollution, it was put under a microscope and the visual observations were noted. Thus, it was hypothesized that if a hair strand faced more exposure to air pollution and got more damaged, then the hair strands subjected to two hours of air pollution would have the most negative effects. The purpose of this experiment was to find the effect of air pollution on hair. The results revealed that hair exposed to two hours of air pollution had the most amount of damage. A chi-square test was done on the data to prove that the results were

statistically significant for two out of the three levels. Hence, the research hypothesis was supported. It was reasoned that the results are due to the fact that longer exposure causes the strand to lose its protective layer and makes it more susceptible to damage. This research could lead to further studies that investigate the effect of air pollution on hair with or without protective measures.

Chemistry - B

First Place
Yana Shah- The Effect of Various Hydrophobic Substances on a Water Droplet's Contact Angle on a Cloth Mask
Mill Godwin High School

As of 2022, the world continues to face the COVID-19 pandemic which first arose in the year 2019. This virus primarily spreads from the inhalation of saliva droplets from person to person, however, while better for the environment, cloth masks were shown to be ineffective in the prevention of the virus's global spread. The purpose of this experiment was to determine which cost effective, non-toxic, hydrophobic substance worked best for repelling water droplets from absorbing into a cloth mask. Cloth masks were coated with 10 mL of silicone lubricant, linseed oil, or essential oils. After 24 hours of drying, a water droplet was placed onto the mask and the contact angle was measured to determine the hydrophobicity of the product. The control for this experiment was the masks with no added hydrophobic substance. This variable was chosen as the control because it represents the hydrophobicity of current cloth masks. It was hypothesized that if essential oil was brushed onto the cloth mask, then it would have the greatest contact angle, meaning the substance had the most hydrophobic properties. The data of the procedure did not support the research hypothesis, however, also showed that all three products increased the hydrophobicity of the original cloth mask, linseed oil showing the greatest contact angle. Six t-tests were performed for this data set, and all six were shown to be significant. It is believed that the results of the data were due to the large amounts of fatty acids contained in the linseed oil, which the other two variables lacked.

Second Place
Simran Kulkarni- The Effect of Temperature on Blue Light Luminous Intensity
Washington-Liberty High School

The purpose of this experiment was to determine at what temperature blue light would be emitted the strongest, using copper sulfate. This information is useful to forensic scientists in making blood glow and reveal itself in crime scenes. The data was measured in lumens per square meter (Lux), so the higher the Lux, the more emitted blue light there was. The experiment was done using a specific temperature of water (which was what the different IV levels were), mixed with specific amounts of copper sulfate crystals, hydrogen perborate, and most importantly, luminol. The measurements of Lux were taken 20

seconds after the reaction was started. There were five trials per each of four independent variable levels, ranging from 0¬∞C to 50¬∞C water. The hypothesis was that if 0¬∞C water reacted with the luminol mixture then the blue light illuminance would be higher because maximum levels of dissolved oxygen are needed to produce the brightest light, and cold water is able to hold more dissolved oxygen than warm water. The results of this experiment supported the hypothesis in that the colder independent variable levels produced higher Lux measurements. This was mainly because after the 20 second period, the warmer temperatures' luminance dwindled down, while the colder temperatures' luminance stayed prominently bright. This correlation helped make the speed of catalysts in chemical reactions visible to the naked eye, and proved that time is a crucial component to the methods of oxidation.

Third Place
Noor Long- The Effect of the Location of the Soil on its pH Level
Washington-Liberty High School

Environmental pollution is defined as the contamination of the biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected. It has a wide range of effects on many different things, including soil pH. Pollution in soil, affected by outside variables, can lead to a change in soil pH. This has proven to be detrimental to nearby habitats. The purpose of this experiment was to test the effect of the different locations of soil on the level of pH. Different soil locations were dug up and diluted with water, using litmus pH tests to determine the pH level. The hypothesis was if the soil is from a potting soil bag (Miracle Grow Potting Mix), then it will have a pH of around 7, because it requires neutrality for it to be recommended for new plant use. The experimental variables were potting soil, yard soil, clay heavy soil, and compost heavy soil, with the control as water. The control (water) had the most neutral level of pH average of 7.33 while the lowest group was the clay-heavy soil location, with an average of 5.80. The mean pH for the potting soil was 6.40, and for experimental group 2, which was yard soil, the average pH was 8.40. The last average was for experimental group 4, which was compost heavy soil, was a pH of 7.60. An ANOVA test was run to determine the statistical significance of the data, and the resulting p-value was 1.41174E-13, which is less than 0.5 so the null hypothesis was rejected. As for the results of the T-Tests, one test was conducted between the data groups of the control, and experimental group one. The T-Test value was 0.000794758 which also affirms the rejection of the null hypothesis. The second T-Test conducted for the control and experimental group four yielded a result of 0.252379786 which is also less than 0.05. There was an overall statistical difference between all levels of independent variables and the control.

Honorable Mention
Parvathi Tadi- The Effects of Salt Water on the Rate of Corrosion of Metal
Mills Godwin High School

Corrosion, which weakens material, creates economic concerns, causes health issues, and wastes natural resources. Most alloys and metals are vulnerable to corrosion, which is a major issue, as metals are mainly used to provide strength/support. For example, in the December of 1967, The Silver Bridge in Ohio, collapsed due to corrosion, resulting in the loss of forty-six lives and heavy economic costs. The purpose of the experiment was to determine how sodium chloride (NaCl) concentrations in water, which mimic realistic saltwater levels, would affect corrosion rates through the rate of temperature increase. The experimenter hypothesized that if steel wool was placed in the five percent saline solution, then the temperature will increase at a faster rate because corrosion releases heat (exodermic). The results of the experiment showed that salt concentration in an aqueous solution does affect corrosion rate, as an increase in temperature was observed. Three t-tests (100% distilled water vs 2.5% salt concentration 97.5% distilled water, 100% distilled water vs 5% salt concentration 95% percent distilled water, and for 2.5% salt concentration 97.5% distilled water vs 5% salt concentration 95% distilled water) were calculated, and they showed that the experimenter's data was statistically significant. The results supported the hypothesis. The reason was that the presence of salt quickens corrosion further due to the presence of sodium and many disassociated ions, allowing more electrolysis reactions. For further study, it should be investigated how saltwater affects corrosion over a week's time and/or can how other environments effect corrosion rates.

Honorable Mention
Thanvi Parupati- The Effect of Sunscreen Types on Planarian Regeneration Following UV Ray Exposure
Mills Godwin High School

The purpose of the experiment was to find out which form of sunscreen was the most effective in protecting the planaria from UVA radiation. UV radiation has affected many people in the world and has caused many medical costs and deaths. If cream sunscreen is used, then the planaria will regenerate the most. For the procedure, planaria were cut. Then spray - sunscreen, aloe vera, and cream sunscreen was applied to a plastic wrap on top of a petri dish with planaria in it. The planaria were then treated to UV rays and measured to see the change in growth. The control in the experiment was no sunscreen. The results revealed that planaria with cream sunscreen were best protected from UV radiation as they had an average of 0.03 cm. T-tests were calculated and a majority of the data was not significant except for spray-on sunscreen vs. cream sunscreen. The results supported the research project. It can be concluded that the results are due to the components like avobenzone, oxybenzone, and octisalate that are in the cream sunscreen. The results were not significant because not enough time was given for the planaria to regenerate and the ruler used was not precise enough. This research could lead to further studies about how UVB light affects planaria instead of UVA light.

Mohnish Gopalan- The effect of aerosol propellants on gas pressure
Mills Godwin High School

The purpose of this experiment was to find which commonly used propellant is the densest. Propellants such as nitrous oxide or carbon dioxide are commonly used. But most spray paints use hydrocarbons as propellants, such as propane and butane. Due to the variety of propellants used in spray paint products, there was no control for the experiment. It was hypothesized that if the mixture of the two gases is tested, it will have the largest change in gas pressure. An airtight seal was created, and the sample was released into the gas pressure probe. The results showed that the mixture of gases had the highest change in gas pressure and the research hypothesis was supported. T-tests were performed on the data. The t-test revealed that all 3 IV levels were significant. This research could influence further studies to be conducted into propellants, aerosols specifically.

Nachaal Chidambaram- The Effect of Heat from Hair Straightening on Hair Porosity
Mills Godwin

The purpose of this experiment was to understand how heat from a hair straightener affects the porosity of 4c hair. The idea of this project was to learn how hair straighteners were damaging hairs' abilities to absorb moisture. It was thought that the higher the heat the more damage and that meant higher porosity of the hair which means the hair's ability to absorb moisture goes down. The research hypothesis for this experiment stated that the hair strands straightened at 400 degrees F would have the highest porosity. 25 strands of 4c African hair were straightened at 300-degree F and then porosity tested. The test used was the water porosity test where a hair strand is placed in water and the location of the hair in the cup is dependent upon the porosity. 25 hair strands were straightened at 350 F, and 25 hair strands at 400 F. A chi-square test was done on the data and the results showed that the study was statistically significant with all three tests as significant. This study supports the research hypothesis and rejects the null hypothesis for this experiment that stated that there would be no difference between the expected and observed values for the different temperatures on the porosities of the hair. The contributions to the results from the experiment are due to the hair straightener damaging the hair, and which caused the hair to have a higher porosity than the hair before any straightening.

Natalie Bowen- Cross-Species Conservation of Embryonic Transcription Genes in
Drosophila melanogaster and Species of Mosquito
Alexandria City High School

Millions of people are infected with mosquito-borne illnesses each year. To combat this, I studied transcription factors in vector mosquitoes that could be used as targets for mosquito-killing pesticides. The mosquito species I studied were Anopheles gambiae, Aedes aegypti, and Culex quinquefasciatus. To better study these mosquitoes, I used Drosophila melanogaster as a reference species due to the copious amounts of research that has been done on it. I identified a protein referred to as tailles in Drosophila that

regulates early embryonic transcription and helps to maintain the central nervous system. Using UniProt I found the FASTA sequence of tailless and next used that sequence in BLASTP to find similar sequences in the mosquitoes. I then used Geneious to help me understand and analyze my data. I found that the tailless proteins have two zinc finger regions that have 88.2% similarity between species and one ligand-binding that had 34.4% similarity between drosophila and the mosquitoes. Although, the similarity between the ligand-binding sites jumps to 66.4% when only comparing the three mosquitoes. These results told me that while tailless activates the same genes in all four species, differing small molecules may activate tailless in the mosquito species compared to drosophila.

River DeFrancesco- The Effect of the Amount of Sunlight Exposure on Aging in Wood, Measured by Change in Color
Clover Hill High School

The experiment answered the question of what color wood would change into when exposed to sunlight. It was hypothesized that wood exposed to sunlight for 10 weeks would age into the lightest color. There were 39 trials for every length of sunlight exposure recorded. For the experiment, pinewood was placed in an area with exposure to full sunlight, and sections of it were photographed every two weeks. The photographs were analyzed by converting the average color of an image into RGB value. Through this analysis, it was concluded that the wood became darker over time when exposed to sunlight. It also had a proportionally higher concentration of blue hue in it as it aged. The null hypothesis of the experiment was rejected. However, the data did not support the research hypothesis.

Saaleh Khan- The Effect of Different Salts on Corrosion of Iron
Mills Godwin High School

The purpose of this experiment was to determine the effects that different salts had on the corrosion rate of iron. Salinity has decreased in the ocean, allowing more oxygen to dissolve into the water, but also allowing corrosion rates to increase. Iron nails that were 10.16 cm long were treated to either plain water, sodium chloride dissolved into water, potassium chloride dissolved into water, or magnesium sulfate dissolved into water. It was hypothesized that magnesium sulfate would produce the least amount of rust when compared to the other treatments. The lowest average rust produced, 0.0136 g, was shown by magnesium sulfate, while the highest, 0.0156 g, was shown by the control. This supports the research hypothesis; however, a t-test was performed on all of the data, showing that it was not statistically significant. These results are believed to be made due to an error on how much iron was available for one trial.

Sarah Eichorn- The Effect of Paper Type in Acidic or Neutral Solution on the Degradation of Paper Strength
Washington-Liberty High School

The purpose of this study was to determine whether type of paper had different degradation rates in paper strength, and whether an acidic or neutral solution affects the result. The independent variable was the type of paper in solution and a smaller sample of 'baseline' trials. The experimental group included cotton rag paper, computer paper, and newspaper, each in acidic or neutral solution. The control group was computer paper in neutral solution. The dependent variable was the amount of degradation in paper strength. The constants were the time the paper spent in solution, the size of paper, the type of weight used to test the strength (e.g., pennies, nickels), and the time the paper spent drying. The hypothesis was if different types of paper are placed into acidic or neutral solution, then the newspaper in acidic solution will lose the most strength compared to the beginning of the experiment because it was the thinnest paper and has ink on it, adding a new variable to it. Additionally, acid has a degrading impact on paper by shortening fibers. The null hypothesis was if different types of paper are placed in acidic or neutral solution, there would be no change in the paper strength from before and after the experiment as compared to the baseline trials. This project was performed by placing paper in different solutions and leaving them for ten days. The papers were removed and tested for strength by suspending them midair and adding weight until the paper tore. The results were then compiled into a chart and summarized into a bar graph. Six ANOVA tests were run, the mean of each level was discovered, and standard deviation was found. The results suggested that the experiment was inconclusive. The hypothesis was not supported. In conclusion, it is possible that paper strength could be affected by being placed in solutions, but this experiment did not provide enough data to prove this.

Sriyutha Morishetty- The Effect of Dietary Components on the Absorption of Acetaminophen
Maggie L. Walker Governor's School

The purpose of this experiment was to study the effect of different dietary components, like sugar, protein, and pectin, on the absorption of acetaminophen at timed intervals. It was hypothesized that if acetaminophen was added to solutions containing plain water, sugar, protein, and pectin then the solution containing pectin would delay the absorption of acetaminophen most compared to the solutions containing plain water, sugar and protein. Acetaminophen, a non- opioid analgesic, is a common ingredient of multiple over the counter (OTC) and prescription medications. It is most frequently commonly known as Tylenol, a drug used to relieve an array of pains such as headaches, muscle aches, menstrual cramps, and sore throats. In this experiment, through a series of steps acetaminophen was added to solutions containing plain water, sugar, protein and pectin. The pH of the solutions was recorded for all the four experimental solutions at timed intervals. Acetaminophen was absorbed slower in solution containing pectin compared to solutions with plain water, sugar and protein as measured by the change in pH over a

period of time. The lower the change in pH of the solution recorded over period indicates slower absorption of the medication into the solution. The greater the change in pH of the solution recorded over period indicates faster absorption of acetaminophen into the solution. This experimental data relates that dietary components could have an impact on the drug release, absorption, and bioavailability of the drug. This study may further expand the understanding of the effect of various dietary components on the pharmacokinetic profile of acetaminophen, which could prevent adverse food-drug reactions and ensure the efficacy of the drug.

Stanley Craig- How simulated aquatic acidification dissolves freshwater Viviparus georgianus snail shells
Collegiate Schools

Atmospheric carbon dioxide levels have artificially risen in recent history, which results in ocean acidification, a process in which atmospheric carbon dioxide enters bodies of water, becomes aqueous, and reacts with the water to create carbonic acid, increasing the acidity of the water. This study aims to determine at which point this process produces noticeable effects on shells from a freshwater aquatic snail. This point was found by attempting to determine the lowest percent concentration of acetic acid in solution that would react enough with the calcium carbonate in empty shells of Viviparus georgianus snails to produce significant amounts of carbon dioxide, therefore indicating a reaction that degrades the structure of shells which would damage a living mollusk. This experiment was done in a lab environment and used 10.0 mL of increasingly diluted solutions of acetic acid that were placed in equal parts in a syringe testing chamber and a test tube in which the syringe was placed, so both were filled with 10.0 mL of acetic acid solution and the syringe with 1.00 g of crushed V. georgianus shells. Each experimental group was tested over a 24-hour period. This experimental design collected the carbon dioxide produced by the reaction between the acetic acid solution and the calcium carbonate in the shells to show the extent to which the reaction occurred. The data shows that at 0.5% acetic acid solutions and below, no detectable amounts of carbon dioxide were produced from this displacement method. The volumes of carbon dioxide produced from the 1.0% and 2.5% acetic acid solutions were an average of 8.4 mL and 10.0 mL respectively, which are significantly different from one another and increasing. Both the 2.5% and 5.0% acetic acid solutions produced 10.0 mL of carbon dioxide, the volume of the container. These results indicate that as the percent concentration of acetic acid increases, so does the volume of carbon dioxide produced. More importantly, however, is the conclusion that at a 0.5% acetic acid solution and lower, no significant detectable amounts of carbon dioxide were produced in 24 hours which indicates that the pH of an aquatic environment may need to lower more substantially (below the typical 7.5-8.5 pH of a natural freshwater system) to produce notable reactions with calcium carbonate of Viviparus georgianus snail shells.

Tess Davies- The Effect of Type of Drink on the Amount of Electrolytes
Washington-Liberty High School

The goal of this experiment was to show the effect of type of drink on amount of electrolytes inside of it. The 5 drinks tested were, tap water, orange juice, nuun, Gatorade, and powerade. This experiment could be helpful for aspiring athletes looking for the right fuel before or after a game, workout, or practice. Orange juice and Nuun had the most electrolytes overall, Gatorade and powerade were in the middle while the control (water) had the least amount of electrolytes. Further experimentation with this experiment could be improved with a more well-constructed conductance circuit, and more accurate and consistent measurements. It was hypothesized that, if the levels of electrolytes are tested in 5 different types of drinks, then Powerade and Gatorade will have around the same amount and the most electrolytes out of the 5 because powerade and Gatorade have similar ingredients, and both contain salt or sodium. The hypothesis was not supported by the data because a T-test was run between Gatorade and powerade and the p-value was 1.11 E-08 which is less than 0.05 meaning that Gatorade and powerade were significantly different. The null hypothesis for this experiment was if electrolytes are measured in types of drinks, then the type of drink will have no effect on the amount of electrolytes in it. The null hypothesis was rejected because an Anova test was run, and the p-value was less than 0.05 meaning the results are significantly different.

Tuong Vo- The Effect of Cooking Method on Folate Content of Spinach
Mills Godwin High School

Folic acid, also known as folate, is one of the forms of vitamin B9. The substance has been linked to help decrease the chance of neural tube defects and other forms of birth defects. Taking a supplement and consuming around 400 grams of natural folate in a day is enough to cause supra-nutritional folate. Spinach is one of the easily attainable leafy vegetables that contain high folic acid content. Even though folic acid content is high in spinach, around 50 to 90 percent of the folate gets destroyed through cooking. This applies with other vegetables as well. The purpose of the experiment was to test which cooking method retains the most folate content by end. This experiment can be applied into the real world because it can help people suffering from folate deficiency by providing additional research and results. Individuals on supplements and folic acid benefit from this, as it can determine which cooking method is optimal based on the amount they need. It was hypothesized that the steamed spinach would have the highest folate content. In the experiment, the control was the raw spinach. The spinach cooked, blended with distilled water, and the pH was measured to interpret the folate content. In the end, the results showed to be significant and the one with the highest folate content was the blanched spinach. It was concluded that the raw and blanched spinach was highest in folate content due to the explanation that folate gets destroyed through heat and cooking.

Engineering - A

First Place
Brock Duma- An Optimized Whitewater Helmet Prototype Designed Using a Newly
Developed Helmet STAR Evaluation System and 3D Printing
Blacksburg High School

Whitewater sports result in 50 deaths and thousands of concussions every year, and the currently available helmets are insufficient. The objective of this study was to create an optimized whitewater helmet prototype designed using a newly developed Whitewater Helmet STAR Evaluation System. The 21 helmet models that were evaluated using the Whitewater STAR methodology were cut vertically and horizontally to allow for cross sectional padding analysis. A material testing system (MTS) was used to evaluate each helmet's padding stiffnesses. The padding Vinyl Nitrile (VN) 600 and VN 740 were found to have the greatest correlation with the highest performing helmets through linear regression and energy absorption analysis. Rhino 3D software was utilized to create the new model of the whitewater helmet. The helmet shell was developed as a modified ellipsoid with a length of 28.5 cm and a height of 13.0 cm above the midline. Three different materials of Acura 60, Nylon, and Acura Clear Vue were selected for the helmet shell in order to test a variety of flexibilities, toughness's, and transparencies. Three different prototypes were constructed in order to optimize the padding and retention of the helmet design. A custom pendulum impactor device was used to test the three different helmet prototypes in accordance with Whitewater STAR. The prototypes were impacted at 3.1 m/s and 4.9 m/s to the front, side, and rear. The final prototype produced a STAR value of 0.01 and performed 25 times better than the highest performing currently available whitewater helmet.

Second Place
Carson Ray- OmniNet: Brain-Based General AI Solutions for Robust Multi-Task
Learning
Roanoke Valley Governor's School

Deep Neural Networks are a form of supervised machine learning algorithm that perform very well on specifically defined optimization tasks such as image recognition and game playing. However, because of their statistical nature, they often do not generalize well to changes in their tasks and are overly fitted to training data. The goal of this project was to develop a neural network algorithm using features based on neuroscience and learning in the brain such as working memory, multi-directional processing, and Hebbian reinforcement training, that can perform successfully on multiple tasks without overfitting to a specific one. On three combined image recognition tasks, a multidirectional convolutional network had a test accuracy of ~75.4%, a squared error of ~0.071, and an overfit factor of ~51.3%. A standard convolutional neural network had a test accuracy of ~75.8%, a squared error of ~0.085, and an overfit factor of ~67.6%. On an individual image recognition task, a multidirectional network had an average test accuracy of

~87.9%, an error of ~0.406, and an overfit factor of ~53.8%. A traditional neural network had an average test accuracy of ~87.8%, an error of 0.420, and an overfit factor of ~57.9%. The other features tested consistently had high levels of error and could not be optimized. But overall, the data supports that using hybrid neural network designs incorporating both traditional regression learning and brain-inspired connectivity could produce general AI systems with the ability to succeed in domains that require less overfitting and greater learning flexibility, such as autonomous driving.

Third Place
Gwyneth Liu- Novel Model of an Adaptive Wave Energy Converter with Spectral Analysis-based Sea State Classification
Mills E. Godwin High School

The objective of this project is to measure the effects of adaptive control on the performance of a wave energy converter (WEC). Ocean wave energy is one of the most promising sources of renewable energy with a measured annual 2.64 trillion kWh. This energy is harvested via WECs, which utilize a power-take-off (PTO) system to convert the wave energy into usable electrical energy. The most common type of WEC is the point absorber, and one limitation of WECs is the unstable electrical power generation across changing climates. To solve this problem, an adaptive model of a point absorber with a hydraulic PTO was designed. The adaptive model consists of a spectral analysis-based sea state classification algorithm and an alterable swash plate angle ratio. In this project, the control is a non-adaptive model, and the dependent variable is the electrical power (MW) generated by the WEC model on a phased simulation of irregular waves of multiple sea states. The results showed that the adaptive WEC generated 19.928% more electrical power than the control WEC, and the results were found to be significant via a t-test. It was found that an adaptive WEC could significantly increase the electrical power generation and maximize performance across sea state changes.

Honorable Mention
Anooshka Pendyal- A Novel Application of Different-Sized Deep Residual Networks (ResNet) to Breast Cancer Identification
Deep Run High School

Invasive ductal carcinoma (IDC) is the most common subtype of breast cancer, and it is important to identify it as quickly and accurately as possible. Currently, identification of IDC is done by hand, which is time-consuming and challenging. Machine learning, specifically convolutional neural networks (CNNs) that specialize in computer vision, can be applied to assist in the diagnosis process. ResNet (residual neural network) is a type of pre-trained CNN that utilizes transfer learning. When a model implements ResNet, it is able to train on a smaller dataset, which is highly relevant to training models with applications in healthcare due to limited access to data. Currently, there is a gap in

knowledge regarding the effect of a ResNet‚Äôs depth on the model's performance in cancer identification. This paper hypothesized that ResNet18 would perform the worst in identifying IDC, while ResNet101 would perform the best and tested the performance of four models, each with ResNets of different depths implemented in them. In this project, the dataset, a collection of slide images with IDC, was obtained from Kaggle, downsampled to address class imbalance, and pre-processed. Then, four models using different-sized ResNets (ResNet18, ResNet34, ResNet50, and ResNet101) were trained and evaluated. Across all sets (training, validation, and testing), ResNet18 performed the worst (F1-score of 0.5816 in testing), while ResNet101 performed the best (F1-score of 0.7249 in testing). As the depth of the ResNet increased, the higher it scored in performance, measured by an F1-score. This could be explained due to the fact that, generally, the deeper the neural network is, the more powerful it is and the better it performs. Another result was that the validation accuracy for all models was unstable. This could be the result of insufficient training and is an improvement that could be made in future research. An interesting point of future research could be comparing the ability of different types of pre-trained networks other than ResNet in identifying cancer. With further training and hyperparameter optimization of the models, there is still great potential for real world application, especially in assisting in the cancer identification process. It is crucial to study pre-trained models due to the fact that they reduce the amount of data needed to train a model, and data is difficult to access in healthcare.

Honorable Mention
Bailey Morris- The Effect of Altering Input Water Pressure on the Power Production of Hydroelectric Turbines
Central Virginia Governor's School

The purpose of this study was to determine whether increasing the input pressure of a water turbine has an effect on the total power generated by the system. The expansion of knowledge on hydroelectric power is essential due the diminishing availability of fossil fuels and therefore the increasing dependency placed upon renewable energy sources. A small-scale water turbine was appropriately connected to a water pressure regulator and a Vernier Go Direct Energy Sensor. Varying amounts of water pressure, from 2 to 20 psi, were run through the turbine and the power generated by each psi was measured and recorded. The mean of the power generated by the lowest pressure, two psi, was calculated to be 1.6 milliwatts, whereas the mean the power produced by the highest pressure, 20 psi, was 522.7 milliwatts. A one-way ANOVA test was conducted on the data, with an alpha level set to .05, and a resulting p-value of 3.871×10^{-51} was produced. A Post-Hoc Tukey Test illustrated between which pressures statistically significant differences occurred and produced a Dmin of 47.734. This statistically significant value partially supported the research hypothesis, which was that an increase in initial water pressure entering the turbine would correlate to a similar increase in power generation. Ultimately, the input pressure of a hydroelectric turbine precipitated a significant impact on the overall power generation of the system.

Honorable Mention
Dawson Richards- Evaluating the Use of Biomimetic Serration in FDM Drone Propellers for Low-Noise Applications
Southwest Virginia Governor's School

Unmanned aerial vehicles (UAVs) produce loud noise which can have adverse health effects. One method of reducing overall UAV noise is by reducing the amount of noise the propellers create. Owls have leading edge (LE) serration on the front of their wings and trailing edge (TE) serration on their wing feathers. By replicating this serration, researchers have determined that both LE and TE sawtooth-shaped serration can reduce aerodynamic noise. However, no propellers are on the market that utilize these biomimetic features. This study sought to test the use of TE and LE sawtooth serration in propellers printed with fused deposition modelling (FDM). Propellers were printed using each type of serration, as well as one using both types on the same propeller. Each propeller was tested at a range of throttles from 0% to 100%, taking measurements of A-weighted decibels (dBA) and rotations per minute (RPM). The study also tested the use of an FDM propeller with no serration and a commonly available injection molded propeller. Logarithmic regression lines were generated using the data for each propeller. It was found that the propeller using the LE serration was the quietest, followed by the propeller using both types, the propeller using TE serration, the FDM propeller with no serration, and finally the injection molded propeller. This study suggests that LE serration may perform more quietly than TE serration, and that FDM propellers can actually operate more quietly than injection molded ones.

Anfal Hosen- Crack The Cipher
Alexandria City High School

The Caesar Cipher is a cipher made by Roman leader Julius Caesar which uses the substitution method to encode the alphabet (Moore et al., N.D.). An example of this would be a shift of 1 would encode the letter "A" as "B". This project aims to create a Caesar cipher and break it with Frequency Analysis and Brute Force. To meet the objectives of my Engineering Goals, I created 3 programs, The Caesar Cipher Program, The Frequency Analysis Program, and the Brute Force Program. The Caesar Cipher Program would encode the message, and the Frequency Analysis and Brute Force Programs would decode the encoded message. The results showed that the Brute Force Method worked on all Messages; however, the Frequency Analysis Method could not work on smaller messages but was able to break the medium and large messages. These results suggest that although the Frequency Analysis works on medium and large messages; however, when trying to decode the smaller messages, it couldn't break it because, in smaller messages, the letter "A" may not be the most frequent letter. The Brute Force method was largely successful as it decoded every single message because it tested all the possible combinations. Therefore, the Brute Force method is more effective than the Frequency Analysis method because it decoded messages by testing all combinations while Frequency Analysis decoded messages by assuming that the letter "A" is the most

common letter and in cases like short messages, the letter "A" may not be the most frequent letter.

Bethany Hinshaw- Automated Mask Detection Using Raspberry Pi and Tensorflow
Harrisonburg High School

With the COVID-19 pandemic, masks have become commonplace and necessary. The objective of this project was to automate the process of mask detection. The design made use of a Raspberry Pi microcomputer and the Tensorflow Python library. This paper explores the background behind the mask detector and details the methods and materials used to create it. These methods consisted of four main stages: wiring, setting up the Raspberry Pi, training the mask detector model and writing the custom mask detection algorithm. From the data collected, it can be concluded that the accuracy is around 87%. There was a 97.1% accuracy when the test subject was wearing a mask and 77.1% accuracy when the test subject was not. This amounted to 27 correct with the participant not wearing a mask and 34 correct when the participant was wearing a mask. Out of the 9 failures, 8 involved a participant not wearing a mask. This mask detector approaches, but fails to achieve the standard set by other mask detectors, which consistently produce over 90% accuracy. Proposed ways to improve the detector are also outlined.

Caleb Greene- The Effect of Material and Density on 3D Printed Structures for Hand Protections
Chesapeake Bay Governor's School

This study aimed to examine what parameters and materials are best for creating personal protective equipment for workers‚Äô hands. Objects created using Fused Deposition Molding (FDM) 3D printing were tested using sudden impacts to replicate workplace hazards that could damage workers‚Äô hands. Four varying materials and two infill rates were tested to see which combination of material and infill created the most survivable structure. The High Impact Polystyrene (HIPS) at 75 percent infill had the highest average survival rate. The Acrylonitrile Butadiene Styrene had the second-highest survival rate and more consistent results.

Eyuel Berhanu- The Effect of Hull Design on Drag
Washington-Liberty High School

The purpose of this study was to determine the effect of boat hull shape on drag. The independent variable was hull design. The experimental group included displacement hull, flat bottom hull, deep v hull, pontoon hull, and tri-hull. There was no control group in this experiment. The dependent variable was the amount of drag force created (N). The constants were water speed, hull material, water level in testing vessel, and testing conditions. The hypothesis was: If different hull designs are tested, then the deep V hull would create the least drag. First hull models of the displacement hull, flat bottom hull,

deep v hull, pontoon hull, and tri-hull were designed and 3D printed. A pressure washer was then used to direct high-pressure water at the hull designs. The hull designs were attached to a spring scale that measured the amount of drag force each hull type encountered. The results showed that the deep V hull had the lowest average maximum drag. The p-value was calculated in an ANOVA test and the p-value was 0.006, making the results of this experiment statistically significant.   These results supported the hypothesis. In conclusion, the study suggests that the deep V hull has the lowest average drag force.

Gabrielle Carter- The Difference in Run-Times Between Solar and Gas-Powered Lawnmowers
Chesapeake Bay Governor's School

Carbon dioxide emissions have been a continuous problem since the industrial revolution due to the heightened use of fossil fuels. These emissions have had a huge impact on the acceleration of climate change as well as the degradation of many environmental habitats. Scientists have been working to find alternate sources of energy since the late 1800s. One of these sources is Solar Power, which can be used in place of internal combustion engines with a quick conversion. This conversion was done on an old lawnmower, and trials were run to test the speed of the mower before and after the conversion. The purpose of this study was to see how reasonable it is for a person to convert their lawnmower and have it be just as usable as before the conversion. The Solar-powered engine was much slower than the combustion engine, and this difference was statistically highly significant. Therefore, it would not be that reasonable for someone to convert their lawnmower unless they used a much smaller gear ratio than was used in this study.

Harris Ilyas- The Effect of Temperature on Lithium Ion Batteries
Central Virginia Governor's School

The purpose of this experiment was to determine whether or not temperature had an effect on the energy storage capacity of lithium ion batteries. The study was conducted in a local high school laboratory during November of 2021. Three groups, each with twelve batteries, were placed in three different locations. The first was placed in a bead bath at a temperature of 56.9¬∞C. The second was placed in a freezer at a temperature of -13¬∞C. The last group was used as a control group and was placed at a temperature of 20¬∞C. At one week intervals, their voltages were recorded using a multimeter. After a period of 6 weeks, the experiment concluded and an One-Way ANOVA was conducted to analyze the data. The voltages of the bead bath group showed a small increase and the freezer group showed a slight decrease. The control group, as expected, remained mostly constant throughout the experiment. A One-Way ANOVA, with an alpha value set at .05 revealed a p-value of 1.58√ó10-8.   A Post-Hoc Tukey Test was then performed with a minimum pairwise difference of .0063 which revealed a statistically significant difference between the bead bath group and the other two groups. This statistically

significant value supported the research hypothesis that higher temperatures have a greater effect on lithium ion batteries. In conclusion, heat can affect the energy storage capacity of lithium ion batteries.

Jayla Adkins- The Effect of Simulated Wingspan on the Distance a Softball is Thrown
Clover Hill High School

The purpose of this experiment was to determine an optimal wingspan between 243.8cm and 188.0cm (simulated as fingertips to fingertips) that would launch a standard sized softball the farthest distance. Knowing the optimal wingspan (within the range of 243.8cm and 188.0cm) for throwing the softball the farthest distance could allow coaches to better select players for each position. This could then advance the game by increasing the probability of a player throwing an opposing player out. The hypothesis was that a longer simulated wingspan would throw a softball farther than a shorter simulated wingspan. The control wingspan was 243.8cm. Each wingspan decreased by 5.1cm from the previous until the length of 188.0cm was reached. Thirty softballs were launched from a Trebuchet for each simulated wingspan. A measuring tape laid at the back of the Trebuchet measured the distance where the softball landed. The softballs before being launched were covered with chalk that left a mark on the ground next to the measuring tape. Each measurement for each simulated wingspan was logged and the mean distance was calculated. The mean launch distance(m) for the control wingspan was 26.7m and 25.8m for the shortest wingspan of 188.0cm. The wingspan of 203.2cm had the farthest mean launch distance at 33.9m. The research hypothesis was not supported since shorter simulated wingspans launched the softball at a farther distance. The experiment's null hypothesis of no significant difference was tested using an ANOVA test and was rejected.

JinSun Lee- Analyzing COVID-19 Data: First-Hand Experience of Becoming a Data Scientist
Douglas Southall Freeman High School

Data Analytics is a broad field of study and a profession that, at its core, addresses the growing amount of technology and corresponding data produced from the multitude of data sources. While data potentially provides scientific and rational ways for people to make informed decisions, the usefulness of a massive amount of data fundamentally depends on analytics. Analytics is how one makes sense of the data and draws meaningful insights. Since the COVID-19 outbreak, hospitals, universities, and government agencies have made COVID-19 datasets publicly available. While the COVID-19 datasets are the crucial sources for understanding the pandemic, they remain cryptic to most laypeople. In this work, we analyzed the COVID-19 datasets available on the Virginia Department of Health website. The goal of the project was twofold. First, we aimed to draw insights from visualizing the COVID-19 dataset. Second, we wanted to see how accessible the public COVID-19 datasets are to a student who is still learning data analytics techniques.

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Joseph Lipanovich- The Effect of Using Varying Numbers of Mirrors, in Conjunction with Solar Panels, on the Amount of Electricity Produced
Clover Hill High School

The purpose of this experiment was to determine the effect of using mirrors in conjunction with a solar panel on the amount of energy output produced by the solar panel. Using solar energy instead of non-renewable energy can reduce air pollution. Solar energy is an expensive form of renewable energy, but mirrors can significantly increase a solar panel‚Äôs energy output and they are inexpensive. The experimental hypothesis was that if more mirrors were used, in conjunction with solar panels, then the amount of electricity produced would increase. A solar panel was placed outside under the direct sun and was connected to a voltmeter to measure the amount of electricity produced. Mirrors were used to reflect solar radiation towards the panel. The number of mirrors was the independent variable and the dependent variable was the amount of electricity produced (Watts, Volts, Amperes). Thirty trials were conducted for each level of the independent variable. The four levels of the independent variable were the control, no mirrors, 1 mirror, 2 mirrors, and 3 mirrors. The mean electric output for 0 mirrors, 1 mirror, 2 mirrors, and 3 mirrors were 41.889 Watts, 42.246 Watts, 42.558 Watts, and 43.086 Watts, respectively. An ANOVA test was conducted on the data to test if it was statistically significant. The null hypothesis was not rejected and the research hypothesis was not supported.

Engineering - B

First Place
Solomon Galpern- Science Fair The Effect of Blade Angle and Fan Speed on Energy Produced by a Wind Turbine Kit
Washington-Liberty High School

The purpose of this experiment was to determine the effect of blade angle (10, 20, 30, 40, 50 degrees) and fan speed (high and low) on how much energy is produced by a wind turbine kit. The hypothesis was that, ‚Äúif the blade angle and fan speed are changed, then the blades with 10-degree angling and high fan speed will produce the most energy‚Äù. This hypothesis was supported as the group with the highest mean average was the group with a 10-degree blade angle at high fan speeds which produced 0.0468 watts. Three ANOVA (Analysis of Variance) tests were performed to determine the statistical significance of the data. The first ANOVA test was done between the values of the blade angles at low fan speed and the second was done between the values of the blade angles at high fan speed. The final ANOVA test was run on all of the data at both low and high fan speeds. All of these yielded p-values below 0.05 allowing for the determination that the data is statistically significant. This data suggests that, as the blade angle increases on a flat bladed wind turbine, the energy produced decreases. The data

also suggests that on a flat-bladed wind turbine, as wind speed increases, energy produced increases (to a point). It should, however, be noted that these results cannot be directly translated from the kit onto a scale turbine. This should not diminish the projects importance as both blade angle and wind speed are crucial to the performance of all turbines.

Second Place
Raphael Sanchez- The effect of Tuned Mass Dampers on Super-Slender Buildings affected by Vortex Shedding
Washington-Liberty High School

The purpose of this study was to test how much building sway on super-slender towers from vortex shedding is reduced when a pendulum Tuned Mass Damper (TMD) was being used. The independent variable was the amount of damping. The experimental group was the building with the pendulum TMD. The control group was the building without the pendulum TMD. The dependent variable was the building sway, as measured by an accelerometer. The constants were the building, the accelerometer, and the pendulum used. The hypothesis was: The trials with the building's TMD installed will oscillate less than the trials that will not have the building's TMD installed. A model super-slender tower with a TMD that was set to the natural frequency of the building was treated with different wind speeds. Along with changing the wind speed, the TMD was installed and removed to test how effective a TMD would be against vortex shedding. Results showed that the TMD was most effective at reducing building sway at high speeds; however, the TMD was not very effective at reducing building sway at low speeds. Thus, the results did support the hypothesis in technicality. In conclusion, the study suggested that TMDs could make a difference in reducing super-slender tower oscillation from vortex shedding, but only at high wind speeds.

Third Place
Laasya Konidala- Automated ROI Detection for Glioma Severity Prediction
Mills E. Godwin High School

Gliomas are the most common primary central nervous system infiltrative tumors, lethal due to their rapid progression and heterogeneous nature. Accurate distinction between high-grade-gliomas versus low-grade-gliomas is key to eradicating cancer proliferation; however, the current standard grading approach, highly-inconsistent histopathological analysis of invasive surgical biopsy samples, is a prolonged, challenging task. Recent advancements in neural network paradigms introduce a hierarchical feature learning mechanism for addressing the glioma grading task. The current approach proposes a non-domain specific Region Growing Segmentation Algorithm (RGSA) for non-invasive glioma severity prediction, prioritizing automated ROI detection and rapid processing time. The RGSA was fed mapped data of local spatial vectors of cancer-rich patches to map the largest connected region spanning from these seed points for ROI prediction. Lateral connections between reconstructed layers and feature maps enhanced the key

spatial recognition aspect of the proposed glioma grading model, advancing the feature extraction and decreasing the computational complexity. The predicted ROI from automated seed points was evaluated against both random seed point and manual seed point initializers. A five-fold cross validation confirmed the statistically significant high predictive power of the automated ROI detection, supporting the research hypothesis. The proposed model had state-of-the-art performance because it analyzed gradient changes in automated seed points, prompting the model to detect subtle structural features critical to glioma tumor profiling. Interestingly, the multiscale semantic features from generated lateral connections inherently plotted the distribution pattern of glioma lesions, identifying prognostic biomarkers of glioblastoma. With further work mapping neoplasm proliferation to molecular expression, the novel RGSA enhances clinical glioma grading procedures.

Honorable Mention
Leonardo Fall- The Effect of Different 3-Dimensional Shapes on the Accuracy and Precision of an Ultrasonic Sensor
Washington-Liberty High School

This experiment was designed to measure the effectiveness of ultrasonic sensors' capabilities by experimenting which shapes had a negative effect on the ultrasonic sensors. It was hypothesized that if different three-dimensional objects were placed fifty centimeters away from two ultrasonic sensors then the triangular prism would have the greatest negative effect on the ultrasonic sensors ability to sense distance correctly as measured by the variation in the results (cm) due to the triangular prisms angled edge. Three different three-dimensional shapes were tested in this experiment: a rectangular prism, a cylinder, and a triangular prism. The triangular prism had the highest mean difference from the constant value of 50cm at a difference of 1.32 cm while the cylinder and rectangular prism had a 0.5cm and 0.44cm difference respectively. The ultrasonic sensors' measurements were the most precise for both the cylinder and rectangular prism due to a standard deviation of 0.39 cm for the rectangular prism's average distance from 50cm and 0.38cm for the cylinder while the triangular prism had a standard deviation of 1.07 cm which was the least precise. An ANOVA test was ran in order to determine the statistical significance of the data. The recorded P-value was 0.015, which was less than the determining value of 0.05; therefore, the data was significant and the null hypothesis can be rejected. The statistical analysis and data presented suggests that the triangular prism has a negative impact on the effectiveness of ultrasonic sensors most likely due to the angled edge of the prism.

Honorable Mention
Madeline Powell- Effectiveness of Material Thickness on Blocking Gamma Radiation
Central Virginia Governor's School

The purpose of this study was to determine if epoxy showed radiation blocking properties and whether or not the thickness of the material had any effect on those properties. This

study was conducted at a local high school laboratory in December of 2021. The three variables were no epoxy (control), 50 ml epoxy, and 100 ml of epoxy. The research hypothesis was that if each group was exposed to gamma radiation for 10 minutes, then 100 ml of Epoxy will block the most radiation. The gamma radiation disk was placed under the material and the Vernier radiation detector was placed above it. At the end of each trial, an average was taken of the radiation counts. A total of 10 trials were run. At the end of the experiment, a single factor ANOVA (alpha .05) indicated a statistically significant difference with a p-value of 2.936 x 10-6. A post hoc Tukey Test revealed that there was a significant difference between the control group and 50 ml of Epoxy and between the control group and 100 ml of Epoxy. This did not support the research hypothesis. In conclusion, epoxy shows the ability to block gamma radiation but the two thicknesses tested in this experiment were not sufficient to yield any differences. However, epoxy shows promise in its ability to block gamma radiation and requires further investigation about its properties in combination with other sources and a more wide-ranging study of how thicknesses affect its blocking ability.

Honorable Mention
Sriharsha Sambangi- Design of Magnetic Heat Exchanger regenerators for Active Magnetic Refrigeration
Mills E. Godwin High School

Cooling, manifest both as air conditioning and as refrigeration, is regarded as one of the most energy-intensive technologies in demand today. Currently, 15% of the world's electric power is devoted to cooling, with that value increasing to 20% in the U.S. and to 25% in Japan; associated with this technology are significant carbon emissions and environmentally damaging leaks of chemical refrigerant (Goetzler, et al). Novel cooling technologies are required to minimize global energy consumption and environmental impact. To drive the development of efficient, sustainable and green cooling technologies, fabrication of efficient magnetocaloric regenerators which are considered as key components of a magnetic refrigerator are of high importance. Regenerators consist of magnetocaloric materials (MCM) with voids and channels to enable efficient heat transfer by using a heat-exchanger fluid. To date, research efforts to produce magnetocaloric regenerators are proved to be inefficient, expensive and with induced defects while processing. To overcome these challenges, a foil shaped, elliptical cylinder pin design structures were developed for studying heat transfer efficiency via pins to refrigerant. The design consists of pin shaped magnetocaloric heat exchange regenerators squeezed in between two rectangular prisms. Using Autodesk CFD 2021 the designs were tested, and the rate of heat exchange was measured based on the variation in length of the longest diameter and the angle of the line tangent to the arc. It is hypothesized that if the 5mm 45-degree pins were used, then water will consistently be at the highest temperature as it exits from the regenerator. The results revealed that on average the simulations preformed for 3mm 35 ¬∞ pins were approximately 1- 2¬∞C more than the other independent variables. A Wilcoxon Rank Sum Test was done and revealed that all the data was significant at a level of .00001. Further research work focuses on regenerator designs and how it affects heat transfer efficiency. With the inherent advantage of creating

pin designed structures with maximum heat dissipation, this pin structured design geometry serves as favorable design for the development of high-performance magnetocaloric cooling devices.

Karin Anderson- The Effect of 3D Geometric Shapes on Light Scatter
Washington-Liberty High School

This experiment was conducted to test out which 3D geometric shapes would scatter light most efficiently. It was inspired by stealth technology, how it works, and ways to better it. To find more information to structure the experiment, topics researched included military stealth technology jet design, radar cross section, and how light reacts to different surfaces. The experiment was conducted inside a black spray-painted cardboard box, and it required printer paper, scissors, tape, a flashlight, a lux meter, and a way to record data. The experiment had 5 levels, 4 independent variables and a control group. The control was a plain cylinder, and the independent variables were as follows; 24 cm V-Shape, 20 cm V-Shape, W-Shape, paper accordion folded. The levels were constructed using printer paper. To conduct the experiment, the level was placed inside the box at a specified place marked by a white line. The box flaps were then closed, light was shined through from a hole in the box, and the amount of light reflected at the flashlight was recorded with a digital lux meter. There were 10 trials conducted for each level, including the control group. The results of the trials found the 24 cm V-Shaped variable to have the least amount of light reflect back at the flashlight. However, the 20 cm V-Shape was the next, then the control, then the W-Shape, and finally the accordion folds. This meant that angles <90 degrees are those best utilized on jets to deflect radar waves.

Malanie Myaing- The Effect of Tensile Strength on Sustainable Textiles
Central Virginia Governor's School

The purpose of this study was to compare the maximum tensile strength of various sustainable, high performance fabrics to minimize the negative environmental impact that could decrease environmental pollution and overall increase the sustainability in the fashion industry for the future. Each textile was cut to ¬⁰ inch wide equal segments and looped and secured to the materials tester machine. The tensile wheel, which increases the force applied to each material, was then spun to the right until the textile being tested fractured. There were 8 trials involved for each textile. The force at which each textile fractured was the force that was measured and recorded in the study. A single factor one-way ANOVA test was performed on the maximum fracture of each of the four textiles with an alpha value set at .05. The p-value recorded was 3.73 x 10-35. A Post-Hoc Tukey Test was run with a Dmin value of 6.551 showing major significance in all results. The most significant textile with the greatest significant tensile strength was hemp, which supported my research hypothesis that if a hemp textile is tested for tensile strength, then it will sustain the greatest force applied compared to organic linen, lyocell jersey knit, and bamboo jersey textiles. In conclusion, the textile that had the greatest tensile strength with force applied was hemp.

Marcus Obligacion- The Effect of Temperature on the Tensile Strength of 6061 Aluminum
Central Virginia Governor's School

The purpose of this study was to examine the effect of temperature exposure on the tensile strength of 6061 aluminum alloy. A sample of the material was secured into a load frame, and the load frame was run, measuring the sample‚Äôs tensile strength. There were nine samples per group, and a total of four groups tested. They were named based on the temperature they were exposed to: Control, 250¬∞F, 350¬∞F, and 450¬∞F. A single-factor ANOVA produced a p-value of 1.92×10^{-11}. This value was compared to the alpha value of .05, showing significance. A Tukey test with a Dmin value of 3490.816 determined that there was significance in the fourth experimental group, "450" with the other three groups. To summarize, exposing 6061 aluminum to 450‚Ñâ significantly decreases its tensile strength. This is useful to know in automobile and aerospace applications, where materials are often needed to be strong and light. Car and airplane engine parts are exposed to varying temperatures, and it is important to make sure that they are able to withstand these conditions without losing their properties.

Naman Agarwal- A Low-Cost Deep Learning Solution for Early Detection of Lettuce Stress in Indoor Farms
Governor's School @ Innovation Park

Indoor farming is a growing sector, gaining significant attention and investment. Yet, there remains no economically viable tool that can signal vegetation stress to growers before it becomes visible to the naked eye. If early warnings to stress could be achieved affordably, the implications are significant: improving plant quality / flavor, improving biomass yield, and detecting catastrophic failures that put commercial operations at risk. Here, I develop software to provide crop health maps based on full-spectrum infrared imagery for lettuce heads. Crop health maps are applicable for indoor operations as it labels each pixel in the image as "stressed", "fine" or "non-photosynthetically active material". Spectral vegetation indices, specifically the NDVI index, could not evaluate the health condition of lettuce heads, so I employed AI with state-of-the-art deep learning techniques that assess stress based on more complex features including the crop's appearance. I collected a dataset of images containing lettuce canopies and trained image segmentation neural networks that classify each pixel of the image. Using a novel time-series technique, the networks can detect subtle responses to stress such as movement indicating a minor loss in turgidity. Using a novel forecasting technique, the networks forecast crop conditions to create maps that indicate canopy health in the future. Our method was evaluated on the dice coefficient which compares the overlap between predicted regions of stress and the true regions of stress. Our method identified stress not visible to the naked eye, including water deficits and pesticide damage. It achieved average dice scores 6x greater than the NDVI method. The patent-pending solution utilizes converted full spectrum cameras that cost $160 per unit and develops a system that provides accurate crop health maps to help growers improve their business's profitability.

Namit Chandra Nallapaneni- The Effect of Method on Microplastic Collection Efficiency
Mills E. Godwin High School

The overall purpose of this experiment is to design a cheap, efficient microplastic filtration device and method to decrease the concentration of plastic debris in water systems. In recent times, microplastics have become increasingly present in our environment. Some oceanographers have even predicted that up to 51 trillion pieces of plastic are currently located in surface waters. Although the effects of microplastics have not been discovered in the short term, researchers have predicted that these particles could cause cancer in humans, transport alien bacteria, and attract chemical pollutants, which could fatally affect marine life. The independent variable present in this experiment is the method of microplastic collection; the levels include the utilization of a modified design of a Sediment Microplastic Isolation device (SMI) and the control, the utilization of a Neuston net. The dependent variable in this experiment is the percentage of plastic isolated by each method. A research hypothesis was formulated that the SMI method will be more efficient than the Neuston Net method. During construction and experimentation, caution was greatly exercised by the experimenter. Two t-tests were performed on the data at a level of significance of .05 with the degrees of freedom of 48. The data pertaining to the difference between the SMI method and the Neuston net did prove to be significant. For continued study, the feasibility and usability of the SMI design compared to various microplastic isolation devices could be studied.

Noah Gabriele- Adapted Board Game for the Visually Impaired
Harrisonburg High School

The purpose of this study was to create an adapted version of the board game Hisss that allows individuals with a visual impairment to play with sighted individuals. Research was cited showing how board games can contribute to childhood development and social interaction skills. With so many board games relying on visual stimuli as an essential part of game play, the writer intended to convert the colored game components to tactile features. Utilizing wood and a laser cutter, tactile game tiles were created to represent the original game‚Äôs colored cards. The research describes the process of creating a design of game components through a series of various prototypes with durability and feature detection as the ultimate objectives. Upon the completion of the tiles design, participants were tested on their ability to identify essential tile features. Based on feedback, revisions were made to the tile‚Äôs design to ensure functionality of game play. The research concluded that the game pieces were able to be easily identified without the use of sight. With all game pieces constructed, further testing is planned for the game to be played by individuals with and without visual impairment, thus determining the success of the study.

Oakley Massey- Comparison of Cardiac Segmentation Methods for Use in Congenital Heart Disease Corrective Surgeries
Laurel Springs School

The research objective of this paper was to determine whether having more control over the segmentation process when segmenting major vessels of the heart produces a clearer and more accurate 3D model. The procedure used to make this determination was to test three different segmentation methods with varying levels of control on four different datasets. Each of the four datasets represented a different type of congenital heart defect. The methods investigated were automated, partially automated, and manual segmentation. The results showed that the automated method allowed the least control over the segmentation and produced the poorest models of the three. The segmentations were inaccurate, and there was substantial extra branching on the pulmonary artery. The partially automated method produced better models than the fully automated method but significantly poorer models than the manual method. Although the models were clean and clear, they were rough and contained several inaccuracies. The manual method allowed the most control over the segmentation and produced the best models. The models were clean, clear, smooth, and accurate. In conclusion, the results showed that the method that allowed the most control over the segmentation process produced the clearest and most accurate 3D models.

Raymond Wen- The Effect of Electricity on Imitation Blood Flow in Gel
Mills E. Godwin High School

Transcutaneous electrical nerve stimulation (TENS) is the use of electricity on the body using electrodes to induce pain relief in that area and is considered a cheap, reusable, and cost-effective way to treat sores and pains. Many theories have been made about the true method on how TENS works but one that has been studied more often is the relocation of pain through increased blood flow. However, blood flow can easily be restricted through exercise as the muscles contract and tightens around the blood vessels. This study is aimed to determine if TENS had a significant effect on the rate of blood flow. A research hypothesis was made stating if the number of hertz is higher, then the flow of blood will take less time to travel. Four groups were a chunk of ballistics gel, simulated blood using corn syrup, and a specific number of hertz that was applied using TENS. The control being no use of TENS to gauge if it was successful without human participants. The data was collected in seconds and the mean and range were calculated. A null hypothesis was formulated stating that there is no statistically significant difference between the number of hertz used on blood flow simulation. A t-test was used to compare the significance of these trials and the results led to all data points being significant and rejecting the null hypothesis. Further studies, based on the data collected, can be done to further understand the workings of TENS and whether the applications in the modern world should be implemented or not.

Richard Houchens- The Effect of Wind Speed and Blade Amount on the Efficiency of a Wind Turbine
Central Virginia Governor's School

The purpose of my research was to find the most effective way to produce energy with a wind turbine at different wind speeds. This was tested by constructing a KidWind turbine kit and testing different amounts of blades at different wind speeds from an industrial fan by connecting the rotor on the turbine to Vernier Graphical Analysis. After data collection, a two-way ANOVA (Analysis of Variance) test was run to find that the data was statistically significant and a Tukey test was run to determine which groups had significant variance. The p-value was 4.59×10^{-41}, and with the alpha value at .05, this was extremely strong. The results suggest that the research hypothesis that if three, four, and six blades are placed on a wind turbine with wind speeds of 2.4 and 2.9 m/s, then lower amounts of blades will produce the most energy at 2.9 m/s and higher amounts of blades will produce the most energy at 2.4 m/s was not supported. The null hypothesis that blade amount and wind speed do not affect the energy output of a wind turbine was also rejected because of the extremely low p-value. In summary, although the research hypothesis was not supported, the null was rejected, suggesting that blade amount and wind speed play large roles in the energy output of a wind turbine.

Weslie Rosenberg- The Effect of Spidron Design on Preventing Breakage, When Used in Packaging.
Clover Hill High School

The purpose of this experiment was to create paper spidrons that prevent breakage, when used in packaging. The problem that was addressed in the experiment was the fact that much plastic packaging has polluted the environment, so it would be resourceful to find a new type of packaging that is biodegradable. The research hypothesis of the experiment was that if the pentagon, hexagon, and octagon spidron designs were placed in packaging, then the hexagon spidron design would best prevent breakage of an egg. In this experiment, three different designs of paper spidrons were made, and were placed in a cardboard box. The cardboard box also contained an egg. The box was dropped multiple times in order to determine if the paper spidron designs were effective in preventing breakage of the egg. After looking at the data, it was found that the pentagon spidrons were the most effective in preventing breakage of the eggs. In the end, the null hypothesis was rejected, however the results of the experiment did not support the research hypothesis.

Environmental & Earth Science - A

First Place
Anju Natarajan- Assessing Structural Differences Between Gall and Non-gall *Solidago altissima*
Collegiate School

Plant galls are tumor-like growths on a variety of plants caused by inducers such as aphids, fungi, and viruses. The galls' characteristics vary based on the host plant and inducer (Kahn, 2005, Mani, 2013). Furthermore, insects have been observed to affect the cell signaling of certain plants when infecting them with a disease, and a similar situation may be happening with midge flies and goldenrod plant galls (Newman et al., 2004). Stomatal density is the measure of how many stomata, or miniscule pores controlled by guard cells in plant leaves, are present on the underside of leaves (Urton, 2018). Since galls grow at a fast rate compared to regular plant tissues, there may be a larger quantity of stomata facilitating photosynthesis in the leaves of bunch galls (Kahn, 2005). The stomatal density of leaves were measured by soaking the leaves then creating impressions of their undersides with hot glue on glass microscope slides, and observing these impressions with a microscope using the Motic Cam 3.0 MP and Motic Live Imaging Module application on Mac OSX. The average stomatal density of gall leaves of late goldenrod (97 ¬± 4 stomata/0.02mm2) is significantly higher than the control group of leaves from late goldenrod stems without galls (60 ¬± 3 stomata/0.02mm2) (Student's t-test, df = 58, Œ± = 0.05, p = 0.0001). A larger stomatal density for gall leaves may serve to facilitate gas exchange for photosynthesis and cellular respiration, both of which dictate the growth rate of plants (Haiden, Hoffmann, & Cramer, 2012). Understanding the manners by which galls are produced by midge flies and other gall-making viruses, fungi, and arthropods, and their effects on host plant responses can benefit farmers in increasing their agricultural yield (Ullrich et al., 2019). Such research may find methods of preventing the galling of native and endangered plant species which may also be negatively affected by galls (Blanche, 2012). Furthermore, understanding the specific signaling pathways which alter the stomatal density in gall leaves may help agricultural scientists optimize stomatal density for crops. There are also some similarities between plant galls and cancerous tumors within humans, such as their histological patterns for their respective species and the effects of cell signaling on each's development, so this ecological research could be paired with oncology to discover new aspects of both phenomena (Ullrich et al., 2019).

Second Place
Ana Sanchez-Armass- Differences in Water Quality in the Washington DC Area
Washington-Liberty High School

The purpose of the experiment was to determine the water quality of different bodies of water in the area, and ultimately to know which one is the safest and cleanest. Water

quality testing is important in these types of bodies of water as they are used frequently by dogs, swimmers, rowers, and are in the middle of heavily inhabited areas. The hypothesis of the pH group in this experiment was that if all the independent variables were tested, the body of water with the largest watershed (Potomac River) would have the highest pH levels due to the fact that it has the largest watershed in comparison to the other bodies of water that were tested. The hypothesis for the nitrate group was if all the independent variables were tested, the body of water with the smallest watershed (Hidden Pond) would have the highest nitrate levels due to the fact that it is set in a location where it is exposed to the most soil, and therefore fertilizer that has nitrates in them. Although this hypothesis was not supported, the results were statistically significant in the body of water with a medium watershed (Donaldson Run Creek) having the highest nitrate levels. The hypothesis for the fluoride group was that if all the independent variables were tested, the body of water with a medium watershed (Donaldson Run Creek) would have the highest fluoride levels due to the fact that fluoride comes from the minerals in rocks, and the creek is surrounded by rocks. Although this hypothesis was not supported, and the results were not significant, the fluoride levels of all the bodies of water, no matter watershed size, were all around 0 ppm if detected at all, which goes to show that it wasn‚Äôt a very important factor to test. pH, nitrate, and fluoride were the dependent variables for this experiment, as they are some of the most important indicators of water quality, which was the aim of this experiment. The results of this experiment show that the body of water with the largest watershed (Potomac River) has the highest pH levels, the body of water with a medium watershed (Donaldson Run) has the highest nitrate levels, and the highest fluoride levels cannot be determined due to not significant results.

Third Place
Anna Grohs- Comparing Polystyrene Adhesive to Commercial Glues
Central Virginia Governor's School

Polystyrene adhesive was studied as a potential environmentally beneficial alternative for commercial glues. The research hypothesis stated, if Styrofoam™ adhesive is used to glue different materials together, the results will show that polystyrene glue is more effective than AmazonBasics™ but not as effective as Elmer's Glue™. To formulate the adhesive, Styrofoam™ (48 g) was combined with D-limonene (96 mL), water (48 mL), and soy lecithin (4.8 g). The polystyrene glue's strength was then compared to that of Elmer's Glue™ and AmazonBasics™ glue using a Vernier Structures & Materials Tester (VSMT). The tensile strength of each adhesive, measured in newtons (N), was performed on both pine blocks and canvas sheets. The materials were adhered with varying amounts of the different glues. Results from the Single-factor ANOVAs revealed significance due to p-values ranging between 1.40×10^{-15} to 1.90×10^{-04}. The post-hoc Tukey test identified that 0.2 mL of both Elmer's Glue™ (475.2 N) and AmazonBasics™ (384.6 N) had a higher tensile strength on wood than polystyrene glue (2.7 N). Similarly, on canvas both the Elmer's Glue™ (15 N) and AmazonBasics™ (7.2 N) had a higher tensile strength than the Styrofoam™ glue (0 N). Therefore, the research hypothesis was

not supported because the data suggested that the polystyrene adhesive was insufficient.Honorable Mention
Alice Zhang- The Effect of Aeration on Blue-Green Algae Growth
Mills E. Godwin High School

The purpose of the experiment was to find the effect of aeration on Blue-green algae growth, a type of algae known for its toxic algal blooms. Aeration is commonly used to reduce algae growth in lakes, however, over aeration can have harmful effects on the environment. Thus, the goal of this study was to find the optimal aeration condition that can decrease algae growth while minimizing environmental disruption. It was hypothesized that if algae was exposed to a daily aeration of 24 hours, then the algae growth would be significantly reduced. The experiment was arranged into four groups based on the different daily aeration times: 0 hours/day (control), 6 hours/day, 12 hours/day, and 24 hours/day. The initial same amount of algae was added into the test tubes of each group. After three days of aeration, the algae cells were counted using microscopic imaging and the software ImageJ. The mean of the algae cells for the levels of 0 hours/day, 6 hours/day, 12 hours/day and 24 hours/day were 348¬±32, 297¬±36, 197¬±34, and 170¬±28, respectively. A t-test indicated that all aeration levels, compared with the control group, significantly reduced algae growth, with the most reduction in the 24 hours/day group. Based on the results, the research hypothesis was supported. The groups of 12 hours/day and 24 hours/day had similar inhibiting effects. Since 12 hours/day has less environmental disruption, it may be a more optimal aeration condition compared to 24 hours/day. The inhibitory results may have been due to the excess oxygen removing nutrients in the experimental growth medium that are necessary for algal growth.

