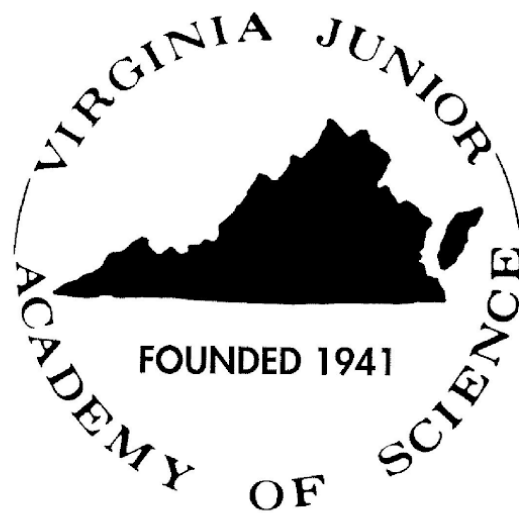


**The Virginia Junior
Academy of Science
*Proceedings***

**79th Annual Meeting
and Research Symposium**



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VJAS Committee Chair's Message

July 25, 2020



Dear Virginia Junior Academy of Science participants,

Greetings and on behalf of the entire Virginia Junior Academy of Science Board and Committee, I would like to thank you for attending the virtual award presentations for the 79th Virginia Junior Academy of Science (VJAS) Annual Meeting and Research Symposium this Spring. In this edition of the *VJAS Proceedings*, we have compiled all submitted research project abstracts that were accepted for the 2020 VJAS Research Symposium program.

First, I would like to congratulate each one of our student finalists. Your caliber of research and the written scientific paper impressed our rigorous panel of evaluators. Your selection into our VJAS program is a remarkable achievement and you should be proud of your research and academic success!

The *VJAS Proceedings* represent the final culmination of each year's Annual Meeting and Research Symposium, where we publish accepted student's abstracts which were presented in front of their peers and judges, as well as the full text of research papers for select winners. For many, this will be the first official publication of their scientific research endeavors and we hope this will be a catalyst for continuation of each student's scientific journey.

As we close this Annual Meeting's unusual chapter, I would like to bring into focus a few final thoughts. This novel coronavirus pandemic has pushed society into a state of disarray as our day-to-day lives have been interrupted and drastically changed. We are facing a challenging public health battle, amidst a world that has never before been this global and interconnected. But remember this – we are resilient. We will overcome these difficult times, together.

Even during this pandemic, we must also remember to celebrate science. Humanity has endured many natural, and man-made challenges over the years, but at each pivotal moment, scientists were at the forefront of solving issues at hand, propelling society forward. I remain confident that with trust in scientists and the rigorous application of the scientific and research methods, we will be successful in solving our current and urgent task.

Finally, I hope that our VJAS finalists – who will be our future scientists, leaders, and decision makers of tomorrow – to take these current world events and glean the importance of sustained investments in scientific research and infrastructure, which will always outperform a more reactionary and reflexive response, in any crises.

Please stay healthy and well. Sincerely,

Se W. Jeong

Chairman, VJAS Board & Committee

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VIRGINIA JUNIOR ACADEMY OF SCIENCE JUNIOR OFFICERS

Shan Lateef - President

Thomas Jefferson High School for Science and Technology, Rising 11th grader

Favorite thing about science:

* Science is in search of the truth and being even a small part of this search is a tremendous honor.

Claire Morton - Vice President

Blacksburg High School, 12th grader

Favorite thing about science:

*Science allows us to make discoveries in order to help society.

Abhishek Kulkarni - Secretary

Mills E Godwin High School, 11th grader

Favorite thing about science:

*There is the possibility to challenge even the most basic of concepts and be correct.

*There is always newer information that leads to enhancements and corrections in the way that science is viewed.

Noah Porter - Co-Editor in Chief

Washington Lee High School, 11th Grader,

Favorite thing about science:

*The mix between focused research and being able to share your discoveries with a community

Karly Ramnani - Co-Editor in Chief

Mills E. Godwin High School, 11th grader

Favorite thing about science:

*Even the smallest advances can save many lives.

Christopher Marotta - Communications

Central Virginia Governor's School/E.C. Glass High School, 12th grader

Favorite thing about science:

* It has not only helped us to better understand the world around us but also improve the lives of humans on a global scale in so many different ways!

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VJAS SPECIAL AWARDS and SCHOLARSHIPS

VAS Botany Award

Jackie Wang; Blacksburg High School

Effects of Inositol Pyrophosphates on the Growth Rate and Physical Characteristics of *Arabidopsis thaliana*

RODNEY C. BERRY CHEMISTRY AWARD

Emily Haueis; Todd Allen Phillips Center for Medical Sciences at Godwin High School

The Effect of Homemade and Commercial Fabric Softeners on Fire-retardant Materials.

WILLIAM W. BERRY ENGINEERING AWARD

Buck Arthur; Central Virginia Governor's School

The Effect of Various Cushioning Materials on the Pliancy of a Running Surface Over Time

ANN M. HANCOCK CELLULAR BIOLOGY AWARD

Harrish Ganesh; Thomas Jefferson High School for Science & Technology

The Investigation of the Interactions between the HIV-1 Envelope Glycoprotein and the Lymphocyte Receptor Integrin $\alpha 4\beta 7$

MATHEMATICS AWARD

Solomon Ralston; Colgan High School

The Kinematic Analysis of Dominant vs. Non-Dominant Lacrosse Shot Speed

STATISTICS AWARD

Brandon Fan; Blacksburg High School

An AI-based System for Early Detection of Natural Disasters and Incidents through Open Data

VABE ZOOLOGY AWARD

Mrunal Kute; Todd Allen Phillips Center for Medical Sciences at Godwin High School

Investigation of Different Concentrations of *Ginkgo biloba* on *Danio rerio* Memory Development in the Prevention of Alzheimer's Disease

CANCER RESEARCH AWARDS

Mahia Rahman; Washington-Liberty High School

Single-cell Analysis of Megakaryoblasts by Laser Ablation Electrospray Ionization Mass Spectrometry and Automated Image Processing with Object Recognition

Karuna Ramnani; Mills E. Godwin High School

The Effect of Navitoclax on Senescent vs. Non-Senescent Cell Viability

DR. AND MRS. PRESTON H. LEAKE AWARD IN APPLIED CHEMISTRY

Ellie Peterson; Central Virginia Governor's School

The Effects of Oxybenzone, Octinoxate, and Zinc oxide on the Heart rate of *Daphnia magna* as a Model for Humans t6y

ROSCOE HUGHES GENETICS AWARD

Claire Morton; Blacksburg High School
The Division Decision: The Cdc13 Protein and Cell Size Control

DR. SMITH SHADOMY INFECTIOUS DISEASES AWARD

Nikki Kumar; Maggie L. Walker Governor's School
Statistical Analysis of United States Influenza Coverage 2010-2019

SPELEOLOGICAL SOCIETY AWARD

Nora Brakman; Sabot at Stony Point
The Effect of Epsom Salt Concentration on Stalactite Growth

VIRGINIA MUSEUM OF NATURAL HISTORY (VMNH) AWARD

Jordan Yocum; Chesapeake Bay Governor's School
A Comparison of the Biodiversity and Species Richness of Bird Species in Native and Invasive Habitats

VIRGINIA SEA GRANT COLLEGE PROGRAM AWARD

Kristen Frank; Chesapeake Bay Governor's School
Assessing Oyster Reef Restoration and its Effect on Nearby Oyster Spat Recruitment

GAMMA SIGMA DELTA AWARD

Teo Huson; Washington-Liberty High School
"Kill or get Killed" A Study On the Allelopathic Properties of the Nut Tree Family Native to Northern Virginia

BETHEL HIGH SCHOOL SCHOLARSHIP

Claire Morton; Blacksburg High School
The Division Decision: The Cdc13 Protein and Cell Size Control

HENRY MACKENZIE ENVIRONMENTAL SCHOLARSHIP (VEE)

Grace Shen; Blacksburg High School
The Effects of Storm Intensity on the Filtration of Microplastics from Sediment

FRANCES AND SYDNEY LEWIS ENVIRONMENTAL SCHOLARSHIP (VEE)

Brooke Eby; Central Virginia Governor's School
Evaluation of the Heavy Metal Remediation Capabilities of *Agaricus bisporus*

DOROTHY KNOWLTON AWARD

Cameron Joyce; George H. Moody Middle School
The Effect of Radiofrequency Radiation on *Phaseolus Vulgaris* Seed Germination

Saniya Sangle; George H. Moody Middle School

The Effect of Physical Activity on Human Memory in Different Age Groups

JOYCE K. PETERSON AWARD

Camelia Sharma; George H. Moody Middle School
The Effect of Hull Cross Section on the Efficiency of a Watercraft

CATESBY JONES AWARD

Sarah Deloney; Massanutten Regional Governor's School for Integrated Science & Technology
Microfossils in Mammoth and Mastodon Dental Plaques as an Indication of Diet

THE VAS BEST OF SYMPOSIUM RESEARCH AWARDS

THE GRAND WINNERS OF THE VAS BEST OF SYMPOSIUM ARE:

Benjamin Bankston; Central Virginia Governor's School
Comparing Microplastic Presence in both Indoor and Outdoor Environments

Chirayu Nimonkar; Todd Allen Phillips Center for Medical Sciences at Godwin High School
The Effect of Magnetic Shielding Geometry on Focality for Transcranial Magnetic Stimulation

THE ALTERNATES OF THE VAS BEST OF SYMPOSIUM ARE:

Shrinidhi Kittur; Todd Allen Phillips Center for Medical Sciences at Godwin High School
The Activation of Somatostatin Interneurons Adjacent to a Cortical

Caroline Klotz; Clover Hill High School
The Effect of Quicklime Concentration on the Swelling Potential of Expansive Soils

VJAS DISTINGUISHED SERVICE AWARD

Dr. Carolyn Conway

ABSTRACTS OF STUDENT RESEARCH PAPERS BY SECTION

HIGH SCHOOL SECTIONS

BOTANY

The Effect of Nanoparticles on Radicle Length of *Pisum sativum*
Elizabeth Eroshenko, Mills E Godwin High School

The purpose of this experiment was to determine if the type of nanoparticle would have an effect on the radicle length of *Pisum sativum*. Nanoparticles (NPs) are used in various commercial products, which can result in infiltration into the environment. This can have negative effects on seed germination and plant growth and development. For this study, *P. sativum* seeds were soaked in NP dispersions (or water for the control), and then placed on moistened filter paper (with the nanoparticle dispersion) to germinate for four days in an incubator. After this time, the length of the radicle was measured. It was hypothesized that if ZnO NPs were applied to *P. sativum* seeds, then they would cause the lowest radicle length. The study showed that ZnO inhibited radicle length the most, followed by TiO₂, CeO₂, and water. Thus, the research hypothesis was supported. An ANOVA test showed that the data was significant overall and follow up Welch's t-tests showed that all tests were significant besides the TiO₂ and ZnO vs. CeO₂. It is believed ZnO caused the lowest radicle length because in high concentrations, Zn can lead to the production of free radicals in plants, which can cause oxidative stress and cell death. This project can help provide insight on how nanoparticle concentration and plant species can affect nanotoxicity. It can also provide support for the establishment of better and safer NP disposal standards.

The Effect of Biochar on its Ability to Promote Growth in a Post-Wildfire Environment
Emily Lionberger, Mills E. Godwin High School

Each wildfire season millions of acres of land around the world are consumed by wildfires. However, biochar is created which could be utilized for plant regeneration. The purpose of the study was to investigate how different amounts of biochar affected *Asclepias fascicularis* growth. A hypothesis was created that if biochar was added to burned soil, then 15 grams of biochar would have the highest growth. The four levels of the independent variable were 0 grams (Group A), 5 grams (Group B), 10 grams (Group C), and 15 grams (Group D). The control group was 0 grams to confirm biochar's effects. An *A. fascicularis* environment, made up of 128 trails (thirty-two per group), was grown for five weeks and then burned. During the process goggles, tight clothing, and a mask were worn for safety and a fire extinguisher was kept nearby. New *A. fascicularis* seeds were planted and biochar was added based on the trials given after burning. The plants were grown for thirty days with height measurements taken in centimeters every six days. The results showed that 10 grams (Group C) of biochar had the highest mean height (3.000 cm) and 0 grams (control, Group A) had the lowest mean (2.247 cm). A t-test proved that Group B ($t = 0.114 < 2.040$), Group C ($t = 1.068 < 2.040$), and Group D ($t = 1.049 < 2.040$) were all insignificant when compared to the control when $df = 31$ and $\alpha = 0.05$. Based on the results, it can be concluded that biochar promotes growth for *A. fascicularis* plants, however too much biochar is harmful for plants. The results indicate that biochar should be used to promote faster plant growth but should be used in moderation.

The Comparison Between Two Prominent Salt Tolerance Mechanisms; Sodium Secretion in *C. quinoa* and Sodium Compartmentalization in *G. hirsutism*
Maria Angel Zamora, Mills. E Godwin High School

The purpose of comparing sodium secretion in *C. quinoa* and sodium compartmentalization in *G. hirsutism* was to analyze which mechanism of salt tolerance is most beneficial for plants. The salinization of soils has had significant economic impacts reducing arable land and agricultural productivity, affecting 950 million hectares of land. Worldwide, this phenomenon has left farmers with less viable land and few options to combat this issue; therefore, plants with higher salt tolerance and research into their mechanisms behind their tolerance are a top priority in future research. It was hypothesized that if a plant has a sodium compartmentalization mechanism, then it will have the most optimal Relative Growth Rate (RGR) determined by growth in centimeters over a 22-day time period. The levels of the independent variable were sodium compartmentalization in *G. hirsutism* (cotton) and Sodium secretion in *C. quinoa*, a negative control with beans, as well as a positive control with all of the tolerance mechanisms. However, instead of being treated with saltwater, they were treated with tap water. The plants were observed, grown, and watered for 22 days. T-tests were conducted between all of the data sets and it was revealed that the data was overall statistically significant. The sodium compartmentalization level performed the best overall with a -9.9% RGR decrease compared to sodium secretion with -19.6% and beans decreasing their growth by -60.5% RGR, supporting the research hypothesis. These results implied that the salt glands that allow compartmentalization are a future key to further research into specific enzymes and genes that code for them and other factors of the glands. Future research could potentially be used to help turn commonly salt-sensitive high-value plants into salt-tolerant plants

The Effect of Nutrients on *Raphanus sativus* Under UV Light
Julia Hudgins, Mills E. Godwin High School

The purpose of this experiment was to test the effects of different nutrients, astaxanthin and vitamin E, on *Raphanus sativus* (radish) plants under ultraviolet (UV) light, and determine which nutrient provided the most protection from UV rays. This will help scientists understand how to protect crops from increasing UV radiation. The hypothesis stated that if a radish plant has the nutrient astaxanthin added to its water, then the plant will grow more efficiently under UV light. Two groups of radish plants were given 5 grams of either astaxanthin or vitamin E. The control was a group of plants with no added nutrient. Each of the three groups were placed under a UV lamp for six weeks, being watered with the designated nutrient once a week. At the end of every week the height of each plant was measured in centimeters. During the sixth week, the number of leaves on each plant was counted. The results revealed that the plants with astaxanthin grew, on average, 0.68 cm more than Vitamin E and 1.38 cm more than the control. The results also revealed that the astaxanthin plants have, on average, .2 more leaves than the Vitamin E group and .7 more leaves than the control group. A t-test was done on the data and revealed that the data for both areas of study was significant for astaxanthin vs. the control but was not significant for vitamin E vs. control or vitamin E vs. astaxanthin. The results supported the research hypothesis.

The Allelopathic Effect of *T. patula* Organs on the Germination & Growth of *S. lycopersicum* & *T. repens*

Eleanor Little & Madalyn Likens, Roanoke Valley Governor's School

Allelopathy is a natural alternative to synthetic chemical fertilizers and herbicides. Allelochemicals alter, stimulate, or inhibit structures and functions of neighboring plants after release into the rhizosphere from the plant source. This phenomenon is utilized by strategic planting or product preparation, a natural option to obtain desired results. This study investigated the allelopathic effects of garden flower organs on common crops and weeds. It was hypothesized that filtrates prepared from *T. patula* organs applied to *S. lycopersicum* and *T. repens* planting environments would inhibit germination and growth, with strongest effect from leaves. *T. patula* stems and leaves were prepared into solutions then used to treat filter paper on which *S. lycopersicum* and *T. repens* seeds were placed. Germination proportions were recorded at 24, 48, 72, and 144 hours; germinated-seed radicle lengths were measured at 144 hours. Tests for flavonoid and tannin presence were performed. Various results were found. The germination proportion of 48 hr *T. repens* seeds in leaf filtrate was significantly less than the proportions of other groups (Chi-Squared, p-value=0.0032). Data collections within other groups showed no significant difference. Mean radicle lengths were found to have several significant differences (ANOVA, p-value=0.0004): *T. repens*-leaf was greater than *S. lycopersicum*-stem, which was less than *T. repens*-control and -stem. Chemical testing revealed tannin and flavonoid presence in stem and leaf *T. patula* extracts. Both *T. patula* organs contain allelochemicals; growth-inhibitory potency is potentially stronger in stems, while germination-inhibitory potency potentially stronger in leaves; *S. lycopersicum* may be more vulnerable to allelopathic influence.

The Effect of Vitamins on *Brassica rapa* ssp. *pekinensis* Growth
Christina Wen, Mills E. Godwin High School

This project in its present form is the result of bioassay experimentation on the effects of vitamins on the growth of Chinese cabbage plants. The initial idea was to optimize the nutritional value of plants humans consume and reduce the negative effects of fertilizers to the ecosystem. However, further research showed that while plants do not gain higher nutritional value, vitamins do affect plant growth, thus different vitamins were experimented with, with the hope that vitamin C would benefit plants the most.

The Effect of Stimulants on Duckweed plants (*Lemna minor*)
Annabel Friedman, Washington-Liberty High School

In almost all pond ecosystems, duckweed (*Lemna Minor*) is a vital producer that keeps the pond healthy. Duckweed is a source of food for small fish and animals, and a shelter for some marine life. This small water plant thrives in nutrient-heavy water, making it a very important tool in keeping water usable. This experiment was conducted to see how duckweed reacts to certain water additives, which can help identify a healthy pond or see how factory runoff can affect a pond ecosystem. The two additives being tested were sugar and Epsom salt. The hypothesis was, If a duckweed is treated with sugar dissolved in water or Epsom salt dissolved in water, the container of duckweed treated with sugar will grow the most in depth and surface area over the course of a month, because the sugar will increase the plants photosynthesis and help it grow. The experiment was set up according to the procedure with the correct materials. The results of the experiment accepted the hypothesis. The sugar experimental group grew significantly more than the Epsom salt experimental group, and also outgrew the control group. The sugar group showed a consistent green color, and the Epsom salt showed a pale green color and minimal growth. The control group also displayed a vibrant green color. According to the raw data tables #1 and #2, the sugar experimental group grew the most over the course of one month. The initial hypothesis was accepted, and the null hypothesis was rejected, confirmed by statistical analysis.

The Effect of Salinity Stress On Catmint Growth
Sudarshan Sriniaiyer, Mills E. Godwin High School

The purpose of this experiment was to see the effect of salinity stress on Catmint growth. In many areas around the world, there is an absence of freshwater and farmers are having a decrease in crop production. If saltwater proves not to harm certain crops too badly, then there will be an increase in crop production. Catmint plants received either no salt, 200mg of salt, or 400mg of salt. These plants were watered with 500mL of water on alternate days for one month. A research hypothesis was formulated that if the catmint plant was given 400mg of salt, then the plant will grow shorter. The control in this experiment were the 25 plants that were given no salt. The reason for having this control was to establish a baseline to compare the results of the plants that were given salt. The results revealed that the plants that received no salt grew the tallest and were the healthiest after one month. A t-test was performed on the data and it was revealed that the data was statistically significant. The results supported the research hypothesis. It is believed that the results are due to the fact that salt degrades RNA molecules, build up toxic levels, separate ions, and disrupt a plant's natural processes. This research could further lead to further study investigating how different plants protect themselves from salt and if certain crops could be grown under salinity stress.

The Effects of Plant Type on Pollution Mitigation
Dawn Harris, Portsmouth STEM @ I.C. Norcom High School

The purpose of this experiment was to display the effects of invasive plants on a balanced marsh environment. The hypothesis was If an invasive plant grows in a balanced environment then, drastic changes will occur to that environment. All of the plants were placed in the same container to mimic plants growing in an actual environment. The soil in the environment was kept moist so the native plants (marsh grasses) can grow. After a week the soil quality was stable enough to measure. The invasive plant (English Ivy) was added to the balanced marsh environment and was observed for two days. Each day the soil quality was tested to identify changes in the environment. The hypothesis was proven to be correct. As expected, the English Ivy has made the ecosystem unbalanced and the soil quality is very acidic. The English Ivy has made the soil acidic and stopped the growth of the native plants by wrapping around other plant's roots. Competition between the two species has grown intensely.

The Effects of Pollution on Aquatic Plants
Amarie Drake & Brooke Pearce, Portsmouth STEM @ I.C. Norcom High School

For our project, we questioned how pollution affects environments with aquatic plants. Our curiosities gave us the ability to test the effects of different pollution types found in the real world on 3 species of aquatic plants. We used 5 1-gallon jugs to simulate habitats for the Elodea, Sagittaria, and Cabomba species. After the habitats were secure, the pollutants motor oil, fertilizer, soil, and acid rain, were added. The jugs were observed over a 3-week period. Our results showed that aquatic plants with high amounts of oil pollution in their water are most likely to die while plants in soil/sediment water thrived the most. These results are most likely caused by the plants' ability to get light for photosynthesis. If given the chance, our project would be edited to include a more diverse range of pollution and plants and include a higher dosage of pollution.

The Effect of Changeable Climate on Physiological Responses of C3, C4, and CAM Plants
Rowen Link, Mills E. Godwin High School

The purpose of this study was to see if changed US summer temperatures would affect the health of C3, C4, and CAM plants. It is well-known that global warming is causing an increase in the country's temperatures, and it shows no sign of stopping. If it causes a significant effect on different plant species, certain food supplies could be in jeopardy. This experiment would investigate those effects and understand what steps could be taken in response. The hypothesis of this experiment was if *Panicum virgatum* and *Courantia lem* are exposed to a temperature of 37 oC, then their vital measurements will be healthier than Lollium also exposed to 37 oC. There was no control for this experiment because there is no plant that is considered normal. The procedure was simple, the plants were split into their respective groups and were subjected to 37 oC. Then, every day for 30 days the vitals of the plants were measured using a Smart Plant tracker. This tracker took all the necessary measurements and compiled them into an overall score of 1-8. These measurements were made of 30 days, then an average score was given by the tracker app. After the experiment, C3 plants had the smallest mean, followed by C4, and finally by CAM. After statistical analysis, all three t-tests showed a significant difference in the vital measurements showing that a changed temperature truly affected the different species of plants' health. This change is due to how transpiration and photorespiration affect the biochemical pathways of photosynthesis. With C3 not equipped to handle them, while C4 and CAM are more capable.

The Effect of Calcium Carbonate on Aquatic Plant Oxygen Production
Raymond Wen, Godwin High School

The purpose of the experiment was to determine the effect calcium carbonate had on the oxygen production from aquatic plants. In past years, aquaculture has been used for commercial fishing and was company controlled. More recently, government-controlled aqua cultures were installed to repopulate certain species of animals that have become endangered species. Unlike company-owned aqua cultures, government-controlled need to be natural and not reliant on artificial factors like chemical fertilizers. This helps to simulate a real environment and will ensure that released organisms are already familiar with their surroundings. A great way to incorporate biotic factors is by using plants. Aquatic plants are great for aquariums, but for more efficient vegetation, fertilizer is ideal. The natural fertilizer that was used was calcium carbonate. Four groups of 25 aquatic hair grass were given 0 grams, 5 grams, 10 grams, and 15 grams of calcium carbonate and the amount of dissolved oxygen was measured. The hypothesis stated that a higher concentration of calcium carbonate will lead to an increase in oxygen. The group that had no calcium carbonate was the most efficient with an average mg/L of 7.1. A t-test was performed for every comparison and proved that the data was not significant. The data did not support the research hypothesis. This is most likely due to the opaque qualities of powdered calcium carbonate which blocked light from reaching the chloroplasts in the grass. This experiment can be improved upon with having each calcium carbonate solution have the same level of transparency.

The Effect of Liquid Fertilizer on Bean plant Growth
Erin McDonald & Caroline Franklin, Washington-Liberty High School

Farmers that struggle with not producing enough crops cause others to not have enough food to eat. Production of food is an important lifestyle throughout America. That was the reasoning behind the decision of the experiment. This experiment tested which fertilizers would work best on bush bean plants. 80 bean plants were grown and measured during the timespan of 15 days. The hypothesis for the experiment was if the pump and grow fertilizer was used it would grow the biggest plants. However, our hypothesis was rejected. The data showed that the control of water worked to grow the plants the best. This was surprising but important data. It shows that the fertilizers that were tested are ineffective and unnecessary for growing plants.

The Effect of the Application of Oxybenzone on the Growth of *Lemna minor*
Addison Chiodo, Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if the presence of oxybenzone has an effect on *Lemna minor* (common duckweed) growth. Four groups were placed in cups of water with different concentrations of oxybenzone (control, 0.001 mg/mL, 0.002 mg/mL, 0.003 mg/mL). Each group was kept under controlled laboratory conditions for four weeks. At the beginning and end of the experiment, the surface area of the duckweed in each cup was measured using ImageJ. The mean growth for each group is as follows: the control group had an average of 14.517 mm; the 0.001 mg/mL, 33.945 mm; the 0.002 mg/mL, 28.299 mm; and the 0.003 group, 35.413 mm. With a p-value of .0147, a one-way ANOVA (alpha .05) determined significance between the groups. A post-hoc Tukey test determined that the data were significant between the control and each of the 0.001 mg/mL and 0.003 mg/mL groups. The research hypothesis that the duckweed in the 0.003 mg/mL group would grow the least was not supported because the Tukey test showed that the 0.003 mg/mL and 0.001 mg/mL groups were significantly larger than the control. In conclusion, this study showed that oxybenzone has a significant effect on increasing the growth of common duckweed. However, more research is necessary to understand the environmental effects because previous research on oxybenzone demonstrates environmental harm.

Analyzing Cadmium, Lead, and Arsenic Phytoremediation Capacities of *H. annuus* and *H. giganteus*
Benjamin Newman & Kevin Cruz, The Roanoke Valley Governor's School for Science and Technology

The purpose of the experiment was to determine the phytoremediation potentials of *Helianthus annuus* and *Helianthus giganteus* in cadmium (II) nitrate, lead (II) nitrate, and arsenic trioxide polluted soil. The independent variables during experimentation were sunflower species, pollutant type, and pollutant concentration. The dependent variables in the experiment were the amount of pollutant in the stems and leaves of the sunflowers and GUS reporter response in β -glucuronidase *Arabidopsis thaliana* strains. Sunflowers of both species were planted in a growth chamber to germinate, then transferred to polluted environments for experimentation. After phytoremediation, sunflowers were removed and dried. GUS line A. *thaliana* were planted in the phytoremediation environments to test for a gene expression response. Soil and stems and leaves were prepared in nitric acid to be analyzed at Virginia Tech by ICP-MS analysis. In the *H. giganteus* cadmium, and *H. annuus* lead and arsenic environments, concentrations in the stems and leaves were proportional to the soil. In the mammoth lead group, there was an inverse relationship between soil concentration and accumulation. Every experimental group indicated that sunflowers are not biologically effective in removing heavy metal pollutants from soil. Observations of A. *thaliana* GUS stains indicated a highly variable pattern of gene expression, suggesting that either high concentrations of metals or sunflowers' allelopathic properties affect gene expression in A. *thaliana*. Further studies are needed. Data indicated that phytoremediation was not successful enough to fully remediate the soil of any pollutant, and the GUS A. *thaliana* did not indicate sufficient phytoremediation.

The Effect of Soil Types and Magnetic Strength on Plant Growth of *Raphanus sativus*.
Anika Makarla, Mills E. Godwin High School

The purpose of this experiment was to find the effects of different soil types and magnetic strength on radish plant growth. Recently, the magnetic field treatment has been introduced as a new approach to enhance the growth of radishes. Radishes were treated with 118 mL of sandy soil with or without a magnet, loam soil with or without a magnet, clay soil with or without a magnet, and garden soil with or without a magnet. The plants grew for 16 days and then their height was measured. Garden soil without a magnet is the control of the experiment. It was hypothesized that loam soil with a magnet will result in the tallest plants. However, plants treated with sandy soil with a magnet grew, on average, 4 cm more than loam soil with a magnet and other soils. A t-test was performed on the data and showed that sandy soil with a magnet (2.284), sandy soil without a magnet (3.090), loam soil without a magnet (3.145), clay soil with a magnet (3.812), clay soil without a magnet (3.170), and garden soil with a magnet (2.205) vs. the control are significant. While, loam soil with a magnet vs. the control (1.652) is not significant. The results did not support the research hypothesis because sandy soil has a lower cation exchange than loam soil, is rapidly permeable to nutrients and pH changes, and magnetism will allow the soil to retain the necessary nutrients for plant growth.

The Effect of the Initial Quantity of Arbuscular Mycorrhizal Propagules on the Growth of Plants
in Soil With a Reduced pH

Josh Sokol, Yorktown High School

Increased soil acidification due to climate change is a subject that currently lacks sufficient research. This experiment aims to remedy the adverse agricultural effects of soil acidification by utilizing the symbiotic relationship between plants and arbuscular mycorrhizal fungi (AMF). AMF can take up to two months to fully associate with plants, but the process can be accelerated when more AMF propagules are present in the soil. In preferable pH soils, association speed is generally negligible. However, the experiment will investigate how plant growth in reduced pH soil is affected by increased initial AMF propagule quantities. The hypothesis is that more rapid colonization will facilitate earlier access to more nutrients, leading to significantly healthier plants. Five groups of twelve bean plants were grown with increasing quantities of initial AMF propagules in the soil. After fifty days of growth, root mass, leaf mass, stem mass, and stem length were recorded. The majority of the data suggested a positive correlation between increased initial propagule quantities and plant health. However, the null hypothesis was accepted. Naturally, slight health variation existed between plants of the same group, but the group with the highest quantity of initial propagules resulted in plants with extreme variance in health, significantly influencing statistical relevance. The likely explanation is that some plants in this group were overwhelmed by excess mycorrhizal associations. To more accurately assess the question, additional experimentation must be conducted with more trials, more exact propagule quantification methods, and reduced AMF propagule quantities to avoid harming any plants.