Honorable Mention
Allison Blake- in Tornado Strength, Frequency and Location in Virginia with Changing Climate
Chesapeake Bay Governor's School

Recent climate change has caused many to attribute the increase and the severity of natural disasters, like tornadoes, to global warming. The goal of this study is to assess how tornado frequency, strength and location have changed over the recent period of the last four decades to see if there have been any significant changes as the atmosphere has warmed. Has climate change had an effect on tornado frequency, strength, and affected locations in Virginia? Using 43 years of metadata from National Oceanic and Atmospheric Administration (NOAA) collected by Doppler Radar, the frequency and strength of tornadoes in Virginia were compared. Data were analyzed by comparing all observed tornadoes in Virginia from the decades 1978-1988, 1989 - 1999, 2000 - 2010, and 2011 - 2021 to create even 10-year increments to sort tornadic data. T-tests we're used to compare data between the differing years of the oscillation cycles, and the variation in strength of tornadoes for each subregion of Virginia, and tornadic strength in relation to decades. Over 700 data points were analyzed in this study, ranging from years 1978 - 2021. Yearly average tornadic activity for the state of Virginia was compared

across the decades of 1978 - 1988, 1989 - 1999, 2000 - 2010, and 2011 - 2021. With the warming climate, the strength of the tornadoes in Virginia has decreased due to the warmer weather generating less wind shear, which is used to create tornadoes. There have been more tornadoes per decade thus far in the 21st century, but they have become weaker than those of the 20th century.

Honorable Mention
Amaya Thacker- The Effect of Fishing and Shipping Activity on Blue Shark Distribution
Chesapeake Bay Governor's School

Blue sharks (*Prionace glauca*) are apex predators that are one of the most often seen sharks in the ocean. In spite of their commonality, blue sharks can be vulnerable to drastic changes in their environments. This study looked into one of the biggest changes that blue sharks have had to survive in recent years, the increasing amounts of marine activity in the world's oceans. By using archival data of aerial blue shark sightings and select areas dedicated to fishing and shipping, the density of blue sharks in these areas was found. This was to see if the sharks appeared to be congregating in or avoiding these areas based on a comparison of their densities when there was high versus low marine activity. The results displayed an apparent trend of blue shark sightings in areas of minimal marine activity, both commercial fishing and shipping, although for shipping the trend was not statistically significant.

Abbey Lennox, Samuel Jacob - Can Silica Save The Glaciers?
Washington-Liberty High School

Global warming has caused glaciers to melt at unnatural speeds. The purpose of this study was to determine if silica could be used to prevent glaciers from melting rapidly. Although scientists have previously tested the effect of silica on how fast ice melts, this experiment was conducted to further investigate the effects of silica's highly reflective surface. The premise of the experiment was to test different amounts of silica on ice cubes to see if the silica affected how much the ice melted. Four amounts of silica were tested in this experiment: 0.0 mL, 1.25 mL, 2.5 mL, and 5.0 mL. The silica was spread across the surface of four different ice cubes and then left to melt for 2 hours under an LED light. The hypothesis of this experiment was that if the amount of silica was changed, then the amount of water melted in 2 hours would be lower because the ice cube was covered in more silica. The results from this experiment ranged from 20.0 to 22.6 mL of ice melt produced. The results showed a negative correlation that higher amounts of silica produced less ice melt in 2 hours. Although there was little difference between the groups, ANOVA and t-tests provided p-values that supported the hypothesis. This information can be used to assist future experiments that test the effect of silica on ice melt and hopefully be used to help prevent the melting of ocean ice in the future.

Abigail Proffitt- The Effect of Climate Change on Rated Storms

Central Virginia Governor's School

The purpose of this study was to analyze possible correlations between climate change factors, using sea surface temperature, and tropical storm and hurricane intensity. The data for each category, rainfall, storm surge, wind speed, and sea surface temperature were collected by using NOAA and the National Weather Service. After data collection, a regression analysis was run for each measured variable from each storm category against sea surface temperature. The alpha of .05, when compared to the p-values for this study showed overall no statistical significance. However, for wind speed and sea surface temperature, Category 2 hurricanes were found significant with a p-value of .02. Since there was only one significant p-value, the research hypothesis was not supported, which stated: If I measure the escalation of climate change through sea surface temperature then it will positively correlate with the intensity of rated storms of the Southeastern coast of America and the Gulf of Mexico. This research can be used to help future studies to evaluate climate change and the potential dangers that come with storm intensity. Correlations between rainfall, storm surge, and wind speed could instead be compared to global surface temperature or ocean heat content. This study could be used in the future to adequately observe how climate change is affecting the weather.

Abigail Taylor- The Effect of Water flow, In Naturally Occurring Bodies of Water, on the pH Level
Clover Hill High School

The question that was addressed in the experiment was at which rate of water flow, in naturally occurring bodies of water, would the pH be most neutralized. The purpose of the experiment was to determine which flow rate would have the most neutral pH level. The research hypothesis was if the body of water moved faster, then the pH would be more neutral than the pH of slower water. Numerous bodies of water with various flow rates including: 0 m/s, 0.07 m/s, 0.09 m/s, 0.1 m/s, and 0.3 m/s were traveled to during the experiment, where the flow rate was measured and calculated and the pH was taken. To determine the flow rate for each body of water, the float method was used, where an object was released at one point of the body of water and was then timed and stopped at a different point. To measure the dependent variable, the pH of the different bodies of water, a pH meter was used. The pH was measured and recorded in a data table, for 30 trials per body of water. The control of the experiment was the flow rate of 0 m/s and the mean pH was 9.43. The water body that had a flow rate of 0.07 m/s had a mean pH of 8.890. The mean pH of the body of water measuring an average of 0.09 m/s was 8.223. The mean pH of the body of water with a flow rate of 0.1 m/s was 7.449. The last level of independent variable, which was a flow rate of 0.3 m/s had an average pH of 7.83. Once the data was collected from all of the bodies of water, an ANOVA test was conducted to test if the data was statistically significant. The results of the conducted ANOVA test stated that there was a statistically significant difference between the different independent variables. The ANOVA test also revealed that the null hypothesis, the flow rate of the water bodies would not affect the pH, was rejected.

Abraham Wisner- Measuring the Effect of *Bacopa caroliniana, Ceratophyllum demersum, and Vallisneria americana* on Phosphorus Levels in Water
Washington-Liberty High School

The purpose of this experiment was to determine which aquatic plant out of *Bacopa caroliniana*, *Vallisneria americana*, and *Ceratophyllum demersum* is best at removing phosphorus from the water. The hypothesis was that if *Vallisneria americana, Bacopa caroliniana*, and *Ceratophyllum demersum* are given equal amounts of phosphorus, then the lowest levels of phosphorus will belong to *Ceratophyllum demersum.* This hypothesis was not supported by the results*. B. caroliniana* was the most effective plant at removing phosphorus from water. The difference between the plants in their phosphorus removing abilities were significant, so the null hypothesis was rejected. The results indicated that *B. caroliniana* can potentially be effectively used to improve water quality in bodies of water in Virginia.

Aden Kim- The Effect of Water Flow Rate (L/h) on Reproductive Rate of Duckweed (fronds/week)
Clover Hill High School

The purpose of this experiment was to determine the effects of water flow rate (L/h) on the reproductive rate of duckweed (fronds/week). Growing duckweed under different levels of water flow rates helps to gain more knowledge about the growing conditions duckweed can reproduce reliably in. Establishing what water flow rates duckweed can tolerate helps to determine if duckweed can be applied to certain purposes depending on the speed of water flow. The research hypothesis was that if duckweed (Lemna minor) was grown in water with varying degrees of water flow rates for 14 days, then the reproductive rate of the duckweed would decrease as the flow speed increased. Thirty six trials of four duckweed fronds were grown in containers with varying degrees of water flow for fourteen days, and the average number of fronds produced by the end of the growth period was used as the reproductive rate. The control had no water flow (0 L/h), and duckweed was grown in environments with water pumps moving water at 120 L/h, 180 L/h, and 240 L/h. The mean reproductive rates for the duckweed plants grown in the control (0 L/h), 120 L/h, 180 L/h, and 240 L/h groups were 4.3, 3.1, 4.0, and 5.4 fronds per week respectively. As the water flow rate increased, the reproductive rate increased, with the exception of the 120 L/h group. An ANOVA test was conducted to test if the data was statistically significant, and the results of the test concluded that the data was significant. An LSD test was conducted to determine where the significant differences lay, and the test concluded that the differences lay between the 240 L/h group and the 120 L/h and 180 L/h groups. Therefore, the null hypothesis was rejected. However, the results were found to be unreliable due to issues with the execution of the experiment, as water flow was unstable, throwing duckweed fronds out of their sections, and because the fertilizer might have been unreliable.

Aleksandra Witkowski- The Decomposition Rates of Wooden vs. Plastic vs. "Biodegradable Plastic" Coffee Stirrers in Different Sediment Conditions
Chesapeake Bay Governor's School

This experiment compared the decomposition rates of "biodegradable" plastics, petroleum-based plastics, and a "real" biodegradable which was wood. These objects were sorted into different conditions: saltwater/sand mixture, freshwater/sand mixture, and freshwater/soil mixture. The weights of each material of coffee stirrer within a certain treatment were recorded before and after a three month period. The prediction of the freshwater/soil mixture and freshwater/sand mixture having the greatest effect on the full decomposition of the potentially biodegradable materials was made. This is due to the presence of microorganisms, which helps to "speed up" the degradation process. Petroleum based coffee stirrers did not show any change within any treatment introduced. The wooden coffee stirrers as a whole decomposed the most, while the biodegradable plastic stirrers did not decompose as much as the wooden stirrers. The biodegradable plastic stirrers, however, did decompose more than the petroleum based stirrers. With this being said, plastic stirrers labeled as biodegradable, do decompose faster than petroleum based coffee stirrers; however, neither decomposed as fast as the wooden stirrers. Biodegradable plastics are a beneficial alternative to petroleum based plastic, especially when unintentionally introduced into the environment. Biodegradable plastics will break down and decompose at a faster rate than petroleum based plastics will.

Alena Topchy- The Effect of Infrastructure on Dissolved Oxygen in Nearby Streams
Washington-Liberty High School

The purpose of this experiment was to determine if infrastructure had an effect on stream health. The independent variable levels were 20 meters, 10 meters, 5 meters, and 1 meter away from a road. The hypothesis stated that if water samples from different sections of Four Mile Run were tested for dissolved oxygen, then the water samples taken 20 meters away from the road would have the highest amount of dissolved oxygen because they would have the least pollution from nearby surfaces of civilization. The hypothesis was supported by the data. At 20 meters, the amount of dissolved oxygen averaged 9.5 mg/L, which was the greatest amount of dissolved oxygen compared to the other independent variable levels. The null hypothesis stated that the distance from the road would have no effect on the amount of dissolved oxygen in the water. This was rejected because the p-value was less than 0.05, which meant that the data was statistically significant. The data showed that the distance from the road had somewhat of an effect on the amount of dissolved oxygen in the stream. This experiment was important because road runoff is a big contributor to water pollution.

Amna Zakriya- The Correlation Between the Intensity/Quantity of Solar Flares and Natural Disasters on Earth
Mountain View High School

The Taal Volcano, located in the Philippines, had a large-scale eruption in 2020, a few years back. It was an enormous disruption with a 4 on the Volcanic Explosivity Index, VEI for short. To put that into perspective, Mount Vesuvius's eruption that destroyed Pompeii was ranked on the VEI as a 5. The Taal Volcano was a major tragedy, killing approximately 200 people in the damage. This is only one of those many stories one will hear about natural disasters ruining people's homes and often ending their lives. This experiment studies the effect of solar flares on natural disasters. Considering the nature of solar flares and many natural disasters' origin, it is entirely possible for the two to be linked. This organization of data can reveal a trend which may not only lead to scientists having more resources for predicting these occurrences, but potentially also a method of controlling them. The initial hypothesis is that tropical cyclones are affected by solar flares the greatest, as an increase in wind, an aftermath of solar flares, is a key component in the formation of these storms. The procedure began by collecting statistics regarding quantity and intensity from internet resources on solar flares and each natural disaster being studied, then compiling all data into spreadsheets. Intensity in each category was compared by standardizing each individual scale to the severity of solar flares being studied. All data was next converted into a graph form where trends were compared, and final conclusions were drawn. The experiment resulted in a direct correlation between Category 1 tropical cyclones and X-flares (in terms of solar flares) as well as earthquakes relating to any level of solar flare, but most prominently between earthquakes rated 5-5.9 on the Richter scale and X-flares. These results suggest the possibility of solar activity influencing tectonic plate movement and potentially other earth systems, along with minor weather results.

Anastasia Kotakis- The Effect of Different Kinds of Roadside Salts on Fescues Grass Plant Growth
Washington-Liberty High School

This experiment was conducted to find the type of roadside salt that affected the fescues grass plants least and had the tallest mean height as well as best overall health. The hypothesis for the experiment was that the control group, plants tested with only water, would have the highest mean height while of the plants treated with salt, the group treated with sodium chloride would have the highest mean height. The groups that were tested were sodium chloride (NaCl), magnesium chloride (MgCl2), calcium magnesium acetate, and the control of only plain water. The roadside salts were mixed with water to create a solution that the plants were watered with 5 mL of, every other day. 20 plants per group were tested and measured every day for a total of 80 plants. Results were then compiled in a data table and mean heights for each group, every day was calculated and graphed on a summary multi-line graph. Standard deviations were calculated as well as an ANOVA test and t-tests. Data was statistically significant with a p-value of 0.00096549, to show that there was a significant difference between the groups. Data from the experiment supports the hypothesis that plants treated with only water would have the highest mean height. On day 14, the control group had a mean height of 10.2 centimeters. The plants with the second highest mean height were sodium chloride with a mean height of 9.3 centimeters, followed by magnesium chloride with a mean height of 8.7

centimeters, and then calcium magnesium acetate with a mean height of 8.3 centimeters. However, no difference was found between the appearance of the different plant groups, other than height. Experiment could be improved by testing the tolerances to roadside salts of different plants or testing different concentrations of roadside salts to see which is most harmful and at what concentration.

Anish Viswanath- The Effect of Earthworms on the Erosion of Soil
Mills E. Godwin High School

This study was completed to find whether or not earthworms have an impact on the structure of soil. Erosion has been a problem in many parts of the world in recent years, and solutions need to be created. The hypothesis stated that if there was 1 earthworm in the soil, then the structure of the soil would be the strongest. Different amounts of red earthworms (control being "no earthworms") were placed in plastic cups with loam soil over a 24-hour period. The earthworms were then removed, and the soil in the cups was placed on blank paper. An electric fan was then used to cause wind erosion which blew soil off the paper. The remaining soil particles left on the paper were weighed and compared to one another. The "1 earthworm" level had the strongest soil structure, the "5 earthworms" level had the second strongest, and the "no earthworms" level had the weakest. 3 t-tests were performed on the data and all 3 showed that the data was significant on a 0.001 significance level. The data also had no outliers showing it had no data point outside of the SD2 range. The reason as to why the levels with earthworms improved the soil structure is likely due to their casts. The 1 earthworm level strengthened the soil more than the 5 earthworms' level most likely because the space which the worms were given was cramped. In further studies, other species of earthworms could be used to test soil properties.

Anna Dang- The Effect of Ocean Acidification on Changes in Shell Mass
Mills E. Godwin High School

The reduction of carbonate ions from carbon dioxide emission buildups has the possibility of creating endangering seawater conditions for calcifying marine organisms when it is absorbed by the oceans. The objective of this experiment was to explore the potential risk of carbonate structures from ocean acidification through measuring the change in mass of shells after exposure to varying levels of acidic water. Mussel shells were submerged in water with pH levels of 8.1 (control), 7.8, 7.5, 7.2, and 6.9 for fourteen days before calculating mass. It was hypothesized that if the shells are immersed in more acidic waters, then the change in mass will be greater. Increases of the difference were especially apparent in the 7.2 pH level. Irregularities within the 7.8, 7.5, and 6.9 pH levels suggested insignificant data which was revealed to be true by performing a t-test. The outcomes of this research demonstrated the prospective risks of pH reduction on carbonate marine structures by comparing mass values. Further research could include studies that investigate changes in the physical conditions of shells.

Environmental & Earth Science - B

First Place
Audrey Johnson- Pseudomonas protegens' Effect on Crop Yield in High Salinity
Environments
Central Virginia Governor's School

Agriculture supports our food needs and is important for our survival. Finding ways to improve crop growth and yield is important to feed the growing population. Plant growth promoting bacteria (PGPB) Pseudomonas protegens may help increase plant growth and stress tolerance. The purpose of this experiment was to see if Pseudomonas protegens are a viable way to increase plant stress tolerance to an abiotic stressor, salt. After inoculating Brassica napus va pabularia (Red Russian kale) with P. protegens using aseptic technique then subjecting them to an abiotic stressor (salt), the results suggested that P. protegens do not have significant impact on the growth of Red Russian kale. Each experimental plant group was given 30 ml of 10g/l salt solution. After analysis of dry mass of roots, stems, and leaves as well as fresh mass of leaves with a two-factor ANOVA test the p-values were .54, .49, .77, and .75, respectively, while the alpha was .05. The research hypothesis that if Pseudomonas protegens were introduced to Brassica napus va pabularia, then Brassica napus va pabularia would have a greater crop yield when exposed to a salt stress than plants not inoculated with Pseudomonas protegens, was not supported by the data collected. The null hypothesis was retained due to the lack of significant differences within the data groups meaning that no one group has a greater crop yield compared to the others.

Second Place
Be′la Williams
Blacksburg High School

In response to global environmental degradation, composting is becoming more important as a sustainable waste management practice, as well as a nitrogen and phosphorus source for crops. However, there is a higher nitrogen/phosphorus demand ratio among common crops, and finished compost tends to have a lower nitrogen/phosphorus supply ratio. This results in excess water-soluble (bioavailable) phosphorus leaching into the environment. Biochar has already been shown to reduce nitrogen losses during decomposition, but its effects on phosphorus are largely unknown. My lab-study revealed that water-soluble nitrate and phosphate decreased as biochar/compost dry weight ratios increased. My field-study combined food waste and wood chips to form compost, which was then divided into two portions. Biochar was mixed with one portion (wet weight ratio: 3:20) while the other portion remained as a control without biochar. During the 55-day decomposition process, it was observed that the biochar-compost mixture had consistently higher temperatures (up to 10¬∞C) but 4-9% lower water content than the

control. The biochar-compost mixture resulted in a larger decrease of both water-soluble (bioavailable) nitrate and phosphate concentrations over time. My lab-study demonstrated that higher biochar/compost ratios resulted in less water-soluble nitrate and phosphate. More research is necessary to determine the cause of this relationship, but the laboratory results suggest biochar is capable of adsorbing both nitrate and phosphate. If biochar's ability to reduce nitrate and phosphate loss to the environment is confirmed, this technology has the potential to improve compost's viability as an alternative to synthetic fertilizers.

Third Place
Brenna Hendrix- The Effect of Oyster Reef Restoration on New Recruitment to Nearby Shoreline Habitat
Chesapeake Bay Governor's School

Environmental degradation has adversely affected communities all over the globe, including the Chesapeake Bay and its oyster reefs. Over the last century the Chesapeake‚Äôs oyster reefs have been lost due to overfishing, habitat destruction, and diseases. Oyster reef restoration is incredibly important for the Chesapeake Bay ecosystem and for local coastal economies; oyster reefs also offer larger benefits by storing carbon to mitigate climate change and support greater biodiversity. This study analyzes the effect of proximity to restored oyster reefs on nearby populations of wild oysters within the lower Chesapeake Bay. Observations were made across the lower Chesapeake estuary in the Piankatank, Rappahannock, and York rivers, where seven sites were sampled in total. When comparing locations near to the oyster reef with locations far to the oyster reef, there was a statistical difference, $p < 0.05$ in oyster abundance. All sites showed significant differences in shell height, however only oysters at near reef sites showed evidence of growth from 2 or more years or spat recruitment. The results of this study demonstrate that local intertidal oyster abundance in the lower Chesapeake Bay has increased within close proximity to oyster restoration reefs. Successful restoration efforts are essential for the Eastern Oyster population and the larger Chesapeake Bay in the face of climate change and continuing human development.

Honorable Mention
Arianna Fortune- Edge Effects of Forests
Chesapeake Bay Governor's School

Having a diverse amount of species in a forest can overall benefit the health and productivity of the ecosystem. A thriving forest consists of clean air and plenty of oxygen while also absorbing CO_2 from the atmosphere to combat against pollution. In order for forests to thrive and be productive there has to be biodiversity. The forest ecosystem is one whole ecosystem, but it is composed of two ecological communities: the interior and edge of the forest. The edge of the forest is known to get more precipitation, sunlight, and organism activity compared to the interior. The interior of the forest does not receive as much sunlight and the amount of precipitation is decreased. Human interaction with the

edge causes soil erosion and chemical runoff. This study compared plant biodiversity as well as soil conditions which include pH, moisture, and light intensity between the interior and edge of both a monoculture, pine forest and a native forest. A Soil Master tester was stuck four inches into the ground to test the pH, moisture, and light intensity. A Shannon Index was used to test biodiversity at three random sites chosen along the edge and interior of both forest types for a total of twelve sites. The interior sites were located 5 meters into the forest from the six edge sites. Each of the twelve sample sites were 2 meters by 1 meters. The different species of plants from each site were photographed, recorded, and counted. The photographs of each species were posted on iNaturalist where they could be identified. Biodiversity was higher at the edge of both forest types. Biodiversity was significantly different between the edge and inner forest (p-value 0.05), but not between forest type (p-value 0.59). The average pH was higher, more basic, in the monoculture forests edge and interior, however it was not statistically between the edge and interior (p-value 0.72) or between forest type (p-value 0.29). The average soil moisture was higher in the native forests edge and interior with each site. Soil moisture was not statistically significant between edge and forest (p-value 0.96), however it was trending toward significance between forest types (p-value 0.14). The average light intensity was higher in the native forests edge and interior. Light intensity was not statistically significant between edge and forest (p-value 1.0), however it was trending toward significance between forest types (p-value 0.09). While trends showed variation in soil and light conditions between forests, they were not significant. However, Biodiversity was significantly greater at the edge of the forest indicating the importance of this unique ecosystem.

Honorable Mention
Ariel Wang- Examining relationships between microplastic size and Lumbricus terrestris transport
Central Virginia Governor's School

The purpose of this study was to experimentally test the effects of how microplastic size impacts movement caused by Lumbricus terrestis. The hypothesis stated, if microplastic pieces varying from size 0.2mm to 0.8mm are placed into a bin for six days, then the Lumbricidae will move the smaller pieces of microplastics more than the larger pieces. Three glitter sizes were added: 0.2 mm, 0.4 mm, 0.8 mm, and a control group which included no glitter. Four trials were run with each size group. Lumbricidaes were added to the bins filled with loam soil and microplastic pieces for six days, then observed for movement. Data was collected through digital images that were imported into ImageJ for particle counting. A two-way ANOVA test determined no statistically significant interaction between particle size and the depth the worms would transport particle, with a p-value of .982 (alpha .05). However, the results did show a statistical significance in the amount of microplastic particles by depth with a p-value of 0.00049 (alpha .05) A post-hoc Tukey test then determined the significance was between the marginal depths of 2 and 6 inches. Although there was partial significance, the data did not support the original hypothesis that microplastic size had an effect on plastic movement caused by Lumbricus terrestis. The focus of this experiment leads to a bigger environmental issue since microplastics

end up in different depths of soil caused by soil life. This plastic pollutant can have potentially harmful effects on soil, animal, and human health.

Honorable Mention
Austin Phan- The Effect of Varying Amounts of Juglone Solution on the Growth Rate of Trifolium repens
Clover Hill High School

The question that was addressed in this experiment was whether or not juglone serves as an effective natural herbicide. The purpose of this experiment was to determine whether or not juglone could be used as a herbicide for future weed management strategies. The experimental hypothesis stated that if the amount of juglone solution in the soil was increased, then the growth rate of Trifolium repens would decrease. Five trials were conducted for each of the 3 levels of experimental independent variables plus the control. The levels of independent variables were 24 milliliters, 16 milliliters, 8 milliliters and 0 milliliters of juglone. The plants were watered with their respective ratios of juglone to water twice a week for ten weeks, and the plant heights were measured along with the number of leaves for the last five weeks of the experiment. After the last five weeks, the control group had the lowest mean height at 2.100 centimeters, and the 24 milliliter group had the highest mean height at 3.306 centimeters. The 16 milliliter group had the second lowest mean height at 2.136 centimeters, and the 8 milliliter group had the second highest mean height at 2.812 centimeters. Over the course of the last five weeks, the 24 milliliter group was consistently the tallest group for all five weeks. The 8 milliliter group was consistently the second tallest group for all five weeks. The control group was the third tallest group for the first two weeks, then became the shortest group for weeks three through five. After the data was collected, an ANOVA test was conducted to test if the data was statistically significant. The results of the conducted ANOVA test stated that there was not a statistically significant difference using a level of significance of 0.05. The experimental hypothesis was not supported, and the null hypothesis was not rejected.

Anne Sullivan- Does Corporate Pollution Pay: Evaluating the Relationship Between Profits and Greenhouse Gas Emissions Among Top Petroleum Companies
Alexandria City High School

This project studies how the profits of big corporations correlate with increasing pollution in our earth's atmosphere, measured by the amount of greenhouse gas emissions they produce, in order to learn more about how to promote sustainability. It focuses on the top 24 global oil and gas companies for the years 2018-2020 because they are among the top corporate polluters. The hypothesis of the project is that there is a positive correlation between profitability and greenhouse gas emissions. The results of the study show that this is true, although it would be helpful to continue to study over time, particularly as companies implement efforts to reduce greenhouse gas

emissions as part of global commitments to reduce global warming through the Paris Agreement. Additionally, it would be helpful to study the full extent of companies' greenhouse gas emissions by expanding it to include Scope 3 downstream emissions. Unfortunately that information is not available for all of the companies studied.

Aquib Syed- The Effect of Iron-Oxide-Induced Electromagnetic Filtration on Agglomerated Microplastic Extraction
Mills E. Godwin High School

The purpose of this experiment was to determine the effectiveness of an electromagnetic filter in extracting microplastics through iron oxide agglomeration. As microplastics continue to accumulate and become a severe threat for humanity, the necessity for an efficient and cost-effective filtering system has arisen, and this study aimed to accomplish this through an electromagnetic filtration system. An electromagnetic filter consists of a ferromagnetic element and copper coils connected to a power source, which generates an electric force. The rationale of this experiment was to determine the efficacy of an iron-oxide-induced electromagnetic filter in extracting microplastics. This study could improve modern-day filtration systems for everyone to benefit from. The hypothesis was that if the iron-oxide-induced electromagnetic filter is used, then the microplastic extraction will be the most efficient. Appropriate safety protocols were followed. Iron oxide was added to microplastic samples and poured down an electromagnetic filter, and microplastic content in filtered samples was measured through a SpectroVis analysis, a microscope analysis, and a turbidity test. The control of this experiment was the metal filter without any electromagnetic field. The data showed that the iron-oxide-induced electromagnetic filter resulted in the most microplastic extraction. Multiple t-tests were performed, and calculated values were greater than the table value. The null hypothesis was rejected, the probability of error was less than 0.05, and the data was statistically significant. The iron-oxide-induced electromagnetic filter resulted in the highest microplastic removal due to the formation of magnetic agglomerates of microplastics, which were extracted by the electromagnetic field.

Arvind Rajesh- The Effect of Various Quantities of Silver Nanoparticles on the Regenerative Capabilities in *Dugesia tigrina*
Mills E. Godwin High School

The main purpose of conducting the experiment is to determine what amounts of silver nanoparticles affect the regenerative capabilities of *D. tigrina*. The regeneration of planarian flatworms, especially changes in the area of the regeneration bud (b¬¨lastema) after surgical dissection, has been proposed as a reliable technique for evaluating silver nanoparticle toxicity (Kustov et al., 2014). Understanding to what extent cellular connectivity is influenced by quantities of silver nanoparticles in planarians will serve as a great model in comparison to certain organisms such as humans. The research hypothesis was that if *Dugesia tigrina* are exposed to various quantities of silver nanoparticles, then the greatest amount of silver nanoparticles (1000 nm) will cause the

planarians to not regenerate as efficiently as to those exposed to the lesser amounts of silver nanoparticles. The investigation was conducted with four groups of *D. tigrina* exposed to four quantities of silver nanoparticles, 0 nm (control), 100 nm, 500 nm, and 1000 nm. Before exposure, planarians were all beheaded at the pharynx with a scalpel. All four levels of the independent variable were exposed to their respective frequency until full regeneration of the body cavity was achieved. Results were recorded on a computer application and the unit of measure was recorded in hours. The 1000 nm group had a greater mean value than the other levels of the independent variable. The mean value for the group exposed to 100 nm of silver nanoparticles was the lowest at 340.92 hours. The other levels of the independent variable, 0 nm, 500 nm, and 1000 nm had mean values of 341.88, 344.68, and 354.56 hours respectively. A t-test was used to reveal that the research hypothesis was not supported by the data collected for each level of the independent variable.

Bansi Bhimjiani- The Effect of Electromagnetic Fields on Spirogyra Algae Cells
Mills E. Godwin High School

The purpose for conducting this experiment was to investigate the effects of electromagnetic fields on Spirogyra algae cells. Over the past few decades, devices and gadgets have been frequently used in daily lives, and electromagnetic fields transmitted from them may pose a serious threat to lifeforms and ecosystems. The four levels of the independent variable that were tested were test tube one (0 spirals/control), test tube two (10 spirals), test tube three (20 spirals), test tube four (30 spirals), and each level had 25 trials. It was hypothesized that if Spirogyra cells are exposed to 30 spirals of electromagnetic fields, then the cells will be negatively impacted. In this experiment, Spirogyra cells were put in test tubes, which were wrapped around in different amounts of copper wire, and all the test tubes were put under a light source. The increasing number of coils on each test tube stimulated various amounts of electromagnetic fields. Samples from each test tube were taken, and the results of the cells‚Äô health were recorded using a ranking system (1= healthy, 3 = unhealthy). The results showed that the median was 3 (unhealthy) for test tube four, which had most spirals and electromagnetic field exposure. A Chi-square test proved that the data was significant and due to the independent variable. The results support the research hypothesis and reject the null hypothesis. Additionally, the results acquired were due to the high intensity Hertz levels of the electromagnetic waves. Overall, this research could lead to further studies that investigate ways of eliminating excess electromagnetic field exposure.

Bladen Williams- Living shorelines, what do they really provide?
Chesapeake Bay Governor's School

Homeowners on the waterfront throughout the northern neck have struggled with coastline management. Sea level rise and erosion is a constant problem for waterfront homeowners. Traditionally man-made structures like bulkheads may be used however, bulkheads have been found to be more harming than replenishing. In the long run

bulkheads start to decay away on a shoreline and cause the homeowner much more money than intended. Two other options are an unaltered shoreline or living shoreline. Unaltered shoreline is just exactly what it sounds like, a shoreline that hasn‚Äôt been touched with some vegetation but no structure. A living shoreline however, can be a structure of rocks with a line of vegetation behind it all used to protect the shoreline. In this study erosion rates, dissolved oxygen levels, and turbidity at living shorelines and unaltered shorelines are compared. To measure erosion at each site two stakes were put out 6.1 meters (20ft) out into the water and 12.2 meters (40ft) out. Samples were taken of the length from top of stakes to the sediment to see how it fluctuated over time. To get dissolved oxygen a titration kit was used at each site and to get turbidity and turbidity tube was used at each site. This study found that the living shoreline had a slightly better erosion control however, it was not statistically significant. The dissolved oxygen was higher at the living shoreline, but the p value again was insignificant at 0.467. The turbidity was found to be better (clearer) in the unaltered shoreline with a significant p value of 0.031. Hopefully this research can be used in a beneficial way to help homeowners and programs to help shorelines. Understanding the best solution to control coastal erosion and maintain water quality is important to a healthy Bay.

Burke Bankston- The Effect of Hydrophobic Coatings on the Efficiency of Solar Panels
Central Virginia Governor's School

The purpose of this study was to determine whether the addition of thin-film hydrophobic coatings on a photovoltaic cell (solar panel) had an impact on the energy output of the panel. The experiment was conducted in a local high school tech lab in 2021. Ten total solar panels were used as four different coatings were applied to eight of them (two solar panels per applied coating), with two saved for a control. There were four different weather conditions tested with data collected every 30 seconds for a total of 400 trials (40 on each cell). The amount of energy produced for every solar panel was recorded for the conditions of light only, water only, sand only, and water with an addition of sand. These tests together run with a two-factor ANOVA with replication, with an alpha value of .05, revealed a p-value of 2.6×10^{-129}. This statistically significant result supported the research hypothesis which stated that the use of these coatings will provide an increased amount of energy under weathering conditions. In conclusion, the provided coatings reduced the weathering effects on the solar panels for an increased output of energy.

Camille Marraccini- The use of natural plant based products for insulation on model homes compared to standard artificial insulation.
Central Virginia Governor's School

The purpose of this research was to find a cheap, effective, and natural alternative source of insulation. Using plant products or waste can be a more affordable option than standard artificial insulation. Fiberglass insulation is known to produce emissions of toxic air pollutants. This could give a large number of people a whole new and improved way of life. The model consisted of a large rectangular plywood box with 1 cm thick walls to

represent the outside of a home. Inside was another box with dimensions that gave exactly 3 cm on every side of the box that was filled with the testing insulation materials. A Vernier Temperature Probe was put inside the inner box, and the entire box setup was put inside a refrigerator. The temperature was recorded over 24 hours, for a total of three trials per insulation group. In total there were nine trials run including the control group of no insulation. The hypothesis was that If powdered hemp hulls were used for insulation in a model Peruvian home using a GE Refrigerator measuring differences in temperature with a Vernier Temperature Probe, then it will perform better than using no insulation. Results from the study, examining the effect of natural plant based waste products, such as powdered hemp hulls, on insulating homes during colder months revealed no statistical difference between the groups. A single factor ANOVA displayed no statistical difference between groups, with a p-value of .234, compared to the alpha of .05.

Conner Benson- Comparison of Benthic Index of Biotic Integrity in Popes and Buckner Creek During the Late Fall
Chesapeake Bay Governor's School

The Potomac River basin is the 2nd largest watershed in the Chesapeake Bay watershed. The Potomac River's current health grade is a B-, declining for the first time in a decade. However, it's a far cry from a D graded just ten years ago. One way to determine the health of the bay and its tributaries is by benthic macroinvertebrates. This study compared the Shannon Diversity index, Evenness, and average macroinvertebrates found between three sampling sites, Pope's Creek, Popes Creek headwaters (Pope's Creek HW) and Buckner Creek, Virginia. All sampling sites are tributaries to the Potomac river and may identify areas of poor water quality that are entering the river. Benthic sediment samples were collected at the three sites over a 3-week period. Sediment was sieved and macroinvertebrates were sorted, counted and identified. Pope's Creek had the highest Biodiversity, evenness and total macroinvertebrate counts followed by Buckner Creek. Pope's Creek had much lower counts for all three measures. Statistical testing found that all three sites were significantly different from each other for all parameters. This study suggests that Pope's Creek headwaters, located in the most developed area, has the poorest water quality. Using tools like benthic macroinvertebrates can be important in locating polluted tributaries so we can better manage and protect the health of the Bay

Corrina Peachey- Breaking the Climate Change Communication Barrier: The Sonification of Speleothems
Massanutten Regional Governor's School for Integrated Environmental Science and Technology

This study developed an alternative means to communicate complex climate change data for the general public. Sonification, or presenting data in auditory form, has potential to bring greater understanding of scientific concepts to those without significant scientific background knowledge. Oxygen isotope data from speleothem formations is a paleoclimate proxy for moisture levels, which is in turn an indicator of precipitation. The

oxygen isotope data ($\delta^{18}O$ values) from eight caves in and around India were sonified. Pitch was established on a decatonic scale based on $\delta^{18}O$ values. Note duration was established based on the time between data points, and dynamics were added to reinforce changes in pitch. The sonified pieces of auditory data were then analyzed and compared to graphs of the original data to investigate significant climatic events and changes. Patterns are evident in the sonified music, and therefore sonification has the potential to be used as a method of climate change communication. A survey was conducted to determine the viability of sonification; results were not statistically significant.

Cynthia Lin- The Development of an Interactive Green-Space Planning Tool for Mitigating Heat Islands in Lynchburg, VA
Roanoke Valley Governor's School

Abstract In recent decades, global change has impacted the health and wellbeing of Earth's community; however, urban populations have been disproportionately affected by "urban heat islands (UHI)." Studies conducted in Lynchburg, Virginia, have also found this to be true, with areas reaching highs of 90°F to 75°F with the principal difference being the area of green space. To effectively mitigate this effect, all groups (city planners, scientists, policy makers, and community members) must understand how to and what to do to create more climate resilient and equitable communities. This demand calls into question the need for an interactive tool to aid the feasibility and access to materials to conduct effective regreening practices to maximize green spaces and minimize Lynchburg's heat index. This program first prompts users to choose between three options: (1) to search a vegetation database for specific qualifying factors from user selected categories, (2) to search specifically for a species, and (3) to highlight possible areas for regreening. Choice 1 allows users to select from categories defined as native status, edibility, drought tolerance, and pest resistance, among others. The program searches through the database and displays information to users. Choice 2 prompts users to enter a specific organism, and the program follows the same pathway. Choice 3 allows users to display a map of Lynchburg with different factors. The creation of this program aims to improve the understanding of sustainable and climate centered practices to mitigate urban heat islands and provide users with information, insight, and initiatives on these practices.

Devan Funke- The Effects of Location and Weather Conditions on Water Quality Indicators
Central Virginia Governor's School

The purpose of this study was to analyze information to pinpoint the safest location and time for recreational swimming activities in water sources and increase public knowledge of water quality factors and issues. This study utilized water sampling techniques and Vernier graphical analysis probes to examine and collect data on water quality indicators such as turbidity, pH, dissolved oxygen, nitrates, and E. coli. Data was collected from

three different locations for three months after several different types of weather conditions. The data was then run through a single-factor ANOVA, with an alpha value of .05, for each variable. The null hypothesis was rejected for all variables besides pH. The p-values for the different variables were; turbidity (5.74×10^{-5}), pH (.084), dissolved oxygen (6.94×10^{-5}), nitrates (7.79×10^{-18}), and E. coli (8.73×10^{-11}). The research hypothesis was supported by the results indicating that the safest place to hold recreational water activities is a less humanly impacted, flowing creek such as Judith Creek. The data also supported that higher levels of human interaction can negatively impact the measurements of water quality. In summation, the study revealed that different locations and different weather conditions do affect water quality.

Environmental & Earth Science - C

First Place
Harriet Shapiro- The Effect of Urban Heat Island Mitigation Strategy on Surface and Atmospheric Temperature
Washington-Liberty High School

Urban heat islands (UHIs) are urban areas with consistently higher temperatures than surrounding rural areas and are harmful because they exaggerate the effects of global warming and contribute to worsening heat waves. The purpose of this study was to determine what UHI mitigation strategy best reduces this phenomenon. The strategies tested were green roofs, cool roofs, cool pavements, and trees, while no mitigation effort was the control. It was hypothesized that the cool roofs would be most effective due to their high solar reflectance and greater surface area. The experiment was conducted by constructing model cities and finding the average increase in temperature after one hour under a heat lamp for each of the mitigation strategies. The results showed that the cool roofs and green roofs were most effective at preventing overall heat gain, with mean increases in temperature of 2.2° C and 2.1° C respectively. Conversely, the control allowed for the greatest temperature increase at 3.0° C. The data collected suggests that all four mitigation strategies tested are successful in reducing UHIs and provides further insight into the best strategies to use for various purposes.

Second Place
Ella Indseth- Bioremediation of Fish Polluted Water by the Macroalgae *Chaetomorpha linum*
Chesapeake Bay Governor's School

Ammonia and phosphate are two chemicals that can be found both in the ocean and a marine aquarium. At low levels these chemicals cause no harm to the health of an ecosystem. But when excess amounts of nutrients from runoff or fish waste enter the water, ammonia and phosphate levels increase drastically. Over the years, researchers

developed different forms of bioremediation in an attempt to save our coastal waters from the devastating effects of pollution from excess nutrients. One form of bioremediation involves using the growth of macroalgae to remove the harmful chemicals and excess nutrients from the water. This study was conducted to investigate the ammonia and phosphate absorption capability of the macroalgae *C. linum* that is currently used in the aquaria hobby. The macroalgae was placed in nutrient-dense water that was collected from killifish to mimic the amount of nutrients that are released into coastal waters from densely corralled fish in the coastal aquaculture industry. A series of water tests were done to measure the impact *C. linum* had on ammonia and phosphate levels over time. The results of this study support that the implementation of *C. linum* in a marine environment would significantly improve the water quality by lowering ammonia and phosphate levels. Further testing must be done to investigate the invasiveness and possible negative effects of *C. linum* but, this study supports that *C. linum* is capable of significantly reducing phosphate and ammonia levels and could aid in the remediation of our coastal waters from non-point sources and aquaculture farming.

Third Place
Hallie Shackleford- The Average Species Richness of Living Shorelines Versus Man-Made Shorelines
Chesapeake Bay Governor's School

The role of shorelines in the habitat of marine life is extensive. They provide shelter and food for the organisms that live there. However, these natural habitats are being replaced by man-made shorelines in order to protect the land. Instead of installing living shorelines, people and companies opt to install revetments, bulkheads, and jetties. The organisms that live near these shorelines are affected by this drastic change in habitat. This study examined the effect of the type of shoreline on the species richness of the area. A seine net was used to catch and observe the number of different species of organism in the water column. Sediment samples were used to observe the benthic creatures. These shoreline sites were beaches, living shorelines, and hardened shorelines with revetment. There were three different sites for each type of shoreline. The nine locations, along the Great Wicomico River, were seined once a week for four weeks during the month of August. One sediment sample was taken from each location and put through a sieve in order to observe its contents. It was found in the seining samples, that the living shoreline samples had the highest average species richness, followed by the revetment samples, with the beach samples being the lowest. In the sediment samples, the beach sample had the highest average species richness, followed by the living shoreline sample, with the revetment sample having the lowest. An ANOVA p-value comparing the species richness for seining was highly significant. However, the p-value for the benthic samples was not significant, however was trending toward significance with a p-value of 0.145. These results most likely occurred, because the organisms in the water column prefer the living shorelines to the other shorelines, but the benthic organisms do not have the same requirements for their environment. The benthic organisms do not need there to be grasses above the sediment, because they live in the sediment. Understanding the benefits to marine life and biodiversity in the Bay should be an important factor when

designing man-made shoreline structures and Living shorelines seem best suited for that purpose.

Honorable Mention
Erika Miyazaki- Environmental Fate and Impact of Commonly Used Disinfection Wipes
Blacksburg High School

This paper analyzes the environmental movement and impact of three chemicals, Alkyl (C12, C14, and C16) Dimethyl Benzyl Ammonium Chloride (ADBACs), active compounds present in many disinfectant wipes sold on the market. All 3 chemicals have shown ecotoxicity effects on aquatic organisms and inducing antimicrobial resistance in microorganisms. For this 50-day study, 2 types of disinfectant wipes („Äúcompostable cleaning wipe‚Äù and ‚Äúdisinfectant wipe‚Äù), sold under the same brand name, were used. One sheet of wipe was buried 8 cm below the soil surface in a clay pot. Every 5 days leachate was collected after 300 milliliters of water was slowly added to the surface of the soil in a pot. Soil and wipes were collected every 10 days and observed under the microscope for soil organism activity and signs of wipe degradation. The leachate and soil samples were analyzed for the presence of the 3 ADBACs using ultraperformance liquid chromatography/tandem mass spectroscopy. It was observed that the compostable cleaning wipes started to show signs of breakdown on Day 30, while the disinfectant wipes did not even at Day 50. The mobility of soil organisms exposed to the water extract of both types of wipes were similar. It was also found that at each sampling time there was an average of 0.0004% and 0.01% of total ADBACs embedded in a disinfectant wipe were present in the leachate and soil samples, respectively. The amount of compounds adsorbed on soil particles were 280 times more than that in the leachates. This short study has demonstrated that the 3 ADBACs can gradually leach in small amounts through the soil over time.

Honorable Mention
Grace Abbott- The Effect of Agricultural Runoff on Water Quality
Washington-Liberty High School

The purpose of this experiment was to determine if runoff of agricultural developments had an effect on the water quality of a nearby stream, specifically on phosphate and dissolved oxygen levels. The hypothesis was that the water farthest upstream from the farm would have the best water quality as there is no runoff from that farm polluting the water. Water samples from 500 meters upstream, 0 meters, 500 meters downstream, and 1000 meters downstream from a farm were tested for phosphate and dissolved oxygen levels. The p-value was calculated to be 1.7201E-10, meaning the null hypothesis was rejected. The conclusion was that agricultural runoff increases the phosphate levels and decreases the dissolved oxygen levels of water.

Diya Johar- The Effects of Environmentally Friendly Cleaning Products on Lumbricina Deaths
Mills E. Godwin High School

The purpose of this experiment was to understand if there would be a significant difference in the number of deaths of Lumbricina based on the groups that were affected by environmentally friendly cleaning products vs the groups that were affected by standard cleaning products. In recent years, there has been a steady increase in global interest regarding the health of the planet. Many people have begun to take action by recycling more often and using products than have been deemed as environmentally friendly. In this experiment, there were 4 groups of cleaning products that were diluted and poured into the habitats of Lumbricina. The independent variable levels were as follows, Mrs. Meyer‚Äôs, Seventh Generation, Great Value, and 409. Mrs. Meyer‚Äôs and Seventh Generation were the environmentally friendly products while Great Value and 409 were the standard cleaning products. A research hypothesis was formulated that if the environmentally friendly cleaning products are diluted and placed into the environment of the Lumbricina, then it will decrease the deaths of the Lumbricina in comparison to the Lumbricina in the environments effected by the standard cleaning products. The results were tested by counting the number of Lumbricina deaths and then comparing the independent variable levels. The results showed that Seventh Generation caused the least overall Lumbricina deaths, and 409 cleaning products caused the most. Yet, the difference was not significant enough to support the research hypothesis. A t-test was performed on the data and revealed that none of the data sets were statistically significant. These results were most likely due to the independent variable levels instead of being due to chance. This research could provide information on whether environmentally friendly cleaning products are worth the investment and if they are actual safe for the environment.

Dylan White,Characterization and Comparison of Two Macroalgal Communities in the Lower Chesapeake Bay
Chesapeake Bay Governor's School

In the Chesapeake Bay, macroalgae live in shallow subtidal and intertidal zones where hard substrate is available. Macroalgae, unlike vascular plants with roots, absorb nutrients through their cell walls which are bathed in the water surrounding them. These attributes make them efficient at photosynthesis and nutrient scrubbers. In the Chesapeake Bay, historically the main primary photosynthesizers have been Submerged Aquatic Vegetation(SAV), however, SAV habitats are dwindling. To fill the primary production needs of the Bay, macroalgae can supplement and replace declining SAV. To identify algal taxonomy, digital photos were taken of all algae samples and each sampled quadrat. Circular quadrats were used to quantify samples by counting the algae inside of each hoop. Based on this study, Ulva, Cladophora, Gracilaria, Dasya, and Ectoctocarpus are recommended genera for cultivation. The data from this study supports better understanding of the diversity and abundance of local macroalgae in the Chesapeake Bay with the potential for use in aquaculture and enhanced ecosystem services.

Elina Coutlakis,Elizabeth Adams-The Effect of California Wildfires on Bird Populations
Washington-Liberty High School

California is facing a climate crisis, but its impact on animals, particularly birds, is yet to be widely investigated. This experiment sought to find the effect of wildfires on California bird populations, whose fluctuations have resounding impacts. With a decrease in the bird population comes decreased biodiversity, seed spreading, and many more issues. The hypothesis for this experiment was: If bird population before a wildfire is compared with populations after, then the population will decrease following the fire because of habitat loss, smoke inhalation, and the loss of young birds. Using 5 different species, Allen's Hummingbird, the American Bittern, the American Coot, Bell's Sparrow, and the Double Crested Cormorant, the experiment examined their populations before, during, and after wildfire years. 10 wildfires were examined for this experiment. Population data was gathered and recorded for a span of 5 years for each fire, starting 2 years before the fire and ending 2 years after the blaze. These data points were then analyzed to determine significance using ANOVA and Chi Squared tests. The Chi squared tests measured the variables in two ways; one comparing the mean population of a bird in each year, and the other comparing all raw data. The independent variable in this experiment was the year of the population count. The dependent variable in this experiment was bird population. The means did show a decrease in population from the year of the fires to the year following the fires. The Allen's Hummingbird's mean went from 61.2 to 57.1. The Double Crested Cormorant's mean went from 322 to 296. However, the Chi squared tests and ANOVA tests showed there was no significance in the loss of wildlife as a result of wildfires, and the null hypothesis was accepted.

Ella Cohen- Effect of Humidity (in %) on Sugar Content of the *Musa acuminata* After 6 Days (in Brix)
Washington-Liberty High School

The purpose of this experiment was to see if humidity had an effect on the concentration of sugar after 6 days in *Musa acuminata*. Enzymes act as a catalyst for chemical reactions that turn starch into sugar, once activated by Ethylene. Therefore, this measure would provide an accurate depiction of the ripening. It was hypothesized that if humidity was changed, then high humidity (99%) would produce the *Musa acuminata* with the highest concentration of sugar in Brix because 97% humidity was found to be the optimum humidity for ripening in a similar study. The bananas were stored at the control (47%), low humidity (62%), medium humidity (75%), and high humidity (99%) and 15 trials were conducted at each humidity level. The mean concentration of sugar was measured by a refractometer instrument. The mean concentration of sugar at 47% relative humidity was 18.9 degrees Brix, at 62% relative humidity was 18.9 degrees Brix, at 75% relative humidity was 19.5 degrees Brix, and at 99% was 17.1 degrees Brix. The p-value was calculated to be 0.0040129, lower than the critical value of 0.05 and the null hypothesis was rejected as an ANOVA test was conducted. T-Tests were conducted which

concluded that the difference between 99% rh and all of the other humidities had a p-value less than the critical value of 0.05, but the difference between all of the lower humidities did not. The results did not support the research hypothesis as the bananas stored at 99% rh had the lowest sugar concentration, not the highest. It was concluded that the results were different because the optimum humidity was lower than previously thought. Another explanation is that in a study that the hypothesis was based on, temperature was tested in conjunction with humidity, and it was therefore unreliable.

Elle Pickard- The Effect of Different Purification Methods on Amount of Bacteria in Water
Washington-Liberty High School

Bacteria are everywhere. They exist on surfaces, in the air, and even in water. Pathogens like *Vibrio cholerae*, Campylobacter, Salmonella, Shigella, and *Escherichia coli* in drinking water can cause many diseases and illnesses such as diarrhea, cholera, dysentery, typhoid, and polio. Globally, 2 billion people drink from a contaminated water source. They are at a constant risk of getting sick from the water they cook with, drink, and bathe in. 500,000 deaths are caused by waterborne diseases each year. To combat this issue, this experiment was conducted. The goal was to test 4 different cheap and accessible disinfection methods and determine the most effective procedure. In this experiment, chlorination via bleach, boiling, solar disinfection, and filtration through a coffee filter were tested. Six Waterworks Bacteria Growth Check Test Strips were dipped into each container of water, and then incubated for 48 hours. The test strips showed that the coffee filter and sunlight group were higher than the control, with both groups at 167,335,000 bacteria per mL vs. the control with 340,000 bacteria per mL. On the other hand, the boiled and bleach groups were substantially lower. With boiled and bleached groups at 83 and 50 bacteria per mL, and with p-values of 0.0002 and 0.0001, respectively, their data was very significant. Boiling was the most consistent method, but bleach was the most effective. Using this data, it can be concluded that boiling water or adding a few drops of bleach into water are both easy and cheap methods to sterilize it. With these two simple ways, people can easily reduce their chances of getting detrimentally sick, and safely stay hydrated.

Emaad Zakriya- The Effect of Organic Vs. Inorganic Fertilizers on the Nitrogen
Concentration in Runoff
Mountain View High School

In our world, environmental issues are running rampant and out of control. These include oil spills, contamination of water through fertilizer runoff, greenhouse gas emissions, and an increased carbon footprint. In order to discover a possible solution to the issue of water contamination, the concept of organic fertilizers were popularized as a replacement for so-called environmentally ‚Äúunfriendly‚Äù inorganic fertilizers. These organic fertilizers claim to be capable of reducing nitrogen runoff into water supplies and reducing harm to the environment. To test this claim, it was required to set up an experiment where the amount of nitrogen runoff that comes from organic and inorganic fertilizers could be

tested. In the experiment, fertilizer would be placed on top of the soil in foam cups, after which water would be poured on and filtered to check nitrogen concentration before and after. The researcher initially suggested that the inorganic fertilizer would produce the largest concentration of nitrogen in the runoff. The experimental results supported this initial claim as it was found that inorganic fertilizer permits the highest percentage of nitrate into the runoff. Simply using leaves as fertilizer allowed the smallest percentage of nitrate into the runoff. Through the data collected, it was possible to conclude that the leaves would be the most ecologically effective fertilizer.

Emma McDaniel- The Effect of *Pistia stratiotes* and *Ceratophyllum demersum* on Efficiency at Removing Copper Ions From Water
Clover Hill High School

The purpose of this experiment was to find how successful *Pistia stratiotes* and *Ceratophyllum demersum* are at removing copper ions from water. The research hypothesis for this experiment was *Pistia stratiotes* would be more efficient in removing copper ions from water than *Ceratophyllum demersum*. To conduct this experiment, 15 *Pistia stratiotes* and 15 *Ceratophyllum demersum* were planted in containers of water with 3 mg/L of copper ions. The 5 trials of the control, which were containers of water with no plant, also had 3 mg/L of copper in the water. First, 10 *Pistia stratiotes* and 10 *Ceratophyllum demersum* were planted, along with 3 controls. The plants were observed for 14 days. The fourteenth day, the plants were tested with copper testing strips that measure quantitative data. Differences between the initial amounts of copper ions and copper ions at the end of the experiment were recorded. The experiment was repeated in a second phase with 5 *Pistia stratiotes*, 5 *Ceratophyllum demersum*, and three control trials. Results showed that *Ceratophyllum demersum* was the most successful in removing copper ions from water. The mean amount of copper ions removed by *Pistia stratiotes*, 2.80 mg/L, was less than the mean amount of copper ions removed by *Ceratophyllum demersum*, which was 2.85 mg/L. The control group removed 2.24 mg/L of copper ions. An ANOVA test was conducted, and the results were statistically significant. The null hypothesis, the mean amounts of copper ions removed from water by *Pistia stratiotes*, *Ceratophyllum demersum*, and the control would be equal, was rejected, as shown in the ANOVA test. The data shown by the experiment rejected the research hypothesis, as *Ceratophyllum demersum* was more successful than *Pistia stratiotes* in removing copper ions from water.

Frances Shapiro- The Effect of Soil Particle Size on Water Runoff
Washington-Liberty High School

With increased urbanization, impervious surfaces have taken over our ground surfaces, leaving little space for stormwater to go. Stormwater runoff has negative effects on the environment as it picks up metals, chemicals, and bacteria, polluted and damaging the water. This experiment was conducted with the goal of determining which soil particle size allows for the least water runoff, minimizing the use of storm drainage systems and

taking advantage of the soil we have. The four independent variables were sand, silt, clay, and loam soils. It was hypothesized that the sand soil would allow for the least water runoff due to the large pores in between particles. 250 mL of water were poured onto the soils in a 35-second time period and a graduated cylinder was used to measure the runoff. The results accepted the hypothesis, as the sand produced the least amount of runoff with a mean of only 30.5 mL of water. The clay soil allowed for the most water runoff, with a mean of 195 mL of water. An ANOVA test was run to determine the statistical significance of the data, yielding a p-value of 1.4×10^{-56}. This value is far under the 0.05 required to be statistically significant, allowing for the null hypothesis, stating that the type of soil would have no effect on water runoff, to be rejected. The results of this study yield important information about the infiltration rates of soil particles and provide helpful knowledge to further study and experimentation on ways to reduce stormwater runoff.

Hannah Mikolop- How Does the Amount of Crumb Rubber on Soil Affect Plant Growth?
Alexandria City High School

The purpose of this project is to determine how the amount of crumb rubber on soil affects plant growth. To find this information, 60 Garden Cress seeds were planted with varying amounts of crumb rubber placed on the soil. All of the plants started growing around the same time but at different speeds. As the days in the trial went on, they were growing at similar rates until some of the variables spiked and surged while others plateaued. Upon further observation, it was discovered that the plants with more crumb rubber on the soil stayed hydrated for longer after the plants had died after previously appearing to be slightly hydrophobic. It can be concluded that the more crumb rubber there is on the soil, the shorter the plant will be, but the longer it will live.

Hemanth Nimmagadda- The Effect of Purification Method Used on Water Quality
Mills E. Godwin High School

The purpose of the experiment was to research the effectiveness of different water purification methods at improving water quality. The water purification methods used were water distillation, iodine treatment, and Potable Aqua water purification tablets. This research is important because safe, clean drinking water is a necessity for survival. This makes it important to have a reliable method of purifying water adequately for drinking purposes. A research hypothesis was formulated that if water distillation was the purification method used, then the water would have the lowest total dissolved solids. The control of the experiment was using no purification method because it was used to compare the samples that were purified to samples that did not receive any treatment. In the experiment, the water purification methods were applied to samples of contaminated water. The total dissolved solids in the samples after purification were measured using a TDS meter and recorded. After experimentation, t-tests were conducted on the data to determine its statistical significance. These t-tests showed that the data was statistically significant. The research hypothesis was supported by the results and it could be concluded that water distillation was more effective at reducing the total dissolved solids

in water than the other methods. This was because water distillation caused solutes in the water to be removed while the other methods were intended for disinfection of water. These methods were also to be used for water purification only in emergencies, making water distillation the ideal method to purify water for drinking purposes.

Henry Guo- The Effect of Sources of Water on Bacteria Growth
Mills E. Godwin High School

The purpose of the study was to understand how sources of drinking water differ in their Colony-forming unit count (CFU count) and how CFU count was an indicator of contamination. The importance of water was incredibly significant in the day-to-day life of a person. The implication for society, if water was contaminated with a high CFU count, was the risk to civilians' health. The more microbes in an area increased the odds of a malicious microbe. The hypothesis stated if a sample of water originated from a river, then it had the highest CFU count. The possible contamination of fecal waste justified that water from a river has the highest CFU count. The control was filtered drinking water, which was common and regulated, making it safe to drink. This allows it to be compared to other sources of water for contamination. The experiments showed that rainwater contained, on average, the most CFUs. River water contained, on average fewer CFUs than rainwater; however, it still contained more CFUs than both tap water and filtered drinking water. The results did not support the hypothesis. A possible reason for this was microbes in the air accumulate in the raindrops as the rainwater reaches the ground. The difference in air quality could affect the CFU count of rainwater, so further testing of rainwater quality from different regions could be conducted. This experiment demonstrated that this approach toward the evaluation of water quality was reliable.

Environmental & Earth Science - D

First Place
Jackson Haught- The Effect of Real-World Oxybenzone Concentration on *Lepidium sativum* Growth
Mills E. Godwin High School

The purpose of the experiment was to test real-world concentrations of oxybenzone, a UV filter harmful to plants found in 81% of personal care products, on the growth of *Lepidium satvium*. Understanding the environmental impacts of real-world oxybenzone concentrations could have prioritized removing oxybenzone from personal care products, especially since there was no effective filtration method for oxybenzone. Neutrogena Ultra-Sheer SPF 30 Sunscreen containing a 4% concentration of oxybenzone was measured using a scale and added to three beakers of water so that the beakers held oxybenzone concentrations of 0 mg/L (control), 1.395 mg/L (the maximum wastewater oxybenzone concentration found on Earth), and 2.790 mg/L (double the amount). Three

groups of 25 cress plants were treated with 10 mL of the solutions every day for 15 days. The plants were then uprooted and measured. A hypothesis was formed that if cress plants were not exposed to oxybenzone, then they would grow the tallest. The plants in the 1.395 mg/L and 2.790 mg/L oxybenzone concentration solutions were 31.6% and 38.6% shorter than the plants in the 0 mg/L group. The data was significant for both the 0 mg/L vs. 1.395 mg/L and 0 mg/L vs. 2.790 mg/L tests but not for the 1.395 mg/L vs. 2.790 mg/L test. The decreased growth could've been due to oxybenzone, which was known to inhibit photosynthetic electron transport and cellular respiration. A permission form was signed by a parent that indicated that they had read and understood the risks and possible dangers involved in the research and they consented to their child participating in this research. The results suggest that governments should prioritize removing oxybenzone from personal care products.

Second Place
Kiersten Hannah- The Effects of Bycatch Reduction Devices on Crab Catch Rate
Chesapeake Bay Governor's School

The native population of diamondback terrapins (*Malaclemys terrapin*) has been on a steady decline throughout the past century on the East and Gulf Coasts. Currently, their numbers are being decimated by the blue crab (*Callinectes sapidus*) fishery. The crab pots employed in this industry catch not only large quantities of blue crabs, but also the diamondback terrapins, which then drown in the pots. Recently, scientists have come up with a solution that will exclude the diamondback terrapins from entering the crab pots while still allowing the blue crabs to enter. These devices are called bycatch reduction devices (BRDs), and the purpose of this study was to test the effects that they have on the number and size of blue crabs caught in their pots. Ten crab pots were deployed, five containing BRDs and five without BRDs, in two parallel lines. At the halfway mark in the study, the two lines of pots were switched. Crab catch rate for each crab pot and carapace lengths of each crab were measured every two to three days for a total of two weeks. This study found that while the BRDs do not affect the size of crabs caught, they do negatively affect the number that outfitted pots are able to catch, perhaps due in part to increased algae growth on the devices themselves.