The Effect of Soil pH on Growth of *Raphanus sativus*
Anika Makarla, Mills Edwin Godwin High School

This experiment was conducted to study the growth of *Raphanus sativus*, otherwise known as the radish, in different soil pH levels. Radishes were studied because of their larger implications to the world specifically in food, the economy, and health, and it was hoped the outcome of the experiment would indicate the best pH to grow radishes for their significance. The research hypothesis formed stated that *Raphanus sativus* will grow the best in a soil pH of 6.8. This hypothesis was not accepted. The independent variable levels chosen for this experiment were selected based on precipitation distinctions in various locations because precipitation affects soil pH. Soil samples were collected, and pH was tested to justify the levels of this experiment: 5.1, 6.2, 5.4, and 6.8. Soil pH 5.1 was the control because the soil was local. The radishes were grown outside using an organized identification system, in which observations were made daily. The radishes received water every three days, and height was measured every four days. At harvest, leaf number, health, mass, and final length were recorded. Results concluded that Heathsville (6.2) and Chase City (5.4) had the best growth because they had the greatest data in categories including height, health, leaf number, and mass. The null hypothesis failed to be rejected as most data was insignificant with a level of significance of 0.05. The reason for the results is most likely due the similar environmental conditions both soils were retrieved from.

The Effects of Air Pollution on Radish Growth
Skylar Middleton, Clover Hill High School

The purpose of this experiment was to determine the effect of air pollution on radish growth. The experimental hypothesis stated that the radishes grown in the unpolluted terrarium would grow to be taller than radishes grown in the polluted terrariums. The experiment was conducted to inform people about the negative effects air pollution has on the growth of vegetation in the environment. This experiment was conducted by planting 30 seeds in three different terrariums. Each terrarium was a different level of the independent variable; the first was the control, the second was 1 pump of hairspray and the third was 3 pumps of hairspray. In each terrarium there were 30 seeds split into 10 sets, each set being a different trial. Overall there were 90 seeds in total because there was a terrarium for each level of independent variable equaling 3 terrariums. Every three days hairspray was added to the correct terrariums. After 30 days of this process the results were collected by measuring the height of each radish plant. The average control was 12.1 cm tall, 10.2 cm tall for one pump and 9.7 cm for three pumps. With the collected data further testing was completed for more in- depth analysis. In conclusion the tests demonstrated that the null hypothesis, the growth of the radishes would not depend on the amount of air pollution, was not supported. But, the experimental hypothesis was supported.

The Effect of Ultraviolet-B Radiation on the Height and Leaf Number of *Glycine max*
Joshua Tipps, Central Virginia Governor's School

The purpose of this study was to determine if Ultraviolet-B radiation affected the height and leaf number of *Glycine max* plants. Over the course of several weeks, garden-variety soybean plants were grown in different UV-B conditions in order to provide a better understanding of this effect. 48 plants were divided into four groups, each group consisting of 12 plants. Each of these groups were exposed to UV-B for various periods of time (0, 7, 14, and 21 days). After 21 days, height was measured with a centimeter ruler and the number of leaves were counted. Upon completion of data collection, the mean height (M=20.94, 19.55, 22.1, and 1, respectively) and leaf number (M=7.6, 6, 8.5, and 0, respectively) of each group was calculated and compared. With the preset alpha value of .05, two single-factor ANOVA tests for plant height and leaf number revealed p-values of .03 and .01. Post-hoc Tukey tests revealed significant differences between the 0-day and 21-day groups for height and leaf number, and the 14-day and 21-day groups for leaf number. However, the research hypothesis, which stated that if *Glycine max* plants are exposed to UV-B radiation for the entire experiment, then the height and leaf number will be lower than those exposed to no or little UV- B, was not supported because the 14-day group had the largest average height and leaf number. The results of this study suggest that Ultraviolet-B radiation has a statistically significant effect on the physical growth of agricultural plants.

Viability of Hybrid American-Chinese Chestnuts as a Caloric Substitute for American Chestnuts
Holland Bill & Nathan Henderson, Harrisonburg High School

The loss of the American chestnut (*Castanea dentata*) by the American Chestnut Blight (*Cryphonectria parasitica*) has dramatically changed the forest landscape over the last 100 years in the Eastern United States. We propose that reintroduction of a disease-resistant chestnut tree would provide an excellent food source for wildlife. This research evaluates the nutritional value of the novel hybrid American Chinese chestnut by using bomb calorimetry to quantify its stored energy value. These data showed that American chestnuts had the highest average heat of combustion with 4879 calories/gram. Hybrid chestnuts had the second highest average heat of combustion with 4290 calories/gram. The Chinese chestnuts had the lowest average heat of combustion with 4251 calories/gram. Our hypothesis has been rejected at this point, as the hybrid chestnuts had a much lower heat of combustion than the American chestnuts and a more similar caloric value to the Chinese chestnuts. However, there could be confounding variables (amount of trials, chestnuts collected from one source, etc.). In addition, this data does not discount them from being a beneficial food source in the Appalachian forests. The hybrid chestnuts could supplement their Chinese counterparts as a food source for wildlife, and hybrid chestnuts would likely provide an alternative to oak trees because of their deterrence of invasive pests. Overall, despite not being a complete substitute for American chestnuts, these data still support its reintroduction into American forestry.

The Impact of Arbuscular Mycorrhizal Fungi on Marigold Development in
Microplastic-Contaminated Soil
Cassady Marion, Southwest Virginia Governor's School

A concerning phenomenon over the last 50 years has been the growing prevalence of plastic pollution in both soil systems and oceanic basins. These partially degraded plastics have left microplastic pollution ubiquitous in soil systems. The effects of this pollution are documented as harmful; microplastics alter soil structure, elemental composition, and a whole other host of issues are presented. One promising solution, however, is the introduction of Arbuscular Mycorrhizal Fungi to plant systems facing pollution-related issues. Arbuscular Mycorrhizal Fungi (hereafter AMF) lives within plant roots and bolsters nutritional uptake and stomatal conductance. These properties aid in the remediation of polluted soils and the development of host plants. This study introduced AMF to Marigold (*Tagetes patula*) seedlings (n=60) in microplastic-contaminated soil and measured AMF's impact on plant development in the soil. After growing for 20 days, the Marigolds inoculated with AMF had significantly more biomass (p-value < 0.05) than their control counterparts. Additionally, the treatment group with AMF in microplastic-contaminated soil was able to grow a statistically similar (p-value = 0.9342) amount of biomass to the regular control without AMF which faced no microplastic pollution. These results suggest that the use of AMF in the development of compatible vascular plant species significantly aids them in the presence of microplastic pollution. Furthermore, the capacity for certain species to create a symbiotic relationship with AMF provides a distinct advantage in the acquisition of nutrients and overall resiliency compared to their competitors. A suggestion for future study would be to examine the larger-scale ramifications of AMF in targeted ecosystems over time and pursue additional tests of AMF's applications in the agriculture industry with lead or arsenic pollution and the presence of plant pathogens.

The Effect of *Manduca sexta* on the Total Phenolic Content of *Solanum lycopersicum*
Margaret Laflam, Roanoke Valley Governor's School

The purpose of this experiment was to determine the effect of tobacco hornworm damage on the total phenolic content of Roma and San Marzano tomatoes. Harm inflicted upon plants causes them to release phenols, which have been shown to have anti-cancer properties in humans, increase antioxidants in plants, and to even impact the taste in many crops. It was hypothesized that damage caused by hornworms would increase the total phenolic content (TPC) of the Roma and San Marzano tomatoes. After being treated with hornworms for one week the plant material was frozen with liquid nitrogen, pulverized, and put into labeled containers. The sample was then massed (0.25 g) and one mL of 80% aqueous methanol solution was added. The mixture was sonicated, centrifuged, and the supernatant was collected (twice for each sample). Reagents were added to each supernatant, the samples were vortexed, and then incubated for two hours. The sample was pipetted into a 96-well plate (two wells each). The absorbance of each well was measured and compared to a standard curve of gallic acid. A Two Sample t-Test showed that the mean TPC of treated San Marzano gallic acid equivalent (GAE) was not significantly different from the mean TPC of control San Marzano GAE. Another Two Sample t-test showed that the mean TPC of treated Roma GAE was not significantly different from the mean TPC of control Roma GAE. Therefore, one can conclude that treating Roma and San Marzano tomatoes with hornworms does not significantly affect the plant's TPC.

What is the Effect of Genetic Modification on the Growth Rate of a Soybean Plant?
Lara Mohamed, Washington Liberty High School

The purpose of this study was to determine if genetic modification affects the growth (in height) of a soybean plant. The independent variable was the genetic modification of the seeds (genetically modified soybeans, non-genetically modified soybeans). The dependent variable was the height of the soybean plant over three weeks. In this experiment, the genetically modified soybeans were the experimental group and the non-genetically modified soybeans were the control group. It was hypothesized that the genetically modified soybean plant would grow at a quicker rate than the natural soybean seed because genetic modification often produces plants that can grow faster than normal plants. Twenty genetically modified and twenty non-genetically modified seeds were grown in foam cups over a 21-day period. Over the three-week period, the heights of the plants were recorded. The results from the error bars and the T-Test suggested that there was a significant difference between the mean height of non-genetically modified and genetically modified soybean plants over a 21-day period. As the genetically modified soybean plants did grow at a faster rate, the research hypothesis was supported. In conclusion, the study suggests that genetic modification does affect the rate of growth of soybean plants.

Kill or Get Killed a Study on Allelopathic Properties of the Nut Family Native To Northern Virginia
Teo Huson, Washington-Liberty

Kill or get killed. In the wild, this is the law of the land, for animals and even for plants. Allelopathic trees and plants are defined as a “biological phenomenon by which an organism produces one or more biochemicals that influence the germination, growth, survival, and reproduction of other organisms”. The purpose of this experiment was to test the effects of Allelopathic Nut Trees native to Northern Virginia on Radishes and Tomatoes germination rate. This experiment was made to inform Virginians, (and people on the east coast) the dangers/importance of Nut Trees and in depth, the allelopathic qualities that can change the balance of an ecosystem. The hypothesis for the experiment was, If the Black Walnut Tree has the chemical juglone which causes allelopathy, then other trees in the nut family will also be allelopathic in some manner, because since they are in the same family, they are similar and therefore have juglone, which causes allelopathy. Procedure went as follows; seeds were collected from American chestnut, hickory, and black walnut trees in Arlington. Then, seeds were let to oxidize and form their juglone chemical compound (if they had it). After 48 hours of oxidizing, water was poured into the different seed’s separate buckets, and a tea like substance was made. This tea like substance is to replicate the natural process of juglone from the seeds entering the ground and poisoning it. Furthermore, the different tea (one for each seed) like substance was used to water the radish and tomato seeds separately. Thus, began my experiment, which lasted 15 days. Data from my experiment showed that while the control flourished, seeds exposed to the different “teas”, did not flourish, and suffered greatly. Furthermore, the Independent Variables strongly affected the radishes, as the mean of the germination rate for the test groups was 43%. To restate that, the average germination rate of the Radishes exposed to the Independent Variables was 43%. Similarly, the tomatoes’ germination rates were also affected by the Independent Variables, as the average germination rate of the test groups exposed to the Independent Variables was 40%. However, to be more specific, the chestnut Independent Variable had the biggest effect on both the Radish seeds and the tomato seeds. The data does support the hypothesis very strongly. However, to truly show that the hypothesis was supported, the T-Test results must be analyzed. The mean of the Tomato T-Test was 0.18365093 and the mean of the Radish T-Test was 0.10867923. This study supports the idea that black walnuts, American chestnuts, and hickories hurt radishes and tomatoes through allelopath

The Effect of Water Purification Methods on Plant Growth
Laura South, Washington Liberty High School

The purpose of the project was to find an effective method to remove bacteria from water taken from rain barrels to determine if treating the water led to a more effective way to grow crops. Although this is a small project, being able to grow more plants with recycled water could help combat the growing issue of world hunger. To do this experiment, radish plants were used. One cup of Activated charcoal was placed in four liters of water, four liters of water was boiled in a pot over a stove top, and four liters of water was filtered using a water filter. Four liters of water were kept untouched as the control. The plants were watered every four days, and the height of the plants were measured every week for four weeks. At the end of the four weeks, the height of the plant was measured above the soil. The mean heights for the plants were: 8.18 cm for radishes treated with boiled water, 7.7 cm for radishes treated with filtered water, 7.68 cm for radishes watered with the control group, and 7.46 for the radishes with charcoal treated water. While there was a slight variation in the results, the experiment's p-Test concluded that there was not a significant difference between the levels. Therefore, the way one purifies rain barrel water, if at all, has no impact on the growth of plants. Therefore, there is no reason to buy filters for rain barrels. This experiment showed that three water purification methods barely did better, and one did worse, than the control. It would not be worth it to spend time or money on purifying recycled water, as it will have little impact on plant growth. Further, in the fight against world hunger, the research shows that recycled water can be used to grow crops without the need to be purified, which could open the door to less expensive watering of crops.

The Effect of Different Fuels on the Growth of *Elodea canadensis*
Lily Allen, Washington-Liberty High School

The intention for this project was to show the effects of different fuels on the growth of *Elodea canadensis*, and therefore demonstrate why proper disposal of fuel and similar materials is so important. Today the world faces lots of environmental issues, but water pollution, although an extreme conflict, can be fixed with proper education and changing of disposal methods. The experiment's independent variable was type of fuel, and the levels were gasoline, diesel, ethanol based e85, and a control being regular water. The hypothesis was that if ethanol is tested on elodea, then it will grow longer than elodea tested on by diesel or gasoline, because ethanol based e85 is a biofuel made specifically to be more sustainable. The results showed that there was no statistical difference between levels and the hypothesis was not supported, but there was lots of room for improvement within the experiment in order to make the data support the hypothesis. The results also showed negative growth on average with all the levels of the IV, which supports the research and the general idea that fuels are not beneficial for plants, and in order to protect aquatic plants like *Elodea canadensis*, fuels should be disposed of more properly.

The Effect of Algae Species Grown in a Photobioreactor on Algal Biomass for Biofuel Production
Madison Goeke, Washington-Liberty High School

The use of petroleum-based products has led to a spike in global warming, with transportation fuels accounting for 21 percent of global CO₂ emissions. A leading alternative source of transportation fuel is algae biofuel; however, biofuel production is not sufficiently cost-efficient to be commercially viable. In this experiment, four algae species (*Chlorella vulgaris*, *Nannochloropsis*, *Tetraselmis chuii*, and *Isochrysis galbana*) were tested for their effectiveness in efficiently producing optimal biomass. These species were grown in a home-built, open-system photobioreactor to maximize CO₂ intake, allowing for a larger biomass yield. A culture media consisting of sterilized water, salts, and nutrients was created and dispersed into various bottles, which were then filled with 50 mL of their given algae strain. After a three-week growth period, the solutions were dewatered through a method known as flotation. In this process, the solutions were boiled, and the algae cells adhered to the rising bubbles, producing a layer of algae on the surface of the water which could be skimmed off. *T. chuii* was the most effective producer of biomass with an average of 162 mg of biomass, compared to the control's 101 mg of biomass. *Nannochloropsis* was significant with 144 mg, and *I. galbana* was insignificant with an average biomass of 68 mg. *T. chuii* and *Nannochloropsis* serve as promising solutions to the implementation of algal biofuels to create a more sustainable fuel industry.

The Effect of Microplastics on Soybean Growth
Ben Tsai, Washington - Liberty High School

The purpose of this study was to find the effect of microplastics on soybean growth. The independent variable was the water that the soybeans were watered with (Nestle Pure Life, Aquafina, Evian, Dasani, and tap water). The control group was tap water. The dependent variable was the length of the soybean roots. The constants were the environment, the amount of water, and the soybean source. The hypothesis was: If soybeans are watered with water containing different amounts of microplastics, the ones watered with the least microplastics will grow the most. 30 mL of water from each independent variable was poured into a plastic bag containing a paper towel and five soybean seeds. This process was repeated, then each bag was placed in a heated area composed of a large cooler, a cardboard box and a heated pad which maintained an average temperature of around 23°C. The roots of each soybean were measured daily for three days. The results suggested that microplastics have no effect on soybean growth. These results reject the hypothesis. In conclusion, the study suggests that soybean growth is not affected by microplastics present in water.

The Effect of Chitinase From Various Sources on Mycorrhizal Growth in Plants
Noah Portner, Washington-Liberty High School

Mycorrhizae is a type of fungus which forms symbiotic relationships with over 80% of terrestrial plants (Bianciotto, V. et al. (1996)). Chitin is an important polysaccharide in fungi such as mycorrhizae as well as many other organisms, and chitinase is an enzyme used to break down chitin. Chitinase is used by plants to help the formation of the symbiotic relationship. The purpose of this experiment was to determine if chitinase originating from plant and bacterial cells, when added to the water used by growing plants, would ultimately affect mycorrhizal quantity on root samples and whether the effect of the plant and bacterial chitinases would differ. The first hypothesis was that greater concentrations of chitinase would correlate with smaller amounts of mycorrhizae on roots. The second hypothesis was that if the added chitinase is of plant origin, then mycorrhizal root coverage would be greater than if the chitinase is of bacterial origin as plants form symbiotic relations with mycorrhizae while bacteria simply use chitinase to destroy chitin bearing organisms. The independent variables were type of chitinase and quantity of chitinase, and the dependent variable was root coverage. A control containing no chitinase was compared with concentrated bacterial chitinase diluted in water in the magnitudes 5 micrograms/ml, 50 micrograms/ml, and 500 micrograms/ml. Banana peel was added to water in the quantities 5g and 10g. The first hypothesis was confirmed and the second was rejected. Though increased amounts of bacterial chitinase correlated with poorer mycorrhizal growth, increased banana chitinase showed the same trend. The data indicates that direct contact with chitinase damages symbiotic mycorrhizae. Therefore, plants utilizing chitinase for other means (such as combatting insect predation) might have a harder time forming symbiotic relationships with mycorrhizae. Furthermore, while chitinase-producing bacteria are abundant, gardening with chitinase rich plants may harm the growth of the other plants.

The Effect of Heavy Metals on CO₂ and O₂ Production of Mung Bean (*Vigna radiata*)
Nishaanth Mulpuru, Mills E. Godwin High School

The purpose of this experiment was to investigate the effect of different heavy metals on the O₂ and CO₂ production of mung bean plants. Human industrial activities greatly enhance metal distribution in the global environment by discharge to soil, water, and air. Heavy metals are becoming a leading agricultural concern, and heavy metals pose short-term and long-term threats to human health. Mung bean seeds were treated with either the control (distilled water), 150 mg/L copper sulfate solution (9.398 μM), or 150 mg/L lead acetate solution (4.611 μM). The CO₂ and O₂ production of mung beans was measured. It was hypothesized that the CO₂ and O₂ production of mung beans given the control will be greater than the mung bean given copper sulfate or lead acetate. The results revealed that the CO₂ and O₂ production of mung beans given the control was greater than the copper sulfate and lead acetate solutions. A t-test revealed that the data was statistically significant, and that the results supported the research hypothesis and are due to the independent variable. The primary toxicity mechanism of heavy metals alters the catalytic function of enzymes and damages cellular membranes. Heavy metals cause an inhibition of chlorophyll biosynthesis where two key enzymes, delta-aminolevulinic acid (ALA)-dehydratase (EC 4.2.1.24) and protochlorophyllide reductase,

are mostly affected. Further studies like the effect of heavy metals on other plants and specific enzymes found in important plant processes could be investigated.

Can Essential Oils be Allelopathic to *Lolium multiflorum* Without Harming *Solanum lycopersicum*?

Shreya Madan, Hidden Valley High School

Objective: As global demand of agricultural crops for food and fuel increases, the need for exploring eco-friendly biological methods to control weeds and enhance food crop yield is rising. Essential oils can be a safe bioherbicide with positive effects on food crops. The objective of this experiment is to study the effects of three essential oils on seed germination and radicle length of *Lolium multiflorum* (ryegrass) and *Solanum lycopersicum* (tomato). **Procedure:** The three essential oils used were turmeric, ginger, and eucalyptus at two different concentrations. Independent variables are the type of oil and low and high concentrations of each oil. Low and high concentrations were created by mixing 0.08ml and 0.16ml of oil in 20ml of distilled water respectively. 20 seeds of both plants were exposed to all three oils at both concentrations in individual petri dishes. A control was also set up with 20 seeds using distilled water for each plant. Seed germination rate and radicle length were measured on the seventh and tenth day respectively. **Data:** Data analysis was completed by calculating means and a two-factor analysis of variance in excel. The mean seed germination and radicle length for tomatoes exposed to turmeric oil was 90% and 19.4mm respectively whereas the ryegrass seeds had significantly lower means (11% and 6.8mm). The means of both seeds were lower when exposed to ginger oil compared to the control (7% vs. 94% for tomato and 8% vs 96% for ryegrass). ANOVA showed significant interaction between the type of oil and concentration with seed germination (p values $< .05$). **Conclusions:** Turmeric oil showed potentially phytotoxic effects on weed, ryegrass without a negative impact on the food crop tomato. Ginger oil possessed allelopathic properties towards ryegrass and tomato, inhibiting seed germination in both.

The Effect of Mycorrhizal Fungi on the Growth of Milkweed in Acidic Soil
Benjamin Barnett, Central Virginia Governor's School

The purpose of this study was to determine whether the presence of mycorrhizal fungi would help plants grow in soil affected by acid rain. *Asclepias syriaca*, or common milkweed, was used as the model organism for the experiment. Three groups were utilized: a control group with standard soil, an experimental group with acidic soil, and an experimental group with acidic soil and mycorrhizal fungi present. The acidic groups were treated with a diluted sulfuric acid solution before planting, as well as weekly throughout the experimentation process. Plant height (cm) indicated milkweed health status. Measurements were taken weekly over a three-week period. The acidic group, acid-fungi group, and control group had mean heights of 4.27 cm, 4.38 cm, and 4.61 cm respectively at the end of the three-week period. A single-factor ANOVA test was performed and found no significant difference between groups ($p\text{-value}=.619$) compared to an alpha value of .05. The data did not support the research hypothesis that if *Asclepias syriaca* (common milkweed) was exposed to mycorrhizal fungi in acidic soil, then the plants would grow taller when compared to plants without the fungi in the same conditions. This study suggests that mycorrhizal fungi do not provide significant benefits for milkweed in acidic soil, suggesting that other mitigators should be employed to help plants affected by acid rain.

CHEMISTRY

The Effect of Different Antioxidants on the Chemiluminescence of Luminol

Trisha Taparia, Mills E. Godwin High School

The purpose of this experiment was to find the effects of different antioxidants on the chemiluminescence of luminol. Tannic acid, ascorbic acid, and glutathione have been used as antioxidants as part of the chemiluminescent reaction to observe the mechanics of free radical scavenging, and they both may have similar impacts on the chemiluminescence of luminol. Solutions made of potassium ferricyanide, sodium hydroxide, hydrogen peroxide, and luminol were exposed to 15 $\mu\text{g}/\text{mL}$ of ascorbic acid, 15 $\mu\text{g}/\text{mL}$ of tannic acid, or 15 $\mu\text{g}/\text{mL}$ of glutathione. There was no control in the experiment because luminol does not have a standard antioxidant that can be used for comparison. It was hypothesized that if 15 $\mu\text{g}/\text{mL}$ of ascorbic acid is added to the luminol solution, then it will have a higher relative intensity compared to 15 $\mu\text{g}/\text{mL}$ of tannic acid and glutathione. The results showed that tannic acid, on average, had relative intensities that were 0.0002 rel higher than ascorbic acid and 0.0003 rel higher than glutathione. Three t-tests were performed on the data and the data was found to be significant for tannic acid vs. ascorbic acid and tannic acid vs. glutathione but was found to be insignificant for ascorbic acid vs. glutathione. Based on the results, the research hypothesis was not supported. The results are due to the fact that small-molecule antioxidants like glutathione and ascorbic acid inhibit the chemiluminescence of luminol. These results can lead to further research on how different amounts of tannic acid affects the chemiluminescence of luminol.

The Effect of Different Contact Lens Solutions on Sustained Release of Hydrogel Crystals
Suhani Samaroo, Clover Hill High School

The purpose of this experiment was to determine the effects of different contact lens solutions on hydrogel crystal release levels. It is important to know which lens solutions allow for the greatest release of liquid by hydrogels for the future of using different combinations of hydrogels and solutions to create intraocular lenses, or IOL's. Post cataract surgery infection, endophthalmitis, is becoming a leading cause of blindness due to inadequate protection by current intraocular lenses. At the moment, there is no confirmed activator for hydrogel release, but once it has been found, hydrogels will be able to create systematic-releasing, antibiotic filled lenses for postoperative infection prevention and protection. In order to measure the release of black tea from hydrogel crystals, 150 hydrogel crystals were soaked in black tea for 24 hours, and then measured with a caliper to ensure constant beginning diameter. Then, the black tea absorbed hydrogels were split into groups of 30 and placed into distilled water, Opti-Free Puremoist, Bio-True, RevitaLens, and Clear Care, respectively. After soaking in the solutions for 24 hours, the circumference of the crystals were measured once again to determine which solution caused the greatest release of tea, or decrease in circumference. The experimental hypothesis was that if 150 black tea absorbed hydrogel crystals are soaked in distilled water, Opti-Free Puremoist, Clear Care, Revital Lens, and Refresh, then Clear Care will allow for the most systematic, periodic release, and this hypothesis was supported. Distilled water caused the hydrogels to grow the most, by 0.8 millimeters in circumference, and Clear Care caused the hydrogels to shrink the most, by 5 millimeters in circumference. An ANOVA test was conducted and the difference between independent variables was found to be statistically significant, resulting in the rejection of the null hypothesis.

The Effect of Temperature on the Surface Tension of Salt Water
Shashidhar Kuruganti, Mills E Godwin High School

This project is a result of the experimentation of different temperatures on the strength of the surface tension of saltwater. The idea was to see how different temperatures change the surface tension of the water. The strength of the surface tension was determined by the amount of weight it took to break the surface tension of water. The temperatures of water were determined by looking at past, current, and projected temperatures for 1969, 2019, and 2069. The current temperature is 17 degrees C, which served as a control for the experiment. Temperatures in different locations have affected surface tension of water over many bodies of water. The values for the t-tests were surprising because the values for the 20 degrees and 13 degrees (1.095) was not significant. Oppositely, the results for the 17 degree and 13 degrees (5.506) and the 17 degrees vs the 20 degree (5.172) were both affected by temperature. The temperature of water has a large effect on temperature based on the results of the experiment. The applications to this data are large because many marine animals are already under threat because of the rising temperatures of water.

AFM-based Nanoindentation Technique: A Novel Approach to Determine the Nanoscale Degradation of PET

Uyen Tran, Roanoke Valley Governor's School for Science and Technology

The purpose of this experiment was to investigate the impact of water type, movement, and sand on the degradation of polyethylene terephthalate (PET). It was hypothesized that if PET was exposed to distilled, spring, and ocean water, then atomic force microscopy (AFM) would be able to investigate the nanoscale degradation of PET using the novel technique of lithography-based nanoindentation. Two square 1 cm pieces of PET were treated in distilled, spring, and ocean water, along with shaking treatments for each water type with or without sand. The samples were individually placed in a 50 mL Erlenmeyer flask and treated for 19 days in the still (control) and shaking conditions. Force-distances produced by nanoindentation were obtained for each surface to investigate surface abrasion resistance of different water types on PET. Surface roughness from topography scans were used to determine the impact of shaking and sand. The alternative hypothesis, that at least one of the amounts of surface roughness was different from the others, was accepted. The p-value of ≤ 0.002 was statistically significant at the 5% significance level, indicating that the mean surface roughness of PET treated with all three types of water, sand, and shaking were not equal. Abrasion resistance values were calculated using depths obtained from topography scans after nanoindentation was performed, which indicated that when untreated PET (25.378 nN/nm) was exposed to each different water type, spring water treated PET (29.716 nN/nm) was the most susceptible to degradation in comparison to distilled (43.715 nN/nm) and ocean water (52.173 nN/nm).

The Effect of Tea Types on Neutralizing Stomach pH Level
Aaditi Parab, Mills E. Godwin High School

The purpose of this experiment was to investigate the effect of different tea types on neutralizing stomach pH level. This was to determine if a certain type of tea could be used as an alternative to over-the-counter antacid medication. This is because antacids present unpleasant side effects to some people and natural remedies usually have lower risks. It was hypothesized that green tea would increase the pH the most out of the 4 teas and the control group that were tested. To conduct the experiment, a hydrochloric acid and water solution was prepared to represent stomach acid. Different types of tea were prepared and added to the HCl and water solution. The pH of the solution after the tea was added was measured. The types of teas that were tested were chamomile tea, ginger tea, peppermint tea, and green tea. The control group was Pepto Bismol because it is a common over the counter antacid medicine. Peppermint tea increased the pH of the HCl solution the most while Pepto Bismol increased it the least. The null hypothesis was rejected, and the data was significant for each level of the variable. In conclusion, peppermint tea is the tea that increases the pH the most, so it is the best to consume when someone is experiencing side effects to antacids. Peppermint tea most likely increased the pH the most because it had the second highest pH out of all levels of the variable.

The Effect of Homemade and Commercial Fabric Softeners on Fire-retardant Materials.

Emily Haueis, Mills E. Godwin High School

The purpose of this experiment was to test the effect of homemade and commercial fabric softeners on the flammability of fire-retardant material. Commercial fabric softeners are known to increase the flammability of fire-retardant fabric, but very little research has been done on homemade fabric softeners' effects. It is important to determine homemade fabric softener's effects on flammability in order to determine whether homemade fabric softener could be used as a safer and more environmentally friendly fabric softener. A study was developed in which five groups of twenty-five strips of fire-retardant material were taken and soaked in different solutions of homemade and commercial fabric softeners. There was another control group of strips which were not soaked in any type of fabric softener. A vertical flammability test was performed on each strip of cloth, and the scorch marks were measured and recorded in mm. The mean for each group was calculated, with the baking soda solution having the lowest scorch mark and the commercial fabric softener having the highest scorch mark. T tests were calculated, and all sets of data were shown to not be significant. It is believed that the results are due to the fabric being legally fire-resistant, but not functionally fire-retardant. This experiment could lead to an argument for tighter regulations on what is considered fire-retardant fabric, which could lead to an improvement in fire safety.