Third Place
Joyce Xu- The Effect of Fibers on Absorption of a Hydrocarbon Mixture
Mills E. Godwin High School

Fibers possess traits that can be utilized to absorb and separate oils from water. This is especially effective in oil spills, which commonly occur during the transportation of products on cargo ships. These spills are destructive to the marine environment, causing internal and external issues of many organisms that reside within the radius of the spill, as well as beyond it. The purpose of this study was to assess the absorption capabilities of four different fibers, including both natural and manmade material. It was hypothesized that if raw cotton, an independent variable manipulated, was placed into a water and oil

mixture it would contain and absorb more of the oil than the other variables. The control of this experiment was polypropylene, which was chosen because of its presence in popularly used oil spill devices. To test the independent variables for their absorption of motor oil, the material was placed into a stirred mixture of water and oil and rested before being removed. Then, the remaining oil and water were poured into a separating funnel and rested again before being drained. Each liquid was measured separately, and the data points were transferred and calculated in a descriptive table. The results of the statistical tests supported the research hypothesis while also rejecting the null hypothesis. Furthermore, the values for each level of the independent variable were significant. These phenomena occurred because of the different levels of hydrophobic and oleophilic factors that each material possesses. This study acknowledged the selection of materials and provided insight concerning the absorption capabilities.

Honorable Mention
Kyle Reviello- The Performance of a Gas Turbine Engine Using Fossil Diesel vs Two Different Biodiesels
Chesapeake Bay Governor's School

Exhaust emissions from vehicles are one of the leading causes of global warming. This study was a two-part study attempting to compare the performance/emission rates of a Turbine engine using bio-diesel and fossil diesel. The study first tried to make bio-diesel out of the abundant invasive aquatic grass Hydrilla verticillata but found that the lipid content of the organism was too low to create bio-diesel out of. The study then focused on testing two different bio-diesels and comparing them to fossil diesel emission rates. This study concluded that the bio-diesels were more emission friendly than fossil diesel, but no definitive conclusion could be drawn in regards to engine performance.

Honorable Mention
Jennine Faruque,Nawah Ahmad,Sejal Sharma- Direct Air Capturer: The Effect of a Direct Air Capturer on the Reduction of Carbon Dioxide
Governor's School @ Innovation Park

In an engineered direct capture system, carbon dioxide levels were monitored and analyzed in relation to the system's ability to chemically alter the CO2 in its environment. This proposed research is in response to increasing CO2 emissions. The system's main component included the chemical reaction between sodium hydroxide and carbon dioxide with the resultant chemicals of sodium carbonate and water. Ambient air was taken into the system to be chemically altered and released back into the atmosphere. The chemical equation being used for reference was: $2NaOH + CO_2 = Na_2CO_3 + H_2O$. Two trials each were performed directly under a car Exhaust location and a Food Court location. For each trial, there was a control experiment, where the carbon dioxide data was collected without the system being activated. In both locations, an RS232 logging software logged the CO2 levels using an AZ7755 Carbon Meter. Statistically, four T-Tests were performed before the usage of the system and after the usage of the system in each trial of each location.

The differences in the means of these were significant to the 5% alpha significance level. In the Food Court, there was a statistically significant difference in the means with a p-value of 1.02,ãÖ10^(-110), but the means were close in actual value. On the other hand, in the Exhaust location, the mean value did decrease due to the high levels of CO_2 already present. The results of this proposed research have the potential to introduce a novel method of CO_2 emission reduction.

Honorable Mention
Micah Johnson- The Effects of Mycorrhizal Fungi on Glycine max Grown in Nutrient Deficient Soil
Central Virginia Governor's School

The purpose of this experiment was to determine whether or not mycorrhizae or burned soil had a significant effect on the growth of crops. The study was conducted in a local high school laboratory through November and December of 2021. There were four groups: the control, the control with fungi (*Rhizophagus intraradices*), the burned soil group, and the burned soil with fungi. Heights were measured every 4-6 days, and dry weights of both above and below ground portions were measured at the end of the growth period. With this data, five two-way unbalanced ANOVA tests (α=.05) were run which showed significance in 7 out of 15 p-values. This being said, only two tests came back with multiple significant p-values, so post-hoc Tukey tests were run on them to find specific differences between the groups. When looking at root: shoot ratios, a Tukey test with a D_{min} of .353 shows that the control group is both significantly different from the burned soil group and the burned soil with fungi group. This motivated another Tukey test involving below ground-weights with a D_{min} of .1761 which led to the control group being significantly different from all other groups and equivalently the fungi group with the burned soil with fungi group. The null hypothesis was rejected, but the research hypothesis, which was that *Glycine max* grown in burned soil would benefit from growing with mycorrhizal fungi, was not supported. In summation, both fungi and burned soil can affect the growth of *Glycine max*.

Jacob Clevenger- The Effect of Different Bio Wastes on Their Potential as Biofuels
Central Virginia Governor's School

The purpose of this research was to determine which bio waste, grass or corn is a more efficient biofuel. This study was conducted in a local high school laboratory during December of 2021. The enzymes within two different bio wastes; grass and corn, were extracted and then added to a conical tube where they were subjected to fermentation with P-Nitro phenol. After a total of eight minutes for each of the fourteen trials, 450 ul of the fermented substrate was added to seven different cuvettes, along with 500 ul of stop solution, and 50 ul or extraction buffer. Once all samples were added to their designated cuvettes, each was inserted into a Spectrophotometer and subjected to a 410 nm wavelength. This measured the absorbance of each sample, determining the amount of enzymes produced during fermentation. A one-way ANOVA determined significance, with

a p-value of 3.64E-08 and an alpha level of .05. The difference in this significance was between the final absorption values of the grass and corn. This significance supported the original hypothesis that grass would result in a more efficient biofuel. These results suggest that all grass has more natural sugars, providing a more effective fermentation process.

Joice Small- Examining Epiphytic Growth on Submerged Aquatic Vegetation
Chesapeake Bay Governor's School

Submerged aquatic vegetation (SAV) in the Chesapeake Bay are facing challenges that prohibit growth and reproductive success, due to both human interaction with the environment and climate change. The Chesapeake Bay once supported 600,000 acres of SAV beds, and now supports less than 100,000 acres. Epiphytic growth on the blades of SAV affects plant success, and may determine the fate of already struggling SAV beds. SAV blades were harvested from plants and the degree of epiphyte fouling on each blade section was found using a grid system to estimate percent cover. Over the study period, the total amount of epiphytes on grass blades increased. The SAV habitat has bottom-up problems, and top down imbalances that negatively affect SAV success. For continued SAV growth in the Chesapeake Bay, we need to control eutrophication, reduce turbidity, and better manage predator-prey relationships in the food web.

Joshua Althaus- The Effect of Carbon Sinks on CO2 Levels in The Air.
Mills E. Godwin High School

The purpose of this experiment was to determine the effectiveness of various carbon sinks and how they perform over time. Recently, more and more carbon dioxide has begun to build up in the atmosphere, which exacerbates global warming. It is necessary to look into various carbon sinks and determine their effectiveness to help quickly combat the rapidly worsening problem. It was hypothesized that if calcium hydroxide-sodium hydroxide was chosen as a carbon sink, then its surrounding environment would have the least amount of CO_2. Three different carbon sinks were placed in separate testing chambers. Every hour for four hours, the amount of CO_2 in each sink's container would be measured in ppm. The three types of sinks used were freshly cut grass, water, and a calcium hydroxide-sodium hydroxide mix. The control was a set of containers without sinks. The results revealed that though grass was able to absorb the most CO_2 in a short period of time and that water had the lowest overall carbon dioxide ppm. The control and chemicals did not perform well. The t-tests revealed that most of the data was significant, with 125 of 135 t-tests having a p value of less than 0.05, inferring that the data was not due to chance. The results may be due to material porosity and volume. This means that materials that take up more space and have more space between each molecule are able to be better sinks due to having more space to store CO_2.

Joshua Eaton- The Effect of Acetaminophen Concentration (mg/mL) on the Reproductive Rate of the Philodina Rotifer
Clover Hill High School

The purpose of this experiment was to determine the effect of over-the-counter medicine on the reproduction of aquatic life. With this data, health officials could determine the safety of disposing of medical waste into aquatic ecosystems. An acetaminophen concentration was added to each culture of philodina rotifers at the beginning of the trial. To determine how much each culture reproduced a microscope was placed on the lid of the Petri dish of each culture and the number of rotifers at the end of each trial were counted. The five independent variable levels were 0 mg/mL, 0.0001 mg/mL, 0.001 mg/mL, 0.01 mg/mL, and 0.1 mg/mL. The numbers of offspring were recorded into a data table and the process of this experiment was repeated until 10 trials were run for each level of the independent variable. Median was recorded as the measure of central tendency because some trial groups had outlier results. The control group of 0 mg/mL of acetaminophen concentration added produced a median of 179.5 number of offspring. The group with 0.0001 mg/mL added produced a median of 154 numbers of offspring. The group with 0.001 mg/mL added produced a median of 44 numbers of offspring. The group with 0.01 mg/mL added produced a median of 29.5 numbers of offspring. The group with 0.1 mg/mL added produced a median of 47.5 numbers of offspring. An ANOVA test was conducted after this data was collected to determine if the data was statistically significant. The ANOVA test results concluded that the data was statistically significant. The experimental hypothesis of this experiment was if acetaminophen was added to a group of Philodina rotifers, then their reproductive rate would decrease. The experimental hypothesis was supported.

Kara Felker- What is the correlation between the temperature anomaly in Virginia and the occurrence of Brown-headed Nuthatches (*Sitta pusilla*) in Virginia?
Washington-Liberty High School

The purpose of this study was to see if *Sitta pusilla* are reacting to higher temperatures associated with climate change by shifting their range north. The independent variable was the temperature anomaly in Virginia (o F). There was no control group. The constants were the databases used for the independent and dependent variables and the month for which the data was collected. The dependent variable was the occurrence of *S. pusilla* in Virginia (Number Per Count). The hypothesis was: If *S. pusilla* occurrence in Virginia over time is compared to Virginia temperature anomalies over time, then as the temperature anomalies increase, the *S. pusilla* occurrence will increase, demonstrating a northward range shift. The null hypothesis was: *S. pusilla* occurrence will remain constant in Virginia, even as temperature anomalies increase. The study was important because it provided insight into how organisms are reacting to higher temperatures associated with climate change, which could help protect other organisms from climate change in the future. The study was completed by compiling the *S. pusilla* occurrence data and the temperature anomaly data into an excel sheet. The dependent variable was calculated using the equation: Number Per Count = number of *S. pusilla* reported ÷ number of counts reporting

S. pusilla. A scatter plot was made to represent the relationship between *S. pusilla* occurrence and temperature anomaly. A Spearman's Rank Correlation Test was run. The data showed little correlation between the variables. Further study is needed to accept or reject the hypothesis.

Kathryn Feldmann, Penelope Roberts- The Effect of *Aspergillus niger* and *Aspergillus brasiliensis* on the Decomposition Rate of Low-Density Polyethylene Plastic
Roanoke Valley Governor's School

This experiment studies the effect of *Aspergillus niger* and *Aspergillus brasiliensis* on the decomposition rate of low-density polyethylene plastic. Plastic waste is posing a deadly threat to the world‚Äôs environment and ecosystems. Therefore, researching bioremediation and finding solutions to plastic pollution is essential to Earth's well-being. The question being posed is: can a natural solution to plastic pollution be found? This experiment focuses on the fungi genus Aspergillus to serve as an answer to this problem, and the purpose is to determine how much of a plastic sample will decompose when exposed to fungi in this genus. To begin, two different species in the Aspergillus genus were selected: *A. niger* and *A. brasiliensis*. Three trials of each fungus and three control trials with no fungi were grown on a potato dextrose agar medium, then fed samples of low-density polyethylene plastic. Over the course of about a month, the trials were weighed and observed; at the end of this period, the plastic was taken out and weighed. The plastic samples ended up with a greater mass, however this is because some of the bacteria and fungi stuck to the samples and would not come off. A One-Way ANOVA test confirmed that our independent variables had no significant effect on plastic decomposition. If further research is done in this area, the increasing plastic crisis could potentially be helped.

Lauren Ferrell- The Effect of Simulated Rain and Wind on Weathering of a Clay Sculpture
Clover Hill High School

The question that the experiment addressed was how simulated rain and wind weathering would affect the height, width, and mass of a clay sculpture. The effect of simulated rain and wind on the weathering of a clay sculpture was investigated to examine how the weathering of clay can lead to landslides and erosions. The research hypothesis stated that rain would affect the height, width, and mass of a clay sculpture more than wind. The three levels of the independent variable were the presence of simulated rain, and the presence of simulated wind, and the presence of no simulated rain or wind, which was the control. There were a total of 30 trials, with rain, wind, and the control, each having ten trials. Clay sculptures were made and placed in an open area where rain and wind was simulated. After the simulation, the mass of the clay sculpture was determined in grams, the height was measured in centimeters, and the width was measured in centimeters. The principal results showed simulated rain having a greater effect on the height, width, and mass of the clay sculpture over wind; the research hypothesis was supported. The null hypothesis was tested using an ANOVA test and was rejected.

Lauren Handley- How differing soil temperatures and Rhizobia introduction affect symbiotic nodule formation and growth in peas (*Pisum sativum*)
Collegiate School

This experiment explores the symbiotic relationship between legumes, more specifically peas, and Rhizobia (symbiotic, nitrogen-fixing bacteria found in legume roots). Using two raised beds, one with endemic Rhizobia, one with added Rhizobia, and both with a temperature gradient for the soil created by a hard, clear plastic hoop cover over the south side of the beds, results show significantly higher numbers of root nodules in the bed with added Rhizobia (82 ¬± 16 nodules) than in the endemic Rhizobia one (21 ¬± 6 nodules) (Student's t-test, df = 17, p = 0.001). Growth rates over the first 35 days after planting are similar for all conditions. The initially similar growth patterns of pea plants may change, however, as these legumes mature, since the amount of Rhizobia nodules is much higher in the raised bed with added Rhizobia. With additional nitrogen resources, peas are able to more efficiently increase crop yield and therefore provide protein sources for consumers. Hence, legumes would be a sustainable food source for humans.

Madison Le- The Effect of Different Colored Light on the Growth of Plants
Washington-Liberty High School

Climate change is endangering the lives of the crops grown across the globe. With unstable temperature fluxes, the crops will die or worsen in quality this will only aggravate other major problems such as world hunger. The purpose of this experiment was to investigate ways to alter the color of the sunlight to benefit the crop quality and boost the germination period. Radish seeds were planted and placed into a cardboard box each group separated by dividers. The use of cellophane helped alter the color of the sunlight each group was exposed to. The way these groups were determined depended on what color of light they would be exposed to. The different groups consisted of two pots with 4 seeds in them each, red, blue, yellow and the control, natural sunlight. These groups serve as levels of the independent variable and the dependent carriable being the reaction or results of the plants. Four seeds were each planted into eight individual pots. Two pots were put under one color of light. After, the cellophane was taped over the box to cover the designated sites. Over the course of 6 days, the plants were each measure and watered the same way, each receiving one tablespoon of water a day. The hypothesis for this experiment was that blue and red light will perform the best of all the different lighting colors because plants absorb more of the energy as opposed to yellow and green lights. The null hypothesis of this experiment is that there will be no significant or no change at all between the different colors of light. The T-test between the plants exposed to yellow light and the control group resulted in the highest p-value of 0.94574. Since the results were all well above the 0.5 mark, the null hypothesis was accepted.

Natalie Walker- The Effect of Potomac River's Water Quality on Water Purifacation

Washington-Liberty High School

The purpose of this experiment was to see if different simple water filtration types could reduce pH, nitrite, and nitrate sufficiently in the Potomac River's water to be useful for human consumption. Specifically, this experiment was trying to prove that Brita filter, mechanical filter, and/or distillation will improve water quality (pH, nitrite, and nitrate), to a drinkable safe standard. It is hypothesized that if simple water purification methods are applied successfully, then water quality will improve to drinkable safe standards because the methods removed the dangerous impurities. The null was hypothesized that if water purification methods have no effect, then the water quality will not improve as the water is being purified. This effect was believed to occur through different filtration types, focusing on different pH, nitrite, and nitrate levels. Water was collected at one source for all testing levels.

Environmental & Earth Science - E

First Place
Violet Janes- The Effect of Richmond Water Chemicals on Fabric Bleaching
Mills E. Godwin High School

The purpose of this experiment was to determine whether the presence of chloramine affects fabric color. This was tested by observing the effects of chloramine solutions on fabric because the hypothesis stated that if chloramine was present, then the fabric‚Äôs color intensity would increase. The rationale is that because bleach and chloramine affect skin similarly; therefore, bleach and chloramine could likely affect fabric similarly. Pieces of fabric were dipped in four different solutions: 5% bleach, 5% chloramine, 0.01% chloramine, and unfiltered water. The positive control was 5% bleach, while a separate group of untouched fabric served as the negative control. To match the positive control, 5% chloramine was used, and 0.01% chloramine was used to match the amount of chloramine in the Richmond water, which contains 0.01% chloramine alongside other chemical byproducts. The average color intensities were measured for each independent variable level using the RGB color scale. The t-test results indicated that the color intensities of the 5% chloramine and bleach group increased significantly, the color intensities of the 0.01% chloramine group insignificantly changed, and the color intensities of the unfiltered water group decreased significantly‚Äîall four groups compared to the control group. The results support the conclusion that chloramine is able to bleach fabric, though not at the concentration that is in the Richmond water. Chemicals other than chloramine may have been the cause of the decrease in color intensities. Further studies can be conducted by using other chemical compounds in place of chloramine.

Second Place
Shane Dunford- Cathodic Corrosion Protection Capabilities of Sacrificial Anodes in Different Types of Soil
Southwest Virginia Governor's School

Sacrificial anodes are metals that are highly active who protect less active metals from corroding There was information on how aluminum was lighter than zinc and lasted longer than magnesium, as well as how magnesium and zinc were most often used in the galvanic protection of pipelines. However, it is not specified how those three anodes protect an underground structure from corrosion in different types of soil. The purpose of the experiment was to find out if aluminum, when placed in silt and loamy soil, provides the best protection against corrosion and if clay soil would cause the worst amount of corrosion in all samples. Steel, aluminum, magnesium, and zinc plates were purchased then cut into desirable sizes and weighed. After that, holes were drilled into them and were connected then weighed again. They were then buried in four different types of soil: loamy, silt, sand, and clay, and given 1 tsp (teaspoon) of water once a week for five weeks. After five weeks, they were dug up and weighed again as well as visually analyzed. The mean change of weight in aluminum was 0.415g (grams), the mean change of weight in zinc was 0.449g, and the mean change of weight in magnesium was 0.475g. A Tukey test was run and statistical data recorded. When compared to a significance level of 0.05, there was no significant change in the metal type (0.376 p-value) and the metal and soil type (0.0267 p-value), but there was a significant change in soil type alone that occurred at the sandy to loamy level (<0.0001 p-value). This data disproved the null hypothesis that all the means of the sample were equal and supported that alternative which stated all the means of the sample were not equal. The conclusions were that aluminum had the worst corrosion protection and sandy soil had caused the most corrosion. This data could be used to help anyone with an underground structure by giving them information on what they can use in certain environments.

Third Place
Yash Saxena- The Effect of Different Machine Learning Algorithms on Water Detection
Maggie L. Walker Governor's School

According to the WHO, around 55 million people across the world are affected annually by droughts, which disrupts peoples' livelihoods by increasing the risk of death, disease, and mass-migration and an estimated 700 million people may be displaced by 2030. Water detection is an application of machine learning in which an algorithm can use satellite data to predict the location of water in in various landscapes. The hypothesis for this experiment was "If all models are tested on a variety of cloudless satellite images in order to detect water in different environments, then the MLP Classifier will detect the most water in satellite images with a low, medium, and high amount of water". The experimenter ran 25 images through the WaterDetect library once per model and counted the number of water pixels. For each individual satellite image, the MLP Classifier predicted the highest average number of pixels in all water content categories except for medium water content images, where the SVM slightly outperformed it. Among the water

content categories, the SVM predicted the most pixels for four out of eleven medium water content images and four out of six high water content images. The MLP Classifier predicted the most pixels for four out of eight low water content images and predicted the most pixels for eleven out of all twenty five images. Due to these results, the hypothesis was partially supported. These results likely occurred because of a characteristic of the MLP Classifier which allowed it to better predict the location of water in images with less water as well more water. This paper suggested that the MLP Classifier and SVM can best detect water in low water content images and medium water content images respectively, but more research is required to determine which model can detect more water in high water content images.

Honorable Mention
Nathan Neblett- The Effects of Sucralose on *Lemna minor*
Central Virginia Governor's School

The purpose of this study was to evaluate the aquatic environmental toxicity of sucralose through a model organism, Lemna minor, being exposed to sucralose solutions of 0 Œºg/L, control; 157 Œºg/L, environmental concentration; 632 Œºg/L, 10x environmental concentration; and 4,711 Œºg/L, 100x environmental concentration. The fronds were photographed at the start and conclusion of the study, an interval of 14 days. The area and number of Lemna minor fronds were calculated using ImageJ analysis software. A one-way ANOVA using individual frond area data yielded a p-value of .001 which was compared to an alpha of .05. A post-hoc Tukey test showed the 632 Œºg/L group‚Äôs mean of 1.03 mm2 was statistically significantly greater than the other concentrations' means that fell in a range of 0.052 mm2. Another one-way ANOVA using percent increase of fronds data yielded a p-value of .0359 which was compared to an alpha of .05. A post-hoc Tukey test yielded that the 137% increase of the 157 Œºg/L group‚Äôs fronds was statistically significantly lower than the control‚Äôs fronds increase of 293%. The research hypothesis of, if *Lemna minor* is exposed to sucralose for 14 days, then the number and area of *Lemna minor* will increase at the same rate as the control except for at 100x environmental concentration where area and frond number will decrease, was not supported. The results suggest that sucralose is an environmental hazard and sucralose exhibits a vertically reflected parabolic dose-response curve on the growth of *Lemna minor*.

Honorable Mention
Shriya Deshpande- The Effect of Hygiene Products on *Daphnia magna* Heart Rate
Mills E. Godwin High School

The purpose of this experiment was to interpret and compare the effect of hygiene products on *Daphnia magna* heartbeats per minute. In the environment, there are numerous hazards such as water pollution and habitat loss which are mostly caused by humans. Due to these man-made hazards, the population of aquatic and marine life is constantly decreasing. Before conducting the experiment, gloves were worn, and all

safety regulations were followed. The *Daphnia magna* were placed in 5 mL of diluted mouthwash, hand soap, micellar water, and water. The control being used was the water. The Daphnia were kept in the solutions for 2 hours each and then their heartbeat was measured. It was hypothesized that if the Daphnia was kept in the mouthwash solution, then, it would have the fastest final heartbeat. The results showed that the Daphnia kept in the hand soap solution had a decreased heartbeat compared to the rest of the solutions. According to multiple t-tests, the only trials that were not significant were the mouthwash versus hand soap trial and the hand soap versus micellar water trial. In conclusion, the data for the experiment was statistically significant because 4 out of the 6 trials were significant. It is believed that the data is largely due to the independent variable while only some is due to chance. This research could allow a further study of hygiene products' performance on other freshwater organisms such as planaria.

Honorable Mention
Treasure Brown,Walker Smith - Effect of Diammonium Phosphate Fertilizer on the Growth and Development of *Lemna minor*
Collegiate School

Duckweed, or *Lemna minor*, is an extremely vital photosynthetic organism to a plethora of aquatic ecosystems. *Lemna minor* is a beneficial environmental regulator and functions as a supplier of crucial shade and oxygen to aquatic organisms. Diammonium phosphate fertilizer (DAP fertilizer) runoff tremendously accelerates the growth rate of producers, including duckweed, and stimulates microorganism growth; the accelerated growth rate of microorganisms and primary producers reduces the dissolved oxygen content of the body of water, killing the organisms in the affected region in a process called eutrophication. Our null hypothesis stated that solutions of diammonium phosphate fertilizer (with varying concentrations) will have no notable impact on *Lemna minor's* relative growth rate or the percent change in mass (g) over 7 days. This study's primary purpose was to investigate DAP fertilizer's impact on an aquatic producer, namely Duckweed, and to decipher if the use of diammonium phosphate fertilizer is essentially advantageous or detrimental to the growth and development of common duckweed. Research was performed by growing common duckweed in solutions of diammonium phosphate fertilizer with concentrations of 0.00%, 0.04%, 0.08%, 0.12%, and 0.16%. After seven days of sitting in the solutions, the duckweed was dried and massed. The relative growth rate (g/day) and the % change in biomass were calculated, via the utilization of the average dry initial biomass of duckweed, and the average dry final biomass of duckweed. Only the control (0%) group experienced positive growth, while the other four experimental groups (with varying concentrations of diammonium phosphate) experienced death and decomposition, exhibited by negative relative growth rates and negative % changes in mass values, leading to the rejection of our null hypothesis. From these results, it may be concluded that eutrophication, caused by the addition/introduction of limiting nutrients to a system, produced hypoxic conditions, correspondingly leading to an increased death rate of the duckweed specimens that resided in diammonium phosphate fertilizer solutions with higher concentrations. A p-value of <0.0001 was

calculated with the relative growth rate values and the % change in mass values, demonstrating the very low probability results were obtained by chance.

Payton Jones- Using CO2 as a Proxy to Track Ventilation Rates
Chesapeake Bay Governor's School

Sick office syndrome is the condition in which people in buildings, such as offices or classrooms, experience symptoms of illness from excessive amounts of CO_2. When high amounts of CO_2 are present, buildings likely have poor ventilation, indicating the rate at which the inside air is replaced with the outside air, is low. Furthermore, as CO_2 increases, temperature often increases. This study observed the correlation between CO_2 and temperature levels in a room over 50 minute intervals to gain insight on room ventilation. Four groups of rooms were tested by their densities (persons/room); no people, low, medium, and high densities in the rooms. Each group's CO_2 was recorded with a CO_2 sensor and the temperature was recorded with a temperature probe. The greatest level of CO_2 was shown in the medium density rooms whereas the lowest amounts of CO_2 were present in the highest density rooms. While the data was statistically significant, the trend did not follow the alternate hypothesis, so both hypotheses were rejected. However, the High-density rooms had the greatest increase in CO2 from the initial reading through the 50-minute monitoring. This data was highly significant and demonstrated a strong relationship between CO_2 produced and room density. For all rooms there was a minimal correlation to the temperature. With knowledge of how CO_2 affects people and is connected to ventilation rates, buildings can better accommodate for individuals present in these rooms, especially with other concerns regarding virus and bacteria transmissions in poorly ventilated buildings.

Pete Wilcox- How do Combinations of Warm Water and Ammonia Affect Brine Shrimp Hatch
Washington-Liberty High School

As the Earth warms and human activities create pollution, oceans are heated and runoff from agriculture and factories deposit ammonia into watersheds. This experiment was designed to test the compounding effects of two contributors to reduced water quality, increased water temperature and added ammonia, on the hatch of brine shrimp. The hypothesis was that hatch would decline in water with worsening water quality. Four groups were tested, the control (optimal hatch water temperature), warmer water, optimal temperature water with ammonia added, and finally warmer water with ammonia. The experiment was run ten times for each experimental group. The control group had the highest number of hatched brine shrimp eggs. The group with the lowest water quality, warmer water and ammonia, had the lowest number of successful brine shrimp hatches. An ANOVA test was run to determine significance. The null hypothesis, that all experimental groups were the same was rejected, and the hypothesis was supported. Brine shrimp and similar secondary consumers are essential in food chains. Increased ammonia and warming waters each may affect brine shrimp negatively; the compounding

of these two threats may have even more significant impacts and conservation efforts should account for this in the future.

Ray Roberts- The Effect of Pond Location and Use on Diversity and Number of Organisms Present in each Pond per Milliliter Sample
Clover Hill High School

 The purpose of this experiment was to determine whether there was a difference in diversity and number of living organisms per milliliter of pond water sampled for a pond used for agriculture with a grass barrier and a pond that had cattle in it. The experimental hypothesis was that if a pond was used for keeping livestock, then it would have fewer living organisms and a smaller variety of living organisms than a pond near agriculture that had a grass barrier to prevent runoff. The experiment was conducted by taking water samples from both Pond 1 which was near agriculture with a grass barrier and Pond 2 which was used to support cattle. Fifteen trials were conducted at each pond. Samples were taken using a collection pole extended over and then dropped into the pond water. The samples were stored in a cooler with an ice pack until analyzed under a microscope. One milliliter of pond water from each sample was analyzed under a microscope to identify the number and frequency of each type of living organism. The results were recorded. The mean of the number of living organisms for Pond 1 was 83.9, while the mean of the number of living organisms for Pond 2 was 116.1. The pond used for livestock had a 28.8 % higher mean number of living organisms than the pond near agriculture with the grass barrier. From the experiment and t-test that were performed, it was determined that the pond used for agriculture with a grass barrier had less diversity and fewer living organisms per milliliter of pond water sampled than the pond with cattle. The experimental and null hypotheses were rejected. The data did not support the research hypothesis.

Samantha Lionberger- The Effect of Tree Species on Leaf Burn Rate
Mills E. Godwin High School

The purpose of this experiment was to figure out whether tree species have different burn rates. Knowing which tree species have the lowest burn rates will help park rangers to know where to monitor and respond to small fires before they become major forest fires. The hypothesis was that if *Quercus rubra* is used, then it will have the lowest burn rate. There was no control because there is no species present in all Virginia forests. First, materials were bought including 25 leaves of four species (*Quercus rubra, Acer rubrum, Pinus taeda, and Liriodendron tulipifera*). The leaves were then massed on an electric scale, and then individually burned. The burn rate was calculated by dividing the grams weighed by the seconds burned. Safety precautions were taken during the entire experiment. The hypothesis was not supported by the data, because the mean burn rate of *Q. rubra* was the highest, not the lowest. The inferential statistics tests performed concluded that any t-test containing *Q. rubra* had a probability of error greater than 0.5 ($p > 0.5$), while any other test had a probability of error less than 0.5 ($p < 0.5$). This shows

that *Q. rubra* was subject to error or chance. In conclusion, *P. taeda* is the species that needs to be watched the least, because it has the lowest mean burn rate. The reason for the results was likely an error with *Q. rubra*. The error could have occurred during massing, as the scale was not big enough for some of the leaves. A way this experiment could be added upon is by using different species, which would allow for park rangers and scientists to have more data pertaining to the burn rate of certain species.

Samyukta Iyer- The Effect of Aluminum Sulfate on the Bacterial Colony Count
Mills E. Godwin High School

Aluminum sulfate is a natural water purifier, which is used in many water treatment plants to filter out bacteria, sediments, and phosphorus, can help many underdeveloped countries. The purpose of the experiment was to test if aluminum sulfate purified creek water by reducing the number of bacterial colonies. The four levels of the independent variable that were tested were 0g, which acted as the control, 5g, 7.5g, and 10g of aluminum sulfate. It was hypothesized that if 7.5g of alum was used, then the water will have the least bacterial colonies. 250mL of water from a local creek were collected in a beaker. The water was streaked onto 25 nutrient agar plates using a cotton swab for the control group. 5g of aluminum sulfate were added to the same creek water. It was stirred for 2 minutes, and the plates were streaked in a zig-zag pattern. This process was repeated for the 7.5g and 10g groups. All the plates were incubated for 3 days at 37 degrees C, and the number of bacterial colonies were recorded. The results showed that the mean was the lowest for the 10g group, which indicated that it reduced the most bacterial colonies. The t-test showed that the data was significantly different. However, the analysis of the data did not support the hypothesis. The results were due to the formation of a floc layer, which attracts all the pollutants and filters the water. The experiment could be further expanded by boiling water to further reduce bacterial colonies.

Sean Kenny- The Effects of Urban Development and Riparian Buffers on Water Quality in an Urban Stream
Chesapeake Bay Governor's School

Urban areas can have a negative impact on the water quality of streams due to polluted runoff. Riparian buffers are often used to mitigate the effects of urban runoff on stream water quality. This study aimed to investigate the extent to which urban development impacts stream water quality, as well as the effectiveness of riparian buffers at maintaining stream water quality. Water quality data was collected seven times from two sites in the Hazel Run stream in Fredericksburg, Virginia. Site A was upstream from a major construction site and at the end of a long stretch of dense riparian vegetation. Site B was downstream from heavy construction and surrounded by relatively less riparian vegetation. The data was not statistically significant, indicating that the water quality at both sites was similar. Both streams were healthy, suggesting that the dense riparian buffer at Site A and the relatively smaller riparian buffer at Site B are both effective during

dry periods. The data also shows that the mitigation practices in place at the site of construction are most likely effective at controlling polluted runoff. A future study could investigate the impact of rainfall on the water quality of the stream, as this study originally aimed to do this but failed due to a lack of rainfall during testing. The findings of this study aimed to bridge a gap in the fields of urban water quality and urban riparian buffers, as well as gain insight into each field individually. As urban areas continue to become more prevalent in today's world and the world's water sources are strained, the findings of this study highlight the importance of maintaining riparian vegetation in order to protect urban bodies of water.

Seonbin Song- Examining the Relationship between Demographic Factors and a Southwestern Virginian Household's Carbon Footprint
Southwest Virginia Governor's School

This study sought to investigate the relevance of various factors to household carbon footprint. The purpose was to aid policy makers in creating laws that could target the factors that contributed the most to emissions, as well as to aid households in making personal decisions to lower their footprint. The data concerning demographic factors was collected using 35 surveys of high school students. The factors relating to location were collected using the online database datausa.io. The survey contained questions largely derivative of an online carbon footprint calculator created by Conservation International; the same calculator was used to generate footprints for all the survey respondents. Using the JMP program, an ANOVA test was conducted to examine the significant relationships between the factors and carbon footprint. It was found that higher household populations and house sizes were associated with higher footprints, while denser housing was associated with lower footprints. There were also inconclusive results that seemed to imply that more college educated households were associated with a higher footprint. Ultimately, the results seemed to be consistent with previous studies, suggesting that policies that encourage denser housing would be effective at lowering carbon footprints.

Steven Lilly, Jr.- Effluent's Effect on the Environment
Chesapeake Bay Governor's School

The Chesapeake Bay is plagued with high levels of nutrient runoff that can lead to eutrophication and impact the life in the Bay. One contributor to the introduction of such harmful substances are wastewater treatment facilities. Untreated wastewater can have high levels of nutrients (nitrogen and phosphorous) and bacteria. This experiment studied the impacts that treated wastewater, otherwise known as effluent, had on a marine ecosystem. Five sites of increasing distance away from the Colonial Beach wastewater treatment plant effluent outflow pipe and a control site independent of the treated wastewater were sampled for Phosphate, Nitrate, and coliform bacteria concentrations. This study found that concentrations of Phosphates, Nitrates, and bacteria are highest at the effluent outflow pipe. Linear regression tests showed that the trend for nitrates and phosphates were not statistically different. However, the decreasing trend of bacteria

colonies away from the outflow was statistically significant. Overall it appears that the dilution and flow of Monroe Bay may be an effective process. Monitoring point and non-point sources of nutrient pollution is critical in helping to maintain the health of the Bay.

Vimridh Vasudev- The Effect of Pollutants on *Trigonella foenum-graecum* Growth
Mills E. Godwin High School

The purpose of this experiment was to find the chemical with the most detrimental effect on plant development. Studying and understanding soil pollution allows scientists to determine how to prevent chemicals from contaminating plants. Soil pollution can also contaminate freshwater and destroy entire ecosystems. The pollutants used in this experiment were pesticide, gasoline, and bleach, three chemicals used frequently in households and various industries across the world. Each chemical, as well as a control of pure distilled water was allotted twenty-five pots, each containing soil and one fenugreek (*Trigonella foenum-gracum*) seed. Fifteen milliliters of each chemical solution were given to twenty-five separate pots every day for a period of six days. Final height was recorded on the seventh day. If trial did not germinate, height was recorded as zero centimeters. It was hypothesized that if plants were treated with bleach, it would result in the least average growth compared to plants treated with gasoline or pesticide. The results supported the research hypothesis; bleach had the lowest average plant height, with a mean of zero. The average plant height of each independent variable was compared to the control. A t-test was performed on the results, and data was determined to be statistically significant, implying that the results were caused by the independent variable and not due to chance or error. It is believed that the results are due to chemicals stunting growth in plants. For continued study, chemical solution concentration should be altered to test effects with different intensities of chemicals.

Wyatt Evans- The Comparison of Freshwater Pond Ecosystems with Various Levels of Human Influence
Chesapeake Bay Governor's School

This study compares fish populations in freshwater pond ecosystems with various levels of human influence. The availability of adequate size food, baitfish or other key forage fish, usually limits Largemouth Bass growth. A healthy freshwater biome requires not only an abundant population of prey species, but also a variety of different sized fish. Three local bodies of water were selected for their differing levels of human influence in surrounding land use. Each site represents one of the three of the most common land use types for freshwater ponds in southeastern Virginia: a natural forest edge environment, a suburban neighborhood, and an agricultural farm pond. Species at the top and bottom of the food chain were fished and trapped for over the months of October and November, 2021. Length, abundance and diversity of all species were analyzed graphically and statistically using Excel. All locations in this study were found to not be statistically different in length of Micropterus salmoides ($p=0.621$), or diversity between sites ($p=0.243$). However the abundance of the predator species was statistically greater

than the number of Largemouth Bass in the forested pond when compared to the suburban and farm ponds (p=0.028). Results of this study demonstrate that the surrounding land use of freshwater ponds has little effect on the fish community and confirm that Largemouth bass are robust and resilient species that can tolerate variations in water quality and the impacts of human influence. This is encouraging for the sport of fishing as anglers should enjoy the availability of Largemouth bass in a variety of urban, suburban, and rural water bodies.

Mathematics: Theoretical & Modeling

First Place
Philip Naveen- Phish - A Novel Hyper Optimizable Activation Function
Mills E. Godwin High School

Deep-learning models estimate values using backpropagation. The activation function within hidden layers is a critical component to minimizing loss in deep neural-networks. Rectified Linear (ReLU) has been the dominant activation function for the past decade. Swish and Mish are newer activation functions that have shown to yield better results than ReLU given specific circumstances. Phish is a robust non-monotonic activation function proposed here. It is a composite function defined as $f(x) = xTanH(GELU(x))$, where no discontinuities are apparent in the differentiated graph on the domain observed. Generalized networks were constructed using different activation functions. SoftMax was the output function. Using images from MNIST and CIFAR-10 databanks, these networks were trained to minimize sparse categorical crossentropy. A large-scale cross-validation was simulated using stochastic Markov chains to account for the law of large numbers for the probability values. Statistical tests support the research hypothesis stating Phish could outperform other activation functions in image classification. In a first of its kind, Phish hybridizes Identity, Hyperbolic, and Gaussian mathematical relationships to create a unique transformation profile using continuity, non-monotonicity, and differentiability. The next generation activation function provides state-of-the-art training dynamics for expediting subvariants of stochastic gradient descent backpropagation. Future experiments could involve using Phish in generative adversary networks training in an unsupervised two-player minimax framework. This project was conducted on an i5 using custom computer programs and mathematics visualization tools under the appropriate antivirus software.

Second Place
Shoshana Elgart- A New Approach to Image Stitching: Minimizing Distortion and Computational Costs
Blacksburg High School

Image stitching, or the techniques with which overlapping images are combined into a panorama for use in medical and satellite applications, relies on an iterative method to first extract feature vectors from each image and consequently align images one by one. When many images are stitched, this iteration and the high dimensionality of traditional feature vectors cause considerable distortion in the constructed panorama and decreases algorithmic efficiency, limiting the accuracy and accessibility of associated scans and maps. This research aims to reduce both error and computational complexity in many-image stitching, by directly and non-iteratively reconstructing the panorama with a matrix analysis and spectral geometry-based approach. In particular, I extract one-dimensional feature vectors for each image from the spectra of corresponding graph Laplacians, and use combinatorial arguments based on Hall's Marriage Theorem to reduce the resulting set of vectors to a non-redundant and almost-orthogonal one. I then construct an optimally close, fully orthogonal set of feature vectors to recreate the entire panorama by designing a novel, non-iterative orthogonalization procedure, a complex problem in matrix analysis. My methods yield a decrease in the distortion exhibited by the completed panorama while simultaneously lowering the time needed to construct it. This project is designed to improve the quality and accessibility of image processing software, with a wide range of applications in yields including spinal radiography, endoscopic surgery, and document mosaicing.

Third Place
Lillian Sun- De Novo Prediction of RNA-Protein Interactions for Discovery of Tissue-Specific Binding Sites and Study of RNA Gain-of-Function Diseases
Thomas Jefferson High School for Science and Technology

In eukaryotes, RNA-binding proteins (RBPs) interact with RNA to control post-transcriptional processes, including alternative splicing, polyadenylation, stabilization, localization, and translational regulation. RBPs and RNAs are differentially expressed between tissues, influencing the transcriptome-wide RNA-protein interactions that occur within each tissue. Current experimental techniques to identify RBP binding sites in vivo, such as UV cross-linking immunoprecipitation and sequencing (CLIP-seq), are expensive, time-intensive, and difficult to perform reproducibly. Here, I introduce a de novo method to predict tissue-specific RBP binding profiles from an RNA sequence in silico. This approach simulates RNA-protein interactions using a probabilistic model that leverages binding affinities predicted from in vitro RNA Bind-n-Seq data and protein compositions measured by mass spectrometry. I apply this method to investigate the binding of 86 RBPs across 30 human tissues, outperforming existing computational methods. I show that the model recapitulates well-studied examples of tissue-specific binding, such as the brain-specific binding of protein NOVA1. In addition, using this approach, I identify NOVA1 as a potential critical protein in the progression of benign adult familial myoclonic epilepsy (BAFME), as NOVA1 binds the UUUCA repeat expansions present in the intronic region of SAMD12. Predictions from this model may aid researchers in understanding functions of RBPs and uncovering their roles in understudied diseases.

Honorable Mention
Ariq Amin- The Effect of the Distance of a Liquid Projectile From a Receiver on the Percentage Coverage of Projectile Droplets
Clover Hill High School

The purpose of this experiment was to determine whether social distancing 6 feet (1.83 m) apart was effective in preventing the exposure of covid droplets through testing whether the droplets would remain airborne when in the vicinity of a Covid positive person. This experiment tested the effect of the distance (m) of a liquid projectile from a receiver on the percentage coverage of projectile droplets. To measure the distance (m) of the liquid projectile from the receiver, projectile droplets were shot at various distances to a piece of graph paper. The temperature and volume of the water were kept constant for each trial. A picture of the graph paper was taken after the projectile droplets were shot, and an online calculator was used to calculate the percentage coverage of the projectile droplets. The hypothesis was if a liquid projectile was shot from at least 1.83 meters away at a target, then the percentage coverage of projectile droplets would heavily decrease compared to shooting a projectile liquid from 0.1 meters away. The percentage coverage values were recorded in a data table for each trial, and the process was repeated until each level had 20 complete trials. For the control (0.1 m), 0.61 m, 1.22 m, 1.83 m, 2.44 m, and 3.05 m, the mean percentage coverage of projectile droplets were 19.961%, 28.829%, 42.632%, 34.904%, 35.440%, and 20.409% respectively. The highest of the means was at the 1.22 m level, the lowest of the means were at the control (0.1 m) level, and the second lowest of the means were at the 3.05 m level. After the data was collected, an ANOVA test was conducted to test if the data was statistically significant. The percentage coverage at 1.83 m showed a higher percentage of projectile droplets than the percentage coverage at 0.1 m, so the experimental hypothesis was not supported. The null hypothesis, which stated that the distance of a liquid projectile from a receiver would not affect the percentage coverage of the projectile droplets, was rejected.

Honorable Mention
Brooke Li- The Effect of Training Data, Methods, and Neural Network Model on Signature Verification Accuracy
Central Virginia Governor's School

The purpose of this research was to study the effect of various training methods, training data, and neural network models on the accuracy of the signature verification neural network. Different training methods incorporated shuffled training data and various training ratios of genuine to forged signatures, modified training data utilized weighted average data of image pixel intensities, and changes made to the neural network model included altering the number of layers and the number of neurons in the second hidden layer. Distinct genuine and forged copies of twenty personal signatures were used for the neural network. Image preprocessing and feature extraction was done to each training and testing signature before being passed through the neural network to decrease fit loss

and increase signature verification accuracy, which were computer outputs. Five statistical tests, three two-sample t-tests and two one-way ANOVAs, were completed at an alpha value of .05. The results suggested that the experiment involving shuffled training data, with p-value 6.99 x 10-5, and number of hidden layers, with p-value 7.13 x 10-4, had an effect on signature verification accuracy. The research hypothesis was supported in these cases. The other three experiments involving changing the ratio of genuine to forged signatures, adding Hu moment data, and decreasing the number of neurons with p-values .824, .863, and .552, respectively, did not indicate significance and did not support the research hypothesis. These results can be applied to real world situations in decreasing the percent of falsely accepted forged signatures.

Honorable Mention
Camellia Sharma- The Effect of Machine Learning Algorithms on Identifying Skin Cancer
Mills E. Godwin High School

Melanoma is one of the most lethal forms of skin cancer, being attributed to about 75% of the skin-cancer related deaths. The survival rate is almost 100% if the cancer is diagnosed early. Traditionally the malignant melanocytes, the pigment-producing cells that cause melanoma, are identified through biopsy. myDermAI presented here is a novel invention for finding and categorizing skin lesions according to malignancy, using computer vision (CV) and machine learning (ML). The purpose of this experiment was to determine which ML algorithm would identify skin cancers with the highest accuracy. All images were preprocessed with the same CV algorithm to reduce variability in the processing pipeline. In this experiment, ML algorithm was the independent variable (IV). Convolutional neural network (CNN), random forest (RF), K-nearest neighbor (KNN), and support vector machine (SVM) were the levels of IV. CNN was the control because it is used often due to its speed and low error rate. Accuracy of categorizing lesions (measured in percent) was the dependent variable. It was hypothesized that if the CNN machine learning algorithm is used, then the accuracy of identification will be the highest. Photos acquired through public images were the input data. The ML algorithms were used to predict the diagnosis of the images in the dataset. The predictions were compared against the actual diagnosis to calculate the accuracy. Independent and pairwise comparison the means t-tests were performed. They showed that the data was statistically significant. The hypothesis was supported because CNN had the highest accuracy of identification while RF had the lowest. The results could be explained by the fact that CNN associates each pixel with their neighbor while other ML algorithms analyze them individually. In the future, more diverse datasets could be utilized. The app must be tested in clinical environment before it can be used by the public.

Josh Tomiak- Online Machine Learning for SMS Spam Detection
Southwest Virginia Governor's School

SMS (Short Message Service) spam is a serious problem for users, both in wasting their time and attention and through threats such as scams and malware. As SMS spam continues to increase in volume, there is growing demand for accurate filters. While many promising SMS spam classifiers have been proposed, little to no research implements these filters in realistic settings that include the well-documented problems of concept drift and class imbalance. Concept drift, or changes in data characteristics over time, is known to be introduced by SMS spammers as they work to subvert filters; class imbalance, or overrepresentation of one data class, is perennial in SMS spam filtering since legitimate messages predominate. To address the research gap, this work tested four highly regarded machine learning classifiers,Äîa Naive Bayes (NB) model, a Support Vector Machine (SVM), and two Convolutional Neural Network (CNN) variants,Äîon two datasets with both concept drift and class imbalance present, where state-of-the-art methods were implemented to combat these problems. Results as average F1-score (n=5) at incremental stages in the datasets show the SVM tending to perform best and the CNNs underperforming in contrast to previous work, demonstrating how concept drift and class imbalance impact performance and informing real-world model selection. Future research could carry out similar methods with more data to determine how well CNNs scale to larger datasets or explore the potential of the paraphrasing methods employed here.

Micah Eberz- Analyzing the Relationship Between Serving and Scoring in Table Tennis
Central Virginia Governor's School

The purpose of this study was to determine whether serving in table tennis, even with the possibility of a fault (failure to make a legal serve, resulting in a point for the other side), actually gives an advantage to the server. Data was collected from three Olympic matches, which consisted of 19 games, adding up to 366 rallies. For each rally, the scorer was recorded along with the number of hits in the rally. Using this data, a chi-squared test of independence, a regression test, and a two tailed t-test produced results. The results supported the hypothesis, which stated that the server has a statistically significant advantage in serving. This was supported by a p-value of .021, compared to the .05 alpha value. The number of hits in a rally did not have a statistically significant effect on that advantage (p-value .245; alpha .05). These results suggested with 97.9% certainty that the server has an edge, but they cannot confidently say that more hits in a rally affects that edge. This data helps support the idea that serving is advantageous and will allow for more precise predictions in table tennis.

Samuel Xiang- Changes in pK and ionization state of SARS-CoV-2 spike receptor binding domain upon human ACE2 receptor binding
Blacksburg High School

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In the era of coronavirus, it has become imperative to develop new avenues of drug research and advance epidemiology prevention. Understanding the exact mechanisms by which SARS-CoV-2 binds to the human ACE2 receptor is key to providing new opportunities to understand viruses and for further vaccine development. Residues that undergo significant changes in pK and protonation state upon binding are integral to the binding of SARS-CoV-2 to the human ACE2 receptor. Identifying these residues allows them to be disrupted by new drug treatments, reducing the virality and severity of coronavirus. To determine shifts in pK upon ligand binding, the computational server H++ was used. Analyzing the SARS-CoV-2 spike receptor binding domain and the Human ACE2 receptor before binding and complexed together allowed analysis of important residues. These residues were identified by undergoing a significant shift in pK (a change greater than 1). The ACE2 Receptor has 23 residues that experienced a significant change in pK, with LYS-476, HID-373, and ASP-38 experiencing the most drastic pK shifts. The SARS-CoV-2 Spike protein's receptor binding domain has 16 residues that experienced a significant change in pK, with TYR-508, GLU-406, ASP-398, and GLU-516 experiencing the most drastic pK shifts. Because these residues experience large shifts in pK, new drugs should target these residue bonds and attempt to disrupt them to prevent the transfer of viral genetic information. This procedure can also be replicated for new viruses in the future, to quickly identify key residues and create drug treatments.

Medicine & Health - A

First Place
Christina Okenquist,Ella Bryant- The Effect of RNA Interference on the Apoptosis of Small Cell Lung Carcinoma
Roanoke Valley Governor's School

Small Cell Lung Carcinoma (SCLC) has limited treatment options available that often result in relapse. Apoptosis, a type of programmed cell death, presents possibilities for treating cancers including SCLC. More specifically, SATB1 and MELK—genes that are overexpressed in SCLC—has been shown to inhibit apoptosis due to the genes' connections with tumor suppressor p53. Therefore, the study aimed to perform RNA interference on the respective genes to induce the apoptosis of small cell lung carcinoma in vitro. To carry out the experiment, the cells were cultured and incubated as necessary before RNA interference was carried out. At the 24- and 48-hour marks following transfection, a Caspase-3 Activity Assay was used to determine the rate of apoptosis. After calculating the caspase-3 activity levels, a One-Way ANOVA test was completed at the 24- and 48-hour marks, respectively, showing the 48-hour group was significant with a p-value of 2.02×10^{-4}. To determine which groups were statistically different at the 48-hour mark, a collection of Two-Sample t-Tests was run, determining the MELK siRNA to be statistically different from the negative control siRNA with a p-value of 1.76×10^{-3}. In addition, MELK siRNA had a higher average caspase-3 activity level than the negative control siRNA, indicating that the RNA interference of MELK increased the rate of

apoptosis. These findings partially supported the hypothesis that the RNA interference of the respective genes would increase the rate of apoptosis since SATB1 siRNA was not shown to significantly influence SCLC.

Second Place
Aashka Shah- Analysis of T cell Recovery in the Early Post-Bone Marrow Transplantation Period
Maggie L. Walker Governor's School

After a bone marrow transplantation, the immune system goes through a period of growth in an attempt to completely recover. T cells play a large role in the success of a bone marrow transplant by affecting a patient's ability to fight infection, fight off remaining cancer cells, and stimulate other immune cell growth, particularly B cells ‚Äì the cells responsible for making antibodies. The purpose of this study was to assess how T cell growth in the first month after transplant affects later B cell growth along with major outcomes, such as survival and relapse. The hypothesis tested was whether a fast and large growth of T cells in the first month after transplant led to a larger B cell population later on. Similarly, this hypothesis was extended to T cell growth theorized to be directly proportional to better survival and indirectly proportional to relapse. Rate of T cell growth was determined by plotting T cell values in the first 100 days after transplant on an x-y axis, fitting the points to a cubic equation, taking its derivative, and finding the value of this derivative at 30 days after transplant. The derivative value was used to test the associations to later B cell growth, survival, and relapse. Machine learning in the form of a decision tree was used to predict whether a patient would survive at least 1 year after transplant based on certain patient characteristics such as T cell growth, age, and relapse status. A weak correlation between early T cell and later B cell growth was found. T cell growth at 30 days post transplant was found to have a parabolic association with survival and an inverse relationship with relapse. A decision tree using the three variables mentioned above was able to predict a patient's chance of survival past 1 year with 79.5% accuracy.

Third Place
Ayla Lampros,Reese Redford- The Effect of Manzamine A on the Growth of Lung Carcinoma
Roanoke Valley Governor's School

Every year cancer claims nearly 10 million lives worldwide. The leading type being lung cancer accounts for 1.8 million of these deaths alone (World Health Organization 2021). Despite hundreds of thousands of hours of research and billions of dollars, there is still no readily accessible cure for this deadly disease. The compound Manzamine A was chosen due to its complexity which yields it to exhibit a range of potent inhibitory effects, including anticancer, antimalarial, and anti-inflammatory. In this study, Manzamine A was tested on human neonatal fibroblast cells and lung cancer cells. In order to test the effect of this unique compound, both cell types were cultured and treated with a series of nine

Manzamine A concentrations that varied from 0.5¬µM to 17¬µM and directly corresponded to the amount of specific media added to each concentration. After 24 hours in an incubator, the cells were observed using a cell proliferation assay. After performing the cell proliferation assay, we ran an ANOVA test, which was able to tell if there is a significant difference between the groups of data. The lung cancer cells ANOVA test yielded a p-value of 2.672E-15, thus rejecting our null hypothesis. Similarly, the human neonatal fibroblast cells ANOVA test yielded a p-value of 2.277E-09, thus rejecting our null hypothesis, meaning there was a significant change in cell regrowth between the concentration levels in both cell types. When a Games-Howell test was later preformed on both human fibroblast cells and lung cancer cells, numerous significances between concentration levels were found. In conclusion, it was found that the 1 ¬µM and 2.5 ¬µM concentrations of Manzamine A leaves fibroblast cells healthy yet kills cancerous lung cells.

Honorable Mention
Abigail Whiting- The Correlation Between Surface Temperature and Dengue Fever Incidence in Countries in the Americas
Washington-Liberty High School

The purpose of this experiment is to discover and quantify the correlation of climate change as measured by surface temperature (‚ÑÉ) on dengue fever incidence per 100,000 people within different countries in the Americas. It can be reasonably hypothesized that there will be a positive correlation between surface temperature and dengue incidence. If that does not occur, the null hypothesis for this experiment is that there is no correlation between surface temperature and dengue incidence. A positive correlation is likely between the independent and dependent variables because of the limiting factors of Aedes aegypti. Data for this experiment was collected from the Pan American Health Organization (PAHO) and the Food and Agriculture Organization of the United Nations (FAO). The results of this experiment concluded that there is a positive correlation between surface temperature on dengue fever incidence in the Americas. The results of this experiment are relevant on a global scale because dengue fever is one of the most common mosquito-borne illnesses, and if scientists can link dengue to climate change, there is a possibility that more effective techniques for dengue prevention can be developed, potentially saving millions of lives.

Honorable Mention
Allison Grove,Kathryn Boerckel- The Effect of Correspondence Between Strains of Prevalent Influenza and Strains Included in the Vaccine on the Effectiveness of the Flu Vaccine in 10 Flu Seasons from 2010-2020
Washington-Liberty High School

The purpose of this experiment was to determine the effect of correspondence between strains of prevalent influenza and strains included in the vaccine on the effectiveness of the flu vaccine in 10 flu seasons from 2010-2020. The hypothesis of this experiment was:

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if the influenza strains used in the vaccine strongly correspond to the common strains infecting the population in a particular season, then the numbers of those infected, hospitalized, and killed by the flu will decrease, because vaccines containing virus strains similar to the influenza viruses circulating most commonly that season are increasingly effective. This study evaluated the prevalent influenza strains, influenza vaccination strains, and estimated medical visits, hospitalizations, and deaths for ten flu seasons over the span of ten years. The flu seasons which had 100% correspondence of strains reflected the lowest number of hospitalizations and medical visits of all evaluated seasons. Subsequently, the flu seasons with the lowest correspondence of strains (33%) demonstrated the overall highest numbers of medical visits, hospitalizations, and deaths. However, the number of deaths for various flu seasons of differing correspondences overlapped. A test for r was performed to test the correlation between correspondence of strains and flu burden estimates of medical visits, hospitalizations, and deaths, respectively. Collectively, the r values conveyed a strong negative correlation between correspondence of flu strains and numbers of estimated flu burden. The results supported the hypothesis as they suggested that influenza vaccines consisting of strains that correspond to commonly circulating strains among the population result in significantly decreased numbers of medical visits, hospitalizations, and deaths due to the flu.

Abdullah Khurram,Raj Joshi- An Analysis of Clinical Gastrointestinal Side Effects from Analgesics by Measuring Relative Inhibition of Enzymes
Governor's School @ Innovation Park

Over-the-counter painkillers (or analgesics) are ubiquitous in modern society, with much of the population able to recognize them by name. What is less known, however, are the negative side effects that analgesics potentially have on the body. Various analgesics inhibit a specific type of enzyme in the body, cyclooxygenases, that produce prostaglandins which are responsible for inflammation and pain. There are two types of cyclooxygenase (or COX) enzymes present in the body: COX-1 and COX-2. Inhibition of the COX-2 enzyme yields desirable pain-relieving effects, while inhibition of the COX-1 enzyme is primarily responsible for negative gastrointestinal side effects observed in analgesics. Therefore, drugs that inhibit COX-1 less and COX-2 more are hypothesized to have fewer side effects while still being functionally effective. Multiple analgesics,Äô binding affinities to these two enzymes will be tested in Schrodinger Maestro molecular modeling software using a binding free energy prediction tool called MM-GBSA (short for Molecular Mechanics Generalized Born Surface Area). The data gathered depicts that acetaminophen has a significantly lower ŒîG Bind value when bound to COX-1 than ibuprofen, supporting the fact that acetaminophen exhibits fewer gastrointestinal side effects than ibuprofen. Although more data is yet to be analyzed, the existing data suggests that COX-1 inhibition and gastrointestinal side effects are correlated. This research may give insight into why certain drugs have certain adverse side effects, advancing the development of safer pharmaceuticals and catalyzing a paradigm shift in the way we look at pharmaceuticals.

Akul Miriyala- The Effect of Different Types of Whitening-Toothpaste on Enamel Hardness
Mills E. Godwin High School

The purpose of this experiment was to determine the effects of different whitening toothpastes on enamel hardness. Recently, whitening toothpastes have been gaining popularity with consumers for a quick way to get white teeth, but the negatives of their formula are not as researched. Eggs (the eggshells of which represent tooth enamels) were treated with either Crest 3D White toothpaste, Colgate Ultra White toothpaste, or no toothpaste, the control. The toothpaste was applied for 12 hours on the egg and then taken off, and the eggs were then submerged in vinegar for 12 hours. After 12 hours, the egg was ranked on a qualitative scale from 0-10. It was hypothesized that the egg group without toothpaste would have the softest shell, indicating the most damage done to its ‚Äúenamel.‚Äù The results revealed that the group without toothpaste was the hardest, with the groups treated with the toothpaste having significantly softer shells, with the Crest 3D White group having the softest shell. The results did not support the research hypothesis, and it is believed that they are due to the fact that whitening toothpastes have more abrasive agents in their formulas which wear away the enamel. This research could lead to further studies that investigate other lesser researched subtypes of toothpastes such as herbal toothpastes.

Anne Eubanks- The Effect of Dimethicone on Transepidermal Water Loss
Mills E. Godwin High School

This experiment aimed to examine the effect of various dimethicone concentrations on the transepidermal water loss (TEWL) of agar samples. The initial objective was to determine the optimal concentration of dimethicone, if any, for strengthening barrier integrity and improving moisture retention of the agar, which has applications in the treatment of common skin disorders as dimethicone is rumored to improve the epidermal barrier integrity of human skin. TEWL was measured using the unventilated-chamber technique, in which agar samples received 25 drops of a solution: 0% control, 15%, or 30% dimethicone and were then placed in a closed, hollow cylinder for 6 hours, after which the difference between their water vapor density and that of the ambient environment was recorded to determine the TEWL of each sample. It was hypothesized that the agar receiving the 30% dimethicone solution would have the lowest TEWL. It was discovered that these samples did indeed have the lowest TEWL, with the 15% concentration in the middle and 0% concentration causing the highest TEWL. This data supported the research hypothesis, and a t-test determined the results to be statistically significant with the exception of the 0% vs. 15% comparison. It is thought that the results were due to dimethicone's occlusive properties and large molecular weight, which rendered it able to form a semi-permeable barrier on the surface of the agar to regulate the evaporation of water into the surrounding environment. As such, a higher concentration of dimethicone best enabled it to perform its protective function.

Bailey Carver- Effects of Collagen on the Heart Rates of Daphnia magna
Central Virginia Governor's School

The purpose of this study was to determine whether the amount of collagen in water negatively affects the heart rate of Daphnia magna. The experiment was conducted in a local high school laboratory in November, 2021. 24 Daphnia magna were randomly divided into three groups. One group was put into beakers with no collagen, one with 2% collagen, and one with 4% collagen. Their heart rates were monitored initially at the beginning of the experiment, after one week of exposure, and then after two weeks of exposure. The heart rates were measured by recording videos under a microscope, slowing them down, and counting the amount of times their heart beat in 15 second increments. The data was analyzed in an ANOVA two-way test. The p-value between the collagen groups was .009. Compared to an alpha value of .05, this was statistically significant. By running two post-hoc tests, it was determined that the average heart rate of the group with 4% collagen was statistically significant; therefore, the research hypothesis, „Äúlf the collagen concentration in the water is greater than 2% then the heart rate of the Daphnia magna will increase„Äù was supported. In conclusion, collagen did have an effect on the heart rate of Daphnia magna and in turn could possibly affect human health similarly.

Beall Roberts- The Effect of Fast Food Consumption on Pain with Menstruation
Central Virginia Governor's School

The purpose of this research was to determine the relationship between saturated fat consumption and pain with menstruation. In this study, surveys were distributed to local gynecology offices for patient participation. Individuals were instructed to complete a Likert scale frequency survey that posed questions about their diets and lifestyles, along with their symptoms of menstruation. The responses were then assigned a number per frequency response, and analyzed using a regression test. The questions selected to analyze included frequency of pain with menstruation and frequency of fast food consumption. The p-value was determined to be .777, and was compared to an alpha value of .05. This study did not support the research hypothesis, which stated that an increase in fast food consumption would cause higher frequencies of pain with menstruation. This study suggested that other options of holistic dysmenorrhea treatment should be further researched, as effective alternatives to NSAID usage.