The Effect of Different Brands and Types of Ready-To-Feed Baby Formulas on the Concentration of Arsenic

Ayathi Gogineni, Clover Hill High School

The purpose of the experiment was to determine the effect of the different brands and types of ready-to-feed infant formulas, specifically the brands of Similac and Enfamil, on the concentrations of inorganic arsenic contained in the formulas. Arsenic, a poisonous metalloid, contaminates many foods and drinks, including rice, seaweed, shellfish, juices, and supported through this experiment, baby formulas and first foods. Symptoms of short-term and long-term exposure to arsenic include diarrhea, rashes, irregular heartbeat, and kidney and liver cancers. Consequently, it is important to research and conclude the safest formulas for infants to prevent their low mass bodies from getting potentially harmed by higher levels of poisoning. The experimental hypothesis for this experiment was that the ready-to-feed Enfamil A.R. formula with added rice starch would contain the highest concentration of arsenic because rice is one of its components. To test this hypothesis, the Industrial Test Systems Quick II 481303 Arsenic Testing Kit was used to perform the James Marsh Test, which includes converting arsenic to arsine gas, on 8 trials of 50 mL of each popular ready-to-feed formula: Similac Pro-Sensitive, Similac for Supplementation, Enfamil NeuroPro, and Enfamil AR. The color produced by the gas for each formula bottle corresponded to a concentration of arsenic in $\mu\text{g/L}$ on a color chart provided by the kit. The mean for Similac Pro-Sensitive was $2.5 \mu\text{g/L}$, for Similac for Supplementation $2.0 \mu\text{g/L}$, for Enfamil NeuroPro $2.4 \mu\text{g/L}$, and for Enfamil A.R. $3.0 \mu\text{g/L}$. The experimental hypothesis was supported, as the ready-to-feed formula of Enfamil A.R. with added rice starch had the highest concentration of arsenic. An ANOVA test concluded that the data collected had a statistically significant difference among the different levels of independent variables and the null hypothesis was rejected.

The Effect of Chlorine Bleach on Latex Swim Cap Elongation to Failure
Matthew McKeague, Clover Hill High School

The purpose of this experiment was to determine the effect of chlorine bleach on the sustainability of latex swim caps. It is beneficial to know the sustainability of swim caps so that consumers have information on when swim caps need to be replaced. The experimental hypothesis of this experiment was that the longer a latex swim cap was left in a chlorine bleach and water solution, then the shorter the swim cap would stretch before breaking. Swim caps were exposed to a chlorine and water solution for 0 days, 1 day, 3 days, 7 days, and 14 days to measure the elongation to failure. Four cups were filled with chlorine and water and 10 equal strips of swim caps were placed in each cup, and these strips were left in the cups for the specified exposure time. These strips were stretched and measured until they tore. The average stretching distance was 114 cm for 0 days, 87 cm for 1 day, 66 cm for 3 days, 61 cm for 7 days, and 35 cm for 14 days. In this experiment, the caps exposed to the solution for 14 days had the shortest stretching distance, and the caps exposed for 0 days had the longest stretching distance. The overall trend of the data had a logarithmic relationship between the exposure time and the elongation length. An ANOVA test was conducted and the difference between independent variables was found to be statistically significant; therefore, the null hypothesis was rejected.

Neutralizing Organic Peroxides
Stephen Rozen & Jake Lanier, Washington-Liberty High School

The expedient destruction of organic peroxides is crucial to emergency responders in certain crisis situations. Triacetone triperoxide (TATP) is one of the most common and dangerous chemicals used in DIY explosives because it can be made from hardware supplies and difficult to detect as it contains no nitrogen. This project intended to find the most efficient chemical TATP neutralizer that would be viable for use in the field. The TATP was produced and used in very small quantities to reduce risk. Several substances, which previous literature had indicated might be effective TATP neutralizers, were tested including a variety of dilute acids, a ferrous sulfate solution, copper chloride, ammonia, and water. Putting the TATP in solution with acetone before adding a treatment was also attempted. 200 mg of TATP was treated with 10mL of each neutralizing solution in a beaker with strong stirring. When it appeared visually that all of the peroxide had been destroyed, the solution was tested with potassium iodide test strips and if no peroxide remained, the timer was stopped and the time was recorded. This visual confirmation method was used because it is comparable to the way that emergency responders might proceed in a real-life situation. If no progress was made, the trials were allowed to run for 20 minutes before the treatment was declared to be ineffective. Of the neutralizers tested, only the ferrous sulfate solution was effective and destroyed the TATP in an average of 2:15 minutes. The ammonia and acetone levels were both considered measurement failures because they reacted with the iodide in the test strips and produced no results. Therefore, we concluded that ferrous sulfate is a good candidate for usage by emergency responders, laboratories, and industry when neutralizing TATP.

A Comparison of Two Cost Efficient Visible Light Spectrometers
Johannah Caudill, Southwest Virginia Governor's School

Spectroscopy is a tool with applications in many disciplines. A comparative study examining the relationship between spectrometers was performed. The purpose of this study was to determine which spectra measuring tool, between a flinn spectroscopy and a papercraft spectrometer, works more efficiently at reading visible light compared to an advanced spectrometer. Data recorded from the three different spectrometer readings of the four different LEDs (Light Emitting Diodes) was analyzed statistically by two matched pairs t-tests. These tests determined if a significant difference between the means of each spectrometer exists. The tests revealed that the papercraft spectrometer mean was not significantly different than that of the reference; the mean difference was 4.35 nanometers. However, the flinn was found to be significantly different in the mean by 11.825 nanometers. Therefore, the flinn spectroscopy was determined to be the less effective option. The study found that the papercraft spectrometer appears to be more similar to an advanced spectrometer when analyzing visible light. This can inform future research in this field by providing an analysis of performance between the two.

The Extraction of Lead from Cathode Ray Tubes Through the Use of Acidic Water Leaching
Hannah Dishner, Southwest Virginia Governor's School

CRT TVs have become outdated in the electronic industry and now make up 20% of the e-waste in our landfills, creating a drastic presence of lead. CRT glass has gained concern due to its wide impact on human health. This research project aimed to show how much lead in CRT glass could leach into certain solutions, to further support such environmental effects. To test to see which conditions influenced the leaching of lead the most, each sample had different glass sizes and pH levels. To do so, solutions were made from 9 different samples, and each were tested 3 times over 3 weeks with a Flame AAS. Results indicated no significant difference between pH, glass size, and the amount of lead released into each solution. The mean absorbance that focused just on pH ranged from 0.009 to 0.001 ppm depending on glass size and the f-stat given was 0.2721. pH 4 glass, however, had the highest absorbance but still had a high error due to a change in pH during testing. The mean absorbance in just the glass sizes ranged from 0.0078 to 0.0018 ppm, while the f-stat given was 0.3493. Future work should include a larger sample size, and buffer solutions, which might result in a better understanding of the relationship between pH and lead seepage in CRT glass. This could gain more attention in the field of health and environmental protection and help further the removal of TVs from trash collection centers.

The Effects of Wastewater Treatment Plant Processes on the Volume of Microplastics Found in
Local Water Sources

Emma Hendrix, Southwest Virginia Governor's School

Microplastics are microscopic particles found in many everyday products in today's market, such as in toothpastes and face washes. Wastewater treatment plants also contribute to the microplastic waste with their grinders, which crush up any inorganic substances. Microplastics can be found in oceans, rivers, and they are processed through wastewater treatment plants (WWTP), which as of now, have limited ways of extracting them from their effluent. This project aimed to quantify microplastics within different samples of water, being collected from two rivers and their designated WWTPs. Once collected, the samples were taken and strained through a series of sieves, ranging from a 60 microns mesh to a 300 microns mesh. No microplastics were found in any of the samples tested. The lack of microplastics in the samples could either demonstrate a lack of microplastics in the sample locations or it could show that the sample sites were so massive that the samples taken could not represent the whole sample site. Since the sample locations were large scale rivers and WWTP pumping millions of gallons through their canals daily, it is likely the samples collected were minuscule in size and too few in score to represent the whole sample site.

How do Certain Ingredients Affect Calorie Count in Cookies?
Megan Layne, Southwest Virginia Governor's School

A third of the world's population is affected by obesity. This disease, which is largely preventable, is an increasing problem in the United States. Much of this problem in America is caused by unhealthy eating habits. There are many manufacturers in the United States who are making newer, healthier products to help with obesity. New, healthier products need to start being made in a wide variety of foods. The objective was to propose one general question: How do certain ingredients affect calorie count in cookies? To experiment, two batches of cookies were made and tested for calorie count using the bomb calorimeter. Batch one was made with a regular recipe. The second batch had lower amounts of sugar, lower amounts of chocolate chips, and butter instead of Crisco. This allows for an analysis of which ingredients could cause higher amounts of calories in cookies. A two-sample t-test was performed by JMP 12.1.0 software program. This showed that there was a significant difference in calorie count between the batches of cookies. Future studies should be conducted to show more foods that can be made healthier by having fewer calories and to show the taste difference between the new low-calorie cookies and low-calorie cookie products that have already been made.

Measuring the Oil Sorption Capacity of Avocado Pits with Alkyl Silane Coupling Agents
Rose Tomiak, Southwest Virginia Governor's School

Petroleum oil is a necessary resource in today's industries, but its use and transportation results in oil spills that pollute surrounding ecosystems for decades. Current oil spill cleanup methods include the use of sorbents to remove oil from ocean water. However, these are primarily made from plastics that become waste after use. Biodegradable agricultural products have been tested for use as oil sorbent materials, but their hydroxyl functionalities cause them to be hydrophilic in nature, which prevents effective sorption of oil in a marine setting. The objective of this study was to chemically manipulate avocado seeds, a biodegradable agricultural product, to decrease their hydrophilicity and increase their oleophilicity. Four groups were created out of avocado seed powder: raw untreated, raw treated, carbonized untreated, or carbonized treated. The four groups were infused in polyurethane sponges and tested, along with a plain polyurethane sponge, in petri dishes filled with water, oil, and water with oil. Qualitative results suggested that the raw untreated group repelled water, but the raw treated, carbonized treated, and carbonized untreated groups attracted and absorbed some amount of oil. Quantitative data was collected by subtracting mean mass differences before and after exposure to a liquid. ANOVA testing showed that all three trials had statistically significant differences, so Tukey HD testing was conducted using JMP Student Edition 12. The statistical analysis generated p-values less than 0.05 for some groups in each of the three trials, which allowed the null hypothesis to be rejected. The results indicated that the carbonized treated group had a mean mass difference of 0.60 mg in water, 802.2 mg in oil, and 6.0 mg in oil and water. This suggests that carbonized treated avocado powder could be used as an effective oil sorbent material in the marine environment. Further research should be conducted in order to determine the most effective methods for carbonizing and treating avocado powder. Future studies should also explore how different carbon chains impact the sorption properties of agricultural products.

The Effect of Different Liquids on the Solubility Period of Iron Supplements
Angela Nguyen, Mills E. Godwin High School

The purpose of this experiment was to find the effects of different liquids on the solubility period of iron supplements. Iron deficiency significantly impacts humans, as iron is vital for metabolic processes, so ingesting iron with the best liquid is necessary for maximal absorption. One hundred fifty milliliters of vinegar was heated and poured into a glass cup, while fifty milliliters of water, coffee, whole milk, and orange juice were heated and poured into their corresponding cups. An iron supplement was dropped into each cup, and a stopwatch was started. Each solution was watched until the tablet completely dissolved, and the time for how long the iron tablet took to completely dissolve was recorded. The control used in this experiment was water with vinegar, where vinegar mimicked gastric acid. It was hypothesized that if iron supplements were dissolved in various liquids, then orange juice would dissolve iron the fastest. The results revealed that the iron supplements in orange juice (61.99 min), on average, took the least amount of time to dissolve compared to water (71.13 min), coffee (102.04 min), and whole milk (111.17 min). Multiple t-tests were performed on the data, which revealed that the data was statistically significant. It is believed that the ascorbic acid in orange juice increases the solubility of iron by keeping the acidity of the stomach and overpowers the effects of calcium on iron absorption, whole milk acts as an antacid and creates a denser solution, and coffee decreases the acidity of the stomach.

The Effect of the Source of the Bromelain Enzyme from Pineapple on the Concentration of Bromelain

Anne Licato, Washington-Liberty High School

Synchronized swimming is an Olympic sport that requires the participants to paint a thick layer of hot, liquid Knox gelatin onto their hair. If swimmers do not comply with this rule, points are deducted from their score. The removal of the Knox gelatin can take up to an hour and is very tedious. The gelatin consists of the powdered bones and cartilage of animals, and when heated with water, painted onto the hair, and left to dry, forms a very hard, clear covering. Bromelain is a protective enzyme found in pineapple that may aid in dissolving gelatin. The purpose of this experiment was to determine which part of the pineapple contains the highest concentration of bromelain. The hypothesis was if bromelain is extracted from the pineapple core, then the bromelain extracted will hold the highest concentration of bromelain, because the core of the pineapple is closest to the stem, which holds the most bromelain. The three pineapple sections tested were the fruit, core, and skin. The sections were each blended and centrifuged to separate the juice from the pineapple solids. To find the bromelain wavelengths, each sample was mixed with a Bradford protein assay dye reagent and measured using a UV spectrophotometer. The wavelengths were then converted to concentrations using a calibration curve. The calibration curve was necessary to convert wavelengths to concentrations and compare the data within ranges for known concentrations. The pineapple skin had the highest concentration of bromelain with an average of 0.527 ug/ml. The core averaged 0.510 ug/ml and the fruit averaged 0.491 ug/ml. However, both Anova tests that were run indicated the data to be not statistically significant. Therefore, the null hypothesis, if bromelain is extracted from the pineapple core, then there will be no higher bromelain concentration as compared to the other sources, is accepted. The data from this experiment could be used to further the research to produce a shampoo to remove Knox gelatin from synchronized swimmers' hair.

The Effect of Cooking Methods of Pork Sausage on the Levels of Nitrates Found (mg/kg)
Ella Morrall, Clover Hill High School

The question that was addressed was: Which cooking method of pork sausage would produce the greatest level of nitrates (mg/kg)? The experimental hypothesis for this experiment was: If the pork sausage were pan fried, the pork sausage would have the most amount of nitrates found because when meat would be exposed to direct heat, the meat was believed to contain more nitrates. The level of nitrates in pork sausage was detected with a Nitrate Residue Detector. The cooking methods that were tested was no cooking, boiling, baking, pan frying, and microwaving. The pork sausage was placed on a cutting board and the Nitrate Residue Detector's probe was placed into the pork sausage and the level of nitrates was recorded. Pork sausage was boiled for 20 minutes on medium-heat, and the level of nitrates was detected by the Nitrate Residue Detector. Pork sausage was pan fried on medium-heat for 12 minutes, and the level of nitrates was detected by the Nitrate Residue Detector. Pork sausage was microwaved for 5-6 minute, and the level of nitrates was detected by the Nitrate Residue Detector. Pork sausage was baked at 177 degrees Celsius for 25 minutes, and the level of nitrates was detected by the Nitrate Residue Detector. Each level of the independent variable was tested 10 times for a total of 50 trials. Boiling the pork sausage had the least level of nitrates found (mg/kg), followed by the pork sausage that was not cooked, the pork sausage that was microwaved, the pork sausage that was baked, and pan frying the pork sausage. All methods of cooking produced more nitrates than without cooking, except for the boiling cooking method. Generally, the levels of the independent variable that exposed the sausage to direct heat, produced the greatest level of nitrates (mg/kg).