Bethelle Lanquaye- The Effects of Niacinamide, Ascorbic Acid, and Coenzyme Q10 on the Vitality and Mobility of *Caenorhabditis elegans*
Governor's School @ Innovation Park

Parkinson's Disease (PD) is a neurodegenerative disease that targets mobility caused by the degeneration of dopamine neurons and the build-up of alpha synuclein protein, which is correlated with oxidative stress. Oxidative stress results from an imbalance between free radicals and antioxidants. This project proposes the use of vitamins (coenzyme Q10,

ascorbic acid, and niacinamide) to combat PD using *Caenorhabditis elegans*. After treating plates with different vitamin concentrations, behavioral assays measuring thrash count (TC), population, and sociability were conducted. When treated with 2.706×10^{-7} mg vitamin C, the worms had an average TC of 172 per minute, a 7:50 dead to alive ratio (DAR), and an average sociability of 9 clusters. The lowest concentration of vitamin B3, 1.052×10^{-9} mg, resulted in the most viable worms with a TC average of 79, a 1:5 DAR, and an average sociability of 3 clusters. Lastly, CoQ10‚Äôs 1.50×10^{-7} mgs proved to be most viable with an average TC of 110, a 4:25 DAR, and an average 2 clusters in sociability. This data partially supports the alternative hypothesis which stated: If 1.052×10^{-8} mg niacinamide, 2.706×10^{-8} mg ascorbic acid, and 1.50×10^{-7} mg CoQ10 is administered, then the *C. elegans* will exhibit the greatest signs of increased vitality and mobility while also maintaining the lowest ratio of dead: live organisms. This data serves as a pretest for an experiment that will treat transgenic worms which will undergo qPCR to measure their expressed levels of the PARK8 gene.

Cassie Kincaid- Surgical Sutures and the Effect of pH Levels on Their Tensile Strength
Chesapeake Bay Governor's School

Surgical sutures are a medical device that allows medical professionals to close a laceration or incision. Sutures can be classified as absorbable or non-absorbable, synthetic or natural, and monofilament or multifilament. Absorbable sutures are broken down by the enzymes found in bodily tissue which is a result of hydrolytic degradation. The speed of this process depends on the pH of the surrounding tissue. As the sutures are broken down, they lose their tensile strength. On the body, different areas have different levels of tension. A suture needs to be stronger at a joint because it moves causing more tension. The selection of the right suture is crucial, otherwise, the sutures could break causing wound to open for a second time. This study uses the submergence of suture materials in pH buffers to prove whether their tensile strength degradation is affected by different pH levels. Three types of sutures (PGA, PDO, MONO) were submerged in three different pH buffers (4.0,7.0,10.0). Over the course of a month, their tensile strength was tested and recorded for further analysis. Both PGA and MONO sutures showed severe loss in tensile strength in pH 4.0. PDO sutures showed the most loss in pH 7.0. The PGA sutures resulted in a significant p-value of 7.29E-04 as well as the PDO sutures with a p-value of 1.26E-05. This allowed the null hypothesis to be rejected and allowed the alternate hypothesis of the PGA sutures to be accepted. The MONO sutures resulted in a p-value 0.155 which forced the acceptance of the null hypothesis. The role that body pH plays in the degradation of suture materials shows how important suture stability is to the healing process.

Divya Ramakrisnan,Hermela Tadesse,Soneha Datta- The Effect of Natural Plant Extracts on *C. elegans* as a Means of Limiting UV Radiation Damage
Governor's School @ Innovation Park

Mitigating the harmful effects of ultraviolet radiation is further becoming a major concern, as skin cancer rates are surging in the United States. Although protective options such as sunscreen exist, they are temporary and do not provide as comprehensive protection as an ingestible would. The purpose of this study is to contribute to current methods of UV impact prevention by providing an additional source of protection through an attainable and reliable plant-based ingestible, in hopes of giving vulnerable individuals another option of protection. Using *C. elegans*, the group conducted the experiment testing *Garcinia mangostana*, *Olea europaea*, and *Melissa officinalis* extracts' benefits on protecting the organisms under UV light at a strength of 365nm. Two behavioral assays, gentle touch and osmosensation, were performed at 0 and 24 hours to quantify the C. elegans' health. Two-way ANOVA tests with replication were performed to analyze the data. Both the plant extract type and the hours since exposure to UV light explain a significant amount of variation in *C. elegans* response level (p-values < 0.001). Furthermore, the olive leaf extract plates had the highest average response rates when both assays were performed. This signifies that the *C. elegans* exposure to plant extracts, specifically *Olea europaea*, assisted in the prevention of UV light damage. Therefore, the hypothesis is supported. In the future, testing different amounts of each extract, utilizing other assays, and including new extracts will be sought.

Eden Hunter- The Effect of Disrupted Circadian Rhythm on *Drosophila melanogaster* Lifespan
Central Virginia Governor's School

The purpose of this study was to determine if disrupting circadian rhythm decreases lifespan in *Drosophila melanogaster* as a model for humans. For this project, the flies were separated into different groups dependent upon varying life cycles and whether they were wild type or mutants with a missing circadian clock gene. One group was constant light, one group was 12-hour light, and one group was 16 hours. Their lifespan was counted in days. To analyze the data, a single factor ANOVA was run. The test resulted in a p-value of .2 x 10-4 and compared to the set alpha value of .05, it determined significance. To find where the significance was, a post hoc Tukey test revealed a Dmin value of 20.742. This suggested that there was significance in the group of 24-hour constant light mutant group compared to the 12-hour wild type group and partially supported the research hypothesis which stated if *Drosophila melanogaster* is exposed to a source of constant light disrupting their circadian rhythm, then the mutant flies will have a longer lifespan than the wild type flies. In conclusion, disruption of circadian rhythm has an effect on lifespan when exposed to constant light.

Medicine & Health - B

First Place
Jacqueline Hou- The Effects of Inflammatory Neutrophils on Endothelial Cell Integrity
Blacksburg High School

Endothelial vascular leakage is responsible for the pathogenesis of diverse acute and chronic inflammatory diseases, such as COVID-19 and influenza, heart disease and arteriosclerosis. In particular, COVID-19 infection exacerbates fluid extravasation to the surrounding tissues, eventually leading to systemic inflammatory diseases that induce sepsis and multiorgan failure. These processes are mediated by inflammatory cytokines and first-responder leukocytes, such as neutrophils; however, the effects of neutrophils on endothelial cell integrity mechanisms have not been well examined to date. In this study, it is shown that naive neutrophils cause significant leakage in brain endothelial tissue, the most restrictive vascular barrier, through the integrated analysis of three perspectives: dye-leakage assay, cell morphology, and molecular biology. An optimized Evans Blue Dye Assay was developed to determine the interaction of murine-derived neutrophils and endothelial cells in vitro; when tested, it was revealed that the endothelial cell barrier is disrupted significantly by neutrophils. Under light microscopy, endothelial cells cultured with naive neutrophils shrink and demonstrate finger-like morphology with oblique gaps. Neutrophils negatively affect the intactness of endothelial cells by reducing expression of adhesion and tight junction endothelial markers E-Cadherin, Catenin beta-1, ESAM, and JAM-1, examined via flow cytometry. Collectively, this data challenges the current understanding that naive neutrophils are non-inflammatory, significantly altering targeted therapeutic intervention for inflammatory diseases such as COVID-19. The methodology of this study provides an optimized in vitro assay to advance the study of drug development affecting endothelial vasculature.

Second Place
Gabriel Ralston,Hamza Lateef,Tony Bright- Concussion Recovery in Youth Optimized using a Comprehensive App-based Program (CRYO CAP)
Governor's School @ Innovation Park

Background: Substantial research suggests that therapeutic hypothermia could ameliorate the devastating impact of Traumatic Brain Injury (TBI). The project‚Äôs goals were: 1) To study the effects of concussion in a validated animal model (Drosophila melanogaster) and determine whether therapeutic hypothermia could mitigate neurocognitive impacts and 2) To engineer a device (CRYO CAP) that delivers consistent cerebral hypothermia to an athlete who has suffered mild TBI, using app-based technology to diagnose the concussion and monitor recovery. Methods: Fly experiment - A ‚Äúhigh-impact trauma‚Äù (HIT) device was used to induce mechanical damage to the brain of subjects. Flies were separated into a control group and a hypothermia group, which was cooled for 3 minutes in a refrigerator at a temperature of 160 C. CRYO CAP has 3 main components: an electrical system, a cooling system, and a helmet. The electrical system includes a 12-volt, 35-amp-hour battery and a 12-volt, 7-amp-hour battery that power the cooling system and app interface. The cooling system utilizes 5 thermoelectric coolers, 2 liquid pumps, and 3 aluminum cooling blocks to form 2 liquid cooling circuits. A single and dual radiator design were tested to compare cooling performance. The helmet is lined with cooling tubing and uses a temperature sensor, at the athlete's temple, which connects to an Arduino microcontroller to relay temperature

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data to the app. The app diagnoses and classifies the TBI using the Glasgow Coma Scale. Mild TBI prompts cooling for 30 minutes. The app then prompts the user to complete the Concussion Symptom Scale (CSS), a validated symptom inventory, which is assessed daily for 14 days. Results: In flies, average time to sedate for control vs. concussion vs. concussed hypothermia was 77.8, 52.4, and 65.4, seconds, respectively (P<.0001). The single and dual radiator designs resulted in temperatures of 11.2¬∞C (10.8¬∞C temperature reduction) and of 8.5¬∞C (11.9¬∞C temperature reduction), respectively. Conclusion: Concussed flies demonstrated much less time to sedate compared with controls, and hypothermia seemed to mitigate this negative effect. CRYO CAP provides therapeutic hypothermia after a concussive head injury, empowers users with technical support, and collects data in real-time that innovatively connects the trainer and athlete at the bench to the physician at the bedside.

Third Place
Emily Yang- The Effect of High-Glucose Diets on *Caenorhabditis elegans* Lifespan
Mills E. Godwin High School

The purpose of the experiment was to determine the effects of glucose on *Caenorhabditis elegans* (*C. elegans*) lifespan. *Caenorhabditis elegans* are commonly used as subjects of human disease research. The rationale of the experiment is to see how carbohydrates, such as glucose, affect the lifespan of a model organism because recently, more people choose to eat carbohydrate-rich meals. Chronic exposure to high levels of carbohydrates in diets promotes the development of metabolic syndromes, which sequentially leads to obesity. By 2030, obesity is predicted to impact over 1 billion people. In this experiment, *C. elegans* were grown on Nematode Growth Medium agar and given a 20 millimoles (mM), 40mM, or 80mM concentration of glucose. The control used was a 0mM concentration of glucose. Each organism was observed with a dissecting microscope daily for 3 weeks and its lifespan was measured in days. It was hypothesized that if an 80mM concentration of glucose is given to C. elegans, then its lifespan will decrease the most. The results showed that organisms given 80mM of glucose died, on average, 7 days earlier than the control of 0mM. The data supported the research hypothesis. A t-test was done on the data, revealing that all the data was significant. It is believed that the results are due to the fact that increased glucose levels increased oxidative stress in *C. elegans,* causing their lifespan to decrease. This research could lead to further studies that investigate the effects of how other carbohydrates or medicines affect *C. elegans'* lifespan.

Honorable Mention
Hadessah Johnson- Compound Screening for Molecular Regulators of ZFP189 Using Luciferase Assay and qPCR
Chesapeake Bay Governor's School

Depression is one of the most common major health illnesses globally, affecting about 5% of the world's population. There are six different classes of prescription drugs

approved to treat depression, the most common classes are selective serotonin reuptake inhibitors (SSRI) and serotonin-norepinephrine reuptake inhibitors (SNRI). Currently, these antidepressant drugs are prescribed by doctors based on patient responses to a questionnaire with no specific analytical methods to target specific depression causes. Zinc Finger Protein, ZFP-189, is a transcription factor protein, which controls and bonds DNA in the brain to RNA transcription of many gene targets. The purpose of this research is to determine specific drugs that would increase ZFP-189 protein or its activity using a luciferase and qPCR protocol with the goal to better match patients with drug therapies. Drug preparation was done by placing bacterially disinfected 10mg of 4 common antidepressant drugs: Venlafaxine, Bupropion, Citalopram, and Imipramine along with DPBS into 1.5µL spin sealed tubes. After narrowing down to a low and high dosage of the target drugs, the procedure of RT-qPCR was performed. Viability bioluminescence of N2a cells was measured in Relative Light Units % (RLU) using ATP Assay with doses of the antidepressants in Concentration µM. When the Reporter Assay showed a decrease in RLU, and the qPCR showed an increase in mRNA, it can be concluded that ZFP-189 increased in value. Based on these findings, in future studies, the Reporter Assay can be used to screen compound libraries to find new antidepressant drugs that will increase ZFP-189 production.

Honorable Mention
Jaya Shah- The Effect of Glucose Sensor on the Functioning of an Artificial Pancreas Model
Washington-Liberty High School

The purpose of this experiment was to see how conductivity affects the functioning ability of the Artificial Pancreas (AP) System. Diabetes is a chronic health condition which impacts how the body converts blood sugar into energy. When blood sugar increases, it signals the pancreas to release insulin. For those with type 1 diabetes, their pancreas cannot produce insulin. This experiment specifically looked at the glucose sensor, represented through a conductivity sensor and circuit, and how it altered the functioning capabilities of the AP. The experiment examined two levels: copper wires distanced 6cm apart, and copper wires distanced 5cm apart. These levels represented two conductivity amounts based on their distance apart. The conductivity detected represented the blood sugar signal to release insulin. The expected outcome was that if both levels were tested using the AP model, they would work effectively, meaning that there would be 50 ¬± 5mL of vinegar leftover and a neutralized solution between 6.5-7.0. This was because the expected function of the AP was to give enough insulin to combat blood sugar. The experiment was conducted by building an AP model made up of a circuit, conductivity sensor, and pump infusion device. There were ten trials for each level. After the device ran, the amount of vinegar left was recorded, and the pH of the newly neutralized solution was tested with a pH meter. After the trials were conducted, the results determined that the hypothesis was accepted. For level 1 (6cm distance), the average amount of vinegar was 43.5mL, and the pH was 6.86. For level 2, (5cm distance), the average amount of vinegar was 58.5mL, and the pH average was 7.02. While there were slight differences in results between level 1 and 2, the artificial pancreas functioned in both levels

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effectively. The acceptance of the hypothesis proved that modifications in the glucose sensor of the AP did not significantly impact the results.

Honorable Mention
Maggie Parkhurst- Analysis of Differential Gene Expression in Blood Samples to Predict Alzheimer's Disease
Roanoke Valley Governor's School

While there are currently some treatments for Alzheimer‚Äôs disease (AD), many are more effective for earlier cases of mild AD. However, many AD patients only show memory-impairment based symptoms in mild cases. Therefore, many people with AD aren't diagnosed to start treatment in its most effective stages. Due to the overall longer life-span of humans, AD is becoming a more prevalent issue since it is more likely to affect older people. Additionally, the ability to test for it with brain scans is costly and not accessible to everyone. Through use of differential expression on peripheral blood within humans with and without Alzheimer's disease, biomarkers will be evaluated to determine top genes that could determine the likeliness of gaining or having AD. GEO datasets were found comparing normal elderly control groups to Alzheimer‚Äôs Disease (AD) groups with source of peripheral blood. These samples are compared using GEO2R to find differentially expressed genes. Using three experiments, the top 100,300, and 500 differentially expressed genes were compared to find overlap to create a list of biomarkers. These were then scored, and a Python code was created to look for these specific genes and predict the likeliness of having AD. The top biomarkers found were RPS25, RPL23AL, BTF3, PRDX1, RPL6, and RPL24. 20 out of the 118 biomarkers were ribosomal proteins. The program resulted in 77% accuracy showing potential for use of peripheral blood as an AD detection source.

Jade Riddle- Evaluating the Effects of Different Insulin Dosing Calculation Methods on Potential Insulin Adherence in Type 1 Diabetes
Southwest Virginia Governor's School

Diabetes mellitus affects over 563 million people worldwide, and its prevalence only continues to rise. Numerous severe health complications are associated with poor glycemic control, so proper use of insulin is important, especially in type one diabetes. However, previous studies have found varying levels of non-adherence to insulin regimens with the most common factors being related to the burdensome and time-consuming nature of taking insulin injections. The purpose of this study was to examine how different insulin calculation methods may affect someone‚Äôs overall satisfaction with their insulin regimen which may have the potential to affect their insulin adherence. The null hypothesis stated that all of the mean satisfaction scores would be the same while the alternate stated that at least one pairing of the scores would be different. Using a modified version of the burden subscale of the DiabMedSat, a three-part survey was created to evaluate participants‚Äô satisfaction with their current method of insulin calculation, a guided worksheet, and an insulin calculation app. For the two new methods,

participants were shown a brief explanation of how the calculations would be performed. The data were analyzed using an ANOVA test which returned a p-value of 0.1297, indicating the collected results were not significantly different. These results suggest that there was no difference in the satisfaction derived from the different calculation methods. However, in the future, this study should be replicated with a larger sample size to verify these results as the sample size (n=6) evaluated here was very limited. Additionally, future research should have these methods put into practice to see if participants‚Äô feelings change when they use a different method to calculate their insulin as well as see if there is any discrepancy in the accuracy of insulin doses given by each method.

Justin Kim- The Effect of *Bacillus cereus* on the Central Nervous System of *Dugesia tigrina*
Central Virginia Governor's School

The purpose of this study was to determine whether the bacteria *Bacillus cereus* had any effect on the central nervous system of planaria (*Dugesia tigrina*). Planaria were divided into five groups, with three control groups and two experimental groups. Afterward, the planaria were monitored in a behavioral chamber to determine if bacterial infected planaria responded to stimuli differently than non-infected planaria. These tests were scored using a contrived unit called the position value, which was the number of planaria from the right well minus the number in the left well of the chamber, and a two-sample t-test was conducted to analyze the data. The final mean values of each group‚Äôs position value displayed seemingly significant results, to which a two-sample t-test, with an alpha level set at 0.05, revealed a p-value of .016 and .036 for light and chemical stimuli, respectively. This statistically significant value supported the research hypothesis, which was that if the *D. tigrina* were fed *B. cereus*, then their central nervous system would be impacted, and thus show corresponding behaviors. In summation, the bacteria *B. cereus* has the potential to cause serious harm in the central nervous system for planaria, which can then be applied to the overall neural health of humans as well.

Lacey Ngo- Assessing and Monitoring Liver Viability Using Raman Spectroscopy and Chemometric Analysis
Roanoke Valley Governor's School

Liver transplant is the only cure for fatal liver injury or disease. Prior to transplantation, liver viability assessment and liver monitoring are needed to determine liver health. Current methods are expensive, time consuming, and subjective based on expertise. The purpose of this study was to determine if Raman Spectroscopy (RS) and chemometric analysis could differentiate liver perfusate samples based on donor attributes. The hypothesis of the study was that liver perfusate samples would differ based on age, Kidney Donor Profile Index % (KDPI%), BMI, and CIT, and samples would not differ based on sex and donor death type. RS and chemometric analysis may improve current methods. RS detects molecular bonds and concentration. RametrixTM uses Principal Component Analysis (PCA) and Discriminant Analysis of Principal Components (DAPC)

to distinguish spectra based on their molecular similarities and differences. PCA can determine the differences in the spectra. 39 liver perfusate samples, 3 control samples, and a Google Sheet with corresponding sample information were collected prior to the project. A Raman spectrum of each sample was collected using the Peakseeker device and RSIQ software. Sample information such as age, cardiac or brain death (DCD or DBD), KDPI%, CIT, BMI, and sex were used for analysis in the PCA and DAPC. PC contributions in the spectra were recorded and molecules were identified using the Raman database for biological molecules. Results for this project indicate that PCA and DAPC could distinguish spectra based on all the factors mentioned. Additionally, PCA results showed that metabolites, acids, and nucleic bases are secreted by livers at different rates based on these factors and this attributed to the differences in the spectra. Chemometric analysis may be used to monitor liver health and to determine liver viability with further studies.

Lauren Rylander- The Effect of Educational Intervention on Knowledge of Tissue Donation in High School Students
Washington-Liberty High School

Knowledge of tissue donation, along with altruism and other factors, has been shown in multiple studies to be a characteristic of the typical tissue donor (Nijkampa et al. 2008, Lwin et al. 2002). Therefore, public education may be a valuable and effective strategy for producing tissue donors (DeJong et al. 1995, Ganikos et al. 1994). Given that most donors are young people (Nijkampa et al. 2008, Tscheulin and Lindenmeier 2016), and thus a key demographic to increasing the number of tissue donors, this study targets high school students. Using a survey-based approach, 68 participants from Washington-Liberty High School took a brief quiz out of 23 points to determine their knowledge of tissue donation. They were assigned to the experimental condition, which provided a 5-minute, peer-led educational presentation video, or to the control condition, which showed a buffer video of the same length, and retook the same quiz. Between the first and second score, there was an average gain of 5.29 points in the experimental group and 0.05 points in the control group. A two-tailed T-test performed between the groups produced a highly statistically significant p-value of $7.99\sqrt{6}10\text{-}8$. Therefore, the study concludes that peer-led presentations could be an effective tool in educating high school students about tissue donation.

Lilly Batthany- The Effect of Length of Time (min) a Mask is "Worn on Distance a Simulated Breath Travels (cm) Through the Mask
Clover Hill High School

The purpose of this experiment was to determine the change in mask efficacy over various lengths of time. Establishing the change in the efficacy of a face mask was socially relevant with the outbreak of COVID-19. If the same mask was worn for a prolonged period, the mask would allow more droplets to pass through as time progressed. The experiment was conducted using hollow mannequin heads, a fog machine, KN95 face

masks, tubing, video recording device, and measuring utensils. The equipment was set up and the distance the fog traveled over increasing lengths of time was recorded at each level of the independent variable (0 minutes, 20 minutes, 120 minutes, and 240 minutes). Each level of independent variable was conducted 15 times. The length of each tendril of fog was measured in centimeters. The data was recorded and measured for the results and the mean was used to measure the central tendency. The measures of variation used were range, variance, and standard deviation. The data was represented in tables and graphs. The research concluded that an increase in time created a steady decrease in mask efficacy. As the time the mask was worn increased, so did the number of droplets that passed through the KN95 mask; rendering the mask ineffective. The hypothesis was supported due to the significant augmentation of fog distance when the length of time was greater. Additionally, the null hypothesis was rejected.

Lynn Tao- Early Breast Cancer Risk Detection: A Novel Framework Leveraging Polygenic Risk Scores and Machine Learning
Thomas Jefferson High School for Science and Technology

Breast cancer (BC) is the most frequent cancer and the second leading cause of cancer death in women; an estimated 1 in 8 women in the US will develop breast cancer during her lifetime. However, current methods of breast cancer screening, including clinical breast exams, mammograms, biopsies, etc., are often under-utilized due to limited access, expense, and a lack of risk awareness, causing 30% (up to 80% in developing countries) of breast cancer patients to miss the precious early detection phase. This study creates a key step that the current BC diagnostic pipeline lacks: a pre-screening platform, prior to traditional detection and diagnostic steps. My project presents BRECARDA, a novel framework that personalizes breast cancer risk assessment using AI neural networks to incorporate relevant genetic and non-genetic risk factors. A polygenic risk score (PRS) was enhanced by employing AnnoPred and validated by K-fold cross-validation, outperforming three current state-of-the-art PRS methods. The UK BioBank, including data from 170,417 women participants, was used to train the robust algorithm. Utilizing the enhanced PRS along with non-genetic information, BRECARDA was validated by 56,806 real-world female individuals and achieved a high accuracy of 93%, indicating its potential for clinical use. BRECARDA can alert high-risk individuals to get immediate screening, enhance disease risk prediction and diagnostic refinement, and improve the efficiency of population-level screening. Furthermore, BRECARDA can serve as a valuable platform to assist doctors in diagnosis and evaluation.

Madysen Davis, The Effect of Laundry Products with Strong Fragrances on the Development of Larval *Drosophila melanogaster*
Chesapeake Bay Governor's School

The purpose of fragrances added to household products is to attract and please consumers, but the general population is unaware of potentially harmful emissions associated with these products. Chemical fragrances in household products are alleged

to cause headaches, respiratory difficulties, and even more serious health problems (Steinemann, 2020). With the fragrance market estimated to be $52.4 billion USD (Statista, 2020), there are no laws in the United States that require producers to disclose the individual chemical ingredients in their products, instead companies are allowed to only write the words "fragrance" or "perfume." The US Consumer Product Safety Commision does not even enforce that companies have their products listed on chemical safety data sheets (SDS) for their products, nor are they required to list the presence of any single fragrance chemical (Steinemann, 2016). Fruit flies were used to see how their survival and development was affected by exposure to fragrances in various common household detergents, fabrics softeners, and scent boosters. The experiment was set up in the chemistry lab fume hood, where the fruit fly larvae were placed into 1 liter jars, with 7 chemical treatment jars and 2 controls. The following substances were the treatment chemicals: Downy Unstopables Fresh, Downy Unstopables Shimmer, Snuggle Fabric Softener, Downy Fabric Softener, Bounce Dryer Sheets, Tide Laundry Detergent, and Purex Crystals. There was an overall reduction in development with the *Drosophila melanogaster* with the exposure to the chemicals. The developmental rate was slower in the fragrance exposure treatments and there was a difference in each treatment as the exposure affected the larvae. The study yielded an R2=0.662, revealing that the fragrances did have some impact on the survival of the *Drosophila melanogaster*.

Michael Foulkes- The Effects of Footwear on Running Form for Short Distance Runs
Chesapeake Bay Governor's School

The goal of this study was to determine the correlation between the footwear worn during short distance runs, and the form of the individual running. Thirteen individuals ranging from high school sophomores to high school seniors were videotaped running on a treadmill in 3 different footwear types for 5 seconds at a speed of 6 miles per hour. The footwear types tested were barefoot, traditional running shoes, and running spikes. The 3 variables chosen to test form were stride length, impact time, and strike angle. Impact time was measured from the frame the striking foot touched the ground to the frame it left the ground. Stride length was measured at the moment of impact from the heel of the front foot to the heel of the back foot. Strike angle was measured at the moment of impact as the angle between the ball of the foot, the heel of the foot, and the ground, with a positive angle denoting a heel strike and a negative angle denoting a forward strike. Each of these variables were tested 3 times per footwear type per person. This study found that stride length was longest in running spikes, followed by barefoot, and finally traditional running shoes. Impact time was shortest in running spikes, followed by barefoot, followed by traditional running shoes. Strike angle was lowest for barefoot, followed by running spikes, followed by traditional running shoes. Each variable was put through a single-factor ANOVA test, and then followed up with a post-hoc Tukey test. It was found that there was a significant difference in impact time between traditional running shoes and barefoot running, and there was a significant difference in strike angle between traditional running shoes and barefoot, and running spikes and barefoot.

Medicine & Health - C

First Place
Saniya Sangle- The Effect of Amount of Sleep on Memorization Ability
Mills E. Godwin High School

The changes in memorization ability of people who sleep less than 6 hours per night and people who sleep more than 6-8 hours per night were studied in the age group of 13-60 years old. It was hypothesized that if the amount of sleep individuals obtained per night is more than 6-8 hours, then the decline in working memory performance would decrease. In the experiment 25 people in each group were given a computerized test which presented a series of letter sequences and were expected to recall each sequence in the order it was presented. The results were discussed in terms of variation in the average number of letters recalled determining the impact of sleep on working memory. There is no control in the experiment since there was no baseline number of letters to be recalled correctly. The mean and max values calculated in statistical analysis shows participants obtained more than 6-8 hours of sleep per night was able to recall more letters and had more accuracy in recalled sequences with more than 6 letters. This supports hypothesis of the experiment. Insufficient sleep was associated with health issues like cardiovascular disease, diabetes, obesity, hypertension, cognitive disorders, etc. Surveys revealed that 62% of the adults in the world reported sleep issues. The 70% reported sleep related challenges since beginning of COVID-19 pandemic. The CDC reported 31.6% adults and 72% of high school students suffered insufficient sleep. The experiment will further improve community understanding of effect of sleep deprivation on cognitive abilities.

Second Place
Pranav Chintkuntlawar- The effect of different antacid medications on stomach pH change
Mills E. Godwin High School

The purpose of this experiment was to test the effect of different antacid medications on the change in pH of a stomach acid. Antacids are a commonly used medicine for treating gastric acid problems such as heartburn and acid reflux. There are many different types of antacids each with a different main ingredient that has slightly different effects making it important to test which antacid is the best one to use. A stomach simulation was made and 4 antacid medications (aluminum hydroxide, calcium carbonate, sodium bicarbonate, and magnesium hydroxide) were each dissolved in the solution. The pH was recorded before the antacid was put in, after 30 minutes of dissolving, and after 60 minutes of dissolving. It was hypothesized that the calcium carbonate antacid would be the most effective at neutralizing stomach acid. The results showed that calcium carbonate was in fact the most effective antacid in this experiment since it quickly reached its maximum potential and still had a relieving effect after a longer period. A t-test was performed on all the data collected. Overall, the results of this experiment for both the 30-minute and 60-minute data sets were mostly statistically significant. For the 60-minute data set, the

comparison between aluminum hydroxide and magnesium hydroxide was not statistically significant. A further study on different antacids not used in this experiment can be done as well as testing calcium carbonate under different controlled pH environments to see if it would be effective in all possible stomach environments.

Third Place
Shriyaa Anand- The Effect of LED Lights on Blood Pressure
Mills E. Godwin High School

This experiment aimed to find the effects of different colored LED (light-emitting diode) lights on blood pressure. Different health and heart issues can prevail depending on different genders and age groups, as they are affected differently and cause different conditions to develop. Recently, red, blue, and green LED lights have been used to understand what causes different conditions to develop, including heart problems and macular degeneration. The test subjects were exposed to the different colors of light for five minutes at a time, with a fifteen-minute break between each interval. To keep the test subject and experimenter safe, all testing areas were sanitized and cleaned before and after the testing time. Consent forms were signed by the test subjects (and their parents, if applicable) and were given a list of all the risks and possible side effects in advance. The control that was used in the experiment was daylight. It was hypothesized that if the test subject was exposed to the red LED light, their blood pressure would increase and be higher compared to blue and green LED light, and the results supported the hypothesis. A t-test was done on the data and it revealed that the data was significant for red light versus blue light and green light versus red light. However, the data was not significant for the red light versus control, blue light versus control, green light versus blue light, and green light versus control. Nevertheless, the results did support the research hypothesis. It is believed that the results are because red light increases circulation with nitric oxide, which widens the blood vessels and capillaries. This research could lead to future studies that investigate the effects of different types of light on blood pressure and other body functions.

Honorable Mention
Qiaojing Huang- The Effect of Similarity in Glycoproteins Between the Strains of Influenza Virus and Strains in the Vaccine on the Overall Effectiveness of Flu Vaccines
Washington-Liberty High School

Influenza, one of the most common infectious diseases, is a highly contagious airborne disease that is seasonally prevalent and manifests as an acute febrile disease with varying degrees of systemic symptoms. Flu vaccines have been the most effective way to prevent the disease and are developed to generate an optimal immune response against HA and NA to create antibodies that specifically target the virus. The influenza virus surface is dominated by two major surface glycoproteins, hemagglutinin (HA) and neuraminidase (NA). These two factors determine virus pathogenicity, transmissibility, infectivity, and major antigenicity. The purpose of this experiment was to discover the

relationship between the similarity of the two surface glycoproteins (HA and NA) between the influenza virus and vaccine and the overall effectiveness of flu vaccines in preventing the flu. It was hypothesized that the effectiveness of influenza vaccines would increase with a higher similarity percentage in hemagglutinin for preventing its ability to attach to host cells, which would shield people from getting the virus. The experiment was conducted by researching, collecting data from reliable databases, and using the BLAST tool. Data of common influenza strains were collected, then aligned and compared with each query protein sequence using BLAST. Surprisingly, based on existing data, while the overall effectiveness of influenza vaccines was rising, the trend of similarity in both hemagglutinin and neuraminidase sequences was not positively correlated. However, the null hypothesis was rejected because the two factors showed a negative correlation although not very significant. This type of analysis is essential because it leads to a better understanding of previous performances and better decision-making in the future.

Honorable Mention
Sophia Jagels- The Effect of Plant-Based Sunscreen Ingredients on Ultraviolet Index Reduction
Mills E. Godwin High School

This study evaluated the ultraviolet (UV) protectant properties of plant-based oils as potential environmentally friendly sunscreen ingredient alternatives. Chemical ingredients in sunscreens have been found to disrupt both oceanic and fresh marine ecosystems. Additionally, commonly used sunscreens, even sunscreens without these ingredients, require further safety research, leading to growing interest in plant-based alternative ingredients due to flavonoid content. In this study, acai berry oil, red raspberry seed oil, olive oil, and no oil, the control, were applied to a piece of plastic wrap and exposed to UV radiation outdoors. The UV index (UVI) reduction was then measured with a UVI monitor. It was expected that if acai berry oil was applied to a piece of plastic wrap, then it would cause the greatest UVI reduction of the independent variable levels tested. Results showed that both acai berry oil and red raspberry seed oil caused the greatest UVI reductions by an average of 0.1 UVI in comparison to olive oil and 1.3 UVI in comparison to the control, therefore not supporting the research hypothesis. The t-tests conducted showed that all data sets were significant except for acai berry oil v. red raspberry seed oil. This may have occurred because both oils are extracted from berries, which contain anthocyanins, a type of flavonoid. Future studies could investigate how to best incorporate the demonstrated UV protectant activities of red raspberry seed oil and acai berry oil into environmentally friendly sunscreens.

Honorable Mention
Zachary Schwehr- The Effect of Vitamin Type on Cellular Regeneration
Mills E. Godwin High School

Regenerative medicine is a new field aspiring to aid in the recovery of injuries and diseases. With hundreds of thousands of people suffering from life-changing injuries and

diseases, the demand for regenerative medicine increases. Hence. this experiment discovered an ideal stem cell supplement testing different types of micronutrients. It was predicted that if planaria are exposed to diluted vitamin B complex, then the eyes will regenerate the quickest among the tested vitamins. Various water-soluble vitamins (vitamin B2, B3, B complex, and C) were experimented with, and they were compared to the control (tap water). Planaria were placed into 50 milliliters (mL) of solution with a 60 micromolar (ŒºM) concentration of each water-soluble vitamin. The time for the eyes to regenerate were noted and analyzed. The results showed that vitamin B complex aided regeneration the most. T-tests were performed on the data and all independent variables levels were statistically significant with the exception of vitamin C. It is believed that vitamin B complex performed the best as B vitamins aid in cell metabolism, which led to increased cellular regeneration. Furthermore, the combination of these micronutrients increases efficacy. Most of the planaria died when treated with vitamin C as they were unable to maintain homeostasis. This was due to the low pH of ascorbic acid.

Aarushi Nayak- The Effect of Antacids on the pH of Stomach Acid
Mills E. Godwin High School

This experiment was conducted to explore the effects different antacids have on the pH of stomach acid. Analyzing the effects of antacids on stomach acidity provides information on which antacids possess the most effective methods and they would be helpful in further research on acid neutralization. Gastric pain is very common in the United States, and around 60 million people experience acid reflux in one month, so this information could, therefore, help many people by contributing to the effectiveness of different antacid treatments. It was hypothesized that if aluminum hydroxide gel was placed in stomach acid, it would become the most neutral. The experiment was conducted by first filling cups with an equal amount of artificial stomach acid. An equal amount of each antacid was measured out and placed in 25 different cups and after 45 minutes, their pH levels were taken. The control had no stomach acid in it to see if time had any effect on the pH. Based on the inferential statistics test, all results were significant. Contrary to the hypothesis, Alka Seltzer had the most neutralized results. This could be attributed to the presence of alginate rafts in this antacid. Helicobacter pylori is present in Alka Seltzer. This bacterium is a very significant contributor in the neutralization of acids and is known to be very helpful. The conclusions drawn from this experiment can be applied when creating more effective antacids or in discovering natural antacids.

Natalie Hudson- The Effect of Aquatic Therapy on Stroke Patients Recovery
Central Virginia Governor's School

The purpose of this research was to determine if aquatic therapy is beneficial for improving the quality of life (QOL) and functionality of stroke patients (FOP). Using data from published studies, several measures of aquatic therapy outcomes were analyzed. The participants in the studies underwent aquatic therapy and measured using four clinical tests. The BIM test assesses disability and monitors changes in disability over

time, the SS-QOL test is an assessment of health related quality of life specific to patients with stroke, the BERG test assesses static balance and fall risk in adults, and lastly the TINETTI test measures gait and balance. The clinical test scores were compared by taking the difference of the scores from each participant from before the therapy (T0), and four weeks after the end of therapy (T2). A one-way ANOVA test produced a p-value of .0021 (alpha = 0.05). A post-hoc Tukey test revealed a Dmin value of 7.88 indicating there was a difference between the SS-QOL and both the TINETTI, and BERG. The research hypothesis that stated, if aquatic therapy is used in the treatment of stroke then it will be beneficial for improving the quality of life and functionality of stroke patients, was supported. Results indicate that aquatic therapy is beneficial for improving the quality of life and functionality of stroke patients. As measured in this study, other means of assessing positive outcomes of aquatic therapy should still be investigated.

Nishorgo Sarkar- The Effect of Fenugreek (*Trigonella foenum-graecum*) Extract on HCC Cell Proliferation
Mills E. Godwin High School

The purpose of this experiment was to study the effect of fenugreek (*Trigonella foenum-graecum*) extract on hepatocellular carcinoma (HCC). Due to severe mortality rates and lack of available treatments, research on potential treatments for liver cancer, such as alternative medicines, is crucial. For the experiment, HepG2 HCC cells were cultured for 96 hours in a 96 well plate in four concentrations of fenugreek extract: 0 mg/mL (control), 0.5 mg/mL, 1 mg/mL, 2 mg/mL. Proliferation was measured by MTT assay, with the hypothesis that 2 mg/mL fenugreek would show highest inhibition of proliferation. Proliferation decreased with increasing concentration of fenugreek, indicating support of the hypothesis as 2 mg/mL had the lowest absorbance in the MTT assay. This was also statistically significant, with all t-tests between each concentration with a p-value below 0.01. Additionally, all t-tests except 0 mg/mL vs. 0.5 mg/mL were significant at an alpha-value of 0.001. Proliferation was inhibited in an increasing and dose-dependent manner. In conclusion, these results indicate that fenugreek might be an effective natural compound to treat HCC and support the importance of research on anti-cancer effect of fenugreek as well as other traditional medicines and associated compounds.

Nivriti Vanga- The Effect of Chelated Mineral Supplements on Absorption
Mills E. Godwin High School

This experiment tests and compares the effect of chelated and non-chelated supplements on absorbance. Recently, with the ongoing pandemic, people have been much more self-conscious about health. This includes taking mineral supplements to benefit the body. Under the category of supplements, there are a specific type referred to as chelated. These are created through chemical reactions with a metal ion and two non-metal ions. This experiment aims at investigating and observing bioavailability with chelated minerals. Additionally, with this information, a conclusion can be made as to which types of supplements should be taken (specifically Iron and Calcium as these minerals were

tested). First, the supplements were taken, crushed into a fine powder, and then mixed into a synthetic stomach acid solution. Then after mixed, a small amount of the solution was placed in a cuvette and the percentage of absorbance was measured using a Spectrometer. It was hypothesized that if various mineral supplements are placed in stomach acid, then Chelated Iron Supplements will have the highest absorbance. The results revealed that the Iron Bis-glycinate Chelate resulted in the highest absorbance while Ferrous Sulfate had the lowest absorbance. Also, it was noticed that both the chelated supplements resulted in average absorbances significantly higher than their corresponding non-chelated mineral. This meant that the results did indeed support the hypothesis. It is believed that the results are due to the difference in the chemical composition of chelated minerals. The results of this experiment also show that bioavailability seems to increase for chelated minerals.

Sherlin George- The Effect of Ripening of *Citrus sinensis* on the Decay of Tooth Enamel
Mills E. Godwin High School

The purpose of this experiment was to perceive the effect of the ripening stage of *Citrus sinensis* on the decay of tooth enamel. Citric acid is a necessary vitamin for immune support but can also be used to prevent cardiovascular, ocular, and prenatal health issues. However, citric acid in oranges can cause damage to the surface of the tooth enamel, which can lead to gingivitis and dental caries. The independent variable was the ripeness of the orange, and the dependent variable was how much light passed through an eggshell which represented tooth enamel. The research hypothesis is: If the *Citrus sinensis* fruit that 2 weeks overripe is used, then it will have the highest change in illumination and mass. Ripe oranges were the control, as they are the standard for orange consumption. The procedure includes placing the eggshells in individual 44.36 mL cups of the pulp of their respective orange, covering the cup with saran wrap. The mass was weighted of the eggshell and the illumination was experimentation before and after experimentation. The null hypothesis was rejected, with three of the six t-tests that were conducted yielding significant results, for both the mass and illumination. A t-test was used to analyze the data, and the data was significant concerning the 6 t-test values that surpassed the table value, and the research hypothesis was supported. A justification for these results was the greater amount of citric acid that is produced as oranges mature as well as when they decay.

Snehitha Ravilla- The Effect of Syringe Design on Medicine Injection Effectiveness
Mills E. Godwin High School

The United States of America's healthcare system was ranked 11th in a 2020 COVID-19 healthcare review, behind ten other high-income countries. One way medical effectiveness margins can be improved is by increasing deliverability, specifically syringe injection effectiveness. This experiment was conducted to determine how various syringe designs, each with different tips, affected the injection effectiveness of the syringe. The purpose was to see how different syringe designs performed in terms of injection

accuracy and precision. A research hypothesis was formulated that the luer lock tip will have the fastest injection rate and have the most impact on treatment effectiveness if the effect of syringe design on medicine injection effectiveness is tested. When each syringe was tested, the plunger was pressed for two seconds. Using a photogate, fluid delivery from three types of 10-mL syringes was monitored in terms of velocity of ejection and distance traveled. The average speed of each syringe and final distance of the fluid were documented in a laboratory notebook. The research hypothesis was not supported by the data from the experiment. In order to evaluate for statistical significance, a t-test was performed on the data. A majority of the results for syringe design having an effect on injection effectiveness are significant. It is likely that the difference in the data sets between most of the syringe designs tested was statistically significant and provided a significant change in data. A limitation of this study is the plunger design of other syringes may differ from the products investigated, an improved plunger design could result in varied results. In relation, an idea for further research would be to test the effectiveness of various plunger designs on syringe flow rate or injection pressure.

Sriman Achanta- The Effect of Prolonged Exposure of UVR on Murine Erythrocytes in Vitro
Mills E. Godwin High School

This experiment was conducted to find the effects of ultraviolet exposure on murine erythrocytes with the intent of finding potential negative effects it could have on the health of those who expose themselves to the sun for extended periods or leave the Earth‚Äôs protective ozone layer of the atmosphere. Erythrocytes were exposed to ultraviolet radiation for one hour, day, and week. A control of no time was used. Cell measurements were taken afterward to determine the area of the cells. It was hypothesized that if erythrocytes are exposed to a week of constant ultraviolet radiation, then those erythrocytes will experience the greatest amount of cell degradation. It was found that erythrocytes exposed to ultraviolet radiation experienced cell degradation, in the form of crenation. The one-hour group experienced an average decreased area of 5.5¬µm2, and the one-day group experienced a decrease of 10.2¬µm2. Although it was found that the one-week trial‚Äôs cells were denatured by lack of oxygen rather than UVR, and subsequently its data was thrown out. A t-test revealed that data was significant except for the one-week trial. Because of this, the data did not support the research hypothesis. Overall, the experiment showed that ultraviolet light did have a significant effect on the quality of the RBCs. This translates to a decrease in oxygen-carrying capacity in vivo. This research could be used for further studies regarding the quality of RBCs in a simulation of an in vivo situation where erythrocytes could be oxygenated during experimentation.

Microbiology & Cell Biology A

First Place
Eleanor Little- Circadian Rhythmicity of Cellular Healing
Roanoke Valley Governor's School

Circadian clocks rhythmically regulate biological functions via oscillators driving numerous physiological and behavioral processes. This study explored how circadian synchronization regulates cellular healing through the testing of circadian-entrained fibroblasts in cell culture. It was hypothesized that fibroblasts wounded at different timepoints in the circadian cycle would demonstrate variable healing rates. Fibroblast cell culture was synchronized with dexamethasone and wounded at four different timepoints in the circadian cycle. Photos of the wounding sites were analyzed to compare cell density and wound diameter rates of change (ROC) between timepoint samples. While cell density ROC were not significantly different between samples (ANOVA, $p > 0.05$), there were significant differences between wound diameter ROC (ANOVA, $p = 0.0115$): timepoint 4 sample had a significantly faster decrease in wound diameter than the samples from timepoint 1 and 2. Additionally, RNA was collected from the wounding timepoint samples and RT-qPCR was performed to quantify gene expression of several target genes (circadian genes CLOCK and BMAL1; healing genes Fibronectin and Fibroblast Growth Factor). Normalized gene expression was compared between timepoint samples. The data exhibited high variability and low expression factors. Further testing is necessary to gain better understanding of the connections between circadian rhythms and healing processes.

Second Place
Caroline Fern, Lucie LeBlonde- The Effect of Green Tea Concentration on the Amount of Oral Bacteria
Washington-Liberty High School

The purpose of this experience was to determine the effect of powder green tea on inhibiting the growth of *Streptococcus salivarius*. Three different concentrations of green tea were tested, 1 gram per 100 mL, 5 grams per 100 mL, and 10 grams per 100 mL with the addition of the control which was sterilized water. The hypothesis was, if *Streptococcus salivarius* is exposed to different concentrations of green tea, then the bacteria exposed to the highest concentrate of green tea (100mL of water to ten grams of powdered green tea) will be the most inhibited due to the fact that highest concentration of green tea contained the most catechins. Catechins are natural antioxidants that help prevent cell damage and antibacterial properties. The hypothesis was supported, and all of the results were proven statistically significant with an ANOVA and two-tailed t-test; they were all effective in inhibiting the bacteria. The size of the zone of inhibition indicated the ability of the green tea concentrate to kill the bacteria. The group with 10 grams of green tea exhibited the greatest zone of inhibition with an average diameter of 3.1 cm, followed by the group with 5 grams displayed a mean of 2.2 cm and finally the 1 gram

with a mean of 0.6 cm. While there was no growth with the control, the results of the other groups displayed that there was a trend between the increase of green tea concentration and the increase in the zone of inhibition sites. The findings that were discovered during this experiment suggest that green tea could possibly be a cheaper, more organic option in the oral health world. In the future, this experiment would be conducted with an increased amount of *Streptococcus salivarius* to promote the maximum amount of bacteria growth to find the most effective results.

Third Place
Anusree Ponnarasi Marikkannan- The Effect of Mutations in T-cell Epitopes of Nucleocapsid Protein between SARS-COV-2 Variants
Mills E. Godwin High School

The purpose of this experiment is to find the effect of mutations in T-cell Epitopes of Nucleocapsid Proteins between SARS-COV-2 Variants. Recently, multiple SARS-COV-2 variants have emerged affecting the livelihoods of many around the world. Mutations in the T-cell epitopes of variants could cause alterations T-cell immune response and recognition. Amino acid sequences of the nucleocapsid protein from different variants were compared to the original Wuhan variant, which was used as a control. It was hypothesized that the Delta variant would have the most mutations in its T-cell Epitopes. The results revealed that the Delta variant did in fact have the most mutations in its T-cell Epitopes. A chi square test was conducted on the data and it revealed that the data was insignificant, so the results did not support the research hypothesis. It is believed that the results are due to the fact the coronavirus family mutates quite slowly compared to other viral families such as the Influenza virus. Coronavirus contains a proof reading mechanism which allows for minimal amount of mutations in the viral genome. This research could lead to further studies that investigate the actual implications of the amino acid changes in a lab and how those mutations could improve viral function.

Honorable Mention
Aanandi Parashar- EFFECTIVE DIFFERENT FOOD PRESERVATION METHODS ON ASCORBIC ACID CONTENT OF FRUIT USING A REDOX TITRATION.
Hidden Valley High School

The nutritional importance of Ascorbic Acid for the optimal function of the human body is well established. In the early months of the COVID pandemic consumers were searching for foods that were practical for storage and available year-round, while maintaining nutritional value. Being water soluble and heat labile, Ascorbic Acid levels can be taken as an index of nutrient quality of processes. However, the amount of Ascorbic Acid in preserved foods is not well known. This study aims to determine the levels of Ascorbic acid in three fruits: oranges, kiwi, and strawberries in fresh, frozen, and dehydrated states using a 1% Vitamin C solution for calibration. Based on a redox reaction, a starch Iodine titration was performed for each of the fruit and state (post processed state). The Vitamin C content varied between the raw fruits. For all three fruits the fresh fruit contained the

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highest level of Ascorbic Acid. A percentage decrease of Vitamin C from fresh to frozen was: 24.76% for oranges, 17.35% for strawberries, and 14.50% for kiwis. The percentage decrease from fresh to dehydrated fruit was: 39.04% for oranges, 9.05% for strawberries, and 19.50% for kiwis. Single factor ANOVA analysis revealed statistically significant differences between the groups for each of the fruits. Oranges ($p<0.05$) 4.55×10^{-11}, Strawberries (p-value)1.54×10^{-9}, and Kiwis (p-value) 3.71×10^{-17}. This study highlights that vitamin C is present in a variety of fruits and preserved fruits can be a good alternative to fresh fruits and a source of vitamin C.

Honorable Mention
Darya Wilson- The Effect of the Coronavirus Pandemic on the Cleanliness of Common Surfaces
Washington-Liberty High School

The purpose of this experiment was to determine whether the Coronavirus pandemic effected the cleanliness of common surfaces. This was determined by comparing bacterial growth on six different surfaces before and during the pandemic. The hypothesis was if bacteria amounts on surfaces before and during the Coronavirus pandemic were compared, there would be less bacterial growth during the pandemic than before because, cleaning became much more widespread amidst public panic regarding Coronavirus. The experiment was conducted by making twenty-four petri dishes of nutrient agar and swabbing each level of the independent variable six times. The bacteria samples were then left to grow for four days and measured using a ruler.
The results were inconclusive due to experimental error on the unit of measurement for the dependent variable, and experimental error on the time the bacteria was allowed to grow. The data did show that phone screen bacterial growth, which in the pre-pandemic experiment had the second most growth, had no growth during the pandemic portion. This shows that there has been an increase in hygiene, since a phone screen is something that is touched daily. However, a conclusion to the initial question, did the Coronavirus pandemic have an effect of the cleanliness of common surfaces, could not be accurately answered due to differences in data collection.

Alahna Moreno,Anisha Ramakrishnan,Gabriella La Cour-Creating Novel Bacteriophage Solutions as a Preventative Measure for *Escherichia coli* Biofilm Formation on Elastomer Biomaterials in Medically Relevant Settings in Vitro
Governor's School @ Innovation Park

According to the Centers for Disease Control, 1 in every 25 hospitalized patients in America has a Healthcare Associated Infection (HAI), affecting around 650,000 patients annually (Magill et al., 2014). Around 41 million or 43% of gastrointestinal endoscopy patients face HAIs annually. Meaning if a drug-resistant strain of E. coli infects endoscopes, then antibiotics given to infected patients become ineffective, making pre-procedure sanitation one of the only means to prevent serious harm to patients. If a peracetic acid and T4+ bacteriophage solutions are used against *Escherichia coli* biofilm

that is found on elastomer biomaterials, then there should be lower amounts of E. coli remaining after treatment, in comparison to treatments using only bacteriophage or current peracetic-acid treatments. The independent variables are 0.2% peracetic acid, T4 bacteriophage, and a combination of both treatments. The control is E. coli growth in each plate, mimicking an unclean environment. The constants of this research would be the bacteriophage, E. coli, solution quantities, and crystal violet (CV) dye. A phage titration determined that the phage were healthy and living based on plaque formation. A crystal violet assay was performed on each of the variables, consisting of incubating E. coli onto microtiter wells, adding the independent variables or control, placing CV dye, and then using a plate reader. If there is a high amount of phage proliferation, then it would be a significant treatment for curbing biofilm growth. For the control trials, the results showed that there has been adequate growth in the wells and that E. coli can grow on elastomer biomaterials in a medical setting. For phage trials, bacterial growth was consistent with control trials. Both the peracetic acid trials and hybrid treatment trials experienced significantly more biofilm decay, while the hybrid trial had the same efficiency as the peracetic acid trial. However, this method still proves that if a wider number of bacteriophages were used, it is still a possible treatment option for biomaterials in the future.

Amy Asubonteng- The Effect of Various Hand Sanitizers, With Varying Percentages of Alcohol (%), on the Percentage of Bacterial Colonies (%).
Clover Hill High School

The purpose of this experiment was to determine the effect of alcohol concentration within 4 separate hand sanitizers on the number of bacterial colonies present. Knowing the effect a certain alcohol concentration has on bacterial colonies will allow for consumers to know which alcohol hand sanitizers are reliable enough to use. To measure the number of bacterial colonies still present, the bacterial colonies were counted separately on agar plates. A mathematical equation was used to measure the exact percentage of the present bacterial colonies on each plate. The five levels of the independent variable were 0% alcohol concentrated hand sanitizer (control), 60% alcohol concentrated hand sanitizer, 70% alcohol concentrated hand sanitizer, and 80% alcohol concentrated hand sanitizer. The presence of the bacterial colonies were recorded in a data table, and this process was repeated until each level had 30 complete trials. The control hand sanitizer had a mean percentage of 78.447%. The 60% alcohol concentrated hand sanitizer had a mean percentage of 0.000%. The 70% alcohol concentrated hand sanitizer had a mean percentage of 0.003%. Lastly, the 80% alcohol concentrated hand sanitizer had a mean percentage of 0.000%. After the data was collected, an ANOVA test was conducted to test if the data was statistically significant, in which it was. The experimental hypothesis was that if the alcohol concentration of the hand sanitizer increased, then the number of bacterial colonies killed would increase. The null hypothesis states that the mean number of bacterial colonies still present after exposure to each hand sanitizer would be equal. Both of the hypotheses were rejected.

Anika Kashyap- Effect of Probiotic Type on Survivability in Yogurt Making Process
Mills E. Godwin High School

The purpose of this experiment was to determine the effect of probiotic type on survivability in the yogurt making process. The findings of this study could allow for greater probiotic intake through products containing a greater probiotic concentration, which could lead to improved public health and less probiotic waste. This information could be used by manufacturers and those who make yogurt at home. It was hypothesized that if the probiotic type is *Streptococcus thermophilus*, then it would have the highest survivability in the yogurt making process. There was no control present in this experiment because a type of probiotic must be present for yogurt growth to occur, meaning that a proper baseline for comparison would not be established. Yogurts consisting of each respective probiotic type were made using an Instant Pot. Dilutions of the yogurts were plated onto agar petri dishes and the bacterial count in each yogurt was then measured. *Bifidobacterium lactis* had the highest survivability. As a result, the research hypothesis was rejected. A t-test was conducted, and the null hypothesis was also rejected, as the data was statistically significant. B. lactis likely had the highest survivability because it had the closest pH level range to that of yogurt making conditions, while S. thermophilus had a further pH level. *Lactobacillus bulgaricus* likely had the second highest survivability because it had a closer pH and temperature range to the yogurt making conditions than *Lactobacillus acidophilus.*

Anna Mohanty- The Effect of a *Staphylococcus epidermidis* Infection on the pH of its Medium
Washington-Liberty High School

The purpose of this experiment was to determine if pH tests could be used as a cost-effective early intervention medical device in wound care, specifically when working with Cesarean surgical site infections in rural areas. This is difficult to examine in actual wounds because the variation in each case, so this experiment was conducted by isolating cultures of *Staphylococcus epidermidis* in nutrient broth. The pH of each broth was measured repeatedly over 90 hours to see if it had been affected by the bacterial presence. The medium was not altered outside of a normal pH range within the four-day period. The results yielded indicate that the null hypothesis should be accepted: a presence of *Staphylococcus epidermidis* does not affect the acidity of a bacterial medium within the early intervention time. But since other vital information is suggested by these results, it can be discerned that pH still has a prominent role in making wound treatment more equitable by utilizing cheaper, but functional technologies.

Bilguun Zolzaya- Dirty Tables: Determining the best Antimicrobial Metal/Material for a Table in Classrooms or Hospitals
Yorktown High School

Surfaces, especially frequently used ones like tables, are places of many infectious agents that are easily transmissible. Hospitals, schools, and common households are in desperate need of new and innovative ways to efficiently sterilize surfaces in order to keep people safe and healthy. This project tested which antimicrobial metal, copper, silver, and zinc, killed E-coli K-12 the best. The hypothesis was "if the copper sheet is used, it will have the least amount of colonies because of its ability to rupture cell walls and cause damage to DNA through the generation of hydroxyl radicals and it's free electrons in its outer orbital that can more efficiently kill bacteria". The different metals were placed into test tubes containing an E. coli K-12 and nutrient broth mixture that was incubated for 72 hours. After the incubation, the contents were micropipetted onto their respective nutrient agar plate and incubated for 24 hours. The plates were then collected and the colonies grown on the nutrient agar plates were counted. The result of the experiment was that each level of independent variable and control, no metal, was too much to count. The original hypothesis was rejected and the null hypothesis, copper, silver, and zinc having no effect on the ability of E. coli K-12 to grow, was accepted.

Cameron Myers- The Effect of Different UV Wavelengths on *E. coli*. K12
Mills E. Godwin High School

This experiment was conducted to test the effectiveness of different UV wavelengths on sterilizing a petri dish containing Escherichia coli. K12. The results could be useful to sterilize hospital rooms fast so they can get another patient in and to clean school supplies from Covid-19. The research hypothesis was, if UVC is used to disinfect E. Coli, then the greatest number of bacteria will be killed. To perform this experiment 75 petri dishes filled with nutrient agar and E. coli. K12, the dishes were exposed on one side, leaving the other side to grow normally, with either UVA, UVB, or UVC for ten seconds. After that they were put into an incubator for 18 hours and once the 18 hours were up the half of the dish given the UV light treatment was compared to the side that hadn't. The control was the side that was covered and was used as a base to compare the side that had the UV treatment. Through this it was found UVC was the most effective at sterilizing, but UVC‚Äôs data wasn't significant. UVA and UVB were found to be significant through a Chi-Square where both came out to be 100 which was more than the table Chi-Square of 13.277. UVC had a calculated Chi-Square of 8 which was less than the table Chi meaning it wasn't significant. UVC was the most effective most likely due to it having the lowest wavelength.

Christina Su- Deleting FGF15 Disrupts Mouse Cerebellum Structure and Excitatory Synapse Formation
Cave Spring High School

FGF15 is a protein in mouse encoded by the Fgf15 gene and its human ortholog FGF19, which related to many human diseases, such as obesity, diabetes, intestinal disease, renal disease, liver-related disease and cancer. It is a new member of the fibroblast growth factors (FGFs) family. It is involved in the early development of ear, eye, heart and

brain during organogenesis as well as in muscle growth during adulthood. It also regulates thalamic regionalization, neurogenesis, and neuronal differentiation by regulating the expression and mutual segregation of neurogenic and pro-neural regulatory genes. So far, the function of FGF15 in mouse cerebellum is not clear. In this study, we used immunohistochemistry and in situ hybridization to explore the function and expression of FGF15 protein in mouse cerebellum. We found that mouse climbing fiber synapses between the inferior olivary neuron and the Purkinje neuron were disrupted, but did not affect parallel fiber formation after Fgf15 gene is deleted. Furthermore, mouse cerebellum structure was also changed. Intriguingly, Fgf15 gene was expressed by astrocytes, instead of neurons. In summary, the Fgf15 gene is essential for mouse climbing fiber formation and maintaining normal mouse cerebellum structure.

Emma Abramson- The Effect of Hand Soaps on the Growth of *Staphylococcus epidermidis* Bacteria
Washington-Liberty High School

The purpose of this experiment was to study the effect of different hand soaps on the growth of *Staphylococcus epidermidis* bacteria. The hypothesis was that if foam soap is used to wash hands, then the least amount of *Staphylococcus epidermidis* will develop. The hypothesis was rejected; Dawn dish soap prevented the most growth of the bacteria and had the largest zone of inhibition, measuring an average of 4.11 cm per petri dish. The Dial liquid hand soap showed similar results, with its average at 4.06 cm. Method hand soap allowed for the most bacteria to grow, with an average of 3.75 cm per petri dish. Additionally, standard deviation was calculated for all groups. All three independent variables had standard deviations under 1 and therefore were precise data. Further tests should be performed about different types of mouthwashes and shampoos, as opposed to hand soaps, on the growth of *Staph epidermidis*. Further experimentation including a fourth level of independent variable with different active ingredients should also be performed to further test this theory. This study is significant because it shows that washing hands is necessary to ease off on the intensity of the Coronavirus and nosocomial infections.

Emma Meehan- Comparing the Effectiveness of Different Sun Protection Products on the Growth of *Saccharomyces cerevisiae*
Central Virginia Governor's School

The purpose of this study was to determine whether or not different topical sun protections had disparate effects on how well the fungus *S. cerevisiae* grew, following ultraviolet radiation exposure. Yeast was used as the model organism for human skin because it shares the same DNA for repairment and reproduction by budding. Four different topical sun protections with the same SPF number were used as the experimental treatment groups. The topical treatments were applied to six jars with a mixture of YPD broth and yeast inoculation that were then put under UV radiation for 40 minutes. The growth of

yeast was measured by determining the percentage of transmittance using a spectrophotometer. A one-way ANOVA test was conducted to analyze the data. The transmittance percentage means for the treatments varied from 96.8-99.9%. After running a one-way ANOVA test, I determined the p-value to be 1.266×10^{-11}, and a dmin value was 1.001. This supported that the study was statistically significant; which was found by comparing the p-value to the alpha value of .05. My research hypothesis was that sunscreen would be the most efficient at protecting and allowing the growth of *S. cerevisiae* was not supported. This experiment shows how significant the effect of UV radiation on human skin is, and how we can try to prevent the skin from further damage moving forward.

Microbiology & Cell Biology B

First Place
Kate Bentov- The Effect of Different Neurotransmitter Solutions on The Growth and Optimization of *Physarum polycephalum*
Central Virginia Governor's School

The purpose of this study was to analyze the effect of different neurotransmitter solutions on the growth rate and optimal movement/path to find food of *Physarum polycephalum* or colloquially "slime mold". Using these results to see their roles in primordial intelligence and survival decision making. The experiment consisted of eight trials for each of the four groups, three experimental and one control. The different neurotransmitters used for experimentation were Gamma-aminobutyric acid (GABA), Monosodium Glutamate (MSG), and Epinephrine (L-Adrenaline). Each trial was placed into a non-nutrient agar petri dish, with a starting food source placed on one end, and a larger reward food source on the other. After one week of growth, measuring the ratio of growth and optimal path taken in comparison to a direct course between the two food sources. An ANOVA test revealed a p-value of 1.2×10^{-5}, which led to running a Tukey test and getting a Dmin value of 3.815. Two of the group's averages surpassed the Dmin value: GABA with a value of 11.254cm2, and the control with 7.269cm2. The experiment suggested the data was significant, and the null hypothesis was rejected. However, my research hypothesis, that Adrenaline would create the best conditions for growth and optimization, was not supported. In conclusion, GABA created the most ideal conditions for *Physarum polycephalum* growth and optimization.

Second Place
Jacob Tiller- The Effect of Liquid Chlorine and Liquid Iodine on *Turbatrix aceti* survivability
Central Virginia Governor's School

The overall purpose of this research study was to identify a cost effective method of preventing water borne roundworm infections. Such infections are prevalent in impoverished, humid areas without access to proper water filtration systems. Varying concentrations of liquid iodine and liquid chlorine were mixed with apple cider vinegar to create solution agents that were then tested on trial groups of 10 *Turbatrix aceti* nematodes. Eventually it was determined that solutions composed of 12.5% liquid iodine and 20% liquid chlorine would be capable of eliminating 100% of the Turbatrix aceti trial groups. Additionally, solutions containing 6.25% liquid iodine and 10% liquid chlorine were developed to eliminate half of each group. These four solutions were tested ten times each, which resulted in the 100% death solutions eliminating all roundworms. The intended LD50's for iodine and chlorine eliminated 55% and 54% of the roundworms on average. The overall p-value was found to be $3.96 * 10\text{-}20$, which was far below the alpha value of .05, demonstrating significance. Following a Tukey Test, significance was demonstrated for all four solutions, but the iodine 100% death concentration was found to be the most significant with a .465 value compared to a Dmin of .025. The research hypothesis, that if *Turbatrix aceti* were exposed to the smallest, still lethal concentration of liquid iodine or liquid chlorine, then the liquid iodine would be more effective, was supported. In the end, liquid iodine was found to be an inexpensive method of preventing roundworm infections.

Third Place
Julia Brodsky- Anti-biofilm activity of isolated bacteriophages for the treatment of multidrug-resistant pulmonary infections
H-B Woodlawn Secondary Program

A rise in the prevalence of antibiotic-resistant infections has prompted a search for alternative methods to combat bacteria in the human body. Bacteriophages are a type of virus that can kill specific strains of bacteria, and were first observed in the early 20th century, just before the discovery of penicillin. The difficulty associated with finding phages targeted to a specific infection is one reason the treatment is used relatively infrequently. The prospect of personalizing phage treatment by isolating new species for individual infections is promising. This study aimed to isolate phage species for multidrug-resistant strains of *Pseudomonas aeruginosa* and *Staphylococcus aureus*, the most common causes of chronic infections in patients with cystic fibrosis. Three samples of human fecal matter, one sample of feline fecal matter, and one sample of rich soil were tested for the presence of both S. aureus- and P. aeruginosa-hosted phages. Using the double agar overlay method of phage enumeration, it was found that six of the ten stocks contained bacteriophages, at titers ranging from $3.9\text{x}10^4$ pfu/mL to $2.8\text{x}10^7$ pfu/mL. The potency of the Pseudomonas-hosted isolates in eradicating biofilms was compared to the efficacy of an antibiotic cocktail and the enzyme cellulase through an in vitro resazurin cell viability assay. Each treatment was performed in sextuplicate. Metabolic reduction of resazurin to resorufin (which proceeds in the presence of live cells) was quantified at 24 and 48 hours of growth using a microplate reader set to measure absorbance at 570nm and 595nm.

Honorable Mention
Hannah Loos- The Effect of Antifungals on *Saccharomyces cerevisiae* Survival
Mills E. Godwin High School

The effects of over the counter, inexpensive antifungals on yeast survival were tested. It was hypothesized that if pomegranate peel extract was added to the *Saccharomyces cerevisiae*, then the most *Saccharomyces cerevisiae* would be killed because pomegranate peel extract has more antifungal components than any of the other independent variables being tested. The experiment was conducted with gloves, goggles, a mask, and an apron for safety; there was a positive control, no antifungals, and a negative control, vinegar. A water bath was used to heat a water, sugar, and antifungal solution in an Erlenmeyer flask to the optimal temperature for *Saccharomyces cerevisiae* to grow. The yeast was added to the solution and after 210 seconds, the CO_2 probe was taped to the lip of the flask and the CO_2 levels were recorded. The data supported the hypothesis because the least CO_2 was emitted with the pomegranate peel extract. It had the lowest mean of 85.0 ppm, most similar to the negative control with 8.2 ppm. Clotrimazole had the highest mean of the independent variables, 184.2 ppm, suggesting that Clotrimazole is the least and pomegranate extract is the most effective in treating oropharyngeal candidiasis. T-tests were performed on the data and implied that all the data was statistically significant. A reason for pomegranate peel extract's antifungal abilities is its numerous antifungal components. Future studies could be done to test these antifungals effects on other types of fungus strands to see if they are effective on diseases other than oropharyngeal candidiasis.

Honorable Mention
Katerina Leedy- Elucidating the Subcellular Localization of NLRX1 in Pancreatic Cancer Cells
Blacksburg High School

Pancreatic cancer is one of the leading causes of cancer-related deaths worldwide, with a 5-year survival rate of less than 10%. NOD-like receptors are under-researched intracellular receptors that appear to play a multitude of cancer-related roles, including regulating inflammation, mitochondria-associated immunity, and metabolism. One NOD-like receptor, NLRX1, has been shown to attenuate inflammation and have potential tumor-suppressing effects. However, the roles and activity of NLRX1 in pancreatic cancer are not fully understood. While it is broadly agreed that NLRX1 modulates several immune and metabolic pathways, the exact mechanisms by which this occurs and even the location of NLRX1 in the cell are disputed. Determining the subcellular localization of NLRX1 is important for better describing its role in pancreatic cancer development. Preliminary analysis using a mitochondrial proteomics database, MitoMiner 4.0, predicted a mitochondrial targeting sequence in both mouse (M. musculus) and human (H. sapiens) NLRX1. Immunofluorescence microscopy on a murine pancreatic cell line (Pan02) was then used to perform colocalization analysis between NLRX1 and mitochondria. NLRX1 was associated with the mitochondria in samples both untreated and co-incubated with

TNF, a pro-inflammatory cytokine known to stimulate NLRX1. These results indicate that NLRX1 is associated with the mitochondria in Pan02 cells. To further specify where in the mitochondria NLRX1 is located, this research begins developing an electron microscopy protocol for Pan02 cells. Use of immunogold labeling to image NLRX1 under a transmission electron microscope provides a feasible method to determine the location of NLRX1 at or within the mitochondria.

Honorable Mention
Laken Evans- The Effect of Ground Beef Variety on Bacterial Content
Mills E. Godwin High School

This experiment was conducted to determine which variety of beef has the highest bacterial content. Ground beef is susceptible to inoculation with potentially harmful pathogens, such as *Escherichia coli*, Salmonella, *Listeria monocytogenes*, and certain other staphylococcal bacteria. The average consumer is not aware of the true bacterial content of the meat they eat, and very few truly understand what the "organic" and "natural" labels mean and what their benefits are. The hypothesis for this experiment was that if conventional, natural, and organic grass-fed samples were tested, then the conventional beef samples would have the highest bacterial content. There was no control for this experiment, as a positive control was not possible due to the dependent variable being unknown bacteria. Twenty-five samples of each type of beef were incubated for fifty hours on MacConkey agar. After the incubation period, the number of bacterial colonies were counted, and qualitative observation was used to classify the colonies into three groups (representing three possibly different bacteria). The conventional samples had the highest bacterial content (an average of 572 colonies per plate) and the natural samples had the lowest bacterial content (an average of 8 colonies per plate). The hypothesis was proven correct, and the data was significant overall, though one of the three t-tests performed showed no statistical difference. The colonies observed on the conventional plates were of a different type than the ones observed on the natural and organic grass-fed plates, which could explain the drastic difference in number of colonies.

Emma Thielecke, Grace Kahoun- The Use of a Fluorescent pH-Biosensor to Image Yeast Organelles
Roanoke Valley Governor's School

The purpose of the experiment was to transform S. cerevisiae cells to express fluorescent genes in the Rosella plasmid. The Rosella plasmid products are two fluorescent proteins, one of which is sensitive to fluctuating pH. Yeast with these plasmids can be used to indicate autophagy has occurred. To create this model system for this project, E. coli bacteria containing the Rosella plasmid were cultured. The plasmid was then extracted and isolated using a Plasmid Mini-Prep Kit. Leucine deficient yeast was transformed using a Frozen-EZ Yeast Transformation kit and the isolated plasmid. Only successfully transformed yeast were able to grow on the media without leucine. There were fourteen

colonies of transformants after the third day of incubation. The S. cerevisiae growth indicated a successful transformation, and the yeast colonies were then observed under a fluorescent microscope. The transformed yeast fluoresced red and green under the microscope, indicating that the plasmid genes had been expressed. These genetically modified yeast can now be used in studies of yeast autophagy and visualizing parts of the yeast cell by students in the future at RVGS.

Esther Ellis- The Effect of Various Dietary Conditions on the Growth of Streptococcus Mutans
Central Virginia Governor's School

The purpose of this study was to determine the effect of different diets on oral health by examining the growth of *Streptococcus mutans* under varying dietary conditions. *S. mutans* was grown in different protein broths to simulate three types of diets. Soytone was used to mimic a vegan diet, tryptone to mimic a balanced American diet, and peptone to represent an unhealthy American diet. Over the course of 10 trials, each of the *S. mutans* cultures were left to grow for about 24 hours in their respective broths. After the growth period, a spectrophotometer was used to quantify the optical density of each culture by measuring the amount of light transmitted through the *S. mutans* broth. Soytone's mean light transmittance (T) was 12.47, tryptone's mean was 18.40, and peptone's mean was 18.99, indicating the highest growth occurred in the soytone group. A one-way ANOVA statistical test was used to analyze the data from experimentation. The resulting p-value of .12 was compared to an alpha value of .05. From these values, it was determined that the effect of varying dietary conditions on the growth of *S. mutans* did not show statistical significance. Therefore, the research hypothesis, "When *Streptococcus mutans* is exposed to different dietary conditions, then the simulation of the unhealthy American diet with the presence of peptone and twice the amount of glucose in its medium, will yield the most bacterial growth," was not supported, and the null hypothesis was retained.

Faith Peerman- Comparing the Antimicrobial Efficacy of Biosynthesized Silver Nanoparticles on S. mutans
Central Virginia Governor's School

The purpose of this study was to determine the biosynthesized nanoparticle solution that had the largest antimicrobial effect on *Streptococcus mutans*. To determine this, three nanoparticle solutions were synthesized from various plants*: Fragaria virginiana* (wild strawberry), green tea leaf extract, and *Lindera benzoin* (spicebush). These solutions were all placed on sterilized filter paper disks, along with a control of distilled water, and then placed into petri dishes with S. mutans. Aseptic technique was utilized when working with the bacteria, and after a day, any zones of inhibition on S. mutans were measured. A single factor ANOVA determined there was significance in the data, as the p value returned was 1.68835×10^{-22}, with an alpha value of .05. A Tukey Test with a Qt value of 3.68 and a Dmin value of 1.990 was then used to find where the significance lied. A

significant difference was found between the wild strawberry and green tea leaf extract nanoparticles, the wild strawberry and spicebush nanoparticles, the control and green tea leaf extract nanoparticles, and the control and spicebush nanoparticles. These findings did not support the research hypothesis, which stated that green tea leaf extract would synthesize the most effective nanoparticle solution on S. mutans. In conclusion, the results suggested that both spicebush and green tea leaf extract have the highest antimicrobial efficacy against S. mutans as they had the highest average zone of inhibition, even though there was no statistically significant difference between the two groups.

Haley Day- The Effect of Environmental Factors on Beta-Carotene Production in Genetically Engineered Yeast
Roanoke Valley Governor's School

Genetically modified nutrient dense food is one strategy for combating food insecurity. One tool that could be used for this is, Golden Yeast, or *Saccharomyces cerevisiae* modified with *Xanthophyllomyces dendrorhous* DNA. This modification allows *S. cerevisiae* to produce β-Carotene unlike its normal counterpart. β-Carotene is a precursor for vitamin A and when the yeast *S. cerevisiae* successfully produces β-Carotene its colonies are a vibrant orange. However, β-Carotene production is inconsistent. When β-Carotene is not successfully produced, *S. cerevisiae* colonies are either red or white indicating an incomplete or reversed β-Carotene production pathway, yielding either Lycopene or Neurosporene respectively. To determine if environmental factors can impact the percentage of colonies that exhibit successful β-Carotene production, modified *S. cerevisiae* were grown in different nutrient conditions and in different temperatures. This experiment found that *S. cerevisiae* grown at lower temperatures yield more β-Carotene producing colonies and no Lycopene producing colonies. While higher temperatures, in this experiment 30°C, yield slightly less β-Carotene producing colonies accompanied by some Lycopene producing red colonies.

Helen Hanke- The Effect of Body Wash on the Zone of Inhibition of *Staphylococcus epidermidis*
Washington-Liberty High School

The purpose of this experiment was to study the effect of diverse types of body wash on the growth of Staphylococcus epidermidis. The hypothesis stated that if Dove Antibacterial Body Wash was used, then the Staphylococcus epidermidis will have the least growth because according to dove, ‚Äúthis antibacterial body wash eliminates 99% of bacteria.‚Äù The hypothesis was not supported by the data because the dove body wash averaged a zone of inhibition of 3.25 cm. Dial body wash measured 3.73 cm, Nivea 3.37 cm, and the control, bar soap, had 0 cm. An ANOVA test was done to determine if a statistically significant difference existed among the means for the groups. The calculated p-value was 0.64, which is more than the critical value of 0.05, meaning the data was not statistically significant. This means the null hypothesis: if Staphylococcus

epidermidis is treated with different body washes, then no difference will occur in the zone of inhibition, is accepted.

Isabella Bushey- The Effect of Temperature and Day Length on the Initiation of Anthocyanin on Fall Leaves
Clover Hill High School

The purpose of this experiment was to find the exact temperature and amount of day length to induce the production of anthocyanin in fall leaves. Further knowledge on this topic will benefit outdoor recreation centers, such as Shenandoah National Park, when planning for the fall season. To determine the correlation between weather conditions and anthocyanin production rate the Rf value of leaves were taken from the months of August through December. During those months, leaf pigments were extracted by isopropyl alcohol, and then, while remaining separated based on tree type, were transferred to a filter paper. After the filter paper dried, measurements of distance traveled of the solvent and solute were taken and recorded in a data table. Leaves collected during the temperature ranges (in degrees C) of 34-32 (control), 32-30.1, 30-27.1, 27-25.1, 25-23.1, 23-21.1, 21-18.1, 18-14.1 and 14-11.1, 11-9.1, and 9-7 were examined. The leaves tested during the control temperature range of 34-32 0C had the lowest Rf value of 0. After the control, a gradual increase occurred in the mean Rf values with the temperature range of 14-11.1 0C as the peak average. Following the temperature range of 14-11.1 0C, a decrease in Rf averages occurred. The research hypothesis stated that anthocyanin production would take place when the temperature was between 18-14 0C, and when the day length was between 12-11 hours. Therefore, the research hypothesis was not supported. After the data was collected, an ANOVA test was conducted to test if the data was statistically significant. The null hypothesis was rejected.

James Anderson- Effect of Antibacterial Hand Soaps and Sanitizers on the Growth of *Staphylococcus epidermidis*
Washington-Liberty High School

This experiment was conducted to determine the effect of antibacterial hand soaps and sanitizers (Dial Gold hand soap, hand sanitizer, Mrs. Meyer's Clean Day hand soap, and Softsoap Antibacterial hand soap) on the growth of *Staphylococcus epidermidis.* The investigation was chosen out of an interest in which accessible hand cleanser is the most effective in preventing topical bacterial infection. The hypothesis was that if Staphylococcus epidermidis is treated with Dial Gold hand soap, hand sanitizer, Mrs. Meyer's Clean Day Hand Soap, and Softsoap Antibacterial hand soap, then the growth of the bacteria cultures treated with Dial Gold hand soap will be the most inhibited because the attraction between BAC and the cell membrane will allow for higher rate of contact between the antibacterial agent and the bacteria, resulting in more antimicrobial action. The null hypothesis was that if *Staphylococcus epidermidis* is treated with Dial Gold hand soap, hand sanitizer, Mrs. Meyer's Clean Day Hand Soap, and Softsoap antibacterial hand soap, there will be no effect on the growth of the bacteria. This study

was conducted in a BSL1 lab in which plates of nutrient agar were inoculated with cultures of Staphylococcus epidermidis. The bacteria was treated with filter paper discs dipped in one of the IV hand cleansers and grown in an incubator for 48 hours. To determine the efficacy of each hand cleanser, the diameter of the inhibition zones of each treated bacteria culture was measured. The data allowed the null hypothesis to be rejected but only partially supported the alternate hypothesis, as it did not account for a lack of statistical significance between the inhibition zones of the bacteria treated with Dial and Softsoap hand soaps. This experiment demonstrated that Dial and Softsoap hand soaps are effective in preventing the growth of *Staphylococcus epidermidis*. Regular cleansing of hands using these easily accessible hand soaps can prevent topical bacterial infection on a daily basis.

Lane Eubank- Various Handwashing Techniques and Their Efficiency in Eliminating Micro-bacteria Prevalent in the Human Microbiota
Chesapeake Bay Governor's School

In recent times as concerns for disease and germs begin to rise, handwashing has become a necessity in every household worldwide. Handwashing is the act of cleaning and keeping hands hygienic with soap and water. Handwashing helps prevent these germs and diseases from living on the human microbiota and ensures good health. The handwashing practice offers many benefits so there are no risks when it comes to touching the eyes, mouth, and nose. This study explores the benefits and differences between different handwashing techniques to ensure the best hygiene for the hands. The different techniques offer a look at how well the hands get washed off and how well the techniques remove bacteria from the hands. This study compared male and female bacteria percentage removal, technique bacteria percentage removal, technique surface area hand cleaning, and hand sanitizer bacteria percentage removal. This study looks at the techniques that include the CDC health recommendation, the participants own personal method, and the medical handwashing technique surgeons use before entering surgery. The information on surface area cleaning was found using a glowing lotion called Glo Germ to observe the surface area of unclean hands after the hands are washed. The bacteria removal was found from swabbing the hands before then after handwashing and observing the growth of the bacteria after incubation. The statistical analysis tests offer p-values of 0.68996072 and 0.77515055 which shows no significance between male and female efficiency and cleanliness, while the values 0.15350292 and 0.16128002 also show no significance between the technique efficiency and cleanliness. The data may show no significance but an obvious trend is present when the data is shown. With further testing it can be inferred that there will be significance but more trials would need to be done to conclude.

Microbiology & Cell Biology C

First Place
Monona Zhou- Live Cell Imaging of the Interactions between an Acetylase and Binding Domain
Mills E. Godwin High School

Histone acetylation is a post-translational modification (PTM), which is important for regulating gene expression. The YEATS domain is commonly known as an acetylation reader, particularly on histones. The protein p300 contains a Histone Acetyltransferase (HAT) domain, which adds acetyl groups to the tails of histones and loosens to the DNA wrapped around the protein to enable transcription. Through these two functions, both proteins are necessary for cell viability via regulating gene expression using epigenetic factors in the nucleus. However, abnormal activity of either proteins stimulates tumorigenesis and the development of various cancers. As a result, studying the interactions between these two proteins helps to better understand the causation of cancer cells and how controlling the activity of these proteins can inhibit diseases. Through analyzing how p300 affects the foci formation rate of the YEATS domain, the purpose of this project is to uncover the relationship between p300, a HAT protein, and the YEATS domain, a histone acetylation reader. The overall hypothesis states that the function of the YEATS domain is influenced through interactions with p300, which is measured through analyzing the foci formation of YEATS. The negative control was expressing only the fluorescent protein (YPet) to determine how many nuclear foci were not due to the target proteins. If p300 and YEATS are shown to interact, inhibiting their co-localization could prevent necessary cellular functions, such as transcription. The experiment was completed by transfecting the target proteins at differently controlled rates. The results showed that by expressing the YEATS domain with p300, the foci number increased while the foci area and number of aggregates decreased. The data was found to be statistically significant through ANOVA tests and was due to interactions with p300 and as well p300's autoacetylation ability. As a result, the interactions with p300 were shown to directly impact the foci formation rate of the YEATS domain.

Second Place
Zain Abed- The Effect of Addatives on the Efficiency of Compost in Terms of Temperature, Bacterial Composition, and Nitrogen/Ammonia Levels
Clover Hill High School

The question that was being addressed in this experiment was which compost additive would make the most efficient compost. The purpose of this experiment was to find the most efficient compost to help increase the cultivation of crops. The hypothesis was that the addition of animal manure would increase the temperature, change the composition of the bacteria and increase the ammonia and nitrogen levels, in comparison to oyster shells. The control was compost without any additional additives. Each level of independent variable was given 10 boxes of compost. The temperature of the compost

boxes was taken daily, and the boxes were aerated daily. The pH of the boxes was taken every three days. The pH was the way to gauge the maturity of the compost. The nitrogen and ammonia levels were taken every 15 days. 5 worms were added to each compost bin and the soil samples used for bacteria identification were collected once before worms were added to the compost and once after the worms were added to the soil. The mean values for the nitrogen ammonia levels of the compost with no additives, the compost with cow manure, and the compost with oyster shell was 0.56 ppm, 0.57 ppm, and 0.59 ppm, respectively. None of the composts were more efficient than others so the experimental hypothesis was rejected. The null hypothesis about no significant difference was tested using an ANOVA test, and the null hypothesis was not rejected.

Third Place
Nisarg Shah- The Effect of Hydrogen Peroxide Concentration on Teeth Deterioration
Mills E. Godwin High School

The purpose of this experiment was to determine how hydrogen peroxide affects the deterioration of teeth. Hydrogen peroxide has been used in many teeth whitening products across the globe, but it is also known to destroy the enamel of teeth and can also affect tooth sensitivity. Teeth were placed in either a 4, 8, or 12 percent solution, which was diluted using distilled water, of hydrogen peroxide for 24 hours with a concentration of 0%, or distilled water, as the control. Afterwards, the solution they were placed in was poured in a cuvette, and the absorbance at 445 nm was measured in Absorbance units (Au). It was hypothesized that if the concentration of hydrogen peroxide was increased, then the solution would absorb more of the wavelength, meaning that the teeth deteriorated more. The results showed that the higher the concentration of hydrogen peroxide, the higher the absorbance at the wavelength. A t-test was done and revealed that the data was significant for all the comparisons except 4% vs. the control, and 4% vs. 8%. These results supported the research hypothesis. It is believed that these results occurred since a stronger concentration of hydrogen peroxide led to a larger amount of the deterioration of the teeth. This caused the teeth to become turbid with enamel that eroded off the teeth. This research could lead to further studies on how other bleaching agents such as carbamide peroxide affect tooth enamel and additionally test their negative effects on teeth.

Honorable Mention
Madison Nelson- The Effects of Usage on Vending Machine Cleanliness
Chesapeake Bay Governor's School

With recent COVID-19 concerns, the amount of bacterial presence on surfaces are more important to the public than ever. Vending machines are renowned, commonly used surfaces that are used by the public. Studies show that the hands harbor abundant amounts of bacteria. With proper and effective cleaning protocols, the bacterial transfer between humans and surfaces is minimal and allows for safe levels of bacterial contamination. This study examines the effects of usage on bacteria percent coverage,

number of bacterial colonies and diversity, and the cleanliness of the machines. The study corresponded between six vending machines, located at Rappahannock Community College, ordered by lowest to highest use. The vending machines were swabbed at two locations: money and flap areas. The samples were observed for cleanliness and plated onto agar plates to observe bacteria quantifications. The trends between usage resulted in significant p-values for bacteria percentage, colonies, and diversity. However, the correlation between usage and cleanliness was not significant. When comparing the locations of sampling, many of the same factors prove significant, resulting in compromised areas on the vending machines. There are many potential explanations that could prove the trends of significance. RCC is a notably public campus, with the assumption of daily cleaning and a janitorial service, the machines are cleaner, but still allow the opportunity to gather bacteria. Also, one of the machines stopped working halfway through experimentation. This study was conducted to help the community and to evade any health risks that contaminated surfaces may cause.

Honorable Mention
Mihir Pokhriyal- Phenolic Acid vs. Flavonoid on the Inhibition of *Escherichia coli* K-12
Mills E. Godwin High School

The purpose of this experiment was to use naturally obtainable phytochemicals, specifically polyphenols, and measure their antibacterial effect on a bacterium causing thousands of yearly infections, *Escherichia coli*. Knowing the antibacterial effects of these compounds would provide integral information regarding the use of inexpensive material for fighting infections. Two widely abundant polyphenols, flavonoids and phenolic acids, were used to test for antimicrobial properties. Specifically, quercetin, a common flavonoid, and benzoic acid, a phenolic acid were used since these are widely available and has many applications for fighting infections in plants. To measure bacterial sensitivity and therefore effectivity of the polyphenols, the Kirby-Bauer disk diffusion method was used to measure zones of inhibition, or an area around the polyphenol without the presence of bacteria. A control without any polyphenol was also used as a baseline measurement. It was hypothesized that benzoic acid would yield the highest area of inhibition, which was supported based on the results. On average, the control, quercetin, and benzoic acid generated a radius of 0, 0.528 and 1.0008, respectively. Three t-tests were conducted and showed the data to be statistically significant ($p < 0.001$). The most likely cause for inhibition was because polyphenols contain antioxidant properties that prevented the growth of E. coli K-12 in those areas. Further studies could include direct extraction of polyphenols from plants rather than a dissolved encapsulated form, as that would most likely be a cheaper alternative, and yield further growth from this study.

Honorable Mention
Timothy Patterson- The Effect of Different Carbohydrates on the Growth of *Escherichia coli*
Central Virginia Governor's School

The purpose of this study was to determine the effect fructose, glucose, and corn syrup have on the growth of *Escherichia coli*. Three nutrient broths, with these substances serving as the main source of carbohydrates, were used as a medium for the bacteria. The CO_2 production of the bacteria was used as a measure of the growth of the bacteria, with more CO_2 ppm in a sealed environment indicating more E. coli growth. The CO_2 production of a plain broth with no bacteria was also measured to use as a control group. A single factor ANOVA with an alpha value of .05 showed a p-value of .0049, meaning the data had statistical significance between at least two of the groups. A post hoc Tukey Test showed that this significance was only between the control group and the groups with bacteria. This meant that the data did not support the research hypothesis, which stated "If different carbohydrates are used in the making of a nutrient broth to sustain E. coli, then the presence of glucose will result in more CO_2 production." In conclusion, the carbohydrate used in the making of a nutrient broth medium did not affect the growth of E. coli.

Mary Willis- The Effects of Sugar Mass on Alcohol Concentration Through Fermentation
Clover Hill High School

The purpose of this experiment was to determine how adding varying amounts of sugar to a yeast and water mixture would affect the amount of alcohol made through fermentation. The hypothesis for this experiment was that the more sugar that was added to a yeast and water mixture, the more alcohol would be produced through anaerobic respiration during the fermentation process. This experiment was conducted with 4 levels of an independent variable with each level having 10 trials. The levels in the experiment were 0 grams of sugar, 8.4 g of sugar, 16.8 g of sugar, and 25.2 g of sugar. For each trial of the experiment, a bottle was filled with 237 mL of water and 5.6 g of yeast. The varying amounts of sugar were poured into the bottles and then the initial gravity was measured using a hydrometer. A balloon was then placed on top of each bottle which was then poked to create a hole into each balloon which was able to act as a makeshift airlock. This allowed for air to escape from the bottles but not let any in, thus creating an anaerobic atmosphere for the yeast to start fermenting in. After the fermentation process appeared to be completed, each trial's specific gravity measurements were recorded, this was repeated two more times and then the initial gravity measurements along with the specific gravity measurements were averaged together to find the final gravity for each trial. Then, using the percent alcohol by volume formula on the final gravity measurements, the percent alcohol by volume for each trial was calculated. The average percent alcohol by volume for each level was then found by averaging all of the trial's percent alcohol by volume measurements. Using these results, an ANOVA test was conducted which stated that there was a statistically significant difference between the levels in the experiment and that the null hypothesis was rejected. The data from the experiment did support the research hypothesis.

Matthew Gavin- Testing the Antimicrobial Properties of Copper
Mills E. Godwin High School

The purpose of this experiment was to test the antimicrobial effects of copper. When researching copper, contaminated drinking water can be found. This is a known third world issue because of the bacteria present in their drinking water. So, one solution to this current problem is copper. Copper kills bacteria at a significant rate. For this reason a hypothesis was formulated that if copper was used as opposed to steel, and aluminum foil, there would be less bacteria present on a petri dish. Also, steel was the negative control used in this experiment. First, nutrient agar plates were made according to the manufactures directions, and each metal was cut into 1cm squares. The metal was sterilized, then after finished drying bacteria was placed onto the metal. Next, the pieces were placed into 1ml of nutrient broth. The plates were inoculated and the bacteria was left to incubate for 46 hours. Finally, the plates were taken out and the results were recorded. The results revealed that copper is a stronger antimicrobial surface than steel, and aluminum foil. A chi square test revealed that the data was statistically significant. The results did support the research hypothesis. The reason for this is because the respiratory chain in E.Coli cells is damaged by copper due to the abundance of Cu_2+ (cupric ion). Finally, to further this experiment, one can test the strength of the properties. If one uses more resistant bacteria instead of E.Coli they could grasp the strength of copper's properties.

Myra Clark- The Effect of the Type of Natural Preservative on the Size of the Zone of Inhibition of *Escherichia coli*
Yorktown High School

The research objective of this experiment was to find out which natural preservative prevents the most growth of *Escherichia coli* through experimentation. To approach this question, an experiment was conducted testing water, cinnamon, salt water, and garlic juice on the growth of E. Coli, and afterwards the zone of inhibition was measured, to find out which substance had the greatest antibacterial effect. The null hypothesis was accepted, stating that no treatment level would affect the dependent variable. The original hypothesis in this experiment, that the salt water would cause the least amount of growth, was not supported by the data, as the average size of the zone of inhibition (the area in which bacteria did not grow) for salt water was 0.18cm, whereas the garlic juice had an average zone of inhibition size of 0.6cm, with the least amount of bacteria growth. With additional research, it was found that allicin, a chemical found in garlic has strong antibacterial effects, likely the reason the garlic had so much less growth than the salt water. Water had a zone of inhibition of 0cm, and cinnamon water had an average size of 0.06cm. Conclusively, the garlic juice resulted in the least amount of E. coli growth, with the largest zone of inhibition.

Pari Wadnerkar- The Effect of the Concentration of Copper Nanoparticles on the Growth of *Escherichia coli*
Mills E. Godwin High School

The purpose of this experiment was to test the effect of the concentration of copper nanoparticles on the growth of *Escherichia coli*. Antibiotic resistance is a growing issue caused by the overuse of antibiotics against bacteria. Copper nanoparticles are a promising solution due to their bactericidal effect, and their ability to target multiple biomolecules at once. Copper nanoparticles were synthesized using the chemical reduction method, by combining absorbic acid and copper chloride dihydrate. In order to test the antibacterial effect, E. coli plates were supplemented with various concentrations of copper nanoparticles. After 24 hours of incubation at 37 degrees Celsius, the cfu/mL was calculated. A hypothesis was formulated that if the concentration of copper nanoparticles increases, then the E. coli growth would decrease. The data showed that on average, the E. coli supplemented with the 60 Œºg/mL copper nanoparticle solution contained less colony forming units. Due to these results, the research hypothesis was supported by the data. A t-test was performed on the data, and the data was statistically significant. The results supported the research hypothesis. This is likely due to the production of reactive oxygen species, and the thin peptidoglycan layer in E. coli cells.

Rithvik Rayala-The Effect of Antimicrobial Solutions on the Inhibition of the Bacterial Growth of E.Coli
Mills E. Godwin High School

Sanitization is a very important part of disease prevention with 775,000 deaths occuring every year due to poor sanitation. An incredibly cheap but effective disinfectant would be very helpful in improving sanitization. Tannin, a compound that is medically significant due to its astringent properties and its antimicrobial properties because of its ability to pass through the cell wall and disrupt the metabolism causing its death. This study aims to test the antimicrobial properties of multiple tannin solutions on *Escherichia coli* K12 and their effectiveness on preventing bacterial growth. Tannins are commonly found in seeds, leaves, buds, stems, roots, and is especially condensed in bark of some trees of the oak and chestnut tree family and the calyx of persimmons This study aims to test the antimicrobial properties of multiple tannin solutions on Escherichia coli K12 and their effectiveness on preventing bacterial growth. The E.coli K12 counts for the tested tannin solutions was 13.88 CFU/ml for persimmon solution and 9.88 CFU/ml for bark solution which were far lower than the 38.8 CFU/ml for the nutrient broth which was designated as the control of the experiment. Results from this study showed that when the E.coli K12 came into contact with the tannin solutions it had less bacterial growth compared to when it was in contact with the nutrient broth suggesting effectiveness in its antimicrobial properties. The effectiveness of tannin on E.coli K12 indicates the possibility of its usage as a cheap easy made sanitizer that can be effective to reduce the likelihood of bacterial infections.

Ryan Ermovick- The Effect of DIfferent Methods of Water Treatment on the Growth of Microorganism Colonies
Yorktown High School

This experiment was conducted to compare the effect of different water treatment methods on the growth of microorganism colonies in water. The hypothesis is that "If the method of water treatment is an Ultraviolet (UV) light, then the least amount of microorganisms will grow because the Deoxyribonucleic Acid (DNA) of the cells will be disrupted." For this experiment, water was collected from a pond in Arlington, VA and treated using four different methods of water treatment: one chlorine-based, one chlorine dioxide-based, one iodine-based, and one using a UV light. A fifth level not
treated was the control. Five water samples for each treatment method were incubated on agar plates for 48 hours, and the resulting number of microorganism colonies were counted. The average number of microorganism colonies for each method of treatment was then calculated. The hypothesis was rejected, as the most effective method of water treatment tested was the chlorine dioxide-based method, not the UV light method. The null hypothesis, which was that there is no effect of the type of water treatment on the growth of microorganism colonies, was also rejected. A one-way Analysis of Variance (ANOVA) test was run on the data to determine if the data had a statistically significant difference. The p-value was less than 0.05, indicating that the data was statistically significant. The conclusions of this experiment can be used to educate people on methods to treat water in places where clean water is not readily available.

Smita Vijay Arumugam- The Effect of Natural Treatments on the Inhibition of *Escherichia coli*
Mills E. Godwin HIgh School

Many patients suffering from an E. coli infection in developing countries don't have access or the money to treatments, but many natural ingredients are being studied and used to treat E. coli infections because of their antimicrobial properties. The purpose of the experiment is to investigate the inhibition rates of natural treatments on the E. coli K-12 strain. The research hypothesis for this experiment states that garlic would inhibit the most E. coli growth. There were four independent variables in this experiment: garlic, ginger, cloves, and not treatment to act as a control. Each treatment was placed in a petri dish inoculated with E. coli and the growth was scaled on a scale of 1-5, 1 being little to no inhibition and 5 being excellent inhibition. The data collected revealed proved that cloves were the best treatment, which proves the original hypothesis incorrect. A chi-square was conducted between the expected and each observed value, revealing that the experiment was significant. This implied that the results did support the research hypothesis. These results are most likely due to certain molecules, such as phenolic compounds which have anticarcinogenic abilities, which exhibits antimicrobial properties. For further study, ingredients that could enhance the performance or enable cloves to disrupt the biofilm of the bacteria of cloves should be investigated.

Tristan Fields- The Effect of Time on the Number of Bacteria Colonies
Mills E. Godwin High School

The purpose of this experiment was to determine the effects of time on the amount of bacteria colonies. Recently, the five-second rule has been used to eat foods off of the floor. The rationale of this study was to inform more people about the dangers of foods contaminated by the floor. This paper's implications were affecting people who believe in the five-second rule and its hospitalizations. Grapes were rinsed in water, cut in half, dropped for the desired amount of time and placed into agar plates using sterilized forceps with the bacteria colony count being recorded every day for five days and after the fifth day, the petri dishes would be carefully placed into an autoclave bag to be autoclaved and disposed of as a BSL-2. For this experiment, the control was zero seconds. The hypothesis used for this experiment was if the time food is on the floor increases, then the amount of bacteria will increase. The results revealed that five seconds had the most bacteria colonies from days three - five. A T-test was conducted on this study‚Äôs data and days three and four are not significant, while days one, two and five were both significant and not significant. The data didn't support the research hypothesis, and the results gathered were believed to be caused by premature exposure of the grapes. This research could lead to more studies investigating more common food types, and which times had the most and least amount of bacteria colonies in five days.

Physics & Astronomy A

First Place
Aryan Mhaskar- Safety of Transcranial Magnetic Stimulation for Parkinson's Patients with Deep Brain Stimulators
Mills E. Godwin High School

The purpose of this experiment was to determine if transcranial magnetic stimulation (TMS) is safe for use in patients with implanted deep brain stimulators. Patients with Parkinson's Disease have struggled with controlling movements, and extreme cases cannot be treated with oral medication, prompting the use of deep brain stimulation (DBS). Although this reduces many symptoms, preliminary research suggests the use of TMS directed to the primary motor cortex to resolve remaining issues. However, TMS may induce high levels of current in implanted DBS probes causing excess stimulation. It was hypothesized that TMS would induce unsafe levels of current in DBS circuitry due to prior research. Control was established of 0% TMS intensity and simulation was conducted using a constructed custom-made and highly accurate DBS circuit geometry implanted into a shoulder-head model of a human. It was found that TMS induces far higher amounts of current than the safety limit of 3.4 mA. These results were statistically significant from the control. It is suggested that TMS not be used on Parkinson's patients with DBS implants and that further research using physical shoulder-head model phantoms and real clinical DBS and TMS equipment be conducted due to conflicting research.

Second Place
Julie Bainter- The Effect of Price on the Accuracy of Chromatic Tuners
Clover Hill High School

The purpose of the experiment was to determine the effect of price on the accuracy of instrument tuners. The results from this experiment could help inform consumers who are wondering if the more expensive tuner options are worth the money as they make their decisions on what tuner to buy. To measure the accuracy of each tuner, a pitch was both increased and decreased until the tuner recognized a change in pitch. Five tuners, the insTuner phone app (control, $0.00), Snark ST-2 ($11.99), Korg CA-2 ($14.99), Korg TM-60 ($22.99), and Boss TU-30 ($34.99), were tested. Each tuner was tested 50 times and the data was recorded in a data table. The mean accuracies for the insTuner (control), Snark ST-2, Korg CA-2, Korg TM-60, and Boss TU-30 tuners, when tested with a sharpened tone, were 1.590 Hz, 0.799 Hz, 0.503 Hz, 0.445 Hz, and 0.812 Hz, respectively. The mean accuracies for the insTuner (control), Snark ST-2, Korg CA-2, Korg TM-60, and Boss TU-30 tuners, when tested with a flattened tone, were 1.462 Hz, 0.823 Hz, 0.542 Hz, 0.347 Hz, and 1.031 Hz, respectively. The research hypothesis was that the cheaper tuners would be less accurate than the high-priced tuners. The null hypothesis of the experiment was that the price of the tuners would not affect the accuracy of the tuners and each one would show the same results, regardless of the price. The null hypothesis was rejected, and the data did not support the research hypothesis.

Third Place
Kalea Wen- The Kadomstev-Rosenbluth Initiative
Governor's School @ Innovation Park

The pursuit for abundant and clean energy has led to the development of nuclear fission, and in the future, nuclear fusion. A fusion reactor is predicted to produce significantly more energy than a fission reactor for equal mass and no harmful waste or byproducts. The complex mechanisms of controlled fusion, the foremost being stability of the fusion source, is currently hindering this possibility. This investigation utilizes the GOLEM Tokamak, an educational toroidal fusion device that superheats plasma to generate energy, to study common instabilities within the plasma, such as magnetic islands. These islands cause loss of temperature and plasma confinement within a tokamak, which are critical for successful fusion. While the precise causation is unknown, this research hypothesizes correlation between the existence of magnetic islands and the tokamak parameters of toroidal field and plasma current strength. 48 shots of plasma discharges with varying toroidal field and plasma current strengths were analyzed for magnetic island presence, quantified in 2 main values: the instabilities' power spectrum amplitude and shape from measurement coils, and the edge safety factor of the plasma. Through linear regressions, significant correlation was statistically proven between the toroidal field strength and both qualities, and the plasma current and the safety factor. The plasma current is predicted to correlate with an environment suitable for MHD generation and not their actual presence. High plasma current and low toroidal field is concluded to best

generate MHD instabilities. This regime is suggested for further study of MHDs on the GOLEM Tokamak.

Honorable Mention
Erik Midkiff- How do Differing Sensor Systems Respond to Natural Environmental Conditions?
Blacksburg High School

In a rapidly modernizing society, vehicular transportation industries are increasingly implementing sensor-based automation systems in commercially available vehicles. Driver assistance systems and safety features rely heavily on sets of different sensors and sensor systems to provide accurate data. As complex as they may be, algorithms and machine learning can‚Äôt make up for unreliable data or data that is simply not present. One leading factor which may cause such anomalies is the presence of natural environmental factors. As computational technology advances, sensors will soon become the bottleneck for safe automated vehicles in adverse weather conditions. In this work, various sensor systems utilizing fundamentally different technologies including LiDAR and radar were tested in rainy weather conditions as induced by the Virginia Smart Road. The data collected over 7 trials in adverse weather conditions was compared with data collected over 8 trials in ideal, dry weather conditions. Two high-accuracy GPS systems also tracked true vehicular location, providing highly accurate true location data against which sensor data could be compared. Statistical analysis demonstrated a significant difference in sensor reading degradation and accuracy between the two datasets. LiDAR was the most negatively impacted, with one tested system experiencing over a 30% increase in degradation. High-frequency radar at 77GHz also demonstrated statistically significant degradation, while low-frequency sensors including 24GHz radar and optical sensors showed insignificant differences in reading degradation. The analysis of the responses of different sensor systems to natural environmental factors is a critical step in determining ideal sensor system setups and configurations.

Honorable Mention
Evan Cline- Most Efficient Knee Angle of a Basketball Shot
Southwest Virginia Governor's School

As basketball has become an increasingly popular sport around the world, the need for more efficient and reliable shooting mechanic techniques has become ever-increasing. One of these shooting mechanics that can most affect the result of a basketball shot is the angle of knee flexion. Many kinematic aspects and angles of the basketball shot have been researched and studied, but the angle of knee flexion has had a lack of overall interest and study. In this experiment, four participants were used to find what the most efficient angle of knee flexion for long-range basketball shots is. These participants each took five basketball shots from nine different ranges of the angle of knee flexion (starting at 180-161 degrees in 20-degree increments). These 45 total shots from the different ranges were repeated over five different long-range distances for each participant. Videos

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of these shots were recorded and then imported to Tracker, a free online video analysis tool for physics, where a protractor was used to find the exact angle measure of knee flexion for each shot. A logistic regression was used to statistically analyze this data and relate the parameters of the shots, which were the distance, the angle ranges, the actual angle measures, and the outcome of the shots (make or miss). This regression measured the predictability that each parameter had on the outcome of each shot. The distance (p-value 0.0001) was the only significant parameter in predicting the result of each shot, while the angle range and actual angle parameters were not significant. Therefore, no conclusion could be made as to what the most efficient angle of knee flexion is for a long-range basketball shot. The skillset and lack of consistency provided by the participants could have been one reason that the distance parameter was the only one of significance to the outcome of a shot. Future research on this subject could use more skilled and consistent participants as well as just a single distance to avoid the domination of the distance parameter in analyzing the outcome of each shot.

Honorable Mention
Kai Styrsky- The Effect of Temperature on the Resistance of Different Metallic Conductors
Central Virginia Governor's School

The purpose of this study was to determine how temperature and material affect the electrical resistance of metallic wires. Various types of probes and metering devices were used to pass an electric current through six kinds of wires (silver, copper, aluminum, tinned copper, brass, and galvanized steel) and measure the electrical resistance. Several pieces of equipment, including an oven and a freezer, were utilized to adjust the temperature of the wires. Data was recorded at seven temperatures, from -20 ‚ÑÉ to 100 ‚ÑÉ at 20 ‚ÑÉ intervals. A two-way ANOVA statistical test was performed to analyze the data. P-values of 0 for the temperature, material, and interaction effect were generated, all of which were compared to an alpha of .05. A post-hoc Tukey test was used to determine where amongst the groups the significance occurred. It was found that nearly every comparison was significant. Across all of the groups, the average electrical resistivities for each material were 1.73 x 10-8 ohm-meters (silver), 1.74 x 10-8 ohm-meters (copper), 2.14 x 10-8 ohm-meters (aluminum), 1.73 x 10-8 ohm-meters (tinned copper), 5.90 x 10-8 ohm-meters (brass), and 8.63 x 10-8 ohm-meters (galvanized steel). The research hypothesis, that the average electrical resistance of a copper wire would be lower than the average electrical resistance of an aluminum wire across a range of temperatures, was supported by the results. In conclusion, both temperature and material have a significant effect on the electrical resistance of metallic wires.

Aaron Sweeney, The Effect of Roof Surface Characteristics On Albedo and Temperature
Chesapeake Bay Governor's School

Albedo is a numerical measure of surface reflectivity derived from the ratio between solar reflectance and solar irradiance. Globally, the highest residential electricity consumption

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is air conditioning, using 17% of total residential electricity, with air conditioning being available to 87% of residences. The purpose of this study is to determine the effects of color, composition, and angle on the albedo and the difference in temperature on roof surfaces. Throughout this study, seven colors, six compositions, and five angles of roof surfaces were tested for their albedo and difference in temperature. Albedo and temperature data were collected from the panels when the solar zenith angle was 0¬∞ from August 19 to September 3, 2021. Results show that regarding the difference in temperature of the different panel surface colors, a statistically significant difference was found with ANOVA p=1.72x10-4. Based on the results of temperature differences for the tested panels, this study suggests that the optimal roof surface combination consists of a white or silver surface, made of wood, set at a 0¬∞ angle. Cool roofs utilize high albedo surfaces to decrease roof surface temperature, decreasing thermal convection into the underlying structure, decreasing air conditioning energy usage during warmer periods, substantially reducing carbon emissions.

Killian Woods- The Variance in Static and Kinetic Coefficients of Friction of Leathers Used in Work Gloves at Different Levels of Water-Based Moisture
Southwest Virginia Governor's School

Personal Protective Equipment (PPE) is an essential component of manual labour – one of the leading causes of workplace fatalities in the United States. While previous research on the tribology of materials and the change thereof caused by the manipulation of relevant conditions, this topic has not been studied with a focus on the PPE and variability in climate and workplace conditions prevalent (and persistent) throughout work in the manual labour field (specifically that of construction). Data and experimental methods from said previous studies were modified and repurposed to study the variance in the coefficients of friction (CoF) of different leather-based materials (commonly used in work gloves, an integral part of manual labour PPE) at different levels of moisture simulated by distinct volumes of distilled water topically applied to the researched substance. The values of each surface's CoF at the different levels of water-based moisture were measured by securing the tested materials surface, applying the appropriate amount of (distilled) water, and then dragging a normal weight connected to a force sensor. The raw data, force values, were then used to calculate their CoF. An ANOVA test with a Tukey HSD follow-up was used to analyze the data, finding statistically significant differences between the dry and wet surfaces, and the different types of leathers. While this study proves valuable information for which materials had the highest CoF (the best grip), comparison and analysis using a lens facilitated by previous studies suggests that a more expansive selection of levels of moisture should be a priority in future studies in order to fully be sure of the significance of their findings.

Laura Wang- The Effect of Cement Alternatives on Deformations Occurred by Force
Mills E. Godwin High School

The cement industry is a big contributing factor to the growing carbon emissions all throughout the world. It is imperative that cement alternatives are implemented to reduce carbon emissions and the cement is being made by using efficient cement. The purpose of this experiment was to find which alternative was the most durable, so deformation tests were performed based on cement alternatives. The research hypothesis formed was if silica fume was added to Portland cement, then the concrete created would have the lowest rating of deformations occurred. The three experimental groups were Portland cement as a control, fly ash cement, and silica fume. Using the same method for each experimental group, 145 grams of cement was mixed with 60 milliliters of water. After being set aside for 24 hours, a weight of 6.8 kg was dropped on cement 90 cm above the ground, and deformations were rated on a scale of one to five. The results showed that silica fume had the lowest rating of deformations formed. This data was statistically significant after three chi-square tests were performed, supporting the research hypothesis created. These results were likely caused by the pozzolanic qualities of silica fume, allowing it to create tighter bonds between itself and the cement, increasing density. By filling the spaces in between the cement, the surface area and density increased and prevented deformations. A continued study could be conducted where a computer model was used to determine the carbon emissions produced by the formations of the cement alternatives.

Madison Brown- An Analysis of Water Maser Observations Using Next-Generation VLA
Roanoke Valley Governor's School

Measuring the Hubble Constant, H_0, has been a fundamental goal within astrophysics for over a century. The Lambda Cold Dark Matter Model (ΛCDM) does not determine H_0 directly but predicts a H_0 of 67.4 ± 0.5 km s^{-1} Mpc^{-1}. A recent goal of the cosmology community is to therefore measure H_0 with a 1% uncertainty to test the ΛCDM. The purpose behind this research is to analyze and predict the uncertainty of the Hubble Constant that will be made available with the planned next-generation VLA (ngVLA) using the techniques of the Megamaser Cosmology Project (MCP). The MCP has so far determined a H_0 of 73.9 ± 3.0 km s^{-1} Mpc^{-1} (4% uncertainty) using geometric distance measurements of six edge-on disk megamasers. The Green Bank Telescope (GBT) and the Very Large Array (VLA), an interferometric array, were utilized to acquire the spectra of megamaser-hosting galaxies in the MCP. We analyzed the distance distribution of known megamasers and the subset of megamasers that can be used for geometric calculations both in the context of current instrumentation (VLA and GBT) and the projected capabilities of the ngVLA. The ngVLA, set to be completed with construction in 2035, will have ~9.7 times the sensitivity of the VLA at the relevant frequencies (~22Ghz) by increasing the number of antennas, and thus, effective area, A_e. As a result, the noise will decrease by a factor of ~9.7. A megamaser source at a given brightness would

therefore be detectable at a distance of ~ 9. 7 times farther when using the ngVLA. Given the homogeneous and isotropic nature of the universe, megamaser galaxies are evenly distributed across this spherical volume. Thus, the number of detectable megamaser hosting galaxies will increase by a factor of ~30. The combined uncertainty from ~30 times more independent distance measurements will reduce the overall H_0 uncertainty by a factor of the projected combined uncertainty of H_0 using megamaser 1 30 observations and the ngVLA is, therefore, ~0.7%, and thus reaching a 1% uncertainty of H_0.

Physics & Astronomy B

First Place
Sam Watchman- Mapping the Milky Way: Observations of Galactic Structure from the 21cm Hydrogen Line
Arlington Tech

This project used observations of the 21 cm hydrogen line to build up a map of the Milky Way galaxy from radio observations using the 20-meter telescope at the Green Bank Observatory. The 21 cm hydrogen line is a radio emission signal from hydrogen atoms spread around the Milky Way and other galaxies. This signal is emitted at 1.420405751 GHz, but that frequency is shifted by the Doppler effect to slightly different frequencies because of the Milky Way's rotation velocity. By analyzing the frequency shifts and translating each spectral data point into a position in the Milky Way galaxy, it is possible to build up a map of the Milky Way and its spiral arms from many observations. For this experiment, this was done with ~260 individual observations, which after processing using Python scripts, created two maps: a heat map and a scatter plot, showing galactic structure. These graphs showed several galactic spiral arms and were consistent with the fact that the Milky Way is a spiral galaxy. The data also matched up with observations from the Spitzer Space Telescope.

Second Place
You Gao- Lunisolar Seismology Analysis - Do Tides Affect Earthquake Frequency?
Chesapeake Bay Governor's School

Quaternary faults analyzed in this study were divided into the quadrangle of the continental United States named the California Faults Zone (32.473, 48.318) latitude. Using the past 10 years of the United States Geological Survey to determine statistical differences between earthquake frequencies, magnitude, and depth during every five day interval of perigee or apogee. Five day intervals of equinoxes and solstices were also statistically tested for perihelion and aphelion, including the nodal periods as equinoxes between the extremes. Earthquake geological data from the past 10 years from December 2012 to January 2022 were collected from the United States Geological Survey archive for the quadrangle bounds (32.473, 48.318) N latitude, (-124.902, -

113.555), W longitude in the California Faults Zones. The USGS ArcGIS helped visualize the fault zones and information on the quaternary faults present within the sampled region. Data gathered from the USGS archive include earthquake depth in kilometers and Richter scale magnitude. T-tests show statistically significant findings for depth between perigee and perihelion with their respective controls of gravitational influence.

Third Place
Sara Lynn Loucks- The Effect of Hand Speed on Stroke Force in Freestyle Swimming
Central Virginia Governor's School

The purpose of this research project was to determine if there is a difference in the amount of force used by a swimmer while freestyle swimming at different hand speeds in order to improve the technical knowledge of the freestyle stroke. Using SmartPaddles, high-tech swim paddles designed to collect data on the force used during swimming, several sets of data were collected from 13 competitive swimmers ages ranging from 14-18 years old. The swimmers' skill levels were assessed to make sure they were appropriate for the study. Participants included both male and female swimmers to account for the variation in both genders. The swimmers were asked to swim six 50 m laps at sprint and ‚Äúeasy‚Äù hand speed paces. Data was collected from these trials using the SmartPaddles and assessed using Excel. The average force measured for the sprint trials was 23.23 N, while the easy trials averaged 19.09 N in force. Using a two-sample t-test and an alpha value of .05, a p-value of .00053 was expressed. This supported the hypothesis that there would be a significant difference in the amount of force applied at the sprint hand speed versus slower hand speeds. Taking all factors into account, it can be concluded that increased hand speed can lead to an increase in the amount of force used by a swimmer to a certain extent. This gained understanding of the correlation of force and hand speed can be used to improve the freestyle strokes of swimmers.

Honorable Mention
Olivia Bartrum- Analyzing the Efficacy of Inorganic UV Filters on Their Ability to Block UV-A Light
Wakefield High School

The experiment was undergone in an attempt to determine if certain inorganic compounds were more effective in the blocking of UV-A radiation. The independent variables in experimentation were the different inorganic compounds used, being Titanium Dioxide and Zinc Oxide. The dependent variable was the UV intensity after the application of Titanium Dioxide and Zinc Oxide, measured in $\mu W/cm^2$. Several control groups were instituted to avoid the development of potential confounding variables, accounting for outside factors that may have impacted the reliability of the data. It was hypothesized that if a UV-A light was placed under Zinc Oxide, it would be able to limit the transmission of UV light to the greatest extent, as a result of Zinc Oxide's photostability. To test this hypothesis, one gram of each inorganic compound was placed on separate sheets of quartz glass, which were raised two inches from the ground. Underneath each sheet, a

UV intensity meter was placed, with a UV-A light placed approximately 8 inches above the quartz glass. Eight trials in each level were undergone, with four levels in total. The results showed that the hypothesis was accepted. On average, Zinc Oxide was able to most effectively limit the transmission of UV-A radiation, with an average UV intensity of 28.625 $\mu W/cm^2$, in comparison to Titanium Dioxide, which had an average UV intensity of 53.25 $\mu W/cm^2$. To determine statistical significance, an ANOVA test was performed. This test demonstrated that there was statistical significance between experimental levels. Based on these results, it was concluded that in general, Zinc Oxide was more effective than Titanium Dioxide at blocking UV radiation, indicating that the usage of Titanium Dioxide may be less beneficial, given it's decreased ability to limit the penetration of UV-A light.

Honorable Mention
Sarah Chretien- The Effect of the Proximity of Celestial Planets on the Number of Sunspots, Solar Flares, and Coronal Mass Ejections (CMEs) Within 11 Years (December 08 - 19).
Clover Hill High School

The purpose of the experiment was to determine whether the proximity of large planetary masses in relation to the Sun affected the occurrence of solar activity. If planetary masses had an effect on solar activity, then scientists from space weather prediction centers would be able to provide more accurate predictions on the occurrence of solar flares and CMEs, which pose a substantial risk to modern infrastructure. These predictions could give technicians a longer window for shutting down electrical grids in preparation for a CME and subsequently prevent major economic losses in damages. The experimental hypothesis for this experiment was that sunspots, solar flares (ranging from C-flux to X-flux flares), and CMEs resulted more often based on the close proximity of large celestial planets with high gravitational pull to the Sun during the solar cycle. The seven levels of the independent variable were the control, which was the average distance of planets to the Sun, and the planets Mercury, Venus, Earth, Mars, Jupiter, and Saturn. Data on sunspots, solar flares, CMEs, and the distance of planets relative to the Sun were collected from the Solar Heliospheric Observatory (SOHO) Repository, the SOHO LASCO CME catalog from the NASA CDAW Data Center, SpaceWeatherLive.com, TimeanDate.com, and Sunpy, which is a python programming resource for solar activity. The data was recorded on an EXCEL spreadsheet and analyzed using the mean as a measure of central tendency. Solar activity occurrences at certain planetary distances were measured using four categories of planetary distances: the first 25% of distances (C1), the second 25% of distances (C2), the third 25% of distances (C3), and the last 25% of distances (C4). There was no noticeable change in solar activity for Mercury in each of the four categories, and while there were differences in sunspot averages for Venus, Earth, and Mars, the averages for solar flares and CMEs were negligible between each planetary distance grouping. Jupiter and Saturn experienced the greatest average of solar activity occurrences in the C2 range and the lowest number of solar activity occurrences in the C4 range. Because the C1 range held relatively low averages when compared to the C2 and C3 distances for Jupiter and Saturn, the experimental hypothesis

was not supported. The null hypothesis was tested using an ANOVA test, and the null hypothesis was not rejected. However, these results may contradict the experimental hypothesis because of Jupiter and Saturn‚Äôs incomplete orbital period during a single solar cycle and the use of only one solar cycle, which does not fully represent the intensity of solar activity from the Sun. Thus, future experiments on the effects of planet proximity to the Sun on solar activity are recommended.

Honorable Mention
Sebastian Amador- Comparison of Star Formation Rate in Spiral versus Elliptical Galaxies
Central Virginia Governor's School

The purpose of this study was to compare the star formation rate of elliptical and spiral galaxies. The images of the six spiral and six elliptical galaxies were collected from the z = 0 Multiwavelength Galaxy Synthesis, viewed in a 3.4 micron wavelength (WISE 1) and a 12 micron wavelength (WISE 3). A program in Python calculated the mean and sum of star formation rate (SFR) throughout the galaxy by measuring the brightness of every point in the galaxy, then placing that value into a formula depending on if it was WISE 1 or WISE 3 data. The program calculated SFR for different distances from the center of each image. Four two-sample t-tests were then run with an alpha value of .05, and showed that there was a significantly higher sum of SFR for the spiral galaxies than the ellipticals, but there was no significant difference in mean SFR between the two types: for WISE 1, the p-value for sum of SFR was 7.409×10^{-10} and the p-value for mean SFR was .288, while for WISE 3, the p-value for sum of SFR was 4.831×10^{-38} and the p-value for mean SFR was .338. Due to this, the research hypothesis that SFR would be higher in spiral galaxies was only partially supported. The results of this study could be used to gain insight on the formation of galaxies and possibly lead to new information on the formation of the universe.

Maria Ziegler- The Relationship Between Types of Galaxies and Central Light Intensity of Young Stars
Central Virginia Governor's School

The purpose of this study was to find whether there was a correlation between the type of galaxy and the central concentration of young stars. The study used data for various galaxies from the NASA/IPAC Infrared Science Archive. In the study, Python, a programming language, was used to extract the young star light intensities from the data files. The light intensity data was summed at the central 20 percent for several different types of galaxies, including irregular, spiral, and elliptical. A two sample t-test was used to compare the light intensity sums for the spiral galaxies and the non-spiral galaxies (elliptical, irregular). The mean intensity sums of the central 20 percent for the spiral, elliptical, and irregular galaxies were 8644.71, 215.07, and 1727.63 MJy/sr, respectively. A p-value of .0446 was received and compared to an alpha of .05. The research hypothesis, that the spiral galaxies would have higher concentrations of young stars near

the middle, was supported. The results of the study suggest that there is a correlation between the type of galaxy and the central concentration of young stars.

Rishav Sen- Classifying Stars in the GAIA Catalog Using Machine Learning
Mills E. Godwin High School

GAIA DR2 is the largest star to date that contains extensive details on most objects in it, such as position, luminosity, color, and velocity. Despite this, the catalog has no data on the MK classification of each star, needing human review of the catalog to find stars of a certain type. In this project, a deep neural network was made using the programming language python and the machine learning libraries of Sklearn, NumPy, and TensorFlow to assign a luminosity class to each star. This would benefit future studies that will use the GAIA catalog as it provides important information not already in the catalog. The data used to classify the stars was the color and luminosity (absolute magnitude) data. It was trained on the data of over 50,000 stars collected from multiple star catalogs. Also, an algorithm was made to assign each star a Harvard spectral class based on its color. The network had four hidden layers with mish activation functions and 1540 hidden neurons in total. The network was trained using a categorical cross entropy loss function to calculate loss and an Adam optimizer to optimize the network. It had an ~82% accuracy in classifying stars and specialized on giant, main sequence, and white dwarf stars. The network's accuracy was compared to that of a simple k-nearest neighbor classifier. The network was then run on the GAIA DR2 catalog and the number of each type of star classified was recorded.

Ryan Fang- The Effect of Different Mixtures of Nitrogen and Air, Used in a Bicycle Tire, on Rate of Pressure Over Time
Clover Hill High School

The purpose of this experiment was to determine the effect of different mixtures of nitrogen and air, used in a bicycle tire, on the rate of pressure over time. The experimental hypothesis stated that if more nitrogen was filled in a bicycle tire, then the rate of pressure would be affected the least over time. To measure the effect of different mixtures of nitrogen and air on the rate of pressure over time, a 14.5-kilometer route was first plotted on Google Maps. Bicycle tires were filled with different mixtures of nitrogen and air, and they were measured before and after rides by a digital tire pressure gauge in order to calculate the change in tire pressure. The levels of the independent variable were 100 percent air and 0 percent nitrogen, 50 percent nitrogen and 50 percent air, and 100 percent nitrogen and 0 percent air. The mean changes of pressure were calculated and recorded in a data table in kilopascals, and this process was repeated until each level had 10 complete trials. The 0% nitrogen and 100% air level had a mean change of pressure of 3.45 kPa. The 100% nitrogen and 0% air level had the greatest mean change of pressure of 3.62 kPa; conversely, the 50% nitrogen level and 50% air level had the least mean change of pressure of 3.28 kPa. After the data was collected, an ANOVA test was conducted to test if the data was statistically significant. It was found from the

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experiment and the ANOVA test that the experimental hypothesis was not supported and the null hypothesis was not rejected.