The Effect of Different Surfactants on Latex Elasticity
Anika Agarwal, Mills E. Godwin High School

Latex is a popular product since it can stretch a great distance without ripping. Surfactants are materials that are used to enhance products since they can modify the surfaces of products. Recently, surfactants have been used on latex to keep them “fresh” during their two to three-month shipment, but surfactants can cause latex to lose its elasticity. The purpose of this project was to determine which surfactants (mineral oil, detergent, hand soap) least affects the elasticity of latex. One-hundred latex gloves were collected, and each surfactant was applied to twenty-five gloves. The last set of twenty-five gloves had no surfactants (control). All of the gloves were then slowly stretched apart using clamps on the ends of the gloves. The length of the gloves, before they teared or snapped, was recorded. The results indicated that detergent affects the elasticity of the gloves the most, with a mean length of 31.29 cm, and mineral oil had the least effect, with a mean length of 62.46 cm. A t-test performed on the data rejected the null hypothesis ($t > 2.0106$ for all levels at $df = 48$; $p > 0.05$). The data supported the research hypothesis that if mineral oil is used as a surfactant on latex, then those gloves will least affect the elasticity of the glove. It can be inferred that because detergent and soaps affect the fibers, they are able to weaken the bonds of the latex, causing it to tear. More repeated trials are necessary before any major conclusion can be made.

The Effect of Various Substances on Prismacolor Premier Colored Pencils' Blending Ability
Jessica Iraheta, Clover Hill High School

Throughout the years, the applications for solvents used in the arts have changed from newer, safer uses to creating better suited, stronger solvents for the intended purpose. Through the experiment, the question of what solvent was the best in blending on Prismacolor Premier colored pencils was answered with mineral spirits being the most similar with the control. The hypothesis of the experiment was if turpentine were used on Prismacolor Premier colored pencil's strokes, the pencil's strokes would blend completely compared to the other blending methods. Within the experiment, each colored pencil's strokes were layered evenly on a Legion Stonehenge drawing paper. A fixed amount of solvent was dropped on top of the pigment, and brushed with a paint brush. Through an application on an Iphone, Color Name, the average red intensity was found for layering, colorless blender, turpentine, rubbing alcohol, and odorless mineral spirits measuring 115.6, 112, 120.6, 134.4, and 131.2, respectively. The average blue intensity for layering, colorless blender, turpentine, rubbing alcohol, and odorless mineral spirits were 128.4, 101.2, 120.6, 132.8, 130.6, respectively. The average green intensity for layering, colorless blender, turpentine, rubbing alcohol, and odorless mineral spirits were 155.6, 127.6, 144.2, 159.8, 153.6, respectively. The data did not support the hypothesis, but the data did allow for the null hypothesis to be rejected.

The Effect the Method of Coffee Brewing has on the TDS of the Solution
Andrew Edmondson, Washington Liberty High School

This project was done in hopes of learning more about the extraction of coffee and how different methods affected this. Precisely, how the method used to brew coffee affects the Total Dissolved Solutes (TDS) of the dissolved brew. This experiment was not completed in hopes of rating “better” coffee, but instead the overall strength of a brew. The hypothesis predicted the placement of the four variables, the drip, the percolator, the French press, and the Mocha Pot. The French press was expected to be the most effective followed by the Mocha Pot, percolator, and drip respectively. The value of pressure as a method of extraction was not accounted for in this hypothesis. This is the main factor that altered the concluded results. The null hypothesis was accepted as the data was too inaccurate and the process too flawed for the data to be accepted. The conclusion was made that although the null hypothesis was accepted, the data did allude to several possible trends. The drip was the least effective due to a complete lack of extraction methods. The percolator scored higher than the drip, only because of the repetitions in the process. The French press and Mocha Pot both did considerably better than all previously mentioned methods, as the pressure they applied was an invaluable asset. The Mocha Pot’s data was very inaccurate due to a serious mistake in the experimental procedures, so although it averaged higher than the French press, there is no clear winner. However, this does contradict the expectation that the French press would have a far higher TDS than the Mocha Pot.

The Effect of Brand on Epsom Salt Solubility
Molly Wernicke, Washington-Liberty High School

Epsom salt, or magnesium sulfate, is generally harmless but can become dangerous when too much is used. When magnesium levels are heightened to an unnatural point, a person becomes at risk for the debilitating condition of hypermagnesemia. In order to answer the question 'how much is too much?' When it comes to Epsom salts, the objective of this experiment was to determine and compare the solubilities of three different brands of Epsom salts: Epsoak, Dr. Teal's, and pure magnesium sulfate. It was hypothesized that if pure magnesium sulfate was dissolved in water then it would be more soluble because it has no other contaminants in its structure that would reduce solubility. This experiment was done by pouring each Epsom salt brand into 100g of water in increments of 1.5g until it could no longer dissolve and was saturated. There were 10 trials per Epsom salt brand, and the process was completed a total of 30 times for each trial. All of the materials were clean, and the water was room temperature. It was important to keep the bags of Epsom salt closed for the majority of the experiment and tilt it to the side when using it to reduce risk of contaminating it. Epsoak ended up having the highest solubility at over twice that of the pure magnesium sulfate, which Dr. Teal's wasn't far ahead of. This result rejected both the research hypothesis and the null hypothesis as the Epsoak had a higher solubility than the pure magnesium sulfate and because there was a difference in the measurements.

The Effect of Chlorine Levels on the Ability of a Swim Cap to Hold Weight
Sophia Schorr, Clover Hill High School

The purpose of this experiment was to determine the effect of chlorine concentrations on a latex cap's ability to hold weight. This is important for swimmers to know so they can predict when their caps would break, and therefore know when to buy new ones so they are not unprepared. The hypothesis was that if the chlorine level were at five parts per million (ppm), then the swim caps will break most easily. The null hypothesis stated that the chlorine concentrations would have no effect on how easily the caps broke. To measure the cap's ability to hold weight, latex caps were put in plastic containers containing water with chlorine concentrations of either 0, 3, or 5 parts per million (ppm) for 122 hours. The caps were then taken out of the containers, washed off, and dried. A cap was then secured in a quilting ring and attached to the side of a porch. Weights were then put in the cap until it broke. The weight the cap could hold before breaking was recorded. This was repeated for all caps. Twenty caps were soaked in each concentration of chlorine. The mean was 15.8 kg for the caps soaked in water with 0 ppm of chlorine, 16.0 kg for 3 ppm, and 16.0 kg for 5 ppm. An ANOVA test was conducted and the difference between independent variables was found to be insignificant.

The Effect of Various Temperatures on Gel Electrophoresis Band Resolution
Sydney Coffman, Mills E Godwin High School

Electrophoresis has a variety of applications and is used to separate and identify samples using bands created. It is also used in paternity tests and crime scenes. For this reason, it is important to create optimal band resolution. The purpose of this experiment was to determine which temperature exposure, 5°C, 20°C (control), or 35°C, would create optimal band resolution. In this experiment, DNA samples from banana tissue were transferred into PCR tubes. These were placed in a thermocycler for multiple cycles. After preparation, the samples were ready for use. After casting a gel box, each trial was exposed to one of the three temperatures. Electrophoresis was completed, and Delta E values were calculated to determine the pigmentation (resolution) of produced bands. The research hypothesis formulated predicted that if the gel and buffer solutions during electrophoresis remain at room temperature (20°C), then the resolution of the bands created will be optimized. The mean calculated Delta E value for bands at 20°C (29.3295) was greater than those of 5°C (19.9611) and 35°C (11.8350), supporting the hypothesis. The standard deviations for the 5°C trials, 35°C, and 20°C were close to zero, showing precise data. T-tests calculated showed statistically significant data and allowed for null hypothesis rejection. Previous research supported experimental findings. Leaving the gel and buffer solution at 5°C positively impacted the viscosity of the gel. However, an increase in temperature resulted in the presence of double-layer polarization, decreasing DNA mobility and resolution. For this reason, the room temperature trials created a balance and therefore optimal resolution.

The Effect of Brand on Epsom Salt Solubility
Malia Wernicke, Washington-Liberty High School

Epsom salt, or magnesium sulfate, is generally harmless but can become dangerous when too much is used. When magnesium levels are heightened to an unnatural point, a person becomes at risk for the debilitating condition of hypermagnesemia. In order to answer the question 'how much is too much?' When it comes to Epsom salts, the objective of this experiment was to determine and compare the solubilities of three different brands of Epsom salts: Epsoak, Dr. Teal's, and pure magnesium sulfate. It was hypothesized that if pure magnesium sulfate was dissolved in water then it would be more soluble because it has no other contaminants in its structure that would reduce solubility. This experiment was done by pouring each Epsom salt brand into 100g of water in increments of 1.5g until it could no longer dissolve and was saturated. There were 10 trials per Epsom salt brand, and the process was completed a total of 30 times for each trial. All of the materials were clean, and the water was room temperature. It was important to keep the bags of Epsom salt closed for the majority of the experiment and tilt it to the side when using it to reduce risk of contaminating it. Epsoak ended up having the highest solubility at over twice that of the pure magnesium sulfate, which Dr. Teal's wasn't far ahead of. This result rejected both the research hypothesis and the null hypothesis as the Epsoak had a higher solubility than the pure magnesium sulfate and because there was a difference in the measurements.

A Study of Various Electrodeposition Methods for Ag, Ni, Cu and Zn Without the Use of
Cyanides
Sydney Bell, TC Williams High School

Electroplating encompasses a wide range of techniques and is broadly defined as the process of coating an object with a metal in order to achieve desired characteristics. While large corporations have complex plating baths that use wide varieties of toxic chemicals, there is little information about electroplating that is accessible to students interested in chemistry. Some methods come from online forums such as YouTube videos and websites. This experiment aims to compare these common methods, such as anode to copper electrolyte solution and acetic acid experimentation, to simple electroplating with pure metal sulfate salts with hydrated compounds of copper, zinc, nickel, and silver. These compounds were plated onto iron electrodes and weighed before and after plating in order to determine the thickness of the plate. Plating thickness was used to evaluate the ease of plate as plating baths that are more temperamental produce a thinner plate. Metals that plated quickly with a simple bath composition are easier for students to plate with. Copper sulfate showed the largest plating thickness with an increase in mass of .691g, compared to the other metals which had thicknesses between averages of .392g, for silver, and .607g, for nickel. Zinc had an average mass increase of .542g. Next, these plated electrodes will be tested for the adhesion of the metal to the cathode to further identify which metal is easiest for students to plate with.

EARTH & ENVIRONMENTAL SCIENCE

Can Oyster Aquaculture Provide High Quality Habitat in the Chesapeake Bay?

Caela Gilsinan, Chesapeake Bay Governor's School

Eastern oysters, *Crassostrea virginica*, are an important food source that provides ecosystem services to the Chesapeake Bay by improving water quality and by providing a diverse habitat. Oyster aquaculture in floating cages throughout the Chesapeake Bay can replicate much of the same ecological processes as wild oysters in reefs. For example, the oysters will continue to live, grow, spawn, filter the water, contribute to the larval pool, and provide beneficial habitats. Oyster aquaculture cages provide a hard surface for many fouling organisms, which allows for more productive habitat and a higher species diversity. This study analyzes a local oyster aquaculture system to determine if it is providing habitat for other organisms in the Chesapeake Bay. This study seeks to determine the effect of oyster aquaculture as habitat in the Chesapeake Bay by observing the animals associated with floating oyster cages. Observations were made at two sites in the lower Chesapeake Bay estuary: Anderson's Neck Oyster Company in Morris Bay near the York River, and the lower Mattaponi River. Organisms were counted and recorded to analyze the abundance and the taxonomic diversity at the two sites. The evidence from the results demonstrate that oyster aquaculture provides ecosystem services in the Chesapeake Bay by providing organisms a favorable habitat. It is evident that oyster aquaculture provides an adequate habitat due to the concluding p-values not being significant. If more oyster aquaculture businesses were placed in the Chesapeake Bay, the ecosystem could become restored along with creating a diverse and high-quality habitat for the neighboring organisms.

The Effect of OTC Drug Type on *Daphnia magna*
Shreya Shanmugan, Mills E. Godwin high school

The purpose of this experiment was to determine the effects of OTC drug type on *Daphnia magna*. Over the past few years, there has been a significant increase in the amount of toxic waste, such as medication, in water systems. If the pollution levels continue to rise at the same rate, then it could potentially become detrimental to aquatic life. During experimentation, the *D. magna* were observed under a microscope with one drop of different solutions made of medication and aged water. The heart rate in each trial was measured for 20 seconds in bpm, and the control used was aged water since it did not have any medication in it. The formulated hypothesis was if *Daphnia magna* was exposed to OTC drugs, then acetaminophen would have the most impact. The results showed that esomeprazole had the most impact on the heart rate with an average of 169 bpm. T-tests were conducted, and the data was proven to be significant, apart from the t-test comparing acetaminophen and esomeprazole. According to the results, the research hypothesis was not supported since acetaminophen had an average heart rate of 173 bpm, however, the t-test proved that the data comparison for acetaminophen and esomeprazole was not significant. The results of the experiment most likely occurred, because the sizes of the *D. magna* slightly varied. Another reason could be that the results could have also depended on how well the medication dissolved in the aged water. This research could potentially extend to the research of the impacts of medication on other aquatic life.

The Effect of pH on the Root Mass of *Raphanus Raphanistrum sativus*
Rishav Sen, Mills E. Godwin High School

The Purpose of the experiment was to determine the effect of pH on the mass of the roots of *Raphanus Raphanistrum sativus*. The hypothesis stated that the plants given water with a pH of 5.6 would have a higher root mass. Acid rain used to be a problem in the US, but it is still a common occurrence in countries like China, which have high air pollution. There were three groups of plants which were watered with tap water. After 16 days, they were given water at a pH of 5.6, 4.95, and 4.3 for 5 days. The control was the group watered with water at a pH of 5.6 since that is the average pH of rain. The results showed that the average root mass of the radishes peaked with water at a pH of 4.95 (0.07g) and was lowest at a pH of 4.3 (0.04g). A t-test was performed, and it found that the data was significant. It is believed the root mass peaked with water at a pH of 4.95 due to the acid rain deposited more nutrients into the soil than it got rid of. This experiment could be done better if it was conducted in the spring and outdoors in a plant bed. It could also be done better if more than one liter of each acidic solution was made and the plants were watered with more than 5 mL of their acidic solution.

The Effect of Aquatic Plants on the pH of Water
Diana Trutia, Mills E. Godwin High School

Aquatic plants, or macrophytes, are present in both naturally and artificially occurring ecosystems, including ponds and aquariums. Regulating the pH of these environments is essential to ensure that life within them thrives. Testing the effects that aquatic grasses, many of which are common on Earth, hold on water pH can provide insight on if and how macrophytes may be a solution to changing or regulating pH. Aquatic grasses were planted underwater to observe their effects on pH level of water over the course of twenty days. Water without any aquatic grass present was used as a control group. Each group of study contained twenty-five trials. Every five days for four intervals, the pH of the water in each container was measured with a digital pH probe. The hypothesis stated that if the species *Eleocharis acicularis* is grown in water, then the pH of this water will be the highest after twenty days. This was supported by the research. Each experimental group, when compared with the control, had a statistically significant difference in water pH three out of four times. Although less frequent, experimental groups also showed significant differences between themselves. Overall, 12 out of 24 comparisons were found to be significant and the null hypothesis was rejected. After five days, the pH of all groups dropped, but later steadily increased between ten and twenty days. These results are likely due to the photosynthesis of the macrophytes: photosynthesis removes carbon dioxide from water, which may raise its pH.