Simran Patibanda- The Effect of Rotational Direction on the Power of Relativistic Jets Emitted from Active Galactic Nuclei
Governor's School @ Innovation Park

An active galactic nucleus (AGN) is a compact area of high luminosity at the center of a galaxy theorized to come from a black hole. Quasars, a type of AGN, emit relativistic jets, or beams of energy, from their black holes. Kerr black holes were observed to determine the impact of prograde and retrograde rotation on jet power, prograde meaning the black hole and accretion disk rotate in the same direction, and retrograde meaning the opposite. It was hypothesized that if the jet power calculations significantly differed between prograde and retrograde motion, then spin direction has an effect on the jet power. A set of 31 quasars from an FRII dataset was used to collect flux and black hole mass data. The Innermost Stable Circular Orbit (ISCO) radius was calculated for prograde and retrograde motion at varying values of the spin parameter a $[0 < a < 1]$. The observational jet power was determined using the calculated radio luminosity and Willmott‚Äôs scale. The observational a and ISCO radii were found using derived relations from the Blandford-Znajek mechanism for energy extraction. The theoretical ISCO radius was plotted against a, and a correlation matrix for various celestial fields was created to evaluate the hypothesis. The scatter plots showed the jet power was similar for prograde and retrograde motion at the same spins. The correlation coefficients between the prograde and retrograde orbits and the jet power were -0.10 and 0.21 respectively, indicating no significant correlation. Since the jet power was independent the hypothesis was rejected. These results give insight on the structure of black holes and the processes that allow relativistic jets to create celestial objects, helping to understand the impact of magnetic fields on relativistic jets and radiation on the Earth's atmosphere. Further research includes expanding the dataset, calculating the theoretical jet power, and testing other metrics such as Kerr-Newman.

Psychology A

First Place
Gabrielle Brown- Connecting the Dots: A look at the working short-term memory of elementary schoolers
Chesapeake Bay Governor's School

In school, students learn important skills with the overall goal to prepare them for life. Because of this, it is important to understand how efficient the methods used to help students learn are. Memory plays a key role in the education system but is memory something that the education system should rely so heavily on? Elementary school is

likely the best place to ask this question. This study looked at the capacity at which students in kindergarten through fifth grade‚Äôs short-term working memory worked efficiently. The study was completed by playing a memory game using dots where students were read colors and had to jump on the colored dots in the correct order. This was tested over three different levels of difficulty. The results showed an upward trend among each grade with the only true anomaly being in the fourth grade, which deviated from the upward trend. The P-value showed significance. Looking at how well short-term memory functions within each grade level is important. If utilizing memory as a primary learning component is not working, then it needs to be understood. If not, the education system may be setting students up for failure in future levels of schooling.

Second Place
Aaleya Fowler- Decision-making and Breathing Patterns Affected by Methods of Animal Presentation
Collegiate School

 For my research, I wanted to see how presentation of options affects participants‚Äô decision-making and breathing patterns when choosing to hold a safe invertebrate animal. Decision-making is experienced continuously throughout people‚Äôs daily lives and often results in some form of consequence (positive or negative). Things such as stress, peer-pressure, societal expectation, and more influence decision-making. By using respirometers and the Vernier Graphical Analysis software, I was able to gather data of elementary school students' decision-making process and how their breathing patterns (measured in breaths per minute (bpm) changed while being exposed to an invertebrate animal. By calculating my data using the chi-squared test and finding the data‚Äôs p value, I was able to conclude that the data shows no significant difference between observed student choices and expected count for worms and that there was no significant difference between observed student choices and expected count for mealworms since the null hypothesis of regardless of whether the animal was identified or not, the student‚Äôs choice to hold the animal or not and their respiration pattern was unaffected remained true. The respiration force rate of students and their highest spike in respiration is also insignificant. Since the p value was less than 0.05, indicating the data is insignificant, and the calculated chi-squared value was less than the critical value, the null hypotheses could not be rejected.

Third Place
Chloe Ro- The Relationship Between Blood Type and Personality
Central Virginia Governor's School

This study was focused on examining if there is any truth in the personality assessment that is common in East Asian Culture with blood type and personality. In this study, data was collected in the form of paper surveys from participants from a local hospital. The surveys included questions on behaviors relating to extraversion and introversion as well as blood type. Each participant received a personality score from 0-10 based on a key

and their answers. Participants were divided into four groups based on the four major blood types (A, B, O, AB). A one-way ANOVA with an alpha value of .05 was used to analyze the data. This resulted in a p-value of .11. Therefore, the research hypothesis that stated, if the relationship between blood type and extraversion is tested, then people with Type O blood type will be more extroverted, was not supported. In conclusion, this study revealed no significant difference between blood types when it comes to personality.

Honorable Mention
Ankita Mandal- The Effect of Social Media During Isolation on Mental Health
Mills E. Godwin High School

Social media has been a reliable source of entertainment for years, but as its use expanded during pandemic-related isolation, users faced greater impacts. The effects of the added exposure to social media on the mental health of teenagers in high school were investigated to observe how impressionable teenage minds have responded to such circumstances and, on a greater scale, the impacts of increased social media use as isolation became more normalized. The three leading platforms tested were Instagram, TikTok, and Snapchat. The hypothesis stated that if a participant used TikTok, then they would experience the most detrimental effects to their mental health for all three checkpoints - stress level, confidence level, and overall mood with aid from a psychologist and mentor. Eligible participants completed an anonymous survey on these checkpoints with ranking scales from 1-5. All participants were informed of the anonymity of their responses and their ability to exit at any time. There was no control as the number of people without social media was not significant. Chi-square tests were performed on each checkpoint for every level. For an alpha level of 0.05 and degree of freedom of 2, all chi-square values for each level exceeded the table value of 5.991, rejecting the null hypothesis in all scenarios and proving the data to be statistically significant. TikTok was most detrimental for two of the three checkpoints, and this indicated the research hypothesis was partly supported. Reasoning for the results defer to the content catered by each platform, features such as likes and comments, and the types of algorithms used.

Honorable Mention
Charlotte Maxwell- Fast Fashion Epidemic: Relationships Between Impulse Purchasing and Environmental Impact Considerations
Central Virginia Governor's School

The purpose of this project is to improve the societal perception of fashion choice impacts by examining clothing purchases and environmental implications. This study examined the differences in purchasing behaviors between two age groups; 14-18 year olds and 30 plus year olds, all recruited from local schools and city government. Each participant was sent a Google Forms survey which asked generic questions about various factors of their clothing purchases and then was analyzed by receiving two different scores calculated from the survey; environmental consciousness (EC) and impulse buying (IB) score. Two

2-sample t-tests and two regression tests were then run, with a set alpha value of .05. The t-tests resulted in p-values .2 (EC) and .08 (IB), and the regression tests resulted in p-values .9 and .9. The research hypotheses that if two different age groups are surveyed about their purchasing habits, then the younger age group will have more of a desire to impulsively purchase clothes and less of the desire to think about the environment; and the EC and IB scores comparison will show a significant inverse relationship for both age groups, were not supported. In the context of the experiment, it can be assumed that age does not have a significant influence on the environmental problems of the fashion industry.

Honorable Mention
Emaline Basye- Reading vs Video vs Interaction: What is the Most Effective Way to Learn
Chesapeake Bay Governor's School

Learning is a crucial factor of life; it would be ideal to know the most effective way to learn. Comprehension, the main process that aids learning, occurs in multiple ways, including through visuals and auditory methods. Due to there being different types of comprehension, there may be a particular learning method that, overall, could be the most effective, or this may be a person-by-person basis. Other factors, such as sex and GPA, have been found to cause differences in learning through other studies conducted. This study compared the effectiveness of different learning methods, reading, video, and interaction, by having 30 participants, with parental consent, learn steps in order to solve a Rubik‚Äôs Cube. Comparisons were not only made between instruction methods, but also the sex, GPA, and matching of a learning inventory survey, all regardless of instructional method, to potentially find other correlations to learning. The results found significant differences between the video and interaction groups and the reading and interaction groups. With these results, it was found that those using an interactive learning method learned a very statistically higher amount compared to those in a video or reading method. No significant differences were found between other compared groups. Knowing that interactive learning proved to be the most effective, this can be used in classrooms, and individually, worldwide to ensure that learners are being given the best instruction tactics in order to learn more effectively.

Andrew Klinger- The Effect of Different Locations on Face Covering Compliance
Washington-Liberty High School

One in less than seven Americans have had a confirmed case of the Coronavirus. A lot of progress has been made throughout this journey, but we are still far from a world without the presence of COVID-19. The purpose of this experiment was to determine whether the location in Arlington, Virginia influenced the number of people wearing a face covering. In this experiment three different Arlington locations were observed: Ballston, Courthouse, and Colombia Pike. The Colombia Pike location had the lowest population density, Ballston was in between, and Courthouse had the highest population density. To

add, both Ballston and Courthouse had populations made almost entirely of young adults (ages 25-34), while Colombia Pike had a population with more middle-aged adults (ages 25-54). It was hypothesized that if the location in Arlington was the Colombia Pike corridor, then the lowest percentage of people would be wearing a face covering outdoors in public. This hypothesis was accepted because the Colombia Pike location observed an average of 9.71% of people wearing a face covering. The Ballston location observed a mean of 14.79% of people wearing a face covering. Also, the Courthouse location had the largest percentage of people wearing a face covering with an average of 26.76%. Please note, this experiment was conducted in early November, before the large surge in Coronavirus cases in Arlington due to the Omicron variant. The null hypothesis stated that the location in Arlington does not affect whether people are wearing a face covering outdoors in public. The data was proven to be statistically significant by an ANOVA test and multiple t-tests. Therefore, the null hypothesis was rejected. This experiment showed that different locations within Arlington, Virginia affected whether people were wearing a face covering.

Arika Gray- The Correlation Between Social Media Usage and Adolescent's General Happiness, Social Satisfaction, and Social Connectedness
Chesapeake Bay Governor's School

Understanding mental health as a teenager can be really difficult, especially with the addition of social media. This experiment seeks to help clarify and provide more insight on how big of a part social media plays in the mental health of adolescents and what this could mean for the future generations. In short, my experiment explored the link between social media and mental health. Every evening for two weeks, I gave participants between the ages of 14-18 daily surveys to fill out. These surveys consisted of a few questions on their current satisfaction with their social interaction and connectedness, overall happiness, and the amount of time they had spent that day on social media. The questions about social satisfaction and happiness were answered using scales, so all of the data was numerical. This data was put into Excel and then analyzed using the Statistical Package for the Social Sciences Bivariate Correlation Analysis tool. I had predicted that the results would show that the longer a person is on social media daily, the happier and more satisfied with their social interaction and connectedness they would be. Contrary to my hypothesis, my study found that social media may have a negative impact on many adolescents' happiness, social satisfaction, and social connectedness.

Claire Chang- The Reliability of Digital Divergent Thinking Tests
New Horizons Governor's School for Science and Technology

As educators shift more toward digitalization in their classrooms, the topic of how digitalization affects all areas of education becomes more prevalent, and of those, specifically testing. Assessments in the present day have also broadened to encompass testing of various processes of thought, including that of divergent thinking. However, it is still inconclusive whether digitalization could affect performance on tests with elements

of divergent thinking, as several studies have produced contrasting results. Therefore, the current study aims to address this issue by administering a divergent thinking test through both digital and paper-and-pencil means. By recruiting sixteen participants from a high school, a test, consisting of the Guilford Alternative Uses Task and the Wallach and Kogan Creativity Test, was administered. The results, analyzed through paired t-tests, indicated that digitalization has a negative effect on the scores of the divergent thinking tests, in the cases of originality, flexibility, and elaboration. However, in the instance of fluency, similar results were produced between the two groups. Thus, it can be concluded that digitized tests that include elements of divergent thinking are not reliable and require more refining in order to be properly instituted in an educational setting.

Colin Mayhew- The Effect of Photographic Presentation on the Visual Appeal of Dog Adoption Candidates
Mills E. Godwin High School

The purpose of this experiment was to determine if the manner in which a dog is presented in a photo significantly affects the visual appeal of dogs, increasing their chances of adoption. The data gathered from this experiment is useful and relevant to current issues because of the highly online nature of dog adoption in modern times and because of need to relieve shelters of their dogs waiting to be adopted. Four different photo styles were tested against each other. A survey was filled out by 25 people. This survey included 10 questions, each question a different breed of dog, each selecting one answer choice from the presented IV levels. It had been hypothesized that the photos exhibiting both eyes towards the camera and heads tilted would perform the best. The results of this experiment concluded that this category did receive the most positive responses. The Chi-square test turned out to be significant, showing that the mode was indeed the mode by a significant margin. Therefore, the hypothesis has been shown to be supported by the data collected and statistics performed.

Eden Mitchell- Autonomous Sensory Meridian Response: The Use of Auditory and Visual Stimuli
Southwest Virginia Governor's School

Around 60 million people across the United States suffer from some type of sleep disorder, including insomnia. Troublesome side effects often result from a lack of sleep, including delayed reaction time, forgetfulness, and a weaker immune system. Many people who do suffer from sleep disorders turn to outside tools to aid them in falling asleep; one of these tools is known as ASMR (Autonomous Sensory Meridian Response). A result of ASMR is stimuli that will create frisson (also called "goosebumps" and "tingles"), which will eventually result in the person who is listening and viewing the video to fall asleep. This research project wanted to determine if there was a significant difference between the total amount of frisson created from auditory stimuli and visual stimuli in order to potentially aid those who are affected by sleeping disorders. In this

research, participants were asked to listen to an ASMR video without looking at the screen and watch the same video without the audio. They kept track of the frisson they experienced by writing one tally mark in the box that corresponded to the section of the project they were on (either listening or watching).A sample size of 30 participants was collected and then statistically analyzed through a matched pair two sample t-test. The p-value (Prob > t) was 0.0146. Since the p-value is less than the level of significance, which was set at 0.05 prior to beginning any testing. The results from this research project support the alternate hypothesis. There is enough evidence to support that there is a significant difference between the total amount of frisson created by auditory stimuli and the total amount of frisson created by visual stimuli. Further research is needed to determine which specific types of stimuli, both auditory and visual, create the most frisson.

Elijah Tegenkamp- Effects of Playing Video Games on Reaction Time in Adolescents
Southwest Virginia Governor's School

While research has been done indicating that playing video games reduces reaction time in humans and older humans, less research has been done specifically on adolescents. This research project tested to see if there was a correlation between the amount of video games played and reaction time in adolescents and additionally if there was a difference in reaction time based on the type of video games (action-based, non-action based, or none) played in adolescents. Participants' hours per week spent playing video games, primary type of video games, and reaction time were measured. The amount of video game play and reaction time were compared using linear regression, and the mean reaction times for the three groups were compared using an ANOVA test. The p-value of the linear regression was 0.0378 and the p-value for the ANOVA test was 0.2308 (with an alpha of .05 for both), which seems to indicate that while the type of video games played has no effect on reaction time in adolescents, the amount of video games played does. Taking into account other research, it would seem that playing video games reduces reaction time in all age groups of humans. Further research could attempt to analyze what aspect of video game play reduces reaction time to help find ways to reduce reaction time.

Eric Zhou- The Effect of Bilingualism on the Stroop Task
Mills E. Godwin High School

Given that previous studies have led to inconsistent results on the benefits of bilingualism, more research and experimentation is needed to gain more insight on the topic. The cause of these inconsistencies may be due to an imbalance of test subjects, the experimentation of the wrong demographic, inconsistencies in the type of tests administered, and the way that the results are measured. This experiment tests monolinguals and bilinguals with the Stroop Task, a neuropsychological test used to assess the cognitive ability of participants. An online Stroop Task was made and administered to a group of 25 monolinguals and 25 bilinguals aged 16-18 to see which group was more proficient at the task. It was hypothesized that if the Stroop Task is

administered to both monolinguals and bilinguals, then there would be no significant difference in completion time. When the data was collected and analyzed, the bilinguals completed the task 0.44 seconds faster, although the data was not significant. Many explanations for this have come up in studies similar to this one, and the most probably reasoning for the results is that the bilingual advantage exists, but since the specific age group is near the peak of cognitive development, the advantage provided by bilingualism is too small to notice. This, along with knowledge that the bilingual advantage is significantly evident in age groups from 60-90, supports that bilingualism provides an advantage with executive function. Further study could involve how different types of experimentation (Stroop, Simon, etc.) affects the perceived bilingual advantage.

Faith Jacob- Secondary Traumatic Stress in Different Fields of Healthcare Workers
Central Virginia Governor's School

The purpose of this study was to examine how certain factors affect Secondary Traumatic Stress (STS) in healthcare workers. The research hypothesis was that females and nurses would have a significantly higher score on the Secondary Traumatic Stress Scale (STSS) than that of males, respiratory therapists, doctors, social workers, and psychologists. Data was collected by contacting other researchers and requesting to use their data. This data was of respiratory therapists, nurses, doctors, social workers, and psychologists‚Äô STS scores. The STSS has three subscales. Having said that, eight tests were conducted. Four t-tests were conducted to compare females and males‚Äô intrusion, avoidance, arousal, and total scores. One-way ANOVA tests were also conducted to compare the respiratory therapists, nurses, doctors, social workers, and psychologist‚Äôs intrusion, avoidance, arousal and total scores. Significance was found in the test run comparing females and males‚Äô arousal scores. With an alpha value of .05, the p-value was .0045. There was also significance under the profession‚Äôs avoidance scores. Again using an alpha value of .05, the p-value was .003. The research hypothesis was partially correct. There was significance found in comparing females and males, but the significance for professions was found between doctors and psychologists, not nurses. This experiment provides evidence that STS is a serious issue that must be addressed in the healthcare field.

Hannah Marrone- STEM Interest Inequality by Gender and Secondary Education
Southwest Virginia Governor's School

With the steady rise of the STEM-force, diversity in the industry is vital now more than ever. Gender inequality has proven to pose difficulties in its success. This has led to the growth of STEM-focused programs for secondary students. As private institutes, the curriculum of these schools vary. The expectancy-value theory of education suggests career interest is heavily influenced by attitude and self-efficacy. Utilizing a survey to understand student interest and attitude towards STEM by program and gender may open sight of the instructional methods that are most efficient. C-STEM published the results of an experiment where a *Students' Attitudes Towards STEM* survey was provided to C-

STEM students and other STEM-based schools. Three categories of information were measured: engineering proclivity, 21st century skills, and career interest. Comparisons of these groups by gender and school were performed where significant differences were identified. A replication of this study was conducted in order to broaden the sources of data collection and provide unbiased figures to the research. Evaluations of the two experiments were conducted employing Chi-Square Goodness of Fit Tests and a Two-Sample T-test. Significant difference was seen in engineering proclivity ($p<0.001$) and numerous of the career interests depending on education: medicine ($p=0.0315$), computer science ($p<0.0001$), medical science ($p=0.0039$), energy ($p<0.0001$), and engineering ($p<0.0001$). Results provided some evidence that C-STEM is yielding students with a higher positivity and interest towards the STEM-force. Significant differences by gender were also expressed within both schools where males had higher interest in computer science and engineering. Low participation (16 surveys returned) caused limitations and reliability concerns; thus, incentives may be issued in future studies to increase sample size. A pre-survey is also suggested. Comparison of a pre and post survey will allow for more accurate results of these schools' influence on their students.

Harbalbeen Rai- Testing Health Literacy in Females in Southwest Virginia
Southwest Virginia Governor's School

It is estimated that millions of people have difficulty in understanding and using health information, which indicates that these people have a low health literacy. Having a low health literacy can be harmful for a person, as they lack the ability to understand how their body functions and what to do when something abnormal occurs. A rising concern is a correlation between health literacy and females' behaviors, especially rural females. Various studies have indicated that females tend to score lowly in terms of their own health literacy. This was extremely prominent in rural areas where basic literacy was not public and informing the public about health topics was not very emphasized. Through this project, 47 teenage females from Southwest Virginia were asked to complete a survey, where the participants rank their confidence in certain female health issues- yeast infection, urinary tract infection, and breast self-examination, then answering questions to see their accuracy on the material. The null hypothesis is that the distribution of correct responses will be the same for all confidence responses, while the alternative hypothesis is that the distribution of correct responses will be different for confidence responses. A chi-square test of homogeneity was conducted, having the confidence be the independent variable and the accuracy of the knowledge-based question to be the dependent variable. As a result, a majority of the questions were not statistically significant (>0.05). This caused the researcher to fail to reject the null hypothesis, meaning that the distribution of correct responses were the same for all confidence responses. Possible reasons for these results could be the sample size (specifically in certain confidence categories), and the wording of the questions. Future research should continue to look more specifically at how health literacy affects a female's daily life or how personal experience may impact one's understanding of health literacy.

Psychology B

First Place
Misthi Choksi- The Effect of Brain Systems on Perceived Effort of Multitasking
Mills E. Godwin High School

The purpose of this study is to determine if using different brain systems influence the perceived effort to multitask. The working memory model is a system that uses information for cognitive utility. In the working memory model, there is the phonological loop, visuospatial sketchpad, and central executive. This experiment focuses on the phonological loop and visuospatial sketchpad and how using these functions effect the perceived effort to multitask. Studying brain functions can help in various ways from research in neuroscience to enlightening people about performance after multitasking. It is hypothesized that if two different brain functions are used, then the perceived effort will decrease. There is no control because there is no normal brain system that the independent variables can be compared to. Conducting the experiment involved participants completing two tasks that involves certain brain systems, simultaneously. A rating scale was used to measure how easy or difficult the tasks were to complete. The results revealed that using the phonological loop and visuospatial sketchpad simultaneously was the easiest to multitask. A Friedman test was conducted, which showed that the type of brain system used led to statically significant differences in the perceived effort of multitasking. The null hypothesis was rejected. A post hoc Wilcoxon signed-rank test was conducted as well, which revealed that there were significant reductions in the multiple comparisons. Since visual and verbal information are processed on different hemispheres of the prefrontal cortex, the brain can perform two tasks simultaneously easier than in the same hemisphere.

Second Place
Madison Hamlin- The Effect of Birth Order on Intelligence Quotient (IQ).
Central Virginia Governor's School

The purpose of this study was to discover if there is a connection between the order in which people are born and IQ, in order to build upon our society, play into people's strengths, and build a better community. This study was conducted at a local high school during November and December of 2021. To make this possible, participants were asked to take an online IQ test and complete a brief survey asking for their birth order. Each IQ score was recorded under the appropriate birth order. An ANOVA test produced a p-value of .83, which when compared to an alpha of .05, showed no significance. The research hypothesis, if people from varying birth orders take an IQ test, then those who are first born will score higher than subsequent places in birth order, was not supported. Although there was no significance, this study was just one step into discovering the implications of birth order, in hopes to expand society's knowledge on individuals.

Third Place
Kaleigh Temple- Determining the Most Effective Method for Word Acquisition
Southwest Virginia Governor's School

People communicate with words every hour of every day. Despite this, there is still a very large communication gap between one person and the rest of the world due to language barriers and even not understanding certain words. Word acquisition is a scheme in which words can be learned. Taking that aspect into account, this project is solely based on finding out which method can best accomplish word acquisition, so that it can be applied in learning to better communicate as a whole. In total, 40 participants were split into four groups of 10. The first group was given a certain word in Swedish along with the definition of the word. The second group was given the same word, but instead of the definition, they were given a picture of the word. The third group used the same word but were orally presented the word and its definition. The fourth group serves as the 'normal', and they were given the word with the definition, picture, and they could listen to it as well. All of these groups had fifteen seconds to review their word, then they were given a list of 20 different words to arrange into alphabetical order. This task was meant to distract them. After arranging the words, they were allowed to select the correct word from four different options. The data collected allows people to determine the method that will be most effective when learning a new language, or simply learning new words. The collected data from this project shows that both visual groups completed their tasks more accurately than the other groups. Therefore, teaching or learning another language would be most effective if taught with definitions on paper and in pictures. One factor that would improve the results had there been no limitation on the project would be the population size. Increasing the population size would allow for more accurate results

Honorable Mention
Jackson Laughon- The Effect of Distractions On a Golfer's Putting Ability
Central Virginia Governor's School

The purpose of this study was to determine if distractions influence golfers while putting. This study was conducted at a local golf course during November and December of 2021. Six participants from a local high school golf team were asked to try to make a putt from approximately six feet away. Each putt was attempted four times while being broken into four groups. One group served as a control, another consisted of crowd noise, and the two other groups included putting with the flagstick in, and using a different, unfamiliar putter. Afterwards, participant‚Äôs putting percentage from each distraction was calculated. These putts were then averaged using a calculator, and an ANOVA single factor test was conducted to analyze the data. The ANOVA, with an alpha level set at 0.05, revealed a p-value of .390. This non-significant value did not support the research hypothesis, which stated: If golfers are subjected to several distractions during putts, then the crowd noise will affect their putting success more than the flagstick and a different putter. Distractions had no statistically significant effect on a golfer‚Äôs putting ability and

are important to understand in not just sports settings, but in a world where distractions occur in our daily lives.

Honorable Mention
McKenna Condrey- The Mental Health Effects of The Coronavirus Pandemic on High School Students
Chesapeake Bay Governor's School

The goal of this study was to analyze the effects the coronavirus pandemic had on high school students‚Äô mental health. A voluntary anonymous survey consisting of 10 questions split into 5 groups analyzed the changes of the participants ability to focus, ability to sleep well, ability to connect with others, feelings of anxiety, and feelings about their future. A Likert scale ranging from 1(never) to 5 (constantly) was used to determine the changes the participants faced throughout the three different phases of the pandemic. The three phases of the pandemic that were analyzed were before the pandemic, during the height of the pandemic, and now as we return to a sense of normalcy. 113 Virginia high school students between the ages of 13 and 18 participated in the survey. Of the 113 participants, 63.7% were female, 35.4% were male and 0.9% were gender non-conforming. On average, the participants felt the most negative mental health changes during the height of the pandemic. During the height of the pandemic adolescents showed statistically lower mental health rates than that of before the pandemic and after. The coronavirus pandemic took a toll on the mental health of high school students in many ways. However, as we return to a sense of normalcy the negative mental health rates of adolescents are increasing back to the rates of before the pandemic. School counseling and other resources should be put in place in high schools to ensure that the mental health of adolescents is restored.

Honorable Mention
Yousif Shakroo- The Effect of Light on Stress
Mills E. Godwin High School

The effect of light on stress was done to determine the overall impact of light on the blood pressure of an individual, and in turn, their stress levels. This was researched because of its implications in treating illnesses such as Seasonal Affective Disorder. It was hypothesized that if individuals were shown a blue-green calm array, their overall blood pressure would decrease and in turn, their overall stress would too. The control was no light, due to how there was nothing shown to the individual. The experiment was conducted by having volunteers first sign a permission form. They were then shown a light array through 3D goggles to minimize the amount of outside light shown to them, and the change in blood pressure from before and after treatment was recorded. On average, the blue-green light array led to the largest average decrease in blood pressure (-13.98 change in the systolic), while the red-white array led to higher blood pressure (+9 change), and the white and no light arrays led to no significant change (-1.2 and -3.8 respectively). All t-tests for blue-green light had significant results (2.294 and 2.012

against a table t of 2.011), while no light and white light were insignificant, and red-white was significant in the systolic while it wasn't for the diastolic. These results could be due to how the brain finds blue-green light more calming, and how the brain finds flashing red-white a bit more stressful.

Jack Pitts- The Relationship Between Color and Long-Term Memory
Central Virginia Governor's School

This study was to determine color's relationship with long term memory in order to provide better understanding of the human brain and strengthen study habits for students. Participants consisted of students from the same region in Virginia and they were asked to remember worded numbers ranging from 1-12 of either different or similar color. Each participant received a new set of colored numbers for each of the three week-long trials. After the data was collected, a Chi-Square test of independence produced a p-value of .99907, and when compared to the alpha value of .05, showed the data to not be significant. The research hypothesis was not supported which predicted that women remember yellow words, and men remember blue words better than the other colored words. The research suggests that in this case, the time during the experiment may have been too long because after a week, the memory of all colored words was not fully retained. While future experiments dealing with color memorization could help students with their study habits, it could, in addition, help people with mental restrictions/disabilities by using the results to help them focus on their reading.

Jessica Long- Music and How it Affects Cognitive-Motor Skills and Relaxation
Southwest Virginia Governor's School

Music has been seen as beneficial to people while working and while relaxing, however, because of how different the brain reacts to music it overall has mixed results. In this study, the goal was to bring more evidence into music being both beneficial to cognitive tasks and relaxation. The hypothesis was classical music will work best for concentration, and listening to music while relaxing would be most beneficial. To test the hypothesis a sample size of 69 students at a magnet high school were used, the range of age being from 15-18. These participants were put into 2 groups, the cognitive task group, and the relaxation group. To test the cognitive tasks portion, participants were asked to sort sheet music in instrumental sections in 5 minutes 2 times, once without listening to anything, once while listening to a randomly selected genre. To test the relaxation portion, participants were asked to fill out two self-assessments, before and after they did the experiment. The experiment part was while relaxing they were listening to a genre of music to which they were randomly assigned. The results for the cognitive group came inconclusive, there were not enough participants to show which genre helped the most or if it helped at all. The results for the relaxation group were significantly different, with p-values of 0.0488 and 0.0129 and 0.001 and 0.008. Showing that listening to music was helpful while relaxing. These results were beneficial to the music therapy area as they can help patients with relaxation. For the cognitive task portion, more research and

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experimentation would be needed to conclude anything with p-values of 0.680, 0.549, 0.871, and 0.538.

John Hoegerl- The Effect of Personality Type on Music Preference
Central Virginia Governor's School

To study the potential relationship between personality type and music preference, research was conducted measuring the personality type and music preferences of twenty-nine students from local high schools. The students took a survey consisting of the Big Five Personality Test and the Short Test of Music Preferences, in addition to other questions about music interest and preferences written for the study. No statistically significant relationship was found between the two variables, with each regression p-value comparing the personality trait to the music preference factor from the STOMP test being above or equal to the alpha value of .05. The two personality traits most closely examined were Extraversion and Neuroticism, and the two STOMP factors most closely examined were Mellow and Intense. The p-value between Extraversion and Mellow was 0.65, between Extraversion and Intense was 0.71, between Neuroticism and Mellow was 0.9, and between Neuroticism and Intense was 0.34. Therefore, the study did not support the hypothesis that if someone likes more energetic, rhythmic music, they are more likely to be extroverted in personality, while if someone prefers more sad or slow music, they are more likely to have more neurotic personality traits. The study did, however, succeed in providing valuable insight into music interest and personality traits.

Kendra Kraisser- The Correlation Between Academic Performance/Grade Satisfaction and Student Stress Levels

Stress affects high school students in different ways. Some may be motivated to work harder while others mentally disconnect to avoid it. The purpose of this study was to determine if any correlation exists between academic performance/grade satisfaction and stress levels in higher level secondary students. With the prediction that as satisfaction increases, stress decreases, a correlation with statistically significant data was found that supported the hypothesis that the students who are more confident will experience less stress. It was also suggested that the aspect in which students feel the most stress is academic overload.

Landon Shepherd- Students Before And After Receiving Information On Portion Sizes Assessment
Southwest Virginia Governor's School

Information on portion sizes is not taught enough to younger children and adolescents. Without such information it can be almost impossible to maintain a healthy diet. This study attempted to determine how much adolescents knew about food portion sizes. In order to answer this question, a survey was conducted that evaluated 40 high school students,

between the ages of 16-18. The survey had a pretest and a post test, where before the post-test the participants were given information about portion sizes to use. Each participant was asked to look at pictures of 4 food types; fruits, vegetables, meats, and grains. The data were analyzed using a matched pairs t-test, and the p-value was calculated at less than 0.0001. This p-value indicated that the pre and post-test were significantly different compared to each other. Other results were calculated, such as the mean scores between each test. The matched pairs test found that the mean score for the pre-test was 26.25%, and the post-test had a mean score of 93.75%. This jump in mean scores, and the p-value showing the test scores would be different, indicated that the information played a significant role in aiding the participants. While there is still a need for further research, the results indicate that adolescents need education about portion sizes.

Madelyn Snow- Testing the Difference in Mental Stimulation Between Playing and Listening to Music
Southwest Virginia Governor's School

Music is a form of art that has been shown to be a mental stimulant. However, there has not been much research on the amount of stimulation or differences between playing and listening to music. This project tested musicians to see if there was a difference in their levels of mental stimulation while performing no tasks, playing their instrument, and listening to a piece of music. The mental stimulation levels were measured by the MindFlex EEG (electroencephalogram) headset, and measured on a scale of 0-5, where zero represents the lowest amount of mental stimulation. The data for each testing criteria were analyzed with an ANOVA test. The test types had the means and standard errors as follows: Baseline 2.34 +/- 0.11, Listening 2.90 +/- 0.11, Playing 2.91 +/- 0.11. The ANOVA resulted in a p-value of 0.0001. After a Tukey HSD test was administered, there was shown to be a significant difference between the levels of mental stimuli in two pairings. Baseline to Playing had a p-value of 0.0005 and Baseline to Listening had a p-value of 0.0006. This means that both listening and playing were significantly different from the baseline readings, demonstrating the mental stimulus that occurs is greater while performing those activities compared to baseline. This was supported by the alternate hypothesis. Since participants were asked to play for two minutes without any music to read, this project could be repeated with a single piece of music for all participants to read. In addition, the MindFlex headset has a limited number of electrodes, so more professional equipment could be used to further this research and obtain readings that include more regions of the brain beyond the frontal lobe. Studies like this could be used to help further our understanding of mental stimulation and the mental benefits of music.

Mary Myers- The Effect of Feedback on Students' Pattern Memorization Scores
Collegiate School

The goal of this experiment is to determine how comparative feedback affects students‚Äô confidence, as well as their scores on a pattern memorization task. Students were

randomly divided into three groups: a positive comparative feedback group (participants were told that their results were above average/better than their peers), a negative comparative feedback group (participants were told that their results were below average/worse than their peers), and a group without comparative feedback after their first attempt (control group). Students filled out online forms to rate their confidence in pattern memorization, memorize a black-and-white pattern of tiles, recall the patterns and rate their confidence again after the second attempt. After the participants' first attempt to memorize a pattern, an email was sent to them with randomly-assigned positive, negative or neutral feedback. Once the randomized feedback was received by the students, which was believed to be true feedback about their first memorization attempt, the students attempted a second pattern task. The second pattern was similar in number of pattern tiles, but in a different sequence. Results show that negative comparative feedback (-1.2 ¬± 0.6 change in pattern tiles memorized correctly) lowered student performance the most, but positive feedback (0.6 ¬± 0.7 change in pattern tiles memorized correctly) and neutral feedback (0.7 ¬± 0.9 change in pattern tiles memorized correctly) showed little to no difference in students' success and confidence. While this difference in memorization performance between all feedback groups is not significant (ANOVA, df = 38, p = 0.06), this initial evidence suggests that more research with a larger sample size might better demonstrate how negative comparative feedback impacts performance. Knowledge about comparative feedback is helpful in many different settings. Whether it's at school or a job, people are constantly hoping to improve their skills, and feedback can help with that by providing insight on performance.

Matthew Magtoto- The Effect of Generation on Peer Pressure Induced Vices
Mills E. Godwin High School

The experiment was conducted to determine if any generations engaged in more vices (underage drinking, smoking, vaping, and drug use) or were affected by peer pressure more than another. Potential implications include further promotion against underage vices and drug abuse, especially if Generation Z partakes in these activities the most. The hypothesis was if three generations are asked about various vices and peer pressure, then the younger generations will answer affirmatively the most. Between the different groups of Generation X, Y, and Z, no control was present due to age having no control. Potential volunteers were given an explanation of the experiment and asked to complete an anonymous survey   about their activity and experiences concerning vices and peer pressure if willing to participate and after signing a Human Informed Consent Form. When data of 25 participants for each generation (75 total) was collected, a graph and tables were created and inferential statistics were performed. Contingency chi-square tests were performed, testing each of the five categories, to determine if the three generations yielded numbers of "Yes" and "No" answers greater or less than the expected values. It was found that alcohol, vaping, and drug use were statistically significant, which also supports the research hypothesis because Generation Z had the most "Yes" answers, followed by Generation Y (except for drug use). Although underage smoking and experiences with peer pressure followed the same trend, the frequency distribution was not far enough from the expected to be statistically significant.

Reese Kennedy- Examining Relationships Between the Stress of Daily Activities and Dreams/Sleep Quality
Central Virginia Governor's School

The purpose of this study was to determine whether stress has a significant effect on dream content, dream recall, and overall sleep quality and quantity. A survey was sent out to 66 students from several local high schools on two sequential Fridays, that asked generic dream questions regarding recall and content, and adaptations of questions from the Pittsburgh Sleep Quality Index (PSQI) and Daily Stress Inventory (DSI). Regression tests performed on the participants' stress levels as related to their dream recall and their overall sleep quality/quantity scores, found the p-value for dream recall to be .014, time of going to sleep .004, time to fall asleep .003, average sleep time .002, and sleep quality .001. T-Tests assuming equal variances were then run on the participants' individual stress scores per category, and whether or not they had dreams related to these stressor events. For homework stress, the p-value was .028, stress relating to the future .0002, extra-curricular stress .0001, stress relating to academic tests/quizzes .002, and for stress relating to a negative experience with another person, .006. All of the above discussed categories were statistically significant (alpha of .05), and supported the research hypothesis: as the stress of daily activities increases, then dream recall and dream content relation will be more likely, and overall sleep quality/quantity will be worse. In conclusion, high stress levels do affect dream content, and make most sleep quality/quantity worse.

Sarah Miller- Relationships Between Participation in High School Extracurriculars and Future Lifestyles
Central Virginia Governor's School

The purpose of this study was to determine if an adult participated in a sport during high school, whether they will be more physically active, have more leadership roles, and have gained more valuable life skills during high school as compared to non-athletes. Thirty-nine adults were recruited from a local high school and they filled out a Google Form, created by the researcher, that asked them many questions that provided numerical and descriptive data. The data was then organized into tables and analyzed. After conducting three two-sample t-tests, with a set alpha of .05, it was determined that adults who participated in a sport during high school were more physically active, with a p-value of .03, and motivated to be physically active, with a p-value of .02, than non-athletes. The t-test results to determine if there was a significant difference between the participants' duration of physical activity was not significant and gave a p-value of .07. The descriptive data showed that sport participants felt like they gained more valuable life skills and all participants that participated in any extracurricular activity now have some sort of leadership role. The data partially supported the research hypothesis that if adults participated in a high school sport, then they will be more physically active than non-athletes, have more leadership roles, and have gained more valuable life skills during

high school. In conclusion, participating in a sport during high school will affect future lifestyles in certain aspects.

Statistical Analysis & Inferences

First Place
Sidhartha Basu- Statistics Behind Identity Fraud
Deep Run High School

Identity fraud in the United States is one of the fastest growing white collar crimes. In addition to causing millions of dollars in losses every year to the economy, it also encumbers the daily lives of victims through not only financial losses but also mental health problems. With rapidly growing online usage coupled with frequent news of major data breaches, identity fraud is expanding rapidly and is becoming increasingly sophisticated. A lot of the academic research in this space has been focussed on identifying individual level cognitive behaviors and interventions. Understanding a social evil like identity fraud is complex and needs to be analyzed and understood at a broader macro-level. This study uses statistical methods to understand the drivers of identity fraud in the US across a broad canvas of variables using data collected from 2005 to 2020. There were a total of 11 regressor variables used in this study including macroeconomic factors, socio-demographic factors, and criminal behavior factors. Using multiple linear regression, ANOVA, and multicollinearity analysis, we narrowed down the variables that are statistically significant in explaining the volume of reported identity fraud cases (dependent variable). The analysis proves that national unemployment rate, percentage of online banking usage and number of fraud crime offenders are the statistically significant variables in the presence of other variables that explain identity fraud at a macro level. Though not statistically significant, the growing number of data breaches and its impact on compromising personal data and hence identity fraud is a practically significant variable and cannot be overlooked. This study lays a macro level foundation to better understand identity fraud to facilitate more focussed research and intervention at the individual and societal level.

Second Place
Aiden Jun - Impact of the COVID-19 on Travel Patterns of Neighborhoods in Henrico County, VA
Deep Run High School

Due to the high death rate of COVID-19 and to prevent the spread of COVID-19, the mandated stay-at-home order has been issued in the United States. Accordingly, the travel patterns and behaviors of drivers have changed. This study evaluated the impact of the COVID-19 on neighborhood travel patterns (the number of trips and driving speeds). Unlike previous studies, this study obtained the number of trips from an

advanced data collection system using the location-based service (LBS) technology and collected hourly speed profiles from portable short-term traffic counters. As a result, this study found that while the number of trips from and to neighborhoods have decreased during the pandemic in comparison to trips during the pre-pandemic, driving speeds have increased during the pandemic. These results were statistically significant based on the result of the paired two samples t-Test. Finally, future studies will be helpful to understand different travel patterns based on age, income, education, household size, and trip purpose. In addition, post-pandemic data still needs to be analyzed and travel patterns need to be continuously monitored in neighborhoods.

Third Place
Colin Berry- Bringing Truth into Fake News: The Diffusion of Fact-Checked Fake Stories on Twitter
Yorktown High School

Several studies have shown that fake stories diffuses significantly faster, farther and deeper than true stories on social media. In this project, I seek to understand what happens to fake stories after a credible fact-checking source has confirmed that the story is false. Although prior research shows that the number of retweets of fake stories is much higher than true stories on social media, I seek to understand whether the diffusion of fake stories (by retweets) changes after a story has been fact-checked and publicly announced on Twitter to be false. This is useful to know because if Twitter can be used to spread false stories, it can also be used to correct false information and a high diffusion rate of the fact-checked tweet would help to discredit the original rumor or false story. Overall, I seek to better understand whether social media can be used to counter or kill the spread of fake stories and how much fact-checking stories diffuse on social media. Using the fact-checking site snopes.com, I analyzed fake stories from the 2021 calendar year that had available links to their origin. Looking at diffusion rates (retweet rates) right before and right after a false story is publicly confirmed to be false on Twitter, my results show no significant difference in diffusion rates over a one, three or five hour window. Considering the diffusion size (total number of retweets for fifteen days after tweet), fake stories have a significantly larger diffusion size than fact-checked stories on Twitter, with fake stories having an average fifteen day total number of retweets of 4659 versus 197 for the fact-checked stories about that false story. Taken together, this study suggests that fact-checked stories diffuse at a considerably lower rate and reach far fewer users of Twitter in addition to having no significant impact on the diffusion rate of the false news it is trying to correct. Although social media platforms provide instant connectivity and access to a wealth of information, this study emphasizes the difficulty of introducing truth into fake stories on Twitter. This suggests that once false information is out, its spread is difficult to stop or correct, making it increasingly important for social media users to reflect and research information before continuing to spread what they read on social media platforms.

Honorable Mention
Nate Stevenson- Analysis of EU-15 Greenhouse Gas Emissions Under the Kyoto Protocol from 1990-2019
Mills E. Godwin High School

This study intends to investigate the rate at which GHG emissions from EU-15 countries alter prior to and after the implementation of the Kyoto Protocol (2005). GHG Emissions (excluding emissions from land, land-use change, and forestry) are analyzed for each country and the average annual rate of change is calculated. The research hypothesis in this study states that the average annual rate of change in GHG emissions for EU-15 countries will decrease more from 2005-2019 than from 1990-2004 due to increased focus on reduction of emissions. The OECD GHG emissions data were collected and imported into R (the computer program used for this study). The dataset was separated into the fifteen members of the original European Union (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom). An additional dataset was created for EU-15 (aggregate emissions from each EU-15 country from each year). Fifteen t-tests were performed on the data of which twelve were significant at $\alpha = 0.01$. Additionally, the research hypothesis was supported by the data. Fourteen of the EU-15 countries decreased emissions at a greater rate following the implementation of the Kyoto Protocol. Additionally, aggregated emissions from EU-15 countries totaled a 15.0% decrease in emissions compared to 1990 by 2012.

Honorable Mention
Sattwik Nath- The Effect of Machine Learning Algorithms on Detecting Apple Freshness
Mills E. Godwin High School

The purpose of this experiment was to find an effective way of determining the freshness of a fruit by using a machine learning algorithm. The initial idea was to create a system that would look through a database of fruits to determine how fresh a fruit is. Often times, people purchase a fruit assuming it is edible, when in reality it is inedible, or vise versa. The goal of this algorithm is to determine the freshness of a fruit by comparing it to other fruits with known freshness. The output of the algorithm was determined by a rating given after comparing the picture with the database. The ratings given were either unripe, ripe, overripe, or rotten. No control was present because there is no normal stage for an apple to be in. Twenty-five unripe, ripe, overripe, and rotten apples were collected to help conduct the experiment. Pictures were then taken of each apple and put into the algorithm. It was hypothesized that if a machine learning algorithm is trained with pictures of apples in different stages of freshness, then it will accurately predict the freshness of an apple. The data from the algorithm was collected and it was determined that it was significant for all four levels of IV. The outcomes showed that it was accurately predicting most of the apples, but had trouble determining overripe apples with only 15 correctly classified. This was most likely caused by the similarity between overripe and rotten apples and a small database.

Honorable Mention
William Xiao- The Effect of COVID-19 on the USA House Market
Mills E. Godwin High School

The purpose of this study was to find the varying effects of COVID-19 on the median house price of metropolitan areas in the USA. Recently, the necessity for houses has increased due to the COVID-19 pandemic and the desire to stay indoors as well as the introduction to working from home. Four different factors were tested upon, COVID-19 deaths, house supply, unemployment rate, and mortgage interest rate. A linear regression model was made to determine the varying level of effects each of the variables has. The control in this study was the 2018-2019 house price data as the COVID-19 pandemic started in March of 2020 so this gives a proper measure of pre COVID-19 house prices. The formed hypothesis is that house supply causes the greatest change in house prices. A t-test was used to compare 2018-2019's house price data with 2020-2021's house price data which revealed that the difference was statistically significant. The results showed that unemployment rate had the largest effect on house prices which did not support the research hypothesis. The reason unemployment rate had the greatest effect is because house supply does not have as much of an impact as expected. Likewise, unemployment rate was affected the most by COVID-19, surpassing the zenith of the 2008-2009 economic crisis, thus causing a greater change in the house prices. Further research can be conducted using other economic sectors like immigration and tourism or by changing the target demographic

Cane Hornberger- The Effect of a New Technology Release on the Stock Market
Central Virginia Governor's School

In this paper two relationships were analyzed. The first was the effect of a company releasing a product and the effects on their own stock price. The second relationship was the effect of a company releasing a product and the effects on the price of other related companies. To perform this analysis, ten release dates from five big tech companies Apple, Amazon, Microsoft, Google, and Meta over the past 10 years were collected. After the release dates were collected, prices of stocks for each company both before and after every release date were collected. To assess the relationship of the stocks to one other around product release dates, multiple regressions were used. The percent change in stock of one company's releases was compared to the other companies,Äô change in stocks to determine if there were any impacts on each other. The results after running the regression statistical tests was that multiple companies had a significant positive relationship with one another, as the majority of the p-values were below the set alpha of .05. This outcome did not support the proposed hypothesis that, when a company releases a new product they will have a negative relationship to companies that are related to them. The hope of this research was to help financial investors make educated investments and increase capital gains.

Emily Giles- The Effects of Heavy Workloads and Other Factors Upon the Mental Health of Student Athletes
Central Virginia Governor's School

The objective of this project was to determine if there was a correlation between the amount of work that student athletes have and their mental illnesses. This data mining project relied upon published research studies pertaining to mental illnesses and injury in student athletes. After collecting all of the necessary research articles, the data was compiled into categories for analysis using a series of regression tests and a paired t-test. Regression test results, compared to an alpha of .05, revealed a significant correlation between mental illness and workload by having a p-value < .0001. The correlation between injury and workload had a p-value of .02976. The final regression including mental illness and injury had a p-value of .0056. The paired t-test for pre and during COVID-19 produced a p-value of .127, which was not statistically significant. Finally, a scatter plot graph was made showing the relationship between injury and mental illness, where the injury was a result of over working. This showed that as injury cases increased so did mental illness cases. All of this demonstrated statistically significant differences which supported the research hypothesis, which was that if student athletes become severely overworked between academic, social, and extracurricular activities, then there will be a correlation between mental illnesses and the workload of student athletes. In conclusion, the amount of time spent working, training, completing school work, etc. have direct and indirect effects on mental illnesses, as seen in student athletes.

Evan Martin- The Effect of Spin Rate on Pitcher and Batter Performance
Central Virginia Governor's School

The purpose of this research is to find out how much a pitcher's spin rate actually affects their performance, as well as that of the hitter. Using five left-handed and five right-handed pitchers data was collected on their average rpms for their fastball, offspeed (changeup), and breaking ball (slider/curveball) from the 2017 year, while also collecting their velocities for those pitches. Then data was collected for four statistical categories which are ERA, WHIP, strike out%, and barrel% from the MLB for all ten pitchers. A single-factor ANOVA was run for the velocity and spin rate. With the alpha level set at .05, the p-values for both tests were 1.41×10^{-05} for the pitch velocity and an 8.02×10^{-07} for the pitch spin rate. Post-hoc Tukey tests revealed that the significant differences were between the fastball and breaking ball spin rates. Six regression tests were done on the breaking ball spin rate and three of the statistical categories. After all the data was analyzed only half of the research hypothesis was supported, which stated that half the data consumed showed significance to the research question. In summary, the experiment and study went collectively well even through the ups and downs.

George White- Minority Involvement in Advanced Placement and Dual Enrollment Courses in Virginia High Schools Over Time
Central Virginia Governor's School

The purpose of this study was to determine if minority student involvement in Dual Enrollment (D.E.) and Advanced Placement (A.P) courses have changed over time at the high school level in Virginia. To investigate this, data that was obtained from the Virginia Department of Education for the 2011-2012 and 2020-2021 school years that included the number of students from each race (White, Black, Asian, 2 or more races, and Hispanic) taking each course type (A.P. and D.E.) was broken down into the 5 regions of Virginia (Tidewater, Piedmont, Blue Ridge, Valley and Ridge, and the Appalachian Plateau). After finding the means of every group (consisting of a region, race, and year) a single-factor ANOVA revealed a statistically significant difference. The alpha value was 0.05 and both p-values were <0.0001. A Tukey test then determined significance between groups occurred with students in all regions when compared to other groups. Only minorities, such as Black and Asian students, demonstrated a statistically significant difference over time in certain areas of Virginia for A.P. Courses. My research hypothesis stating: If the years increase over time, then minority involvement in Advanced Placement and Dual Enrollment level classes in Virginia would show a statistically significant increase when compared to other racial and regional categories, was partially supported. In conclusion, a few minority groups‚Äô involvement in Advanced Placement level classes significantly increased over time in Virginia high schools. Dual Enrollment saw no significant minority involvement increase.

Nicholas Hoelting- The Effect of Conditioning on Leg Cramps in Tennis Players
Mills E. Godwin High School

This experiment was conducted with the purpose of analyzing how conditioning affects leg cramps so that tennis players and other athletes may be able to prevent leg cramps by changing their conditioning regimens. The benefits of conditioning may be immense for many tennis players, but not all of them realize how important it is to pursue conditioning outside of tennis. The research hypothesis, ‚Äúlf a person performs conditioning two or more times per week, then they will not suffer leg cramps frequently‚Äù was tested by printing out surveys and informed consent forms, locating participants that agree to complete these forms, and collecting and analyzing the data from the forms that the participants completed. The data collected showed that the group that conditioned three or more times a week reported suffering a leg cramp longer ago than any other group did, but the data was not statistically significant and failed to reject the null hypothesis. In addition to this, the frequency distribution for the group that conditioned three or more times per week did not support the hypothesis, as four out of eleven participants that conditioned three times per week reported suffering a leg cramp zero to three months prior to being surveyed. This was most likely due to the varying amounts of tennis that the participants played, their age and race, the reliability of their conditioning regimen, and the muscle groups that they focused on while conditioning.

Zoology

First Place
Rania Lateef- Dozing off with Drosophila: The Effect of Disrupted Circadian Rhythms and Sleep Deprivation on Mortality, Mood, and Addiction
Charles Colgan High School

Background: Many environmental factors can disrupt sleep and circadian rhythms, yet the consequences of such disruptions are poorly understood. The main goals of this project were to study the effects of disrupted circadian rhythms and sleep deprivation on Drosophila melanogaster‚Äôs (1) lifespan, (2) depression like behaviors and (3) propensity to consume caffeine containing media Methods: Three experimental groups were used: controls, Circadian Dysfunction (CD) and Sleep Deprivation (SD). Circadian disruption (CD): used flies with Tim01 mutation, which eliminates circadian behavioral rhythms. Sleep deprivation (SD): used flies subjected to hourly light exposure and mechanical disruption, for 72 hours. In order to assess the effect on lifespan, the percent of flies surviving over time, within each group, was calculated. Impaired geotaxis, or loss of climbing motivation, was assessed as a measure of a depression like state. Preference for caffeine containing food was evaluated using a constructed choice chamber where caffeine enriched and regular media were presented to flies. Group differences were analyzed with survival curves. Chi-square tests were used for the categorical variables. Results: Survival curve analysis showed that Flies with the timeless gene mutation (tim01) have a significantly shorter lifespan than controls. Geotaxis was not significantly impaired by sleep deprivation (OR 1.89, P = 0.24), but it was negatively affected by circadian dysfunction (OR 3.26, P = 0.024). Both the CD (OR 26.3, P<0.001) and SD (OR 5.43, P = 0.017) groups showed a preference for caffeine containing food, after 72 hours of exposure to it, although the CD group was much more affected than the SD group. Conclusion: Sleep and circadian disturbances can negatively influence physical and mental wellbeing and the accompanying molecular mechanisms, as well as disrupted brain physiology, must be studied. It is critical to identify and minimize social and environmental disruptors of such biologic rhythms.

Second Place
Melody Ngo- The Effect of an Appetite Suppressant on *Daphnia magna's* Feeding Rate
Mills E. Godwin High School

The purpose of this experiment was to find the effects of a popular appetite suppressant, *Garcinia cambogia*, on *Daphnia magna's* feeding rate.   With the increased pharmaceutical use and overweight population, appetite suppressants will become a major aquatic pollutant. The ecosystem and economy heavily rely on filter feeders such as D. magna to clean freshwater bodies, and appetite suppressants could be detrimental to their filter-feeding.   D. magna were given Nannochloropsis green algae as a food source and were exposed to 0 mg/L, 2 mg/L, 5 mg/L, and 8 mg/L solutions of *Garcinia cambogia*. Absorbance with a SpectroVis measured the amount of algae consumed after

24 hours. The control was pure spring water or 0 mg/L of Garcinia. It was hypothesized that the highest concentration of *Garcinia cambogia*, 8 mg/L, would cause D. magna to eat the least green algae. The mean results showed an indirect relationship where algae consumption decreased as appetite suppressant concentration increased.   A t-test revealed all data was significant except for the control vs 2 mg/L, the lowest concentration of Garcinia. The results supported the research hypothesis. It is believed D. magna's decreased feeding is due to less energy and mobility from intoxication and increased serotonin from Garcinia's hydroxycitric acid. This research should help further studies investigate other behavioral aspects of D. magna and find what substances create synergistic and antagonistic effects with *Garcinia cambogia*. These studies will help society understand the importance of preventing appetite suppressants from becoming an aquatic pollutant.

Third Place
Tanish Singh- The Effect of Regenexx Stem Cell Formula on Cellular Regeneration
Mills E. Godwin High School

The purpose of this experiment was to test the effects of different vitamins present in the Regenexx Stem Cell Formula on the cellular regeneration of planaria. *Dugesia tigrina*, commonly known as planaria, contain a remarkable stem cell system called the adult pluripotent stem cell, most commonly referred to as neoblasts. These cells allow adult vertebrates to fully regenerate all body systems, even from small tissue amounts. This growth and organism are heavily studied because of its modeling for humans. The pharmacological properties of Stem Cell Growth Supplements and other such vitamins are still being researched. Planarian exposure is vital towards the testing of these so-claimed growth boosters, as their development dictates a similar figure to humans. Planaria were placed in 4 different dilutions of the Regenexx Formula, including 1%, 0.1% 0.01%, and 0%. Their growth was assessed for 2 weeks, and the length was derived. The control used was 0%, as it was just spring water. It was hypothesized that if 0.1% solution of Regenexx Stem Cell Growth Formula was used, then it would have the greatest mean growth (in mm). The results revealed that the research hypothesis was correct as 0.1% dilution had a mean length of 13.1 mm, which was greater than the control of 10.2 mm, and 0.01% solution of 11.7. The 1% solution was deemed too powerful, as all organisms in this solution died after 1 day. All values were statistically significant, and the probability of results being due to chance is less than 0.01. This implies that results were most likely due to the independent variable. This research could lead to further studies on planarian growth effects in different environments and drug exposure.

Honorable Mention
Ananya Nanduru- The Effect of Various Electrical Light Sources on Positive Phototaxis in *Drosophila melanogaster*
Mills E. Godwin High School

The purpose of the experiment was to find the effects of various electrical light sources on the behavior, specifically light-attraction, or phototaxis, in fruit flies. The phototaxis of fruit flies can clearly be observed in any household, where fruit flies are commonly known to cause disruption. Phototaxis is useful to study, because this knowledge can possibly stop infestations and disease. To study this, a light-housing device was constructed with four sections: an LED Section, an Ultraviolet Section, a Fluorescent Section, and a section with no light, which was the control group. 100 fruit flies were obtained, and each fly was presented to the device. Its "choice" was recorded. It was hypothesized that the Ultraviolet Light would have the most flies attracted to it. The results indicated that the LED light was the mode, which means that the flies were most attracted to the LED Bulb. The results did not support the research hypothesis, but the data was statistically significant at a 0.01 level. There are multiple reasons why the research hypothesis was not supported, particularly the intensity of the light bulb and the circadian rhythms of the flies, but the data was still significant and the results were due to the independent variable. Multiple studies, and this experiment, support the idea that Drosophila melanogaster exhibits positive phototaxis, but experiments can be performed on other insects as well. Experiments with different kinds of taxis can also be applied to further study and compared to the results of this experiment.

Honorable Mention
Bridget Blaszak- The Effect of Granular Stabilized Chlorine on the Presence of Regeneration in Dugesia tigrina
Mills E. Godwin High School

The purpose of this experiment was to examine the effect of granular stabilized chlorine on the presence of regeneration in Dugesia tigrina, or brown planaria. Granular stabilized chlorine is the most commonly used chemical in pool sanitation, and many believe that swimming in chlorinated water accelerates the healing of wounds. The research hypothesis stated that if brown planaria are exposed to a solution containing a higher concentration of granular stabilized chlorine, then a greater number of brown planaria will exhibit a blastema. Three solutions containing 0.0, 2.5, and 4.0 milligrams of granular stabilized chlorine per liter of spring water were equally divided up into 75 petri dishes. Seventy-five brown planaria were bisected and placed in these petri dishes. The control of this experiment was the organisms that were placed in the solution containing 0.0 milligrams of granular stabilized chlorine. After 14 days had passed, the specimens were observed and categorized as "death", "no blastema present", or "blastema present". The results suggest that brown planaria that are exposed to a higher concentration of granular stabilized chlorine are more likely to die or fail to exhibit regeneration, as the mode for the specimens exposed to 4.0 milligrams was "death". A chi-square test affirmed that the data was statistically significant. However, the results did not support the research hypothesis. A possible explanation for the results of this experiment is the toxicity of granular stabilized chlorine towards brown planaria. It was concluded that granular stabilized chlorine has a negative effect on the presence of regeneration in brown planaria.

Honorable Mention
Nadine Greer- The Effect of Increasing CO2 Levels on Brine Shrimp Hatching Rate
Clover Hill High School

The purpose of this experiment was to determine the effect of increasing levels of carbon dioxide on the hatching rate of brine shrimp, *Artemia sinica*. Knowing that CO2 levels are increasing in the oceans caused by global warming, this experiment predicted the effects on brine shrimp and the crustacean subphylum. The initial research hypothesis stated that as more CO2 was added into the tank, the hatching rate of the brine shrimp would decrease. Using different amounts of CO2 tablets, buckets containing 10 trials of brine shrimp eggs were used to determine the hatching rate. There were a total of ten trials for each of the four levels, a control with zero tablets added, the first level with two tablets, the second level with four tablets, and the third level with six tablets. For a total of three days, tablets were added consistently to each bucket once a day. On the fourth day, the hatched brine shrimp were counted from a portion of each trial. The control group with zero tablets added had a mean amount of 17.05 hatched brine shrimp. The first level with two tablets added had a mean amount of 9.35 hatched brine shrimp. The second level with four tablets added had a mean amount of 6.25 hatched brine shrimp. The third level with six tablets added had a mean amount of 3.64 hatched brine shrimp. To test if the data were statistically significant, an ANOVA test was conducted after the data was

collected. The experiment findings were determined to be significant and the null hypothesis was rejected. From the experiment data and ANOVA test that was conducted, the brine shrimp that were exposed to the lowest amount of CO_2 had the highest hatching rate, and the brine shrimp that were exposed to the highest amount of CO_2 had the lowest hatching rate. Thus, the hypothesis was supported.

Aarushi Rao- The Effect of Antioxidants on Ultraviolet Radiated Stem Cells in *Girardia tigrina*
Mills E. Godwin High School

In its current state, the intent of this experiment was to determine how antioxidants effected stem cell regeneration in *Girardia Tigrina* (planaria) after UVB exposure. Pluripotent stem cells with high proliferative efficiency and minimal donor morbidity provide a solid foundation for treating diseases, strengthening medical procedures, and expanding the scope of *in-vitro* treatments in medicine. One hundred twenty-five planaria were exposed to UVB radiation for 25 minutes in order to limit regeneration through overexposure and damage the planaria's cells. Each planaria was then bisected and given 5 milligrams (mg) of either Spirulina, Quercetin, Niacinamide, Epigallocatechin-3-gallate (EGCG), or no antioxidant, which served as the control. After 21 days, the regeneration of each worm was measured. It was hypothesized that if planaria regenerate after being exposed to UV radiation, bisected, and introduced to an antioxidant, the planaria given Epigallocatechin-3-Gallate would regenerate the most. The results showed that the Spirulina and EGCG groups displayed the same amount of cellular regeneration, indicating that the research hypothesis was partially supported. Except for 2 t-tests, the Spirulina verses EGCG group and Quercetin versus EGCG group, the data for antioxidants effecting planarian regeneration is statistically significant. Antioxidants do have an effect on stem cell self-renewal pathways, possibly inhibiting the growth of several cancer cell types while stimulating cell proliferation and differentiation. This experiment demonstrated that antioxidants had a beneficial effect on planaria regeneration, while also pointing to future research that could involve using a WST-1 Cell Proliferation Assay Reagent or ATP concentration tests to better understand cell viability.