The Effect of Eco-Friendly and Non-Eco-Friendly Car Soaps on the Height of Grass
Tessa Muldowney, Washington-Liberty High School

The purpose of this study was to determine the effect of eco-friendly and non-eco-friendly car soaps on the growth of grass. The independent variable was the type of car soap. The levels were 3D Pink Car Soap, Chemical Guys All Purpose Super Cleaner, Mothers 05674 California Gold Carnauba Wash & Wax, and Armor All Car Wash Concentrate. The grass seeds receiving no car soap were the control group. These grass seeds only received water. The dependent variable was the height of the grass seeds over a 16 day period. The constants included the type and amount of water, the amount of car soap, the frequency of watering, the type and number of grass seeds, and the type and amount of soil. The hypothesis was: If eco-friendly and non-eco-friendly car soaps are used to water grass seeds, then the grass seeds receiving 3D Pink Car Soap will have the smallest difference in height between the grass seeds receiving no soap, because 3D Pink Car Soap is pH balanced. To complete this experiment, four different soap solutions were made by combining and mixing both car soaps and water. Grass seeds were watered with various eco-friendly and non-eco-friendly car soaps over a 16 day span. A metric ruler was used to measure each grass seed cell (100 in total) in centimeters. The results suggested that none of the experimental groups, eco-friendly or non-eco-friendly, had any growth. In conclusion, the study suggests that both eco-friendly and non-eco-friendly soaps have a negative effect on the germination of grass seeds.

The Effect of Socioeconomic Status' of Arlington Zip Codes on Positive Lead Samples (400ppm)
in Public Elementary Schools
Amelia Sahm, Washington-Liberty High School

The purpose of this study was to determine how socioeconomic status relates to lead levels of school soil. The independent variable was the socioeconomic status of three zip codes in Arlington, where the schools are located. The socioeconomic status included percent of black residents, percent holding a bachelor's degree or higher, and median income. The control group was the zip code with the median socioeconomic status (22201). The dependent variable was whether the soil sample had 400 ppm of lead or more, measured using lead testing kits. The other controls were testing kits, soil amount, and data source for socioeconomic status. The hypothesis was: zip codes with higher socioeconomic statuses will have less lead in their soil. This study investigates whether children from poorer zip codes are more at risk of toxic exposure to lead on their school playground. The list of public elementary schools, their zip codes in Arlington, Virginia, and data on median income, percent black, and percent with bachelor's degree (BA) were compiled in an Excel spreadsheet where a regression test was done. In the experiment soil samples were taken with a soil probe from six schools in three zip codes. They were tested for lead levels of 400 or more ppm using a SenSafe lead test. One quarter of samples tested positive. However, the results showed that socioeconomic status of zip codes is not related to the positive lead levels (400 ppm) in Arlington elementary schools. The hypothesis was not supported by the results and the null hypothesis could not be rejected as the p-value was over 0.05. In conclusion a low socioeconomic status does not increase the amount of positive lead samples found in elementary school playgrounds. Even so, the experiment shows that high lead levels were common.

Utilization of Bacterial Nanocellulose as a Platform for Methylene Blue Detection and Adsorption

Adithya Iyer, Roanoke Valley Governor's School

The purpose of this research was to test a gold nanoparticle coated bacterial cellulose (BC) composite and a bentonite clay and polyvinyl alcohol embedded BC composite for, respectively, detection and adsorption of methylene blue (MB). If gold cellulose was used for surface enhanced Raman spectroscopy signal augmentation of MB, then it would increase SERS detection signals at high AuNP concentrations, high MB levels, and at moderate pH levels. If a bentonite clay-based cellulose composite was used for MB adsorption, it would effectively adsorb low concentrations of MB within an applicable time frame. Various AuNP concentrations on BC versus SERS signal augmentation was tested, and gold cellulose was tested for signal augmentation against different pH levels (4-11) and various MB concentrations (0 μ M-10 mM). The clay composite adsorption against various MB concentrations was tested, and MB adsorption for composite versus cotton was analyzed. Optimal signal augmentation occurred for higher AuNP concentrations, moderate pH levels (6-8), and MB concentration had no clear relationship with signal augmentation. Adsorption spectrophotometric results indicated decreased light absorbance for higher MB concentrations (4-8 mM), and increased light absorbance for lower MB concentrations (0-2 mM) over time, perhaps due to clay particle introduction into solution. The bentonite composite did not adsorb MB as effectively as cotton, but MB particles attached to clay in solution, increasing solution transparency. BC can be used for MB detection and adsorption,, provided that it is placed in moderate pH conditions, contains high AuNP concentrations, and is exposed to high MB concentrations.

The Effects of Location on Air Pollution
Mya Pickens, Portsmouth STEM @ I.C. Norcom High School

The purpose of this experiment was to determine the different levels of ozone and particulate matter in different areas around the city of Portsmouth. The experiment was conducted using the hypothesis that if the ozone level is high in an area then there will be more air pollution. In the experiment cards were created and filtered with gel to be able to see the ozone on the cards. Another set of cards were created with petroleum jelly rubbed across them to catch different particulate matter. Results were interpreted by comparing the color of the gel on the filtered paper to the Schonbein scale for ozone. The results showed how the ground level ozone in the area is not hazardous but unhealthy for sensitive groups.

Phytoremediation of Lead (II) Nitrate by Mosses Collected from Roanoke, Virginia
Emma Kate Greer & Fiona Murphy, Roanoke Valley Governor's School

The purpose of this experiment was to determine if local moss found by bioprospecting can phytoremediate lead (II) nitrate. A 250 ppm solution of lead (II) nitrate was made using distilled water and hydroponic nutrients. Thirty mL of this solution was added to twenty different 50 mL beakers, ten of them containing moss and the other ten not. Thirty mL of this solution, used as a control, contained only the water and hydroponic nutrient. These three groups were set aside under light for two to two and a half weeks. After this time period, all groups were tested color metrically for lead using lead test strips. The positive control contained around 100 mg/L Pb²⁺, while the negative control and the experimental group contained close to 0 mg/L Pb²⁺. An acid digestion was performed on the moss. After centrifugation and filtration, the supernatant was tested using Flame Atomic Absorption Spectrophotometry. The results showed that the moss grown in the lead solution absorbed an average of 155.464 ppm of lead. The overall conclusion of the experiment is the moss absorbed the lead from the lead solution.

Using Bioprinted Algae Structures to Determine Which Algae Species is Most Effective at Removing Nitrates

Kendall Kelly, Haley Day & Dhruvi Patel, Roanoke Valley Governor's School

The purpose of this experiment was to determine which species of algae, *Chlorella*, *Selenastrum*, or *Ankistrodesmus*, was most effective at removing nitrates from contaminated water. The results of this experiment suggest that the algae beads show potential as a method to reduce nitrate levels in contaminated water, with some limitations. It was hypothesized that *Chlorella* would demonstrate the greatest decrease of nitrate levels. Tinkercad was used to design a square structure. The Cellink bioprinter was used to print the structures consisting of sodium alginate and each species of algae, with the control being just sodium alginate. A calcium chloride solution was pipetted onto each structure to form a bead. They were placed in test tubes containing 20.0 mL of a 10ppm nitrate solution, made from potassium nitrate. For the duration of eight days, an initial and final nitrate level were collected using a Vernier nitrate ion probe to demonstrate the change in nitrate levels. Using a paired t-test, all algal species demonstrated a statistically significant p-value, demonstrating lower nitrate readings after eight days. A future study includes exploring the decrease in nitrate levels from the control group, possibly due to the composition of sodium alginate. A one-way ANOVA demonstrated a significant difference between the control and *Chlorella*, supporting our hypothesis stating that *Chlorella* would be the most effective algal species at reducing nitrate levels. The one-way ANOVA also demonstrated there was no significant difference between the control and *Ankistrodesmus*, therefore it was the least effective at removing nitrates.

A Comparison of *Muscari neglectum* Starch to Corn and Rice Starches in Starch-Based Bioplastics

Michelle Zheng & Catherine Chen, Roanoke Valley Governor's School

Plastic pollution is harming the Earth, and bioplastics have been created to possibly reduce the amount of petroleum plastic. The purpose of the experiment was to find an environment-friendly alternative to plastic bags using an invasive weed. It was hypothesized that *Muscari neglectum* would show similar properties to corn and rice starch-based bioplastics. The rice and *M. neglectum* starches were manually extracted. The corn, rice, and *M. neglectum* starches were individually mixed with citric acid, gelatin, glycerol, and distilled water, then simmered and poured onto a plexiglass sheet to dry. The dried plastics were measured with a caliper, and tensile strength and water solubility tests were used to measure the plastic properties. Two One-Way ANOVA tests were conducted for the tensile strength and stretch length of each plastic, which resulted in p-values less than the alpha value of 0.05. A Tukey Post Hoc Analysis conducted for the tensile strength resulted in a significance between all plastics, indicating unequal tensile strengths. A Tukey Post Hoc Analysis conducted for the stretch lengths resulted in a significant difference between corn and *M. neglectum* and rice and *M. neglectum*, but not between corn and rice. Although *M. neglectum* did not show similar properties to the corn and rice starch-based bioplastics, the *M. neglectum* starch plastic was stronger but less flexible than the corn and rice starch plastics and was more water soluble than the corn starch plastic. This shows that *M. neglectum* is sufficient for replacing plastic containers.

Is Tornado Alley Moving?
Trinity Webb, Ocean Lakes High School

In recent years, scientists have begun to notice a change in tornadic activity in the United States. In fact, studies conducted by The Weather Channel posit that Tornado Alley may be moving entirely. If true, then resources such as severe weather warning systems and tornadic activity maps in the United States will have to be updated. This research aims to test that theory. Data from the National Oceanic and Atmospheric Administration (NOAA) regarding recorded tornadoes from 1950-2018 was accessed for this analysis. Using the published data, for every five-year period up until 2014, 50 tornadoes were randomly selected using the random integer function on a TI-84 Plus calculator. For every tornado, data has been recorded for the date, time, latitude, and longitude. From there, the data for every tornado was inserted into 13 separate ArcGIS maps - one for every five-year period. Using these maps and comparing them side by side, the supposed shifting of Tornado Alley could be proven. This means that more of the eastern half of the United States need to start preparing and becoming familiar with the signs and risks of tornadic activity. Precautions such as a tornado siren should be implemented in addition to more publicly broadcasting when there is a tornado warning in more areas in the near future, and the general public needs to be informed of this occurrence so that they might prepare as well. Further studies are to be conducted in the future alongside expert meteorologists during college.

The Effect of Quicklime Concentration on the Swelling Potential of Expansive Soils
Caroline Klotz, Clover Hill High School

The purpose of this experiment was to determine which concentration of quicklime would yield the greatest reduction in swelling potential of soil types: MH, an elastic silt of high plasticity, CL, a silty clay of medium plasticity, and CH, a sandy clay of medium plasticity. In-situ expansive soils are extremely hazardous to buildings and other structures, and frequently cause cracks or collapses, due to excess movement in the foundation. Through soil modification by lime treatment, the swelling potential of expansive soils can be reduced; thus, it ensures a safe and stable soil foundation for construction sites. The hypothesis was: If MH, CL, and CH clays were treated with 0%, 2%, and 4% concentrations of quicklime, the clays mixed with the 4% lime would yield the greatest reduction in swelling potential of the expansive clays. The lime concentrations: 0%, 2%, and 4%, were added to soil types: MH, CL, and CH. After the lime treatment was given 24 hours to set, the Swelling Potential Test was conducted. The Swelling Potential Test consisted of: placing a controlled amount of soil into 10 graduated cylinders, adding water, and leaving the soil to absorb the water overnight. The swelling potential was measured by calculating the percent increase from the original soil volume to the volume after the water addition. The mean swelling potential for the MH 0% lime was 18.8 (percent change in volume), 12.6 for 2%, and 11.2 for the 4%. The mean for the CL 0% lime was 17.1 (percent change in volume), 12.6 for 2%, and 6.6 for 4%. The mean for the CH 0% lime was 14.3 (percent change in volume), 13.7 for 2%, and 11.2 for 4%. As the lime concentration increased, the swelling potential for the MH and CL soil types decreased significantly. Although the CH 2% and 4% lime groups yielded an insignificant reduction in swelling potential. The soils with 4% lime concentration yielded the greatest reduction in swelling potential.

The Effects of a Paper Plant on the Water Quality of a River
William Lankford, Central Virginia Governor's School

The purpose of this study was to determine whether a paper plant had a significant effect on the water quality of a river. This was done by collecting 20 water samples upstream and downstream from a paper plant. Nitrates, dissolved oxygen, conductivity, temperature, and turbidity were then compared between the two locations using a paired two sample T-test. Five groups of macroinvertebrates were also collected at the two locations and were compared using a chi squared test for independence. After using an alpha value of .05 for all tests, the only tests that returned a p value below .05 were nitrates (.007) and dissolved oxygen (9×10^{-6}). The means for the upstream and downstream nitrate values were 9.56 and 10.37 mg/L respectively, while the means for dissolved oxygen were 10.93 and 10.71 mg/L respectively. The research hypothesis, "if water quality is measured both upstream and downstream from a paper plant, then pH, temperature, conductivity, and turbidity will increase nitrates will not change, and dissolved oxygen content and pollution tolerance of macroinvertebrates will decrease from upstream to downstream of the paper plant" was not supported. The part of the research hypothesis that was supported was dissolved oxygen which decreased from upstream to downstream of the paper plant. This experiment determined that the paper plant did not affect any of the water quality indicators except dissolved oxygen and nitrates, therefore industry has minimal effect on the health of aquatic ecosystems.

The Effect of Lead Acetate on the Germination of *H. annuus*
Thomas Lipscomb, Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine the germination behavior of *H. annuus* in lead-contaminated soil. This study was conducted at a local high school laboratory in December 2019. Approximately 300 seeds were cold-shocked and sterilized in a hypochlorite solution. They were then plated with aseptic technique into the respective concentration groups of cell culture medium: 0 mg/L, 50 mg/L, 100 mg/L, and 200 mg/L. After germinating for nine days, I measured radicle growth (mm), and the data was analyzed with a one-way test. I found no statistical difference between groups ($p=.063$) at alpha of .05. Therefore, the research hypothesis that "If *H. annuus* seeds were germinated in lead-contaminated environments, then the two higher levels would fail to germinate" was not supported. In summation, lead acetate had no effect on the germination of *Helianthus annuus*. Therefore, according to this study, *Helianthus annuus* may not be a viable option for phytoremediation.

Assessing Oyster Reef Restoration and its Effect on Nearby Oyster Spat Recruitment
Kristen Frank, Chesapeake Bay Governor's School

The Virginia oyster, *Crassostrea virginica*, is the keystone species of the Chesapeake Bay. The oyster population has declined due to overfishing, habitat loss, water quality problems, and disease. These factors have resulted in the oyster population being less than 1% of what it was in the historical past. The Army Corps of Engineers has installed 25 acres of restoration reef in the lower Piankatank River at a cost of \$2 million. With previous reefs constructed in 2014, 2015, and 2017, this effort has resulted in a total of 50 acres of restored oyster reef in the Piankatank River. Smaller scale community supported restoration reefs have also been built in the Piankatank at Cherry Point on Gwynn's Island, in Urbanna Creek and in Jamison Cove in Urbanna, Virginia have been in place for about 5 years. Additionally, the Virginia Institute of Marine Science (VIMS) has been monitoring the oyster spatfall levels for many decades. Four sites were studied to determine the changes in the oyster population and patterns recruitment of spat, as well as metadata from the VIMS was analyzed to understand reproduction through the years for this experiment. In the field study, there was a mean of 37 oyster spat near the reefs and zero oyster spat away from the reefs. However, when determining if the oyster reefs were providing spat near and away from the reef a t-test $p=0.312$ concluded the sites were not significantly different. To determine whether oyster restoration was producing more spatfall over time, the total spatfall from 1998 to 2018 was analyzed. From 1998 until late 2010 there was consistently low oyster spat supply. After 2010, the oyster spatfall average was much higher. Overall the spatfall totals dating back to 1998 showed a clear increase in spat supply at the same time as the multiple reef restoration projects.