Abhinav Tadinada- The Effect of Various Lights on the Regeneration of Brown Planaria
Mills E. Godwin High School

The purpose of this experiment was to study the effect of various lights on planaria regeneration. Red light is used in Low Level Light Therapy (LLLT) and is proven to have rejuvenating effects on skin. However, other lights such as blue light may also be just as effective in healing. Planaria were bisected and the length of the head segments was measured. Then, they were placed in a Petri dish under a red, blue, or white light. After 20 days, the length of the planaria was measured and the difference between the between the pre-regeneration and post-regeneration length was calculated. The control in the experiment was white light because it is the most common light. It was hypothesized that if the planaria were exposed to red light, then they will regenerate faster. The results of

the experiment showed that planaria that was exposed to red light regenerated more than planaria that was exposed to blue or white light. A t-test was performed on the data and all data was significant at a 0.01 level of significance. This implies that the results are most likely due to the independent variable. The research hypothesis was supported by the data. The results are believed to be because of red light being able to penetrate deeper into the skin than blue light. Red light also stimulates the mitochondria which could have increased cell proliferation. For further study, the optimal photoperiod for red light could be investigated.

Amanda Tan- How Exposure of Planaria to Choice Chamber Stimuli Affect Behavioral Responses of Resulting Planaria Fragments
Collegiate School

Competing environmental stimuli can result in learned behaviors that differ from instincts. The aim of this experiment was to examine the behavioral responses of planaria (positive chemotaxis and negative phototaxis) when they were exposed to competing environmental stimuli in choice chamber conditions as well as exploring if learning of choice chamber conditions is stored in the head or tail region of planaria fragments. The flatworms were exposed to a three-section choice chamber filled with water and were placed in the middle section at the beginning of the experiment. One section was covered with cardboard to simulate darkness while the opposing section contained egg yolk in room-lit conditions. There were six groups of planaria consisting of (1) a control group of eight whole planaria, (2) a group of whole planaria who were exposed and then cut, (3) the heads of the exposed-first planaria, (4) the tails of the exposed-first planaria, (5) unexposed heads, and (6) unexposed tails. Statistical analyses show a significant difference between visits of head fragments with prior exposure compared to expected visits based on control head fragments without prior exposure (chi-squared test, $œá2$calculated = 55.2 >>> $œá2$critical = 5.991, df = 2, p = 0.000); but there is no significant difference between these head fragments with prior exposure and whole planaria with prior exposure (chi-squared test, $œá2$calculated = 0.990 << $œá2$critical = 5.991, df = 2, p = 0.61). The exposed-then-cut heads may demonstrate learning from the choice chamber conditions. Statistical analyses show significant differences between exposed-then-cut tail visits and expected visits based on tail fragments with prior exposure (chi-squared test, $œá2$calculated = 6.38 > $œá2$critical = 5.991, df = 2, p = 0.041), and there is a significant difference between tail fragments with prior exposure and whole planaria with prior exposure (chi-squared test, $œá2$calculated = 33.9 >> $œá2$critical = 5.991, df = 2, p = 0.000). Cut tails with prior exposure are spending significantly more time in the middle than either control group and they do not mimic the behavior of whole exposed planaria (tail fragments are not retaining learning). This experiment indicates that learning within these flatworms occurs predominantly in the head region.

Annie Yuan- A Look Inside Planarian Radiation Resistance Across Different Regenerative Stages

Mills E. Godwin High School

The purpose of this experiment was to study the radiation resistance of planaria to low dose ionizing radiation across different regenerative stages. Low dose ionization may cause planaria stem cell mutation and eventually death (apoptosis). Stem cells can also show radiation resistance by repairing and regenerating after mutation induced by ionizing radiation. Thus, the study of planarian radiation resistance at different regenerative stages will shed light on the interactions between cell apoptosis and DNA repair, key mechanisms in human cancer development. It was hypothesized that planaria exposed to ionizing radiation immediately after being injured would regenerate the least. In this experiment, planaria were split into three test groups which were exposed to 3 grays (Gy) of ionizing radiation 0 days, 7 days, and 14 days, respectively, after they were injured. One group of planaria was not exposed to radiation and served as the control. After 21 days, the regeneration of the planaria was measured by subtracting final length from initial length. The results showed that planaria irradiated immediately after injury regenerated an average of 1.8 millimeters (mm) less than planaria exposed to no radiation, 0.1 mm less than planaria exposed to radiation 7 days after injury, and 0.3 mm less than planaria exposed to radiation 14 days after injury. T-tests were performed, and all levels of independent variable compared to the control were statistically significant, but the comparisons between the independent variables themselves were not statistically significant. The results supported the research hypothesis. It is believed that the results are due to planaria's increased radiosensitivity during the migration of neoblasts to a wound site in the 14 days following injury.

Bridget Falgui- The Effect of Magnetism on Planaria Regeneration
Mills E. Godwin High School

The purpose of this experiment was to determine if magnetism affects the regeneration process in planaria. For a while, scientists have been incorporating stem cells into scientific practices, and a faster, better way to grow stem cells would help a lot of people by regenerating and repairing damaged cells. In the experiment the planaria were dissected and measured for their starting lengths. Then, the planaria were placed in separate Petri dishes and split up into three groups of 25 for each IV level. After they were monitored for 2 weeks, they were measured, and the data was recorded. The hypothesis that was formed for the experiment was that if the planaria were exposed to a low magnetic field (100 gauss) then the low magnetic field would have a greater impact on the regeneration process of the planaria. The results revealed that planaria that were affected by 1000 gauss grew 0.2 mm greater than 100 gauss and 0.1 mm greater than 0.5 gauss. The 0.5 gauss acted as the control since it is Earth's natural magnetic field. A t-test was executed, and the test showed that there was no significant data. Overall, the results did not support the research hypothesis. The results in the experiment are most likely due to chance instead of the IV. Since the 1000 gauss did the best, an extension to this experiment would be using a higher gauss to see the effect the gauss level has on planaria regeneration length.

Kavin Bhurtel- The Effect of Water pH on Hydra Growth and Feeding Rate
Mills E. Godwin High School

The purpose of this experiment was to determine the effect of water pH on the growth and feeding rate of hydra. Due to freshwater acidification, many organisms have found themselves in water pH levels outside of their optimum range and understanding the effect of this on their behavior and physiology was important. A research hypothesis was formulated stating that hydra in acidic environments will have lower growth and feeding rates than hydra in neutral and basic environments. Hydra were placed in 5, 7, and 9 pH environments respectively, with 7 pH being the control, and their growth and feeding rates were compared at the end of a 5-day period. The results showed that hydra in the acidic environment had significantly lower growth and feeding rates compared to hydra in the neutral and basic environments. T-tests performed also echoed this, revealing that the data was wholly significant for hydra growth and mostly significant for hydra feeding rate, with the exception of the t-test between 5 and 9 pH. The research hypothesis was thus supported by this data. These new findings support already existing research on freshwater organisms' responses to acidic environments, and similar causes for the results in these experiments can also be found: simply, their bodies are not used to it. Further studies on the effect of pH on other aspects of a hydra can also be considered with the results that have been collected.

Likitha Appalapuram- The Effect of pH Level on *Artemia salina* Reproduction Rate
Mills E. Godwin High School

This project was conducted in order to investigate the effect of various pH levels on the reproduction rate of *Artemia saline*, otherwise known as Brine shrimp. Brine shrimp are a huge part of various aqueous ecosystems as they are the primary prey of a wide range of animals ranging from birds to fish and are, therefore, a very important species to maintain. They are also closely related to Horseshoe crabs, whose population numbers are considered threatened, when it comes to reproductive and habitable qualities. In this study, four different pH levels, 7, 8.3, 9, and 10) were tested for their ability to assist Brine shrimp eggs in hatching. A solution of each pH contained 25 eggs over a period of 36 hours (El-Magsodi, 2016). A hypothesis was formulated that the solution with a pH of 8.3 would contain most hatched eggs. The results supported the research hypothesis to be true, but the chi-square tests performed rejected the null hypothesis, resulting in statistically insignificant data. It is believed that the results are due to the factor that Brine shrimp are not sensitive creature, but ones that are able to survive various conditions, and the experiment didn't contain an extremely wide range of pH levels, so it didn't make a large difference in affecting the Brine shrimp eggs. This research could be used to further investigate the reproductive habits of Brine shrimp through other factors like temperature, salinity, etc.

Srinidhi Subramanian-The Effect of the Electromagnetic Spectrum on Planaria
Regeneration
Mills E. Godwin High School

The purpose of this experiment was to find the effect of the electromagnetic spectrum on humans by studying planaria regeneration. Humans are exposed to different types of radiations every day. Studies have shown that certain types of radiation, such as ultraviolet, are harmful to cells, by influencing cell reproduction and regeneration, specifically stem cells. In this study, planaria were exposed to infrared radiation, ultraviolet radiation, and radio waves. Sunlight was used as the control. The hypothesis was that if the planaria were exposed to ultraviolet radiation, then they will regenerate the least among the four groups in a two-week period. Four planaria groups were given a 14-day regeneration period. Their growth was measured at the start of the study and at the end of day 14. The average change in growth was calculated. The results did not support the research hypothesis. One factor that may have impacted the results is that the experiment was performed in late Fall when the sun didn't give off as much heat; heat is important for regeneration. The planaria group exposed to infrared radiation regenerated the most and the planaria group exposed to radio waves regenerated the least, on average. T-tests were performed for ultraviolet radiation and infrared radiation, which were not significant. However, a t-test was also performed for radio waves, which was significant. This research could lead to further studies on the effect of different amounts of heat on injury repair.

FIRST PLACE CATEGORY-SECTION AWARDS

These awards are given to the best papers, as determined by either the Section Judges or, if multiple sections, by a group of Honor Judges.

VAS BOTANY AWARD

The award is given by the Botany Section of the Virginia Academy of Science, to the best paper on a botanical subject.

William McGee
Chesapeake Bay Governor's School
The Effects of Broadcast Seeding on Secale cereal Growth and Abundance

Mackenzie Cauthorn
Chesapeake Bay Governor's School
Does Using the Side-dressing Method Increase the Growth and Yield of Corn?

RODNEY C. BERRY CHEMISTRY AWARD

The Rodney C. Berry Chemistry Award is given for the paper that evidences the most significant contribution in the field of chemistry.

Arjun Modi
Mills Godwin High School
The Effect of Starches on Digestion Time Utilizing Salivary Amylase

Yanna Shah
Mills Godwin High School
The Effect of Various Hydrophobic Substances on a Water Droplet's Contact Angle on a Cloth Mask

ANN M. HANCOCK CELLULAR BIOLOGY AWARD

This award is given to the best paper in cellular biology and is presented in memory of Anne M. Hancock who retired from Patrick Henry High School in Hanover County and who gave many years of service to the Jr. Academy not only by teaching but also serving on the Jr. Academy Committee.

Eleanor Little
Roanoke Valley Governor's School
Circadian Rhythmicity of Cellular Healing

MATHEMATICS AWARD

The Mathematics Award is given for the paper that evidences the most significant contribution in the field of Mathematics.

Philip Naveen
Mills Godwin High School
Phish - A Novel Hyper Optimizable Activation Function

STATISTICS AWARD

The Statistics Award is given for the paper that evidences the most significant contribution in the field of Statistics.

Sidhartha Basu
Deep Run High School
Statistics Behind Identity Fraud

VABE ZOOLOGY AWARD

This award is presented by the Virginia Association of Biology Educators and is given for outstanding research in the Zoology section.

Rania Lateef
Charles Colgan High School
Dozing off with Drosophila: The Effect of Disrupted Circadian Rhythms and Sleep Deprivation on Mortality, Mood, and Addiction

SPECIAL INTEREST AWARDS

Students apply for these awards, and they are judged by special panels. (If any awards are not given, we did not receive any papers meeting the standards of the award.)

CANCER RESEARCH AWARDS

These awards are to recognize outstanding science papers related to cancer research. These awards are provided by the American Cancer Society.

Nishorgo Sarkar
Mills Godwin High School
The Effect of Fenugreek (Trigonella foenum-graecum) Extract on HCC Cell Proliferation

Laasya Konidala
Mills Godwin High School
Automated ROI Detection for Glioma Severity Prediction

Camellia Sharma
Mills Godwin High School
The Effect of Machine Learning Algorithms on Identifying Skin Cancer

DR. AND MRS. PRESTON H. LEAKE AWARD IN APPLIED CHEMISTRY

The Dr. and Mrs. Preston H. Leake Award in Applied Chemistry is given to the author of a research paper which best exemplifies how chemicals, chemical principles, or chemistry have been used, are used, or might be used to enhance or even to save life.

Kyle Reviello
Chesapeake Bay Governor's School
The Performance of a Gas Turbine Engine Using Fossil Diesel vs Two Different Biodiesels

ROSCOE HUGHES GENETICS AWARD

The Roscoe Hughes Award is given for the best paper in the field of Genetics.

Maggie Parkhurst
Roanoke Valley Governor's School
Analysis of Differential Gene Expression in Blood Samples to Predict Alzheimer's Disease

Gamma Sigma Delta Award
Virginia Tech Chapter of the Honor Society of Agriculture
Given to a student in recognition of excellence in research dealing with the application of new technologies and/or concepts in agriculture, forestry, or veterinary medicine

Naman Agarwal
Governor's School @ Innovation Park
A Low-Cost Deep Learning Solution for Early Detection of Lettuce Stress in Indoor Farms

DR. SMITH SHADOMY INFECTIOUS DISEASES AWARD

This award is given to commemorate Dr. Smith Shadomy by the Virginia Chapter of the National Foundation for Infectious Diseases to the paper that evidences outstanding research in the field of infectious diseases.

Bilguun Zolzaya
Yorktown High School
Dirty Tables: Determining the best antimicrobial metal/material for a table in classrooms or hospitals

SPELEOLOGICAL SOCIETY AWARD

Given by the Richmond Area Speleological Society for outstanding research addressing karst or topics related to speleology (bats, caves, carbonate geology, paleoenvironments, limestone fossils, sinkholes, etc.)

Corrina Peachey
Massanutten Regional Governor's School for Integrated Environmental Science and Technology
Breaking the Climate Change Communication Barrier: The Sonification of Speleothems

VIRGINIA MUSEUM OF NATURAL HISTORY (VMNH) AWARD

245This award is presented by the Friends of the Virginia Museum of Natural History in

recognition of a significant contribution in the study and interpretation of Virginia's Natural Heritage.

Brenna Hendrix
Chesapeake Bay Governor's School
The Effect of Oyster Reef Restoration on New Recruitment to Nearby Shoreline Habitat

VIRGINIA SEA GRANT COLLEGE PROGRAM AWARD
This award is given by the Virginia Sea Grant College Program for outstanding marine or coastal research.

Hallie Shackleford
Chesapeake Bay Governor's School
The Average Species Richness of Living Shorelines Versus Man-Made Shorelines

SCHOLARSHIP WINNERS

BETHEL HIGH SCHOOL SCHOLARSHIP
This scholarship of $1000 is awarded to a student (9-12 grades and not a team project) who has produced an outstanding written paper and is a first-place winner. The money is paid to the student's college or university in two equal payments during the first year. This scholarship comes from the interest earned from a $10,000 endowment contributed to the VJAS by the students of Bethel High School, Hampton, Virginia.

Sam Watchman
Arlington Tech
Mapping the Milky Way: Observations of Galactic Structure from the 21 cm Hydrogen Line

Scholarships from the Virginia Environmental Endowment

HENRY W. MACKENZIE ENVIRONMENTAL SCHOLARSHIP (VEE)
Henry MacKenzie Environmental Scholarship - This $5,000 scholarship will be awarded to the student whose paper evidences the most significant contribution in the field of Environmental Science dealing with the James River Basin and Chesapeake Bay. The Virginia Environmental Endowment and VJAS offer this scholarship in tribute to the outstanding and generous services of Judge Henry W. MacKenzie, Jr., one of the founding directors, who has a great interest in the James River and the Chesapeake Bay.

Ella Indseth
Chesapeake Bay Governor's School
Bioremediation of Fish Polluted Water by the Macroalgae Chaetomorpha linum

FRANCES AND SYDNEY LEWIS ENVIRONMENTAL SCHOLARSHIP (VEE)
Frances and Sydney Lewis Environmental Scholarship: A $5,000 scholarship for the best effort by a student in grades 9 to 12 in the field of environmental science. This

scholarship is in the name of Frances and Sydney Lewis and is given by the Virginia Environmental Endowment.

Anna Grohs
Central Virginia Governor's School
Comparing Polystyrene Adhesive to Commercial Glues

VJAS Honor Awards Middle School

These are the highest awards that the Virginia Junior Academy of Science presents. Special panels of honor judges evaluate the projects and determine the awards.

DOROTHY KNOWLTON AWARD

Given to the middle school student or team presenting the best project in the life and earth sciences. This is given in honor of Dorothy Knowlton, the former Science Coordinator of Arlington County, who was instrumental in advancing experimental design with the science curriculum.

Deepanshi Kumar
George H Moody Middle School
The Effect of Ginger (Zingiber officinale) as Fertilizer on Bean (Phaseolus vulgaris) Plant Height Growth

JOYCE K. PETERSON AWARD

Given to the middle school student or team presenting the best project in the physical sciences. This is given in honor of Joyce Peterson who has been an outstanding teacher in the Arlington County Schools.

Tess Vithoulkas
George H Moody Middle School
The Effect of Different Condenser Materials on the Production of Water with a Solar Still

OUTSTANDING EIGHTH GRADE RESEARCH PROJECT, Grade 8

Given to the eighth-grade student or team presenting the best project.

Tess Vithoulkas
George H Moody Middle School
The Effect of Different Condenser Materials on the Production of Water with a Solar Still

VJAS GRAND MIDDLE SCHOOL AWARD, Grades 7-8

Given to the middle school student or team presenting the best project.

Tess Vithoulkas
George H Moody Middle School
The Effect of Different Condenser Materials on the Production of Water with a Solar Still

VJAS Honor Awards High School

These are the highest awards that the Virginia Junior Academy of Science presents.

Special panels of honor judges evaluate the projects and determine the awards.

JONES/ELLETT AWARD
Given to the individual senior (12th grade) student presenting the best project.

Brock Duma
Blacksburg High School
An Optimized Whitewater Helmet Prototype Designed Using a Newly Developed Helmet STAR Evaluation System and 3D
Printing

VJAS GRAND HIGH SCHOOL AWARD, Grades 9-12
The top research project by an individual or team of students in grades 9-12.

Brock Duma
Blacksburg High School
An Optimized Whitewater Helmet Prototype Designed Using a Newly Developed Helmet STAR Evaluation System and 3D
Printing

VJAS Delegates to AJAS, Grades 9-11

VJAS Delegates to AJAS
A panel of honor judges selects the honorees from among the students (grades 9-11) who won first place in a senior high section.

Attendance at American Junior Academy of Science (AJAS): Winners are given a certificate and an invitation to represent VJAS at the annual meeting of the American Junior Academy of Science (AJAS) and to present at a poster session. Students who represent the Commonwealth of Virginia are required to attend all activities and house with the students (if applicable). When VJAS/VAS finances permit, cash awards are given to each individual or a team to help defray expenses. The cash award will be the same for an individual or team, so if a team is selected, they will need to determine who will represent the team or provide local funding for the other team members. The top four papers are ranked by the judges and VAS/VJAS will provide cash awards in this order when VAS/VJAS finances permit. VAS/VJAS will attempt to fully cover the expenses of the winners followed by the alternates.

VJAS Delegates to AJAS
THE WINNERS ARE

First Delegate
Sam Watchman
Arlington Tech

Mapping the Milky Way: Observations of Galactic Structure from the 21 cm

Hydrogen Line

Abstract

This project used observations of the 21 cm hydrogen line to build up a map of the Milky Way galaxy from radio observations using the 20-meter telescope at the Green Bank Observatory. The 21 cm hydrogen line is a radio emission signal from hydrogen atoms spread around the Milky Way and other galaxies. This signal is emitted at 1.420405751 GHz, but that frequency is shifted by the Doppler effect to slightly different frequencies because of the Milky Way's rotation velocity. By analyzing the frequency shifts and translating each spectral data point into a position in the Milky Way galaxy, it is possible to build up a map of the Milky Way and its spiral arms from many observations.

For this experiment, this was done with ~260 individual observations, which after processing using Python scripts, created two maps: a heat map and a scatter plot, showing galactic structure. These graphs showed several galactic spiral arms and were consistent with the fact that the Milky Way is a spiral galaxy. The data also matched up with observations from the Spitzer Space Telescope.

Introduction

The 21 cm hydrogen line is a spectral line emitted by neutral hydrogen atoms, especially in interstellar space. It is emitted at a frequency of 1.420406 gigahertz (GHz), in the radio spectrum. The signal is emitted by neutral hydrogen atoms of the interstellar medium in the Milky Way galaxy, and is not affected by interstellar dust that blocks visible light and other radiation wavelengths (Encyclopedia Britannica, 2020). The frequency is shifted slightly by the

Doppler effect (Encyclopedia Britannica, 2019) created from the rotation speed of the Milky Way galaxy (about 220 km/s). The Doppler effect shifts the frequency emitted by an object based on the relative speed of the observer and emitter (the rate of change of the distance). Because the rotation speed and direction of the Milky Way are known (Klesman, 2020), this makes it possible to identify the location of a hydrogen line emission source based on the direction to the object, or its galactic longitude, and the relative velocity, measured from the Doppler shift of the frequency.

With enough observations, it is possible to build up a "map" of the Milky Way galaxy from the intensity of the hydrogen signal at each measured position in the galaxy (Englmaier et al, 2011). This could either be done by using every single point of the data to create a heatmap, or taking the peaks of each spectrum and plotting their positions as points. Either method could be used to show galactic structure.

The 20-meter telescope at the Green Bank Observatory in Green Bank, West Virginia, is equipped with an L-band receiver covering a frequency range of 1.3-1.8 gigahertz, which includes the 1.42 gigahertz hydrogen line signal (Duncan & Ghigo, 2013). The receiver is calibrated to provide accurate signal power level readings, and is cooled to 15 K. This telescope is well-equipped for the types of observations used in this project, which involve getting a Doppler shift spectrum for every point along the galactic plane. The galactic plane is a line drawn across the sky that the Milky Way appears to follow. The data for this project was collected in November 2021 using the 20-meter telescope.

This experiment examined the various galactic structures present in the Milky Way galaxy. The independent variable was the position of each point in the Milky Way's galactic plane, given by coordinates (x, y) with the galactic center as the origin and distances given in kiloparsecs (1 kpc = 3261 light years, or about $3.0851 * 10^{16}$ kilometers). The dependent variable

was the signal power level at each point measured in Kelvin by the radio telescope. (This is not Kelvin in the temperature sense, it means the power level at the antenna (Gary, n.d.).) Some constants were the sensitivity of the telescope used, the location of the telescope, the angular separation between each observed point, the number of points in each spectrum, and the type and length of each observation. The sample rate of the telescope in 1024 channel mode is 15259 cycles per second (Duncan & Ghigo, 2013). For a 60 second observation there were 915,540 individual samples or trials.

The hypothesis for this experiment was that if data was collected on the level of hydrogen signal present at each point in the Milky Way galaxy, then the plotted data would show structures including spiral arms and clumps because the Milky Way galaxy is a spiral galaxy (Britannica, n.d.).

Methods and Materials

This project requires no physical materials other than access to the 20-meter telescope at the Green Bank Observatory and a computer to run Python scripts. Some other materials are the Python program language, the matplotlib, scipy, and numpy libraries, and Python scripts created to do the data processing (see appendix).

Spectral data was collected for points 1 degree in separation along the galactic plane from longitudes 353 degrees to 253 degrees. (Part of the galactic plane is excluded because it is in the southern part of the sky and not visible from the Green Bank Observatory's 38N latitude.) The data collected was then converted from frequency-vs-signal power graphs to Doppler shift velocity-vs-signal power graphs using the Doppler velocity/frequency function:

$$v_r = c\left(\frac{1420.405751 - f_{measured}}{1420.405751}\right)$$

Where v_r is the relative velocity of the source, $f_{measured}$ is the observed frequency,

1420.405751 is the hydrogen line rest frequency in megahertz (Britannica 2020), and c is the

speed of light (299792 km/s). This equation gives output in km/s, where a positive value would

be going away from the observer and a negative value would be going towards the observer.

The coordinate system used for this project was 2 dimensional, which is simplified but

works for the purposes of this study. Each point in the plane of the Milky Way has coordinates

(x, y), with the center of the Milky Way as (0, 0) and the Sun as (0, -8), meaning the Sun's

distance from the center is around 8 kiloparsecs (abbreviated kpc) (Hunt, Bovy, and Carlberg,

2016). The galactic longitude (L) is the angle from the galactic center to the Sun to the observed

point (e.g. point (-4, -4) would have an L angle of 45 degrees) (Swinburne University of

Technology, n.d.). The equation for the observed relative velocity for a given point in the galaxy

is (Stanimirovic, 2014):

$$v_r = R_0 * sin L * (\frac{V_P}{R_P} - \frac{V_0}{R_0})$$

Where R_0 = Sun-Galactic Center distance (8 kpc), L = galactic longitude, V_P is the

velocity of the observed point, which generally is around 220 km/s, R_P is the observed point's

distance to the galactic center, and V_0 is the velocity of the Sun, which is also around 220 km/s.

This equation can be rewritten by substituting the radii variables (R_0 and R_P) for the

distances given from the x and y coordinate system defined earlier using the Pythagorean

distance formula. This gives the equation:

$$v_r = \sqrt{x_0^2 + y_0^2} * sin L * (\frac{V_P}{\sqrt{x_p^2 + y_p^2}} - \frac{V_0}{\sqrt{x_0^2 + y_0^2}})$$

This was plotted as a 3d equation with the z axis as v_r. When plotted as a contour map, this made the graph (Figure 1):
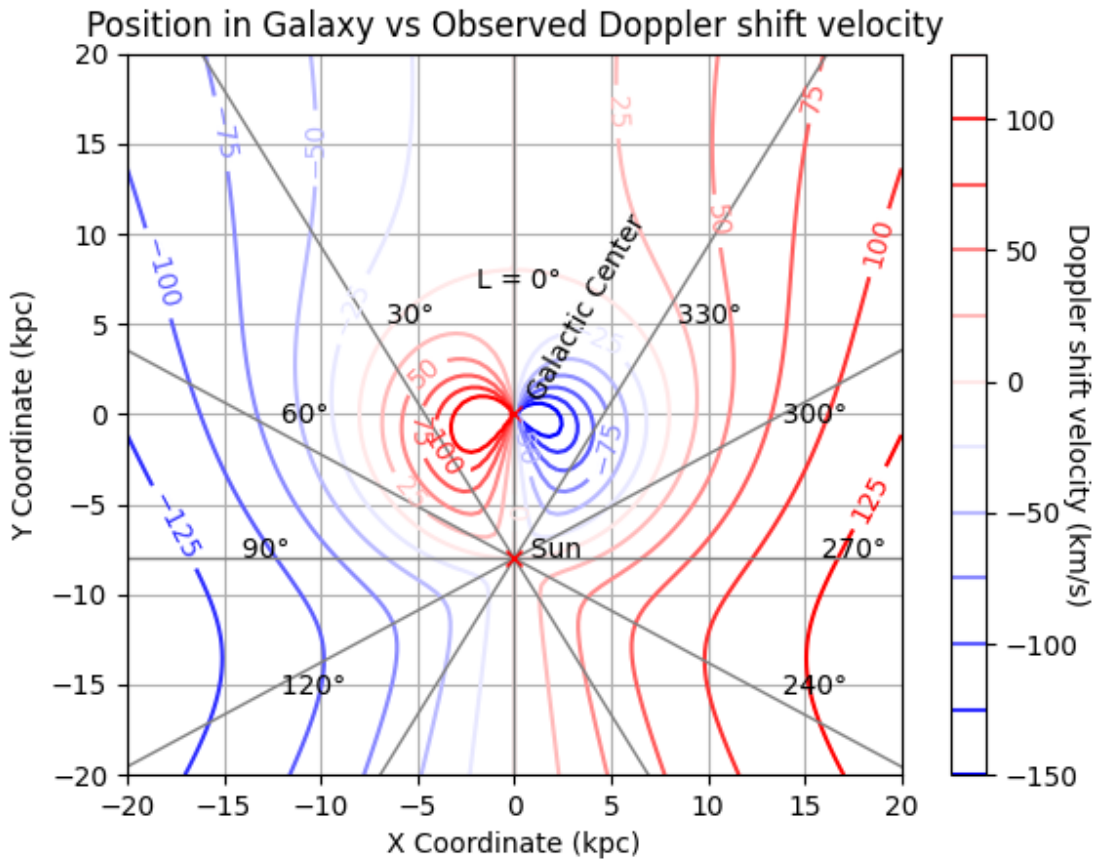

Figure 1: A graph of each point in the galaxy's galactic longitude and Doppler shift for a source at that point.

This graph shows the relative Doppler shift velocity that would be observed for every point in the Milky Way galaxy. This is the rotation model that was used for this project, where each point in the galaxy given by coordinates (x, y) is associated with a Doppler shift velocity and a galactic longitude L. This is the inverse of what is required for the data processing, where the galactic longitude and Doppler shift velocity are inputs, and the (x, y) coordinates are outputs. To get the position of a point in the Milky Way based on the galactic longitude and

Doppler shift velocity, first it is required to rewrite the original equation for v_r so that it instead

outputs R_P:

$$R_P = V_P \left(\frac{v_r}{R_0 \sin L} + \frac{V_0}{R_0} \right)^{-1}$$

This means that for a given point with longitude L and Doppler shift velocity v_r, the

point must be distance R_P from the galactic center determined by the above equation. This in turn

means it must be on a circle centered on the origin with radius R_P. The point also has to be at the

longitude L, so it must be along a ray extending from the Sun at angle L. The intersection of a

circle with radius R_P and the ray represents the point where the hydrogen emission source must

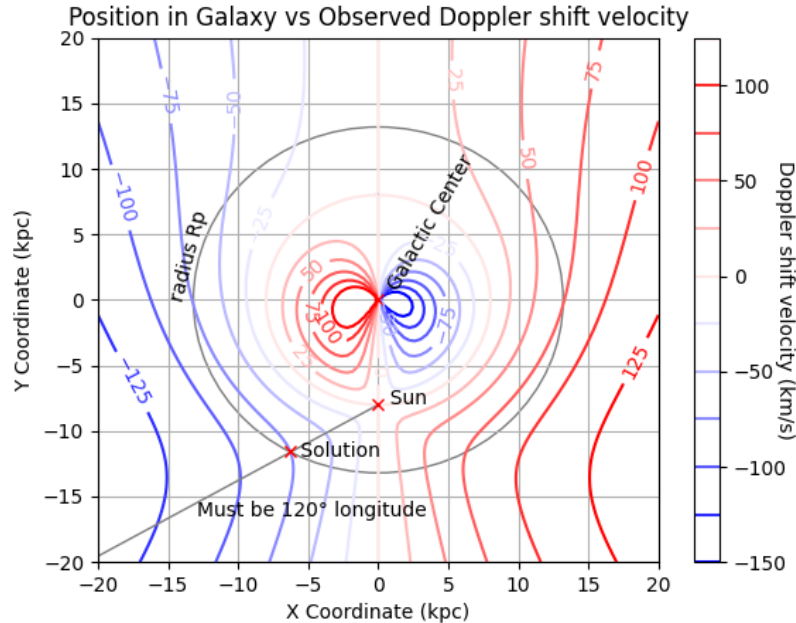be. Figure 2 shows an example for v_r =-75 km/s and L = 120 degrees:

Figure 2: Example galactic position solution for v_r = -75 km/s and L = 120°.

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This graph shows how the circle with radius R_P and the ray extending from the Sun with angle L intersect, at the point where the hydrogen emission source must be. In this example, it is (-6.3, -11.6).

This model presents one source of inaccuracy in this project: for a point where the distance from the observed point to the galactic center (R_P) is less than the distance of the Sun to the galactic center ($R_0 = 8kpc$), the model determining the x, y coordinates of the observed point has two solutions, because the ray crosses the circle twice. This is one of the biggest sources of inaccuracy for this project, which solves this by just plotting the given signal power value at both possible points. This created some uncertainty with the structures in that region of the galaxy, although they were still relatively accurate to reality.

Safety

There are no safety concerns for this project, as it uses remotely-ordered observations.

Results

After the data was collected, it was run through two data processor Python scripts to generate the two following graphs. The Python scripts had two major components: a function that determines the position in the Milky Way for each data point, using the mathematical process described above, and a function to graph the data set in each graph type.

The first graph (Figure 3) is a scatter plot of all peaks in every spectrum for every galactic longitude, made with "XYPeaksPlot.py". It shows all of the bright regions of the Milky Way, and it shows several arcs of bright hydrogen regions all around the galaxy. The second graph (Figure 4), made with "XYHeatmap.py" shows all of the data collected, plotted as a heatmap with a scale indicating the signal power received at each point. It shows similar galactic structures as the scatterplot, with more detail in some regions. It does have a strange artifact:

wave-like patterns on the opposite side of the galactic center from the Sun, and away from the Sun in the direction opposite the galactic center. This is probably caused by low data point concentration in those regions. Part of each graph is excluded because that part of the sky was too far south to be observed from Green Bank.
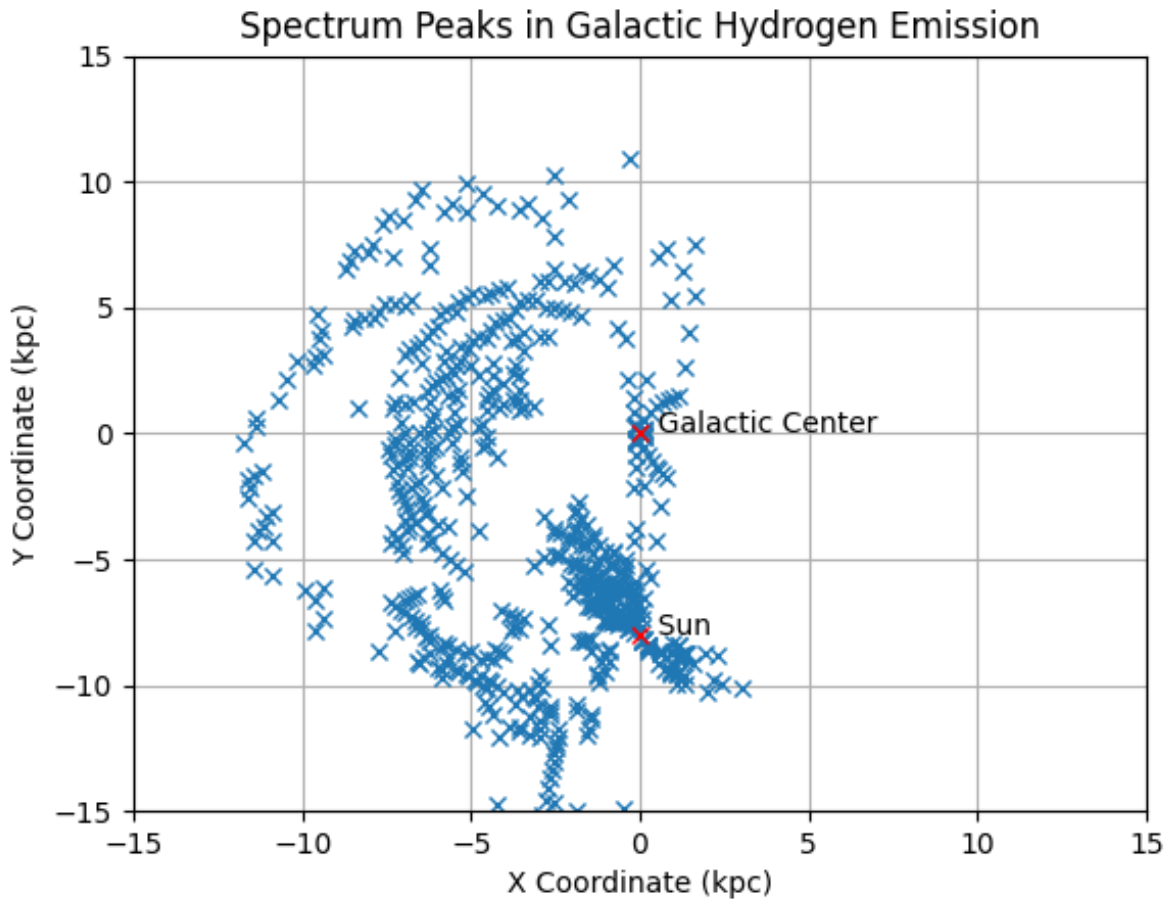

Figure 3: A scatter plot of 715 peaks identifying regions of increased hydrogen line radio emission. This shows several galactic spiral arms.
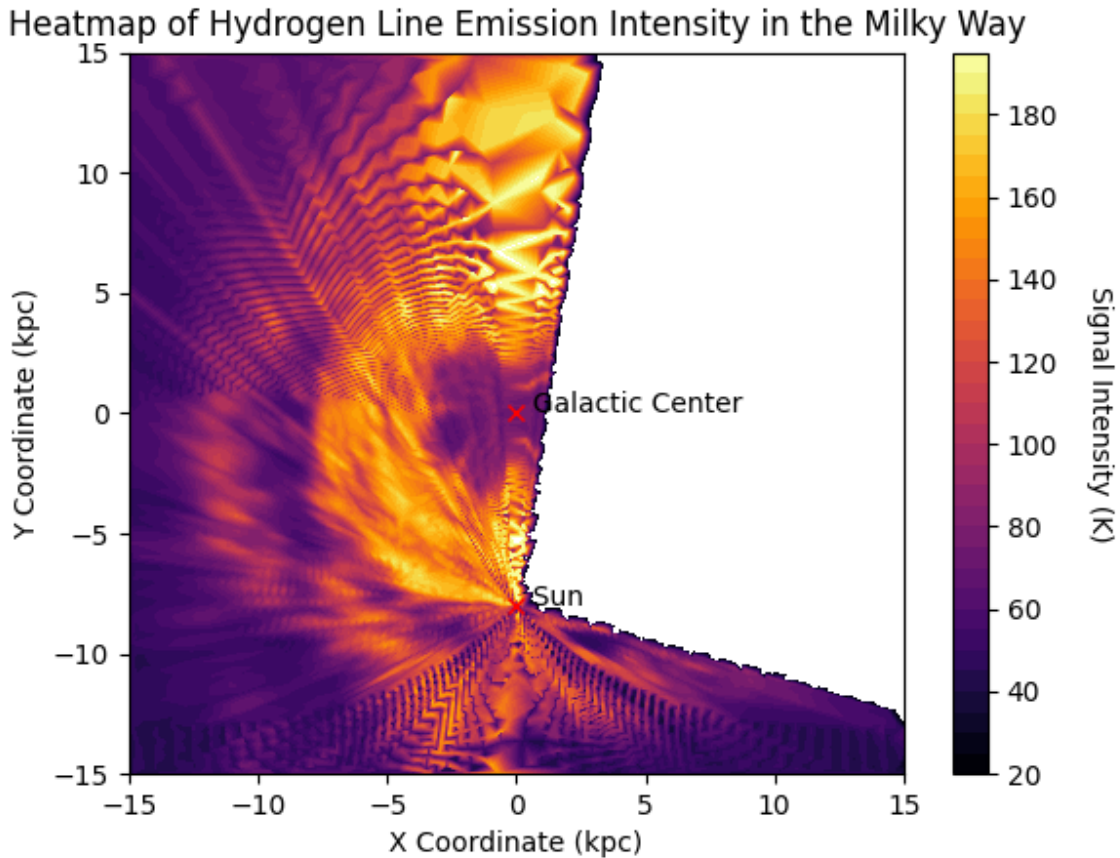
Figure 4: Heatmap of hydrogen distribution in the Milky Way, illustrating several galactic spiral arms.

These graphs show several interesting examples of galactic structure. First, there is an outer arm which roughly follows a circle centered on the Galactic Center with a radius of about 10-15 kpc. This arm shows one unusual feature, which is a strange rift around (-8, -7). Second, as seen in the heatmap and the scatterplot, there is a bright circular region with a radius of about 7 kpc. The heatmap shows this bright region with 2 especially bright sub-regions. Finally, the scatter plot especially shows an intense local arm right near the Sun, about 5-10 kpc long, extending in opposite directions from the Sun.

Discussion and Conclusions

In conclusion, several galactic spiral arm structures were observed in the data from this experiment. This confirms the hypothesis that the Milky Way is a spiral galaxy, and that it has spiral structures that can be observed from 21cm hydrogen line data.

There were several sources of error in this experiment that could have been corrected to produce more accurate results. The first one stems from the algorithm used to determine the position of an emission source in the Milky Way. A more accurate algorithm could have been used, perhaps one that sorted between different position possibilities based on existing data, like measured star distances. Another potential source of error came from the diminishing of signal power as distance to the source increases, caused by the inverse square law. This could be corrected by brightening regions farther from the Sun (Campbell et al, 2017).

The data collected here can be compared with previous surveys of galactic structures. By overlaying the scatter plot data onto a galaxy map created by NASA with data from the Spitzer Space Telescope (Hurt et al, 2008) as seen in Figure 5:
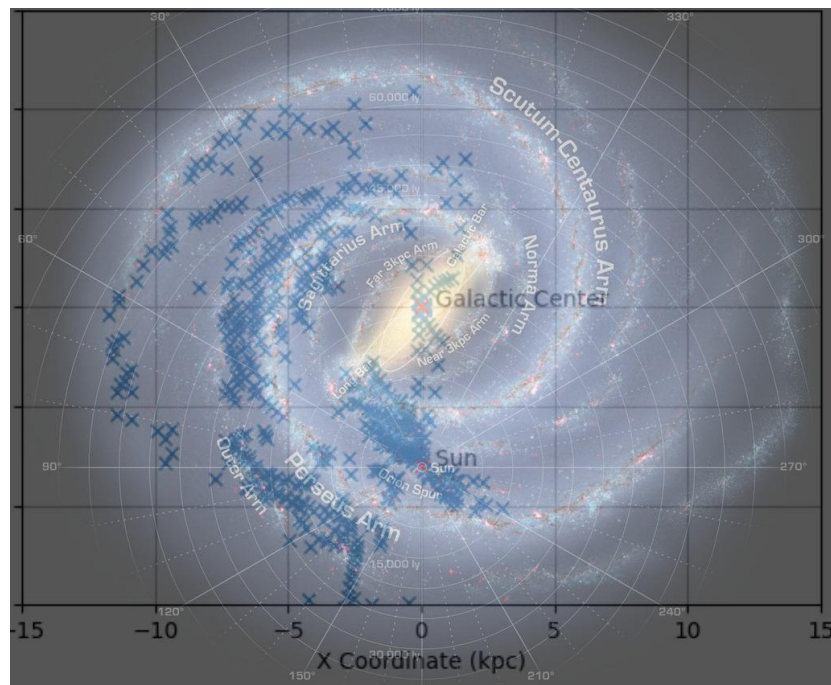

Figure 5: Scatter plot data set overlaid onto data from the Spitzer Space Telescope.

This combined image shows that the data sets mostly match, with some exceptions. There is a region with many recorded points close to the Sun that does not appear in the Spitzer data, probably because this hydrogen is closer and so it appeared brighter. Some features that match up between this data set and the Spitzer data are the outer part of the Scutum-Centaurus Arm, the Sagittarius Arm, the Perseus arm, and the Outer Arm (all labeled in the diagram).

There are several ways that this project could be extended in the future. A simple one would be to use a more powerful telescope to collect more and higher-resolution data, or to have another telescope in the southern hemisphere which could collect data for that part of the sky and complete the galaxy map. There are some ways to solve the shortcomings of this project, like comparing the data to data gathered about stars to solve the two-solutions uncertainty problem.

Another way to improve this project would be to collect data for different galactic latitudes offset from the galactic plane, to build up a 3D map of the Milky Way. Finally, the data could be integrated with data from other spectral lines to form a map of where different elements are distributed in the Milky Way. All of these ideas would improve understanding of the Milky Way's structure.

<div align="center">**Literature Cited**</div>

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Appendix

Link to data and Python scripts:

https://drive.google.com/drive/folders/1tvkSbA5c8k46uckbXUylC8nLfFbhImEg?usp=sharing

More info on Green Bank 20-meter telescope:

https://www.gb.nrao.edu/20m/index.htm

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Phish: A Novel Hyper-Optimizable Activation Function

Abstract

Deep-learning models estimate values using backpropagation. The activation function within hidden layers is a critical component to minimizing loss in deep neural-networks. Rectified Linear (ReLU) has been the dominant activation function for the past decade. Swish and Mish are newer activation functions that have shown to yield better results than ReLU given specific circumstances. Phish is a robust non-monotonic activation function proposed here. It is a composite function defined as f(x) = xTanH(GELU(x)), where no discontinuities are apparent in the differentiated graph on the domain observed. Generalized networks were constructed using different activation functions. SoftMax was the output function. Using images from MNIST and CIFAR-10 databanks, these networks were trained to minimize sparse categorical crossentropy. A large-scale cross-validation was simulated using stochastic Markov chains to account for the law of large numbers for the probability values. Statistical tests support the research hypothesis stating Phish could outperform other activation functions in image classification. In a first of its kind, Phish hybridizes Identity, Hyperbolic, and Gaussian mathematical relationships to create a unique transformation profile using continuity, non-monotonicity, and differentiability. The next generation activation function provides state-of-the-art training dynamics for expediting subvariants of stochastic gradient descent backpropagation. Future experiments could involve using Phish in generative adversary networks training in an unsupervised two-player minimax framework. This project was conducted on an i5 using custom computer programs and mathematics visualization tools under the appropriate antivirus software.

Introduction

Deep-learning algorithms are capable of solving complex problems. They use a series of synaptic weights and perceptrons to mimic the human thinking process. The success of training deep neural-networks (DNN) relies much on the activation function used in them. In each perceptron, two phases occur: a summation and transformation. In

the summation, the inputs are multiplied with synaptic weights, which are initially generated at random, with a Hadamard product (Silaparasetty, 2020). The transformation step consists of the summated vector being parsed through an activation function in addition to an optional bias (Sharma et al, 2020). Early architectures used TanH and Sigmoid extensively. However, the more complex DNNs required better activation functions.

The most commonly used activation function in DNNs is Rectified Linear (ReLU) (Agarap, 2018). It is a less probability inspired piecewise function with no discontinuities. It has a jump discontinuity when differentiated due to the sharp turn at the origin. Experiments demonstrated that ReLU increased the performance in DNNs, outperforming TanH (Abdelouahab et al, 2017) and Sigmoid (Pratiwi at al, 2020). However, ReLU has some faults. One of the biggest ones is the dying ReLU issue, but luckily leaky ReLU partially solved this issue via augmenting the negative domain of the function (Dubey and Jain, 2019).

Swish and Mish are newer activation functions that have recently gained traction (Ramachandran et al, 2017). They are both composite and comprise at least one existing activation function. Unlike ReLU, these functions are non-linear, and their derivatives are void of discontinuities. They both perpetually increase and pass through the origin (0, 0). The new activation function created here would follow the parameters of Swish and Mish (Misra, 2020).
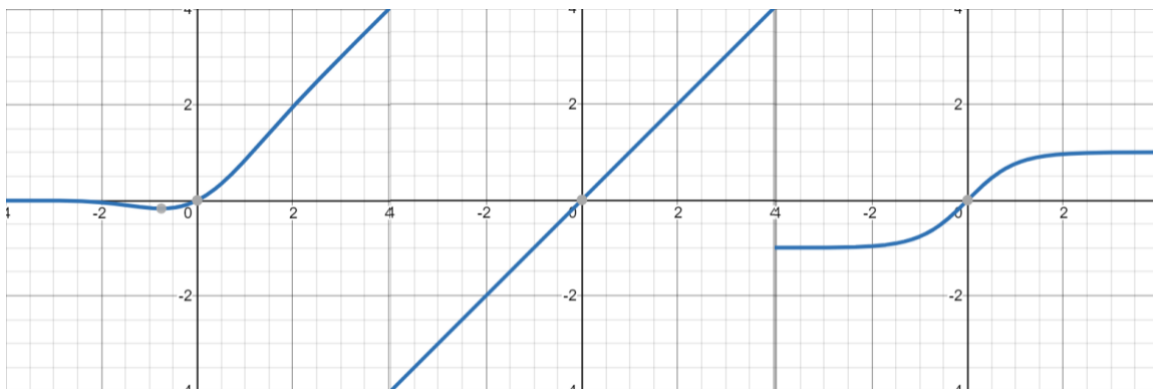

Figure 1: Three Functions Comprising the Self-Regulatory Component of Phish

A new activation function named Phish is proposed here. Phish is defined as f(x) = xTanH(GELU(x)). On the interval from [0, infinity], it is completely positive and passes through the origin (0, 0). It combines three existing activation functions. The functions are Gaussian linear error unit, identity, and hyperbolic tangent from left to right in figure 1. The identity function allows the function to be self-regulated, which is a property common within effective activation functions (eg: Swish and Mish). This function is specialized for classification, therefore the outer function for decision-making was effectively TanH. Lastly, GELU was chosen as the inner function to add non-monotonicity to the range.

An experimental simulation to compare Phish to existing functions will be conducted. The levels of IV will be GELU, Swish, TanH, Sigmoid, ReLU, Mish, and Phish. There was no control. The dependent variable was the minimization of sparse categorical crossentropy (SCC), which is one of the most common loss functions in classification. Several constant variables will be held (eg: DNN layers, optimizer, output transform, and learning rate).

Methods and Materials

To calculate the update gradient, the rate of change in loss L must be determined. Theoretically, though impractical, this can be determined via calculating the slope between two datapoints with an infinitesimal distance. The standard error can be approximated via finding the instantaneous rate of change in loss (ie: determining a partial derivative in respect to z). When

$$\frac{\Delta L}{\Delta z_k^{[l]}} \approx \frac{\partial L}{\partial z_k^{[l]}}$$

the calculated error can be propagated to every weight in the neural-network. Using the weighted input, loss derivative, and activation function derivative, the update gradient can be calculated using basic algebra such that

$$\frac{\Delta L}{\Delta z_k^{[l]}} = \frac{\partial L}{\partial z^{[l-1]}} = \frac{\partial L}{\partial z^{[l]}} A^{[l-1]'}(z^{[l-1]})$$

across many iterations. *Due to space constraints, optimization and further analysis of partial derivatives has been omitted.* As can be seen, the activation function and its derivative are critical in the training of deep neural-networks (DNNs) in supervised classification, or in unsupervised classification (eg: discriminators in generative adversarial networks). Substituting various activation functions can vastly alter the
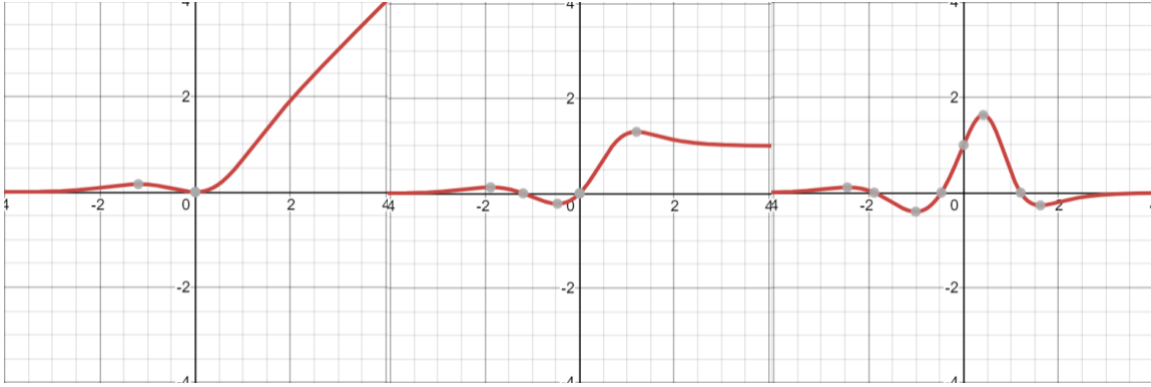
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minimization of loss.

Figure 2: Graphs of Phish(x), Phish'(x), and Phish''(x)

In figure 2, Phish, along with its first and second derivatives, are graphed from left to right. Much like Mish, Phish is a composite function. It comprises two existing activation functions, those being TanH and GELU. The inner function GELU is defined as

$$\text{GELU}(x) = \frac{x}{2}\left[1 + \frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{2}}} e^{-t^2}dt\right]$$

to act as a smooth approximation of ReLU

$$\text{ReLU}(x) = x^+ = \max(0, x) = \begin{cases} x \text{ if } x > 0 \\ 0 \text{ if } x < 0 \end{cases}$$

such that no discontinuities occur on the differentiated graph. ReLU is perhaps the most used activation function in DNNs. It has shown to be effective in large-scale classification problems, often used in image classification.

The outer activation function TanH, is defined with equation

$$\text{TanH}(x) = \frac{e^x - e^{-x}}{e^{-x} + e^x}$$

Since Phish is expressed in terms of other equations and variables, the true form of the equation can be determined. Therefore, through substituting variables and rearranging the terms, the Phish equation in the most pure form can be defined as

$$\text{Phish}(x) = x(\text{TanH} \circ \text{GELU}) = x\frac{e^{\frac{x}{2}\left[1+\frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{2}}} e^{-t^2}dt\right]} - e^{-\frac{x}{2}\left[1+\frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{2}}} e^{-t^2}dt\right]}}{e^{-\frac{x}{2}\left[1+\frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{2}}} e^{-t^2}dt\right]} + e^{\frac{x}{2}\left[1+\frac{2}{\sqrt{\pi}}\int_0^{\frac{x}{\sqrt{2}}} e^{-t^2}dt\right]}}$$

Using the backpropagation equation derived in the introduction, the activation function can be used to calculate update gradients. Such gradients for Phish require its derivative. This was attained by substituting the Phish derivative yielded using the chain rule.

266 $$\frac{\Delta L}{\Delta z_k^{[l]}} = \frac{\partial L}{\partial z^{[l-1]}} = \frac{\partial L}{\partial z^{[l]}}\text{Phish}^{[l-1]'}(z^{[l-1]})$$

Based on the definition of the Gaussian error function being

$$\mathrm{erf}(z) = \frac{2}{\pi} \int_0^z e^{-t^2} dt$$

where z is any complex number, the derivative can be calculated by substituting integrals, rearranging the terms, and applying the chain rule and fundamental theorem of calculus onto all sides. This gives the new form

$$\therefore \frac{\Delta L}{\Delta z_k^{[l]}} = \frac{\partial L}{\partial z^{[l-1]}} \times \frac{d}{dz^{[l-1]}} \left[z^{[l-1]} \frac{e^{z^{[l-1]} \left(\mathrm{erf}\left(\frac{z^{[l-1]}}{\sqrt{2}} \right) + 1 \right) - 1}}{e^{z^{[l-1]} \left(\mathrm{erf}\left(\frac{z^{[l-1]}}{\sqrt{2}} \right) + 1 \right) + 1}} \right]$$

For the purpose of conciseness, the full algebra of the Phish derivative was omitted from this paper. However, writing the Phish derivative in terms of functions as shown below makes it much easier to read.

$$\mathrm{Phish}'(z^{[l-1]}) = \frac{\mathrm{Phish}(z^{[l-1]})}{z^{[l-1]}} + z^{[l-1]} \, \mathrm{TanH}'(\mathrm{GELU}(z^{[l-1]})) \, \mathrm{GELU}'(z^{[l-1]})$$

One Intel i7 computer using a Ubuntu Oracle VirtualBox running on the Windows macro operating system was obtained. Python3 was installed onto the machine with machine-learning and linear algebra dependencies (ie: SkLearn, TensorFlow, PyTorch, NumPy, and SciPy). Custom computer code was developed to test and compare Phish. For the procedure, 170,000 training and 50,000 testing images were gathered. The images were preprocessed via normalization and cropping. The preprocessing was limited to generalize the training process. An artificial neural-network was fabricated for testing. It comprised an input layer, six hidden layers, and an output layer. The output layer always used SoftMax. The models were compiled with the Adam optimizer. Binary classification crossentropy loss was substituted with SCC such that J(w) is defined as

$$\therefore J(w) = -\sum_{j=1}^{n} \frac{-1}{n} \, y_j \log(\widehat{y_j}) \Big) + (1 - y_j) \log(1 - \widehat{y_j})]$$

where w represents the arbitrary parameters of a given network with the y values representing the predicted and true labels. This was done so the network would assume correct classifications can only be a single prediction.

SoftMax was used for the output layer. It is a deep-learning probability distribution function used in multi-class identification problems (eg: 2020-2021 ImageNet contest) defined as

$$\sigma(\vec{z})_i = \frac{e^{z_i}}{\sum_{j=1}^{K} e^{z_j}}$$

where the input and output functions of the network calculate the subsequent input vector. During testing, K=10 was constant because each of the databanks used had ten

possible labels. The levels of IV were tested using a cross-validation. This was done twenty-five separate times for each activation function. The minimization of SCC was recorded.

Due to the hardware limitations (ie: lack of graphics processing units and cloud services). Therefore, a large-scale cross-validation was not feasible. A memoryless stochastic model was more favorable for such a purpose. Thus a Markov chain was developed to simulate the process, and can be seen in the appendix. The combination of the two methods calculated the loss. For each cross validation, the prediction statistics were implanted as transition states in the Markov chains, and each trial consisted of 10,000 predictions averaged into one value. A permission form was signed by the parent that indicated that they have read and understood the risks and possible dangers involved in the research and they consented to their child participating in this research. At night hours, 75% of blue light was omitted from the computer screen and one hour breaks were taken between sessions to rest the eyes of the programmer. This project was conducted under the supervision of instructors using school-issued antivirus software. No hazardous substances, pathogenic bacterium, or human participants were involved in the procedures. All the datasets were open-sourced and were retrieved using commands built into TensorFlow-Keras. No images were downloaded.

Results

Graph 1: The Effect of Activation Functions on Minimizing Sparse Categorical Crossentropy
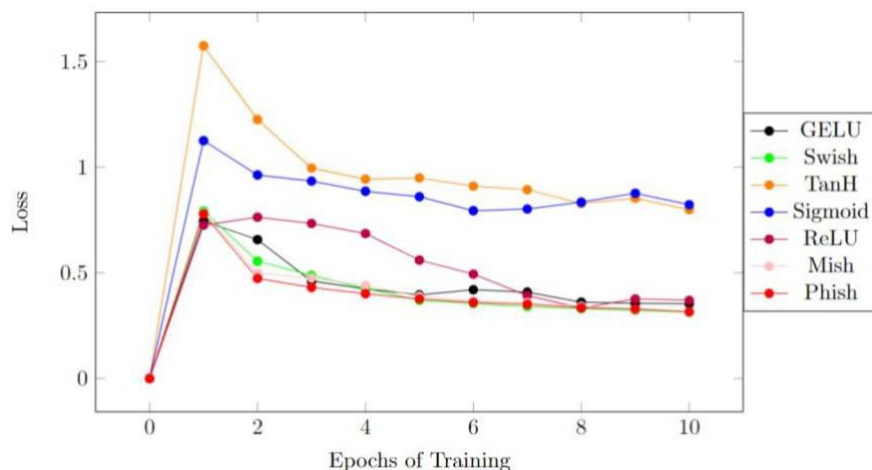
Table 1: Statistical Analysis of the Effect of Activation Functions on Minimizing Sparse Categorical Crossentropy

T-Test	Calculated Value	Table Value	Result
Phish vs. GELU	3.336	2.011	Significant
Phish vs. Swish	1.996	2.011	Not Significant
Phish vs. TanH	56.331	2.011	Significant
Phish vs. Sigmoid	35.088	2.011	Significant
Phish vs. ReLU	4.281	2.011	Significant
Phish vs. Mish	1.782	2.011	Not Significant

The effect of activation functions on minimizing the loss in classification for DNNs was determined in this experiment. Various datasets were used to simulate backpropagation during classification problems. GELU, Swish, TanH, Sigmoid, ReLU, Mish, and Phish can be seen in graph 1. This particular graph shows the trend when training on MNIST fashion. The graph was the average loss across epochs calculated from twenty-five trials. Across the various epochs, it can be seen that Phish and Swish had a similar minimization of SCC. TanH and Sigmoid had significantly lower reduction of loss compared to Swish and Phish. The standard deviation and variances were low, with every datapoint existing within the second standard deviation range.

Similar patterns were apparent when the networks trained on MNIST numbers and CIFAR-10 image databanks. *Because of formatting, the results of those measurements were not presented in this paper. Additionally, the standard deviation and variance tables were omitted for the same reason.* Phish consistently outperformed TanH and Sigmoid. It was either on-par or slightly superior to Swish. It also showed similar training patterns to GELU. The results of the experiment show that Phish is a promising alternative activation function.

Table 1 shows some of the compared levels of IV. Independent parametric t-tests. were calculated to determine the significance of the data collected. The value of significance was at 0.05, and was granted 48 degrees of freedom (ie: number of IV levels subtracted from the total number of trials compared). A table value of 2.011 was used. A null hypothesis was generated. It stated that there would be no difference between any of the tested activation functions when given the task of minimizing SCC.

The majority of comparisons relating to Phish were significant. In each case of

significance, Phish outperformed the competing activation function. Phish showed to outperform Swish and Mish as well, but the difference was not notable such that a t-test could identify significance. Experiments with larger datasets and deeper models could be used to further investigate the relationships between Swish, Mish, and Phish in the future.

Discussion and Conclusions

The purpose of this experiment was to determine the effect of activation functions on minimizing loss in DNNs. It was found through various experiments that in general, continuous, differentiable, and non-monotonic activation functions are favorable for classifying images. A new activation function invented here produced the best results. Some of the highlights of the robust Phish activation function are:

1. *It has more aggressive transitions between concavity, which can be observed via the critical numbers on the second derivative shown in figure 2.*
2. *The first and second derivatives carry no symmetry, while other activation functions with the self-gated property (ie: Swish and Mish) do.*
3. *There exists a relative maximum in Phish(x), Phish'(x), and Phish''(x) when the domain is negative via the first and second derivative critical numbers.*

The function minimized sparse categorical crossentropy effectively had the most stable loss minimization as well as the lowest loss after the ten epochs.

There were many sources for error in the experimentation. The first was that Phish was only compared to three other activation functions. Another flaw was that only one architecture was tested for classification, where many could have been tested. Other combinations of optimizers, metrics, losses, and layers may result in different findings. In addition, a true simulation of the loss was never conducted. The simulations were partially cross-validation, but the other component simulated sequences of predictions using stochastic Markov chains. To remedy these errors in the future, various types of classification algorithms could be tested using the activation functions. More functions could be compared as well. Lastly, better computers and cloud servers could be used to conduct the advanced simulations required to test Phish, that would otherwise be impractical on a laptop.

Future applications of the activation function proposed in this research may vary. The first application would be further testing on types of datasets. MNIST and CIFAR-10 were used in this research. MNIST is a relatively simple dataset that most deep-learning models could solve (Xiao, 2017). CIFAR-10 consists of RGB images, which requires

better models to solve (Pandit and Kumar, 2020). Still, testing Phish on MNIST and CIFAR-10 only would limit knowledge on its properties. ImageNet is a public databank consisting of RGB images with an average resolution of 469 × 387 pixels (Russakovsky, 2015). It is organized according to the WordNet hierarchy, and is often used when testing pre-trained convolutional neural-networks.

Specialized layers in the networks used for testing were omitted throughout evaluation. Further testing could determine the effect of Phish on such models. Specific examples would include recurrent neural-networks. These networks were engineered to solve the vanishing gradient problem (Zaremba, 2014). Gated recovery unit and long-short term memory algorithms are extensions of recurrent neural-networks (Hochreiter and Schmidhuber, 1997). When testing time series data, Phish could be implemented in these algorithms via substituting Sigmoid layers.

Furthermore, Phish could be used in generative adversarial networks. These algorithms comprise of two models, often multilayer perceptrons, engaging in a minimax game. The first model is the generator, which captures the distribution of a given dataset. The second one is the discriminator, which differentiates samples from the dataset and ones made by the generator. Ideally, the loss of the discriminator would be maximized with the accuracy yielding ½ everywhere. Testing Phish in a model with the purpose of maximizing loss would be an interesting future study (Goodfellow, 2014). Phish is a high-powered activation function, so it may take longer to train deep-learning models than less computational intense activation functions (eg: TanH, Sigmoid, and ReLU). A future development could involve generating a lighter approximation of the mathematical form.

Phish is a robust non-monotonic activation function. It delivered higher performance in MNIST and CIFAR-10 image classification than Sigmoid and TanH. It rivals Swish and Mish in loss minimization. The next-generation training dynamics provided by Phish using three unique mathematical relationships deliver state-of-the-art enhancement to subvariants of stochastic gradient descent backpropagation by increasing the heterogeneity in the rate of change and concavity. Despite extensive searching, no activation function defined as f(x) = xTanH(GELU(x)) was found. Additionally, Phish is the first activation function publicly proposed by a high school student. This project was conducted under adult approval with antivirus software. TensorFlow-Keras, PyTorch, and MXNet applications of the function were each created. *Once again, due to the formatting guidelines of VJAS, the link to the GitHub code was omitted because the experimenter's name is shown.*

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Appendix

A. Mathematical Formulation of the Robust Phish Activation Function

The properties of Phish remained consistent throughout the project before functions were tested. However, many functions were tested via compositing equations (eg: Sigmoid $\times$ GELU, Sigmoid $\times$ ReLU, Sigmoid $\times$ Softplus, etc.) and multiplying them by the input. Such an approach has shown to be successful in both Swish and Mish. _Space consuming measurements were omitted from this paper due to the sheer quantity of them (eg: 45 combinations $\times$ 25 trials $\times$ 10,000 iterations from the Markov chain = 11,250,000 measurements)._

Only forty-five combinations of functions were tested. Theoretically, an infinite number of functions exist that could be functional when used in backpropagating DNNs. However, testing all of those would be highly impractical. Therefore, a set of criteria was developed to help in choosing the functions before implementing them. This saved time and computational cost.

The list of criteria was developed in accordance with previous activation functions proposed in research. Some common properties of functions included in the design of Phish are

1. _Continuity was prioritized as the first condition. Almost every activation function used in machine-learning is fully continuous on the domain $\mathbb{R}$. Continuity implies no holes or asymptotes throughout the function._

2. _Differentiability was the second criteria. Not all activation functions fulfill this (eg: ReLU, and leaky ReLU). However, Swish and Mish found success using this property. For this criteria to be fulfilled, a slope must exist at each point._

3. _Self-regulatory activations (eg: Swish and Mish) transform the input recursively. In this case it was the identify function. In the past this property has shown to be useful in increasing the performance of deep neural-networks._

4. _Non-monotonicity is uncommon in traditional activation functions. However the more modern functions (eg: Swish and Mish) have this property. Non-monotonicity indicates that the derivative of a function is positive and negative at some point on the domain $\mathbb{R}$._

Based on these criteria, a list of functions was fabricated. This allowed for the list of potential functions to be reduced from trillions to forty-five. It was found that defining the function as f(x) = xTanH(GELU(x)) was the most effective in minimizing loss. The larger scale function was modeled based on ReLU, however the smaller scale values were formulated to exhibit increased heterogeneity in rate of change and concavity. This was done to mimic the success found with ReLU for the larger updates, but to provide better training dynamics for later stages of training where ReLU falls short by eliminating the possibility of dying neurons.

B: Validation Augmentation using Probability and Stochasticity Graph Models

A Markov chain is a stochastic graph model based on probability. They are favorable for simulating large sequences of events because they are memoryless. Each chain yields a stochastic transition matrix (Meyn and Tweedie, 1993). The Markov model on Ω results in the stochastic process $(X_1, X_2, X_3 ... X_t)$ in which the transition state between x and y complies with the properties and, In addition, it complies with the probability and stochasticity

where each row converges to 1 (University of Auckland, 2018). This Markov model is continuous, with no termination node with 100% probability of returning to itself on the graph, and a 0% chance of transferring to any other stage. Since this Markov model will be ran for extended periods of time, the law of large numbers states that the actual probability of the event occurring will approach the theoretical probability, especially since there are only two possible stages in this model. Therefore, the chance of starting at either stage was 50% always (Meyn and Tweedie, 1993).
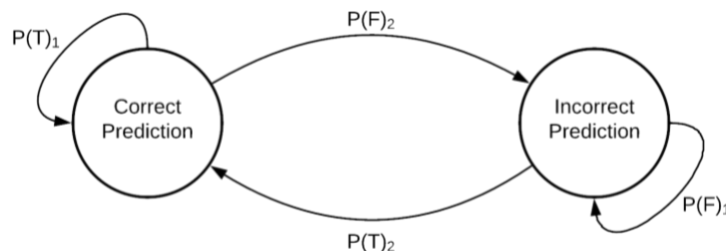
Figure 3: Markov Chain used for Augmenting Cross-Validations

The Markov chain utilized here is a two stage graph with four global locations and two local ones for each stage. A minimalistic representation of the adjacency matrix could be fabricated accordingly with 4 $\times$ 4 dimensions. The probability values were

guaranteed using transition matrix

$$\omega_{ij} = \Omega = \begin{bmatrix} P_1(T) & P_2(T) \\ P_2(F) & P_1(F) \end{bmatrix}$$

$$\omega_{ij} = \Omega = \begin{bmatrix} P_1(T) & P_2(T) \\ P_2(F) & P_1(F) \end{bmatrix}$$

The Markov simulation was conducted where the transition probabilities were retrieved from a cross-validation. For each activation function, a DNN was trained across ten epochs. The prediction ratios were implanted into four graphs. Each graph was simulated for 10,000 iterations twenty-five times to follow the ideal experimental design. *The flowcharts showing the Markov chain's integration into the simulation were omitted because of the space limitations.*

C: Training Dynamics and Backpropagation of the Deep Neural-Networks

Activation functions are derived with the purpose of generating non-linearity to the inherently linear data. Backpropagation is the process where each synaptic weight in deep-learning algorithms are iteratively finetuned to complete a task using loss calculated between the expected and actual outcomes. Suppose there is a multilayer

$$z = \sum_{i=1}^{n} x_i w_i + b$$

perceptron with weights, and biases adjusted through an arbitrary activation function. In this multilayer perceptron, as with most, the weights are defined the matrix to represent the baseline values, which are usually randomly generated within a [-1, 1] interval. The less complex bias vectors can be represented by a one dimensional version of the matrix seen above. In addition, the weighted sum (ie: values parsed through the activation function) is

The weighted input can be obtained and parsed through the activation function to receive the intermediate column vector.

$$z^{[l]} = \begin{pmatrix} z_1^{[l]} \\ z_2^{[l]} \\ z_3^{[l]} \\ . \\ . \\ . \\ z_n^{[l]} \end{pmatrix} \in \mathbb{R}^{n^{[l]}}$$

The testing model comprised an initial flattening layer, six hidden layers, and one output layer. The flattening layer manipulated the image data into a one-dimensional array for the next layer. The six hidden layers used one of the activation functions tested and contained between thirty-two to one hundred and twenty-eight layers each. The output layer was always ten neurons because MNIST, and CIFAR-10 both have ten classes. It used SoftMax instead of a Sigmoid, as probability of classification was distributed between more than two classes. The models were trained using the Adam optimizer, which combines aspects of the previously engineered AdaGrad and

RMSProp methods. *Due to the space constraints, the screenshots of the custom Python3 and R computer code in addition to the flowcharts showing the integration of the models into the simulator were not included here.*

VJAS Alternate Delegates to AJAS

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The Effect of Urban Heat Island Mitigation Strategy on Surface and Atmospheric Temperature

Abstract

Urban heat islands (UHIs) are urban areas with consistently higher temperatures than surrounding rural areas and are harmful because they exaggerate the effects of global warming and contribute to worsening heat waves. The purpose of this study was to determine what UHI mitigation strategy best reduces this phenomenon. The strategies tested were green roofs, cool roofs, cool pavements, and trees, while no mitigation effort was the control. It was hypothesized that the cool roofs would be most effective due to their high solar reflectance and greater surface area. The experiment was conducted by constructing model cities and finding the average increase in temperature after one hour under a heat lamp for each of the mitigation strategies. The results showed that the cool roofs and green roofs were most effective at preventing overall heat gain, with mean increases in temperature of 2.2° C and 2.1° C respectively. Conversely, the control allowed for the greatest temperature increase at 3.0° C. The data collected suggests that all four mitigation strategies tested are successful in reducing UHIs and provides further insight into the best strategies to use for various purposes.

Introduction

As a result of human activity, climate change has accelerated significantly over the last century. In fact, the Intergovernmental Panel on Climate Change reported an increase in global temperature of 0.9° C from 1880 to 2012 and estimates an additional 3-4° C increase over the coming century, should no further efforts be made to combat it ("Global Warming", 2021). Over the past summer in particular, the impacts of climate change have been made painfully clear. Massive heat waves occurred, particularly in the western United States, that set all-time temperature records in several locations ("Record-breaking June 2021 Heat

Wave", 2021). This is especially notable given that heat waves are one of the leading weather-related causes of death in the United States ("New York City", 2021).

While heat waves and global warming impact regions across the United States and the world, they disproportionately effect urban areas due to a phenomenon called the urban heat island effect. Urban heat islands (UHIs) are cities or other urban areas with consistently higher temperatures than surrounding rural areas. This occurs because manmade surfaces, such as roads, buildings, and other infrastructure, re-emit more of the sun's heat than the natural landscapes they replace, such as vegetation and water ("Learn About Heat Islands", 2021). The effects of these heat-trapping urban surfaces are further exaggerated by heat from cars, air conditioners, and other similar technologies (University of Sussex, 2017).

Due to the difference in temperature at the earth's surface and in the atmosphere higher up, UHIs can be measured in two different ways. Surface heat islands are measured by surface temperature and are most pronounced during the day, when the sun is shining, particularly during hotter weather. For example, on a 30° C or hotter day, traditional urban surfaces such as conventional pavement and roofs can be around 30° C warmer than the ambient temperature. Atmospheric heat islands are measured by comparing the air temperature of cities to their rural counterparts ("Learn About Heat Islands", 2021). While much less intense than surface heat islands, atmospheric heat islands are still very significant. In 2017, air temperatures in American cities were 0.5-4.0° C warmer than in nearby rural areas during the day and 1.0-2.5° C warmer at night (Aram et al., 2019).

UHIs have significant implications for the cities they effect, with one area of impact being public health. Extreme heat now accounts for more deaths in cities than all other weather-related events combined. This is due to a combination of factors, including an increase in

global temperatures and heat waves due to climate change, overall higher temperatures in cities, and higher overnight lows. The human body is significantly less capable of recovering from extreme heat when temperatures at night never reach below about 27° C, which is far more common in cities than in rural areas due to UHIs (Walker, 2019).

While less obvious than their impact on public health, UHIs also create a substantial economic burden. In fact, one model estimates that the total economic costs of climate change for cities in this century could be 2.6 times higher when UHIs are taken into consideration than when not (University of Sussex, 2017).

Although cities cover only 1% of the earth's surface, they account for 80% of the gross world product, 78% of global energy consumption, and around half of the world's population, making reducing UHIs (and their subsequent environmental, health, and economic costs) a top priority (University of Sussex, 2017). Fortunately, there are several measures that can be taken to do so. Four strategies commonly used to mitigate UHIs are green roofs, cool roofs, cool pavements, and increased vegetation (Blanchfield, 2011).

Green roofs are a layer of vegetation planted over a flat or minimally sloped roof. They reduce the roof temperature and surrounding air temperature through evapotranspiration and by providing physical shade. While green roofs can be quite costly up front, research by the Lawrence Berkeley National Laboratory suggests that the benefits of green roofs could add up to $14.00 in savings per 30-cm^2 compared to conventional roofing materials over a 50-year life cycle. Additionally, green roofs have a plethora of other benefits including enhanced storm water management and water quality, increased insulation for the building (and therefore decreased energy costs), and reduced greenhouse gasses and air pollution ("Using Green Roofs", 2021). Sedum, a succulent-like genus of plants that are commonly used for

green roofs due to their ability to withstand difficult conditions such as a thin planting medium and extreme drought (Axelrad, 2019), were used for the green roofs in this experiment.

Cool roofs are roofs that are coated with a high albedo (highly reflective) surface. In hot weather, the high solar reflectiveness and emittance of these surfaces can cool the surface of the roof 28-33° C more than traditional roofs and can result in saved energy and money. A California study found that cool roofs produced annual net savings of almost $.50 per 30-cm^2 ("Using Cool Roofs", 2021) and a 2021 analysis of UHIs suggested that high albedo surfaces (including both cool roofs and cool pavements) were the most efficient urban land cover conversion for reducing UHIs (MacLachlan et al., 2021). One unintended drawback of cool roofs is potential loss of desired heat gain in the winter.

Cool pavements are pavements made with high-albedo surfaces and work in much the same way as cool roofs. Additional benefits of cool pavements include lower tire noise, enhanced automobile safety, and better nighttime visibility. Cool pavements are currently the least widely used of these four strategies and vary in design based on local conditions, making it difficult to estimate their net benefits or costs ("Using Cool Pavements", 2021). A high-albedo paint was used for both the cool roofs and cool pavements in this experiment.

Lastly, trees and other vegetation reduce surface and air temperatures through shade and evapotranspiration, similarly to green roofs. Through evapotranspiration alone, trees can reduce summer temperatures by 1-5˘ C and shaded surfaces can be 11-25˘ C cooler than unshaded surfaces. Furthermore, although trees were found to be quite expensive up front across five major US cities ($15.00-$60.00 per tree), they produced benefits ranging from $1.50-$3.00 for each dollar invested annually ("Using Trees", 2021). New York City's

Million Trees Initiative is a prime example of a major city taking advantage of the cooling capabilities of trees to combat UHIs ("New York City", 2021). In this experiment, hypnum, a genus of moss known for its carpetlike growth pattern ("Sheet Moss", 2020), was suspended over the simulation to represent tree canopies.

The purpose of this study was to determine which UHI mitigation strategy is most effective in reducing surface and atmospheric temperature. To do so, model cities were constructed using plywood and the appropriate mitigation strategy was applied. A heat lamp was then used to simulate heat from the sun and the increases in surface and air temperatures were measured. It was hypothesized that the cool roof would be the most effective in preventing heat gain due to its high solar reflectance and greater surface area. Additionally, the primary purpose of cool roofs is to reduce UHIs, and they are designed specifically to do so, suggesting they would be highly effective in this experiment. The independent variable was the mitigation strategy, with the experimental groups being sedum roofs, high-albedo painted roofs, high-albedo painted ground, and moss "tree canopies." The control was no mitigation strategy. The dependent variables were the increases in surface and air temperature. The null hypothesis stated that the mitigation strategy would have no effect on the temperature. The simulation size and layout, heat lamp type and distance from the simulation, amount of time under the heat lamp, and method of taking the temperatures remained constant.

Methods & Materials

Prior to the experiment, model city blocks were constructed using 0.5 cm thick plywood. A 40 x 40 cm panel was measured and cut to serve as the base for the simulation. Then, four additional panels were cut, two measuring 14.5 x 14.5 cm and two measuring 15.0 x 14.5 cm. These were arranged as walls on one corner of the base. A 15 x 15 cm roof was later added to form a 15 cm cube representing a building. All wood was adhered using wood glue and 3.5 cm thick wooden struts were used in the corners of the building to provide structure and
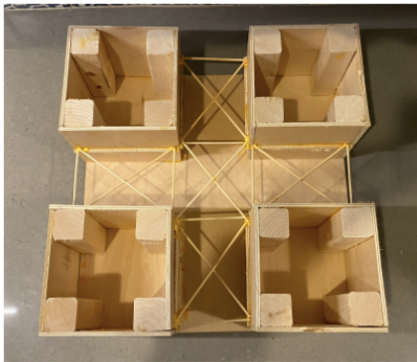
Photo 1: One of the two completed wooden simulations (taken by student).

support. This process was repeated in each of the remaining three corners of the base to form a structure resembling four city blocks and the intersection between them. Wooden skewers were then arranged in a lattice pattern between the buildings as support for the moss "tree canopies" used later in the experiment (Photo 1). Two models were constructed to allow for simultaneous trials. Finally, as the control, the bases were painted black and the buildings were topped with black roofing tiles. The mitigation strategies could then be applied one at a time to isolate their effect.

Next, the four mitigation strategies were prepared (Photo 2). For the green roofs, a layer of Sedum spurium was placed on top of the roofs and 2 cm tall strips of wood were glued around the perimeter of the roofs to contain the plant material. For the cool roofs, 2 layers of a

Photo 2: The 5 independent variable levels. From left to right: no mitigation strategy, green roofs, cool roofs, cool pavement, tree canopies (taken by student).

white elastomeric coating were applied to the roofs. Similarly, the coating was applied to

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strips of posterboard that were measured to fit between the buildings in the simulation, serving as cool pavements. Finally, a layer of sheet moss was placed over the wooden skewers between the buildings to simulate tree canopies.

To conduct the experiment, each simulation was centered 75 cm under a 50-watt, 120-volt, incandescent heat lamp. One of the mitigation strategies was applied to each simulation. Then, the air temperature 20 cm above the base of the simulation and surface temperatures at the middle of the base and the middle of the roofs were measured. The temperatures were taken with a Taylor Precision instant read thermometer by placing the tip at the desired spot and waiting for one minute to obtain an accurate reading. The heat lamps were then turned on and the simulations were left for one hour (Photo 3). After the hour had passed, the new temperatures at the same three locations were measured and recorded and the increases in temperature were calculated.

Photo 3: The simulations under the heat lamps with the control (taken by student).

The experiment was paused for at least half an hour between trials to allow the area to cool back down, and the same procedures were used for each of the mitigation strategies. Once a day, the sedum roofs and moss "canopies" were watered with 100 ml of water using a spray bottle. This was always done after testing so that the evaporating water did not interfere with the results. The experiment was repeated until 10 trials were obtained.

Throughout the experiment, several safety measures were taken. Whenever working with wood or power tools, adult supervision was present and safety goggles were worn. Additionally, care was taken to always cut away from the body of the researcher when using a

saw to avoid injury. At the end of the experiment, all organic materials were composted since they posed no environmental threat.

To analyze the data, the difference in starting and ending temperatures for each mitigation strategy were averaged at each of the three locations. This data was then organized into a bar graph with error bars representing the standard deviations. Finally, an ANOVA test was conducted to determine the statistical significance of the data.

Results

Data Table 1: The Effect of Urban Heat Island Mitigation Strategy on Mean Temperature Increase						
	Air Temperature		Ground Temperature		Roof Temperature	
Mitigation Strategy	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
No Mitigation Strategy	3.0	0.4	3.7	0.7	7.7	0.9
Green Roofs	2.2	0.3	3.6	0.3	6.0	1.1
Cool Roofs	2.1	0.4	3.3	0.3	5.5	0.7
Cool Pavements	2.7	0.5	2.9	0.5	7.5	1.0
Trees	2.7	0.5	1.4	0.7	7.5	0.7

Graph 1: The Effect of Urban Heat Island Mitigation Strategy on Mean Increase in Temperature
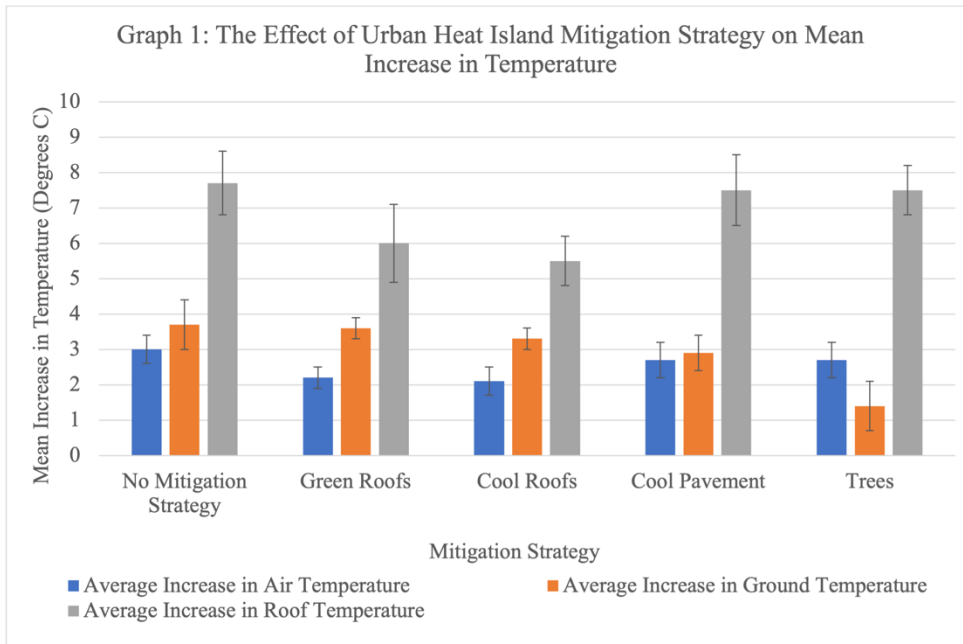
The independent variable in this experiment was the mitigation strategy and the dependent variables were the increase in air, ground, and roof temperature. As seen in Data Table 1, for air temperature, the cool roofs allowed for the least heat gain, with a mean increase in temperature of only 2.1° C. This was followed closely by the green roofs, with a 2.2° increase while the control (no mitigation strategy) averaged an increase of 3.0°, the highest of all the groups. Similarly, the control had the highest mean temperature gain for the ground and roof temperatures, averaging 3.7° and 7.7° respectively. The trees had the lowest mean temperature gain for the ground temperature at 1.4° and the cool roofs had the lowest mean temperature gain for the roof temperature at 5.5°.

Overall, the standard deviations for each group were low. For the air temperature, none of the standard deviations were greater than +/- 0.5, suggesting high precision and significant data. As the means increased, the standard deviations tended to increase as well. For example, the roof temperature was the dependent variable with the highest means across all groups and these groups also had the highest standard deviations. However, they were still relatively low (no more than +/- 1.1), meaning the data was still fairly precise.

Data Table 2: ANOVA Test Results			
Dependent Variable	Air Temperature	Ground Surface Temperature	Roof Surface Temperature
P-value	3.5×10^{-5}	9.0×10^{-13}	1.1×10^{-6}

To determine the statistical significance of the data, ANOVA tests were conducted. As displayed in Data Table 2, the p-values for each of the dependent variable levels were far less than 0.05, meaning there was a statistical significance in the data. This allowed the null hypothesis, which suggested the mitigation strategy would have no impact on temperature, to be rejected. T-tests were then run to better understand the significance of the data, and the

results showed that the only groups that were not statistically significant were those with similar means. For example, even though the standard deviations were quite low for the air temperature for the green and cool roofs (+/- 0.3 and 0.4 respectively), the difference was not significant because the means were only 0.1° different from each other.

Discussion & Conclusion

The purpose of this study was to determine which UHI mitigation strategy is most effective in reducing the effects of UHIs. It was hypothesized that cool roofs would be the most successful and prevent the most heat gain. The hypothesis was generally supported by the results, as both the cool roofs and green roofs allowed for the lowest increase in temperature, although there was no statistical significance between the two. Additionally, all four mitigation strategies were more effective than the control, as was expected.

The reason for the greater cooling capabilities of the roofs in this experiment compared to the cool pavement and trees may have to do with the surface area. The roofs comprised a greater surface area (56% of the total surface area of the simulation) than the cool pavement and trees (44%). As a result, the superior performance of the roofs could simply have been a result of their greater abundance. However, the ratio of roof to ground used in this experiment was very purposeful. An analysis of geographically diverse cities found that pavement covers approximately 30-45% of land in cities ("Using Cool Pavements", 2021), meaning that the proportions used in this experiment were representative of an actual city (and more generous towards the cool pavement if anything). Furthermore, the green and cool roofs were located closer than the cool pavements and trees to the point at which the atmospheric temperature was measured, which is another possible explanation for their greater effectiveness.

In terms of the ground temperature, the trees yielded the lowest mean increase in temperature, followed by the cool pavement, while the differences in temperature between the green and cool roofs and the control were not significant. The lack of effectiveness of the two roofs in reducing the ground temperature makes sense, given that these two mitigation strategies do not provide shade or otherwise directly effect the ground. Between the trees and cool pavement, the superior cooling capabilities of the trees may be related to the difference in how they work to combat UHIs. Cool pavements refer to any pavements that are in some way modified to be cooler than conventional pavements ("Using Cool Pavements", 2021). Typically, this is achieved by using a higher-albedo surface, which reduces temperatures by reflecting heat (as was done in this experiment). Conversely, trees combat UHIs by providing physical shade, which prevents as much heat from reaching the pavement in the first place. In this way, trees have been shown to decrease surface temperatures by 11-25° on a hot day ("Using Trees", 2021). The results of this experiment suggest that the physical shade provided by trees is more effective at cooling a surface than the solar reflectance provided by cool pavements.

A similar but opposite pattern was observed for the roof temperatures. The green roofs and cool roofs were much more effective than the control, while the cool pavements and trees did not yield any significant difference compared to the control because they did not directly affect the roofs. The results of this experiment are conducive with other studies. Both green roofs and cool roofs have been shown to decrease surface temperatures by anywhere from 28-40°, green roofs by providing shade and removing heat from the air ("Using Green Roofs", 2021) and cool roofs by reflecting heat. ("Using Cool Roofs", 2021).

While this experiment provided potentially valuable insights into the ways to combat UHIs, it is important to understand the limitations of the data. Overall, the experiment was conducted on a very small scale and as such, it is hard to predict how well the results apply to a real city. Another potential inaccuracy could be the "trees" used in the experiment. Moss was used as a canopy to represent shade provided by tree islands in the middle of roads in a city. However, the moss may have provided denser coverage and more shade than actual trees, which could have skewed the results. In the future, the use of larger simulations or the comparison of these strategies in real cities where they have already been applied could address these concerns.

Overall, this experiment confirmed the effectiveness of these four UHI mitigation strategies, all of which are vital to combat the growing environmental, public safety, and economic problems posed by UHIs. Furthermore, the data collected suggested that green roofs and cool roofs are the most effective of the four. However, it is important to consider that every city is geographically diverse and the mitigation strategy that makes the most sense may be highly dependent on the layout on the city. As such, a future study that isolates the effects of these surfaces outside of the context of a city might be useful because the results could be more easily applied to suit the unique land use needs of individual cities.

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Live Cell Imaging of the Interactions between an Acetylase and Binding Domain

Abstract:
Histone acetylation is a post-translational modification (PTM), which is important for regulating gene expression. The YEATS domain is commonly known as an acetylation reader, particularly on histones. The protein p300 contains a Histone Acetyltransferase (HAT) domain, which adds acetyl groups to the tails of histones and loosens to the DNA wrapped around the protein to enable transcription. Through these two functions, both proteins are necessary for cell viability via regulating gene expression using epigenetic factors in the nucleus. However, abnormal activity of either proteins stimulates tumorigenesis and the development of various cancers. As a result, studying the interactions between these two proteins helps to better understand the causation of cancer cells and how controlling the activity of these proteins can inhibit diseases. Through analyzing how p300 affects the foci formation rate of the YEATS domain, the purpose of this project is to uncover the relationship between p300, a HAT protein, and the YEATS domain, a histone acetylation reader.
The overall hypothesis states that the function of the YEATS domain is influenced through interactions with p300, which is measured through analyzing the foci formation of YEATS. The negative control was expressing only the fluorescent protein (YPet) to determine how many nuclear foci were not due to the target proteins. If p300 and YEATS are shown to interact, inhibiting their co-localization could prevent necessary cellular functions, such as transcription. The experiment was completed by transfecting the target proteins at differently controlled rates. The results showed that by expressing the YEATS domain with p300, the foci number increased while the foci area and number of aggregates decreased. The data was found to be statistically significant through ANOVA tests and was due to interactions with p300 and as well p300's autoacetylation ability. As a result, the interactions with p300 were shown to directly impact the foci formation rate of the YEATS domain.

Introduction:
The YEATS domain is an importantly conserved sequence in the human genome and is found in various human proteins, one of those being GAS41 (Glioma-Amplified-Sequence41 (Zhao et al, 2017). GAS41 has been shown to be amplified within cancerous cells, such as glioblastomas, non-small cell lung cancer (NSCLC) cells, and astrocytoma while being necessary for cell viability. The YEATS domain in GAS41 is used to recognize lysine acetylation and assist in the expression of target genes. (Hsu et al, 2018). As a result, understanding the activity of the YEATS domain will help to determine the domain's correlation with cell viability and devise potential cancer treatments that target this domain. The goal of this project is to understand the nuclear interactions between p300 and the YEATS domain as well as how they affect the YEATS domain's function in regulating gene. Past research papers experimenting with the YEATS domain have mentioned the p300 protein; However, looking deeper into their interactions has never been tested before.
If p300 and YEATS are shown to interact, then inhibiting their co-localization could also prevent necessary cellular functions, such as transcription, from occurring. As a result, further knowledge of the YEATS domain could help devise potential methods to use as cancer treatments that involve targeting this domain, thus determining possible applications of utilizing domain in the medical field. Determining the function of the YEATS domain helps to clarify the function and role of the GAS41 protein, relating to gene expression (Heisel et al, 2010). The protein p300 is also a necessary peptide for regulating cellular functions. Besides histones,

p300 also acetylates transcription factors, such as p53, which activates genes for cellular apoptosis. By acetylating p53, p300 can activate the protein's activity, which is important for stopping abnormal cell growth, such as of cancer (Li et al, 2019).

The proteins, p300 and YEATS, are proteins involved in initializing transcription within the nucleus (Sun et al, 2015). However, both proteins' roles in the regulation of nuclear epigenetics are different. The protein p300 is known as a Histone Acetyltransferase (HAT). Like its name suggests, the coactivator adds an acetyl group to the tails of histone proteins, specifically on lysine sites in Histones H3 and H4, such as at H3K27. The acetylated histone then acts as an active marker for target genes to assist in initiating transcription. By doing so, the DNA will loosen and separate from the histone, thus giving more access for transcription-related protein, such as transcriptional activators, to bind and begin preparing the DNA segment for gene expression. As a result, by acetylating H3K27, p300 can recruit histone acetylation readers to promoter and enhancer regions of specific genes, thus activating transcription (Ma et al, 2021).

GAS41 mainly binds to acetylated histones at active promoters within proximity of the starting sites for transcription (Hsu et al, 2017). In the nucleus, GAS41 acts as a co-regulator for initiating transcription. The protein can both activate and repress the transcription, depending on the type of and which transcription factor it interacts with. For example, the protein interacts with various transcription factor complexes to help stabilize these scaffolds while binding to DNA, allowing GAS41 to act as a co-activator. (Heisel et al, 2010, Ding et al, 2006).

The YEATS domain regulates gene control through loosening the DNA wrapped around histone octamers to provide RNA polymerase II the ability to bind and begin transcription. For specific target genes, this domain can also repress transcription through binding to gene promoters and inhibiting other transcription factors from binding to promoter regions, which inhibits the recruitment of RNA polymerase II (Zhao et al, 2017). Through localizing at target chromatin regions, YEATS domain can self-associate and form puncta within the nucleoplasm by condensing at highly acetylated areas and helping to regulate the expression of target genes (Gao et al, 2020). As a result, the dependent variable was the nuclear foci formation rate of the YEATS domain. The number and size of puncta formed in the nucleus is dependent on the amount of protein expressed and the potential interactions with p300. By co-expressing the YEATS domain with other proteins, the domain's foci formation rate either increases or decreases based on the potential interactions, which affects the transcription rate of necessary genes controlled by the YEATS domain (Weids, 2016). The dependent variable is measured through confocal microscopy and image analyzation to determine the foci area, number of foci per cell, and number of aggregates per cell.

The independent variable was the amount (μg) and type of protein exogenously expressed. The negative control was expressing the fluorescent protein (YPet) only to determine how many nuclear foci are not due to the YEATS domain since the YEATS domain was tagged with YPet to visualization. To simplify the study, the core domain of p300 (p300c) was used. The mutated version of p300c, p300c (D1399Y), contains a point missense mutation, which inhibits the HAT domain and was used to determine how the absence of functioning HAT activity affects the interactions with the YEATS domain. Besides the control, the six independent variable levels were transfecting 0.1 μg of the YEATS domain, 1 μg of YEATS domain, 1 μg of YEATS domain and 1 μg of p300c (D1399Y), 1 μg of p300c (D1399Y), 1 μg of p300c Wild-Type (WT) and 1 μg of YEATS domain, and 0.1 μg of both YEATS domain and p300c WT. The amount of each protein expressed was altered by 10 folds of 0.1 and 1 μg, while the YEATS domain was transfected alone and with p300c WT to determine how changing the amount and protein interactions of the YEATS domain affects the foci formation rate of the YEATS domain. The first hypothesis states that when changing the amount of protein expressed, higher expressions of the proteins will result in an increased number of protein-protein interactions. As a result, expressing 1 μg of YEATS and 1 μg of p300c was hypothesized to contain the highest

average number of foci per the nucleus. This is because this variable level contains the highest possible amount of protein transfected (1 μg). Also, overexpressing p300 helps to increase acetylation rates, thus allowing for increasing the amount of needed reader function in the nucleus (Ma et al, 2021). The second hypothesis states that if p300c (D1399Y) is transfected, then no nuclear foci will form since the D1399Y mutation abolishes the HAT domain's function, ultimately preventing the protein from catalyzing histone acetylation and condensing to form foci (Ganner et al, 2020). The third hypothesis states that the HAT domain of p300 affects the foci formation rate of the YEATS domain. As a result, it is hypothesized that more foci will form when YEATS is transfected with p300c WT than with p300 (D1399Y) or alone. The protein p300 helps to promote histone acetylation, which allows for increased reader function of the YEATS domain and promotes their protein interactions (McCullough & Marmorstein, 2016).

Methods and Materials:

The plasmids used for expressing p300c WT and p300c (D1399Y) were created through first linearizing the vector using the SpeI and EcoRI restriction endonucleases. The insertion gene fragments, p300cWT-NLS and p300c (D1399Y)-NLS (Nuclear Localization Signal: to localize proteins in the nucleus), were taken from two separate plasmids borrowed from Dr. Qin Peng's lab and amplified through a PCR reaction. The PCR reactants were digested with restriction endonucleases (AgeI and EcoRI for p300c WT-NLS and p300c (D1399Y)-NLS) in a 40 μl reaction overnight in 37 °C. The ligation of the insertion genes with the vector was completed at room temperature for 2 hours in a 20 μl reaction.

The plasmid was transformed into competent cells by first adding the DNA to a solution of competent *Escherichia coli (E. coli)* K-12 cells with a 1:100 ratio for 30 minutes on ice. The solution was heat shocked before adding SOC media and shaking the solution in 37 °C for an hour. Afterward, the cells were plated onto Ampicillin (Amp) petri dishes using glass beads and incubated overnight. Once the single colonies were grown, they were inoculated into 50 μl LB media +Amp and shaken in 37 °C for 2 hours. A colony PCR was carried out for each sample to verify the insert before amplifying the correct plasmid samples in 6 mL of LB media +Amp overnight and then completing mini-prep to extract the plasmid. This procedure was repeated for the plasmid needed to express the gene of the YEATS domain (pSIN-YEATS-YPet-NLS).

For the 0.1 μg level for p300c and the YEATS domain, transfection was performed using the lipofectamine 3000 with 0.1 μg of each plasmid added. The amount of p3000 reagent varied based on the amount of plasmid DNA added (2:1 ratio). Then the transfection solution was added to the HEK293T cells, while at 70-90% confluency, in a 24-well plate. The HEK293T cells were washed with Phosphate-Buffered Saline (PBS) and the cell medium (DMEM) was replaced before the transfection solution was added. After transfection, the cells were placed in 37 °C for 36-48 hours to allow for the cells to express the targets proteins before imaging. This procedure was repeated for the remaining variable levels except the amount and types of plasmids varied for each variable level.

The transfection results of each independent variable were then collected using the ZEISS Celldiscoverer 7 with LSM 900 for confocal microscopy and imaging. Quantification of the imaging was completed using the NIS- Elements Advanced Research Software for cell data analysis. The foci size, number of aggregates per cell, and number of foci in each cell were then recorded for each independent variable level. Representative images of cells from each independent variable level can be seem in Figure 1. Data analysis was completed by calculating the median, mean, range, standard deviation, and one-way ANOVA tests for each independent variable level (Table 1). Bar graphs were created for visual analyzation as well (Figure 2).

Potential risks include the use of hazardous chemicals, microorganisms, and plasmid DNA. Safety precautions include wearing gloves, a lab coat, and a face mask while working in a clean work environment at all times. The hood (a Thermosafety Cabinet) was used when

dealing with cells. Hands were washed before and after going to the lab. No drinking or eating in the lab was allowed and ethanol was used to clean the lab environment along with any necessary surfaces. All reusable hand tools were washed after use. A 10% bleach treatment was added to cellular waste solutions and no longer needed petri dishes that contained bacteria colonies to decontaminate before disposal. All disposable materials used in experiments were discarded in a biohazard disposable bag. All experiments were always supervised by at least one qualified scientist. The potentially hazardous biological agents included were Ampicillin (from Fisher Scientific, BSL-1), non-pathogenic *E.coli* K-12 (from Thermofisher, BSL-1), plasmid DNA Sciences, BSL-1). (from addgene, BSL-1), and HEK 293T cells (from The Cell Bank of the Chinese Academy of Sciences, BSL-1).

Results:

Figure 1: Images of Cells from each Independent Variable level.

1 µg YEATS	0.1 µg YEATS	1 µg p300c (D1399Y)	1 µg YEATS and 1 µg p300c (D1399Y)	1 µg YEATS and 1 µg p300c (WT)	0.1 µg YEATS and 0.1 µg p300c (WT)

Figure 2. Graphing the Central Tendency for The Effect of The Amount (µg) and Type of Protein Exogenously Expressed on: A) the Average Foci Area (px), B) Average Foci Number per Nucleus (count), and C) Average Number of Aggregates per Nucleus (count).
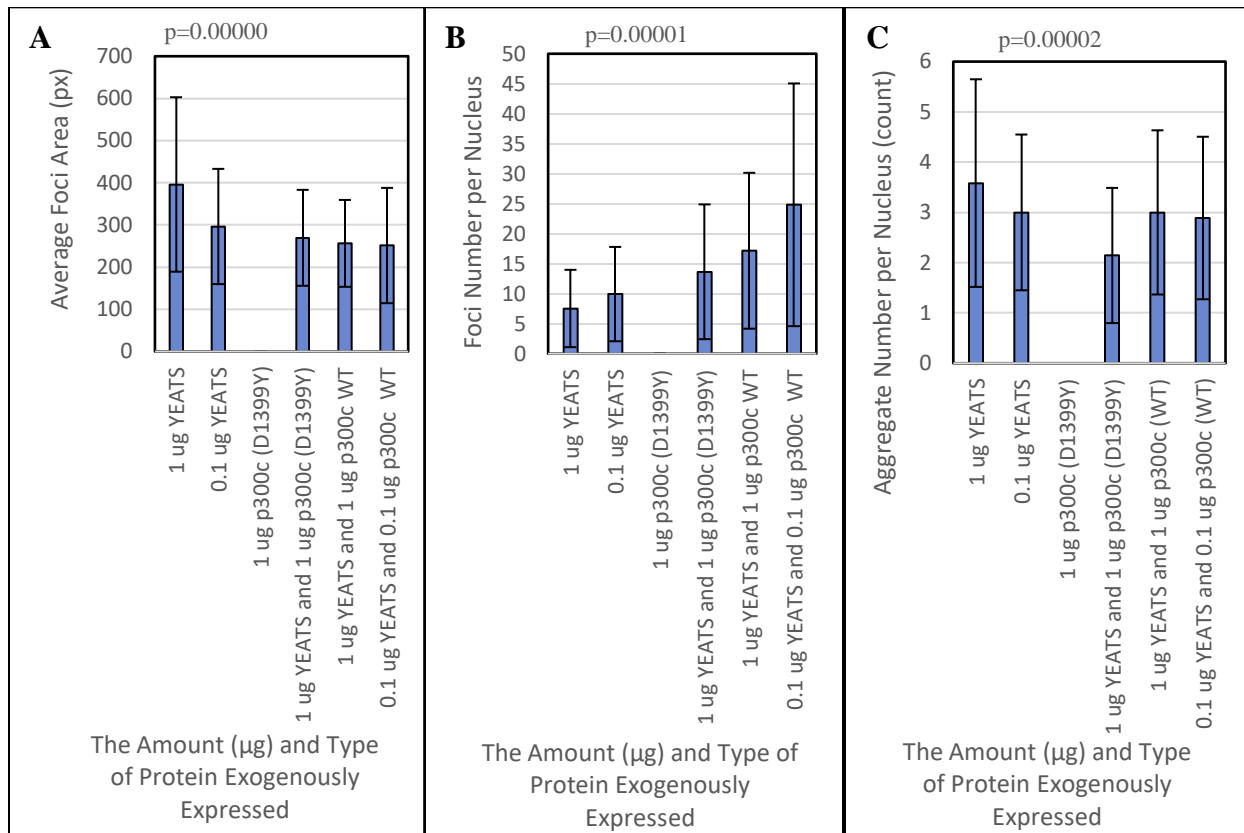
A p=0.00000

Average Foci Area (px)

700
600
500
400
300
200
100
0

1 ug YEATS
0.1 ug YEATS
1 ug p300c (D1399Y)
1 ug YEATS and 1 ug p300c (D1399Y)
1 ug YEATS and 1 ug p300c WT
0.1 ug YEATS and 0.1 ug p300c WT

The Amount (µg) and Type of Protein Exogenously Expressed

B p=0.00001

Foci Number per Nucleus

50
45
40
35
30
25
20
15
10
5
0

1 ug YEATS
0.1 ug YEATS
1 ug p300c (D1399Y)
1 ug YEATS and 1 ug p300c (D1399Y)
1 ug YEATS and 1 ug p300c WT
0.1 ug YEATS and 0.1 ug p300c WT

The Amount (µg) and Type of Protein Exogenously Expressed

C p=0.00002

Aggregate Number per Nucleus (count)

6
5
4
3
2
1
0

1 ug YEATS
0.1 ug YEATS
1 ug p300c (D1399Y)
1 ug YEATS and 1 ug p300c (D1399Y)
1 ug YEATS and 1 ug p300c (WT)
0.1 ug YEATS and 0.1 ug p300c (WT)

The Amount (µg) and Type of Protein Exogenously Expressed

Table 1. Statistical Analysis for The Effect of The Amount (µg) and Type of Protein Exogenously Expressed on Foci Area (pixels, px) (Top), Foci Number per Nucleus (count) (Middle), and Aggregate number per Nucleus (count) (Bottom)

Descrip-tive Statistics	IV: The amount (µg) and type of protein exogenously expressed					
	1 µg YEATS	0.1 µg YEATS	1 µg p300c (D1399Y)	1 µg YEATS and p300c (D1399Y)	1 µg YEATS and p300c WT	0.1 µg YEATS and p300c WT
Mean Range Min Max	396.030 px 781.750 px 0.000 px 781.750 px	296.376px 538.125 px 116.875 px 655.000 px	0.000 px 0.000 px 0.000 px 0.000 px	269.560 px 398.914 px 123.800 px 522.714 px	256.337 px 426.541 px 108.400 px 534.941 px	251.277 px 667.233 px 105.100 px 772.333 px
Variance Standard Deviation 1SD 2SD 3SD	42755.800 206.775 189.255-602.805 -17.520-809.580 -224.295-1016.354	18656.335 136.588 159.788-432.964 23.199-569.552 -113.389-706.140	0.000 0.000 0.000-0.000 0.000-0.000 0.000-0.000	12927.836 113.701 155.859-383.261 42.159-496.9613 -71.542-610.662	10606.108 102.986 153.351-359.323 50.365-462.309 -52.621-565.295	18676.567 136.662 114.612-387.937 -22.050-524.599 -158.712-661.261
Number	29	30	29	23		

296

Descriptive Statistics	IV: The amount (µg) and type of protein exogenously expressed					
	1 µg YEATS	0.1 µg YEATS	1 µg p300c (D1399Y)	1 µg YEATS and 1 µg p300c (D1399Y)	1 µg YEATS and 1 µg p300c WT	0.1 µg YEATS and 0.1 µg p300c WT
Mean	7.536	9.933	0.000	13.652	17.160	24.821
Range	30.000	38.000	0.000	41.000	52.000	73.000
Min	0.000	1.000	0.000	2.000	5.000	3.000
Max	30.000	39.000	0.000	43.000	57.000	76.000
Variance	41.564	61.789	0.000	126.237	168.890	409.411
Standard Deviation	6.447	7.861	0.000	11.236	12.996	20.234
1SD	13.983-1.089	17.794-2.073	0.000-0.000	24.888-2.417	30.156-4.164	4.588-45.055
2SD	-5.358-20.430	-5.788-25.655	0.000-0.000	-8.819-36.123	-8.832-43.152	-15.646-65.290
3SD	-11.805-26.877	-13.648-33.515	0.000-0.000	-20.054-47.359	-21.827-56.147	-35.880-85.523
Number	29	30	29	23	25	28

Descriptive Statistics	IV: The amount (µg) and type of protein exogenously expressed					
	1 µg YEATS	0.1 µg YEATS	1 µg p300c (D1399Y)	1 µg YEATS and 1 µg p300c (D1399Y)	1 µg YEATS and 1 µg p300c (WT)	0.1 µg YEATS and 0.1 µg p300c (WT)
Mean	3.583	3.000	0.000	2.1429	3.000	2.889
Range	6.000	4.000	0.000	4.000	4.000	5.000
Min	1.000	1.000	0.000	1.000	1.000	1.000
Max	7.000	5.000	0.000	5.000	5.000	6.000
Variance	4.265	2.400	0.000	1.8100	2.667	2.611
Standard Deviation	2.065	1.5492	0.000	1.3452	1.633	1.616
1SD	1.518-5.649	1.451-4.549	0.000-0.000	0.798-3.488	1.367-4.633	1.273-4.505
2SD	-0.547-7.714	-0.098-6.098	0.000-0.000	-0.548-4.833	-0.266-6.266	-0.343-6.121
3SD	-2.612-9.779	-1.648-7.648	0.000-0.000	-1.893-6.178	-1.899-7.899	-1.959-7.737
Number	12	6	12	7	4	9

The purpose of this experiment was to understand how the interactions between the YEATS domain and p300 impact the foci formation rate of the YEATS domain. The dependent variable, of observing the behavior of foci formed by the YEATS domain, was measured by determining the foci area, number of foci per nucleus, and number of aggregates per nucleus.

The number and size of the nuclear puncta present was dependent on the amount and type of each protein expressed as well as the protein-protein interactions present. The independent variable was changing the amount (µg) and type of protein exogenously expressed.

For measuring the area of foci, the independent variable level of 1 µg of YEATS domain transfected was shown to have the largest average foci size (396.030 px) and 1 µg p300c (D1399Y) had the smallest average (0.000 px). The independent variable level of 1 µg YEATS was found to have the highest standard deviation (42755.800) while 1 µg p300c (D1399Y) has the lowest (0.000). The trend for standard deviation was the same for variance of the independent variable level. For measuring the number of foci in each cell, the independent variable level of 0.1 µg YEATS and 0.1 µg p300c WT was found to have the highest mean (24.821 foci per nucleus) and 1 µg p300c (D1399Y) was found to have the lowest (0.000 foci per nucleus). For standard deviation, the independent variable level of 0.1 µg YEATS and 0.1 µg p300c WT was had the highest value (20.234) and the variable level of 1 µg p300c (D1399Y) had the lowest value (0.000). The same trend for standard deviation was also observed for variance in the variable levels. The statistical analysis for measuring foci area and number of foci per cell is in Table 1 and the central tendency versus the each, separate independent variable is in Figure 2.

Aggregates are abnormal clusters of denatured protein that form when the amount of protein expressed is beyond the cells' ability to withstand. As a result, this variable was measured to determine if too much of protein was expressed and whether the cells formed more foci or aggregates. For measuring the number of aggregates per nucleus, the independent variable level of 1 µg YEATS was found to have the highest mean value (3.583 aggregates per nucleus), with 1 µg p300c (D1399Y) having the lowest (0.000 aggregates per nucleus). The standard deviation for the variable level of 1 µg YEATS was the highest (2.065) while the level of 1 µg p300c (D1399Y) was the lowest (0.000). This same trend for standard deviation was also present for variance. The statistical analysis for measuring the number of aggregates per nucleus is in Table 1 and the central tendency versus the independent variable is in Figure 2.

One-way Analysis of Variance (ANOVA) tests were calculated for each foci characteristic measured (foci area, number of foci, and number of aggregates) to determine whether the data was statistically significant. The statistical tests were also completed to determine whether the independent variables levels had significant difference from each other and if the results were due to chance or sampling error. The level of significance for this experiment was 0.01. The null hypothesis of the experiment stated that there is no statistically significant difference in changing the amount and type of protein expressed for the YEATS domain's foci area (pixel, px), number of foci per nucleus, and number of aggregates per nucleus. Due to the one-way ANOVA tests calculated for these three foci formation characteristics (p = 0.00000, p = 0.00001, and p=0.00002 respectively) having p-values less than the significance level, the null hypothesis was rejected. The data has enough support to state that there is significant difference between each independent variable level and the results were not due to chance. The first hypothesis, stating that expressing 1 µg of YEATS and 1 µg of p300c will show the highest amount of proteins interactions, was not supported by the data. Since the mean of 1 µg of p300c and 1 µg of YEATS had the second highest mean (17.160 foci per nucleus) of number of foci per nucleus, the hypothesis was rejected because the variable level of expressing 0.1 µg of p300c and 0.1 µg of YEATS had the highest mean (24.821 foci per nucleus). The second hypothesis, which stated that no foci will appear if the protein p300c (D1399Y) is transfected, was supported by the data due to none of the cells in this variable level containing any nuclear foci. The third hypothesis, which stated more foci will form when YEATS is transfected with p300c than with p300c (D1399Y) or alone, was supported. This is because transfecting YEATS with p300c WT showed a higher average number of foci per cell than both the single transfection of YEATS and co-transfection of YEATS and p300c (D1399Y).

Conclusion:
The purpose of this experiment is to understand how the interactions between p300 and the YEATS domain impacts the foci formation capabilities of the YEATS domain. When the YEATS domain was transfected with p300c WT, at both 0.1 and 1 µg, the number of foci per cell was found to be the highest. However, transfecting YEATS with p300c WT at amounts of 0.1 µg and 1 µg, the cells expressed the lowest sizes of foci area. Expressing the YEATS domain by itself was shown to have more aggregation than when expressed with p300c WT at 0.1 and 1 µg levels. Cofactors bind with transcription factors to form transcription complexes. There are two types of cofactors, co-activators and co-repressors. Like the name suggests, co-activators stimulate transcription while co-repressors inhibit the action (Spiegleman et Heinrich, 2004). As a co-activator, p300 can initiate transcription through adding acetyl groups to histones, specifically at lysine sites on Histones H3 and H4 and recruiting histone acetylation readers to promoter and enhancer regions of target genes (Ma et al, 2021).

Autoacetylation, or acetylation of self, occurs within the HAT domain of p300 to promote and enhance p300's HAT activity. This self-acetylating function occurs specifically at an activation loop within the HAT domain (Karanam et al, 2007). By hyper-acetylating this lysine-abundant auto-inhibitory loop (AIL), p300 self-activates its catalytic activity. When the AIL is not acetylated, then the loop inhibits the HAT domain's activity by interacting with the protein's substrate binding pocket, which blocks access to the domain's active site. (McCullough et Marmorstein, 2016). However, when acetylated, the AIL no longer interacts with the substrate binding pocket, allowing the HAT domain to properly function (Ortega et al, 2018).

By increasing the amount of p300c present in the nucleus, the rate of autoacetylation in p300 increases and, therefore, allows for an increase in p300's HAT catalytic activity. An increase in HAT activity amplified the amount of histone acetylation in the nucleus, which helped the YEATS domain perform its reader function at a higher rate (Thompson et al, 2004). The average number of foci in a nucleus when transfecting the YEATS domain with p300c (D1399Y) was higher than when YEATS was expressed alone. This is likely due to other domains in the p300c protein interacting with the YEATS domain to assist in the protein's acetylation reader function despite the absence of a functional HAT domain. The p300's core contains four domains, a HAT, RING, PHD, and bromodomain (Bd). In tertiary form, p300c's four domains often interact with each other, thus affecting each domain's individual function. Of the four, the HAT and Bd are the main two domains that interact with and bind to chromatin (Delvecchio et al, 2013). The bromodomain acts as a histone acetylation reader, similar to YEATS (Banerjee et al, 2015). Through the activity of these domains besides the HAT domain, interactions of these subunits with the YEATS domain caused the colocalization and foci formation rates to occur at a higher rate than when YEATS was expressed alone (Delvecchio et al, 2013).

Expressing the YEATS domain at lower amounts, of 0.1 µg, also caused less aggregation than when protein was expressed in larger amounts (1 µg). Overexpression of proteins is also harmful towards the condition of protein foci, as it causes protein aggregation, which different from foci (Weids, 2016). As a result, transfecting proteins at overbearingly large amounts causes cell damage by disrupting the balance between protein degradation and folding rates. By doing so, the expressed proteins begins to misfold and form aggregates. Rather than forming distinct circular foci, the overwhelming amount of exogenous protein interferes with the formation of puncta and causes large and irregular nuclear aggregates to appear instead (Wieds et al, 2016).

The first research hypotheses, stating that expressing 1 µg of YEATS and 1 µg of p300c will show the highest amount of proteins interactions (thus, the highest number of foci per the nucleus), was not supported by the data because this variable level had the second highest average number of foci per nucleus. Since the amount of protein expressed at 1 µg was 10 folds higher than at 0.1 µg, the YEATS domain was more prone to forming aggregation

clusters rather than foci. The mutated version of p300, p300c (D1399Y), contains a missense point mutation within the protein's HAT domain. This mutation eliminates the HAT activity of p300. Without a functional HAT domain, p300 cannot autoacetylated or acetylate any histones anymore, which was the main factor that allowed for interactions between the YEATS domain and p300 (Ganner et al, 2020). Since p300 contains a bromodomain, the co-activator is able to recruit other p300 molecules to highly acetylated areas of histones and form nuclear puncta (Ma et al, 2021). Without the histone acetylation function, the p300 protein cannot associate with other p300 molecules at acetylation-rich chromatin regions and condense to form puncta since there is not enough acetylation present (McCullough et Marmorstein, 2016).

The data (Table 1) does not support the second hypothesis of this experiment, which stated that no foci will appear if the protein p300c (D1399Y) is expressed, was supported by the data since all the cells in this variable level showed no foci. With the HAT domain's function inhibited, p300c (D1399Y) could no longer form foci by colocalizing at highly acetylated areas of chromatin, showing that without the HAT domain, p300 is unable to regulate gene expression (Ma et al., 2021). The last hypothesis, which stated more foci will form when YEATS is transfected with p300c WT than with p300 (D1399Y) or alone, was also supported by the data, Expressing the YEATS domain with p300c increased the average number of foci per cell by around two folds, which supported the hypothesis. This is because increasing the amount of p300 increased the amount of acetylation rates (Karanam et al., 2007). With an increase in histone acetylation rates, the YEATS domain was able to use more its reader function capabilities and colocalize with p300 at concentrated areas of histone acetylation. These protein-protein interactions allowed for protein condensation of the two peptides at targeted chromatin spots.

Similar research also found that through p300's HAT function, the protein is able to recruit other acetylation reader proteins to colocalize and form foci. Other papers also discovered how the Bromodomain4 protein is highly reliant on the HAT function of p300c for colocalizing (Ma et al, 2021), which showed how p300 uses its histone acetylation function to attract and allow for interactions with reader proteins. One-way ANOVA tests showed that the data was significant for all the different dependent variables measured. Sources of error include that the p300c protein was not tagged with any fluorescent protein, which creates some uncertainty of whether the colocalization between p300c and YEATS was present. Another source of error is that the specific amount of protein each cell in each variable level expressed could not be controlled, causing variation in the amount of plasmid taken up and expressed by each cell. Improvements for the experiment include being more precise in measurements and conducting the procedure more in-depth. Recommendations for further study are to investigate the role of YEATS and p300c together during the cell cycle. Tracking the two proteins' movements in the mitosis may provide further insight on their relation in gene expression and cell viability.

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Appendix:

Figure 3: Experimental Design Diagram

Title: Live Cell Imaging of the Interaction Between an Acetylase and Reader Domain.

Hypothesis:

1. If 1 ug of p300c and 1 ug of YEATS is transfected, then this independent variable level will show the highest average number of foci in the nucleus.
2. If the protein p300c (D1399Y) is transfected, then no foci of the protein will appear in the nucleus when imaged.
3. If p300 and the YEATS domain are co-transfected, then more foci will form compared to when YEATS is transfected with p300 (D1399Y) or by itself.

Independent Variable: The amount (ug) and type of protein exogenously expressed.

0.1 ug YEATS domain	1 ug YEATS domain	1 ug YEATS domain and 1 ug p300c (D1399Y)	1 ug p300c (D1399Y)	1 ug YEATS domain and 1 ug p300c WT	0.1 ug YEATS domain and 0.1 ug p300c WT	1 ug pSIN-YPet (control)
29 cells	30 cells	29 cells	23 cells	25 cells	25 cells	28 cells

Dependent Variable: The colocalization rate, foci formation rate, and potential interactions, measured by foci size (px), the number of foci per cell (counted), and the number of aggregates per cell (counted).

Constants: Same confocal microscope used for imaging (ZEISS Celldiscoverer 7 with LSM 900), same imaging analysis software (NIS- Elements Advanced Research Software), same plasmid used for transfection of the YEATS domain (pSIN-YPet-YEATS-NLS), the same temperature the cells were grown at (37 Degrees Celsius), the same type of cells used (HEK 293T).

Ertle Thompson Memorial Endowment Award

The Ertle Thompson Memorial Endowment Award is established to honor Dr. Ertle Thompson, a long-term leader of VJAS and a former president of the VAS. When financial circumstances allow, these awards will be presented annually to the winners selected as the VJAS Delegates to the AJAS. The purpose of the funds is to help support attendance at the annual meeting of the American Association for the Advancement of Science and the American Junior Academy of Science.

Sam Watchman
Arlington Tech

Philip Naveen
Mills Godwin High School

Dr. R. Dean Decker Honorarium Award

The Dr. R. Dean Decker Honorarium award this year of $500 each is to go to the teacher/sponsor of the two top student winners of the AJAS trip. The monies can be used at the discretion of the recipients as long as it is related to the attendance at the

AJAS meeting.

Tinequa Reese Dana Delano
Arlington Tech Mills Godwin High School

AWARDS FOR SPONSORS

THE FRANKLIN D. KIZER DISTINGUISHED SERVICE AWARD

This award recognizes the exceptional contributions to VJAS of a STEM teacher.
Criteria:
● The recipient will be a teacher who has contributed to the VJAS by sponsoring student research projects, serving as a reader, judge, and/or member of the VJAS Committee.
● The teacher will be nominated and chosen by the VJAS Committee.
● The award of up to $500 will be used for professional development, and the recipient will propose a professional development activity to the Director of the VJAS. Examples of acceptable proposals include attendance to a professional meeting, tuition for a science/math course, or software to enhance their teaching effectiveness.

THE FRANKLIN D. KIZER DISTINGUISHED SERVICE AWARD

Maria Klein
Clover Hill High School

THE FRANKLIN D. KIZER SCIENCE TEACHER OF TOMORROW AWARD

This award recognizes an outstanding Virginia science teacher and provides an opportunity for professional development through attendance at the annual VAST meeting.
● The recipient is a teacher with a maximum of 5 years of teaching experience.
● The recipient will have sponsored student participation at the VJAS annual meeting.
● The recipient is nominated and chosen by the VJAS Committee.
● This award will be used to support the professional development of the recipient by providing the funds needed to attend the annual VAST meeting. The maximum amount of the award is $500.

THE FRANKLIN D. KIZER SCIENCE TEACHER OF TOMORROW AWARD

Sandra Marr
Collegiate School

OUTSTANDING SERVICE AWARDS

VAS HONORARY MEMBERSHIP

This award which includes one year's membership in the Virginia Academy of Science including a subscription to the *Virginia Journal of Science* is awarded for outstanding service to the Junior Academy and the VJAS Committee.

Harrish Ganesh

VAS AWARD FOR DEDICATED SERVICE TO VJAS

The support of VAS makes all of this possible. In addition to several awards that have already been given by VAS, this award recognizes a past VJAS officer or a VJAS

member who has continued to provide support as a volunteer to the Junior Academy even after completion of high school.

Kayla Holston

VJAS DISTINGUISHED SERVICE AWARD

A special certificate is presented to a person for exceptionally outstanding service to the VJAS and public recognition is given at the Research Symposium. This is the most prestigious award that the VJAS Committee gives.

Dr. Tara Lateef