The Effect of Nanosilver on the Death Rate of *Lymnaea stagnalis*
Sophie Shearman, Clover Hill High School

Nanosilver is a substance, popularized by commercial industries, and utilized in goods such as cosmetics and cleaning products. An ever-greater quantity of silver nanoparticles is finding its way into wastewater and eventually rivers and streams, where little is known about the possible adverse effects of silver nanoparticles on aquatic ecosystems. The purpose of this experiment was to determine the effect of nanosilver concentration on the death rate of the pond snail, *Lymnaea stagnalis*. The independent variable of the experiment was the concentration of the colloid nanosilver solution in micrograms per liter ($\mu\text{g/L}$), and the levels were 0 $\mu\text{g/L}$ (control), 5 $\mu\text{g/L}$, 10 $\mu\text{g/L}$, and 25 $\mu\text{g/L}$. The different concentrations of nanosilver solutions were assembled using a colloid silver mineral supplement of 500 parts per million (ppm) and bottled pond water. Using tweezers, one live pond snail was placed directly into each solution for each level per trial. After each trial, the snails were assessed for the following signs of life: movement, respiration, and function. The dependent variable was the death rate of the *Lymnaea stagnalis*, measured as a percentage. The research hypothesis of this experiment stated that if the concentration of nanosilver were increased, then the number of living *Lymnaea stagnalis* would decrease. The control, 0 $\mu\text{g/L}$ concentration, had the lowest death rate while the concentration of 25 $\mu\text{g/L}$ displayed the highest death rate. The data did not support the null hypothesis, which stated that the concentration of nanosilver would not affect the number of living *Lymnaea stagnalis*.

The Effect of Plant Xylem on Water Quality
Eden Allen, Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine whether plant xylem filtration had an effect on the presence of *E. coli* in water samples. This connects to the real-world application of finding a solution for the global issue of water scarcity. Water samples, collected from a local river, were run through a gravitational plant-xylem water filter over the course of 48 hours. Three species of plants were used for filtration - *Picea glauca*, *Pseudotsuga menziesii*, and *Pinus sylvestris*. At the end of each trial, the water that had passed through the filter was tested for the presence of *E. coli* using a coliform indicator test kit. The results from the filtered water samples were compared to the control group, which were water samples that had been taken straight from the river with no form of filtration. After collecting the results, a Chi-Square Goodness of Fit test was run on the data. This produced a statistical value of .2. With an alpha value of .05 and 2 degrees of freedom, the critical value was 5.99. The statistic value was much less extreme than the critical value, which led to the retention of the null hypothesis. Because the null hypothesis was retained, the research hypothesis could not be supported. In summation, plant xylem used as a point-of-use filter had no significance on the presence of *E. coli* in water samples.

The Effect of the Active Ingredient in Sunscreen on the Heart Rate of *Daphnia*
Andrea Goodell, Washington-Liberty High School

Coral reefs are the most diverse marine ecosystem on the planet and their biggest threat is coral bleaching. Recent studies have shown that a large factor of coral bleaching is sunscreen. The chemicals are washed off swimmers and affect all different types of marine life. The chemicals have been shown to accumulate in animals' tissues for years, even being passed to their offspring. Sunscreen impacts algae's ability to photosynthesize, the immune and reproductive systems in sea urchins, and cause a defect in mussels causing softer and malformed shells. This project tested the effect of different active ingredients (oxybenzone, octinoxate, and zinc oxide) in sunscreen on the heart rates of daphnia, a single celled organism with a heart rate that can be seen through a microscope. I hypothesized that exposure to the sunscreen active ingredient oxybenzone, would cause the greatest decrease in daphnia heart rates. The null hypothesis was that there would be no significant difference between the heart rates of daphnia exposed to different active ingredients. The hypothesis was partially supported by the results. Daphnia exposed to octinoxate had the lowest heart rate with an average of 51.067 followed by daphnia exposed to oxybenzone with a heart rate of 58.200. However, a T-Test showed there was no significant difference between the two chemicals. Daphnia exposed to zinc oxide had an average heart rate of 68.600 and daphnia in spring water, the control, had the highest heart rate with an average of 78.867. The T-test showed no significant difference between the heart rates of daphnia exposed to the control and zinc oxide. The ANOVA test showed a significant difference among all the ingredients; therefore, the null hypothesis was rejected.

The Effect of a Slope's Topography on the Magnitude of a Landslide
Anna Bolejack, Washington-Liberty

This experiment was to help others know of the risk of landslides and what conditions are most likely to cause a landslide. The purpose of the experiment was to determine if the magnitude of a landslide would change based on the topography of the slope. The hypothesis stated that if the slope was cut at a ninety degree angle or if more clay was added, it would create a bigger landslide. For the first experimental group, a hill was created with clay making up the bottom 2/3 of the height and topsoil making up the final third. This slope was at its natural repose angle. The second experimental group had a hill of clay making up the bottom 2/3 of the height and topsoil making up the final third. It was at its natural repose angle and also had a cut of ninety degrees halfway up the slope. For the third experimental group, a hill was created with the clay making up the bottom 1/3 of the height and topsoil making up the final 2/3. It was also at its natural repose angle with a ninety degree cut halfway up the slope. Water was sprinkled on each slope at a rate of eight mm per hour. The results showed that more dirt slid off the slope and therefore created a bigger landslide when the slope was cut. The results also showed that decreasing the amount of clay makes less of a landslide. It also indicated that water can strengthen the overall structure of the hill made of dirt by bridging the gaps in between the dirt particles. In the first experimental group there was no landslide, but signs of possible movement were shown. Cracks along the side and peeling at the very top showed how the dirt was kept from sliding by the water. In the end, changing different aspects of the slope's topography changed the magnitude of the landslide.

The Effect of Paper Waste on the Growth of *Schedonorus arundinaceus*, *Lolium perenne*, and *Cynodon dactylon*.

Laura Hernandez, Central Virginia Governor's School for Science and Technology

The purpose of this research was to determine if paper waste had an effect on the growth of grass seeds such as *Schedonorus arundinaceus*, *Lolium perenne*, and *Cynodon dactylon*. The researcher conducted this study in a local high school lab over the course of two months. To grow the seed with paper waste, sheets of paper were made through the hydrogen bonding of kraft pulp. For each seed type, there was an experimental group and a control group; there were four samples for each seed type. The main experimental group contained paper waste, while the control group had the same conditions, but no paper waste. The number of grass sprouts was collected from each sample and run through a two-factorial ANOVA to determine any significant effects, interactions or differences. The ANOVA, with an alpha level set at .05, had an interaction p-value of .147. While the interaction effect was not statistically significant, the seed factor (p-value of .000) suggested a significant difference between the effects of the seeds on growth. The statistical analysis did not support the research hypothesis: "If *Schedonorus arundinaceus*, *Lolium perenne*, and *Cynodon dactylon* are grown in a harsh environment, then *Lolium perenne* seeds introduced into paper waste will have the highest percentage of seeds sprouted," but the data did suggest that paper waste aids plant growth. In conclusion, according to the data, paper waste had a significant effect on the growth of *Schedonorus arundinaceus*, *Lolium perenne*, and *Cynodon dactylon*.

An Arsenic Filtration Mechanism Using a 3D Bioprinted Cysteine and Silicon Carbide Model
Madison Brown, The Roanoke Valley Governor's School for Science and Technology

Arsenic has been linked to an increased risk of cancer and diseases. These complications are rooted in the issue of arsenic contamination within water. Researchers have considered that arsenicals have a high affinity for cysteine; this has led to research using cysteine (NAC) to bond with arsenic waste within water as a method for removal. A silicon carbide mechanism is also applicable; additional researchers used a silicon carbide filter to remove arsenic contamination from water and concluded that silicon carbide has a considerable filtration efficiency for arsenic. Silicon carbide also had the possibility to increase the print fidelity of sodium alginate-based hydrogel for bioprinting. The purpose of this experiment combined the unique characteristics of cysteine and silicon carbide in order to 3D bioprint a filtration mechanism for arsenic. It was hypothesized that a SiC + NAC+ sodium alginate filter will decrease arsenic concentrations to a level of 15ppb. Cysteine and silicon carbide were added to sodium alginate and bioprinted into a rectangular grid. Filters were soaked and stirred in 25ppb sodium arsenite. The filtered water was analyzed using flame atomic adsorption spectroscopy. A one-way ANOVA showed a p-value of 0.032. A follow-up Tukey HSD Test was conducted to determine that there is a statistical difference between the groups SiC + NAC + sodium alginate and NAC + sodium alginate. However, both additives, NAC and SiC, were not effective in removing arsenic contamination from water.

Microplastic Concentration in Indoor and Outdoor Dust
Benjamin Bankston, Central Virginia Governor's School

The purpose of this study was to determine whether or not there were significantly more microplastics, microscopic pieces of plastic, inside than outside a local high school. The data for this study was collected in November of 2019. Samples of dust were collected in eight different locations both indoors and outdoors over three days for a total of 24 samples. The dust was then density separated for two weeks and 0.5 mL was pipetted out and observed through a dissecting microscope. The resulting mean number of microplastics per sample outdoors was .917 and indoors was 7.583. A two sample t-test assuming equal variances comparing the indoor and outdoor numbers of microplastics yielded a p-value of .02 against an alpha value of .05. This statistical significance supported the research hypothesis that if dust is collected from both indoor and outdoor areas, then there will be a larger number of microplastics collected per sample inside than outside. Select samples were also viewed in a FEI Quanta 600 FEG Scanning Electron Microscope (SEM) at a university research institution where pieces of unsaturated aliphatic hydrocarbons and other mixtures were identified. In conclusion, location where dust is collected does have an effect on the number of microplastics per sample. Microplastics are potentially dangerous particles that, based on this study, are very frequent in places that humans spend time in.

Testing the Ability of Barbieri to Bioremediate Dissolved Lead and Copper
Melany Fuentes, Southwest Virginia Governor's School

Increased awareness of the adverse effects heavy metals pose on individuals and the environment warrants the need for methods to remove heavy metals from water sources, particularly after the uproar against the water contamination in Flint, Michigan. Furthermore, water contamination has led to various cases of heavy metal poisoning, particularly in regions of Asia where traditional herbal medicine is used without research into contaminants. Methods of removing heavy metals from water sources include the use of plants to facilitate bioremediation efforts without the high access cost of more technologically advanced means. Research focused on Barbieri, commonly known as java moss, and its ability to absorb dissolved lead and copper from water for future application in bioremediation efforts. Three groups were used for testing: a control group, a lead group, and a copper group. Each group consisted of 12 samples with Barbieri added to absorb dissolved metals in the respective solutions. After one week, the plants were removed from the samples in order for testing to be conducted on the final concentration of solution. The copper groups had an average of 24.86 ppm in each testing group and the lead had an average of 3108 ppm per testing group. Results were analyzed using two separate one variable t-tests, one test based on lead results and the other on copper results. Ultimately, the copper group resulted in a p-value of 0.8230 which suggested insignificant findings. The lead group yielded a p-value of <0.0001 which suggests significant findings. This study suggests that Barbieri demonstrates potential to bioremediate dissolved lead from its environment but not dissolved copper.

Determining the Toxicological Effects of Polyurethane Foam and Complex Leachate on *Artemia nauplii*
Virginia Worrell, Southwest Virginia Governor's School

Plastics are of increasing concern in the marine environment. When released into the environment, plastics break down into microplastics (<5mm) and release additives that have given the plastic properties such as flexibility, color, and flame retardancy. A specific microplastic of interest is polyurethane foam (PUF), used in mattresses, gymnasium foam, etc., because it contains a high concentration of additives. These additives, despite being previously examined, have never been examined as a mixture, as they would appear in the environment. For this project, triphenyl phosphate (TPP), tris (1,3- dichloro -2- propyl) phosphate (TDCPP), compound mixture DE-71 (contains various polybrominated diphenyl ethers), PUF leachate, and a mock leachate (containing a mixture of individual additives) were evaluated at different concentrations for toxicity to the model assay organism, *Artemia* sp. It was hypothesized that toxicity of additives would be amplified when combined with others, with the mock leachate and PUF leachate being the most toxic of the exposures. At the conclusion of 96-hour acute bioassays, PUF leachate and DE-71 were not toxic to *Artemia* at concentrations tested (less than half of the population died and there were no significant differences between average mortality in treatments and controls). However, significant mortalities were recorded in the mock leachate, TPP, and TDCPP (ANOVA p-value of <0.0001). Statistical testing determined a significant difference between the controls, high (nonzero confidence interval(CI):[72.47,117.53]) and medium (CI:[49.21,94.27]) concentrations of mock leachate, and between the controls and the high concentrations of TPP (CI:[29.14,74.20]) and TDCPP (CI:[48.31,93.36]). LC50 for each of these treatments were calculated to be at environmentally significant concentrations below their water solubility (<2 ppm for TPP and <7 ppm for TDCPP). This shows the magnified toxicity of chemicals as a mixture, which should continue to be researched in the future. Another topic of interest for future work would be the long-term effects of these additives and the mixture of additives, as they are very slow to degrade and can persist for long spans of time.

The Effect of the Concentration of Nitrogen in Fertilizer on the Average Length of Leaves and
Number of Leaves per Plant

Lily Odenwelder, Washington-Liberty High School

Nutrient pollution is a longstanding environmental issue that threatens water bodies around the world because nutrient pollution decreases the amount of dissolved oxygen in the water, killing or displacing the wildlife and harming local economies. The purpose of this experiment was to find an effective suburban fertilizer with a lower nitrogen concentration because nitrogen is a prevalent nutrient pollutant. The project tested fertilizers with a high nitrogen concentration (30%), a medium concentration (12%), a low concentration (2%), and a no nitrogen concentration, in order to assess the effectiveness of varying nitrogen content levels when growing radishes. The hypothesis that radishes treated with the highest nitrogen concentration fertilizer would grow the longest leaves and the most leaves was not supported by the data. Specifically, plants treated with the 30% nitrogen solution grew the second smallest leaves, averaging 9.20 mm long, and the second smallest amounts of leaves, averaging 1.64 per plant. Plants treated with the 2% nitrogen fertilizer grew the most leaves, averaging 2.48 per plant, and the 12% nitrogen fertilizer's plants grew the largest leaves, averaging 13.04 mm long. The no nitrogen fertilizer grew the fewest number of leaves, with an average of 1.56 per plant, and the smallest leaves averaging 7.48 mm long. An ANOVA test was run for leaf length and leaf number and the data for both variables was found to be statistically significant. Therefore, the two fertilizers with low (2%) and medium (12%) nitrogen concentrations were determined to be effective and practical fertilizers for suburban use and would pollute less nitrogen into the environment.

The Effects of Storm Intensity on the Filtration of Microplastics from Sediment
Grace Shen, Blacksburg High School

80% of plastic debris found in marine environments come from land-based sources. Microplastics constitute a majority of those plastic debris. Current research on microplastics focuses on their presence and effect in marine environments. However, many of the microplastics present in marine environments are transported there from freshwater streams and urban systems. One process by which microplastics are transported from urban systems to the marine environment is the release of microplastics by sediment after a storm. The goal of this project is to study the release of microfibers from sediment after different strengths of storm scenarios. Microfibers are the leading type of microplastic and make up more than 85% of microplastics worldwide. Three different storm scenarios - small, medium, and large - were created by using a drill press and paint stirrer, and the amount of microfibers released in each storm scenario in relation to the size of the storm were measured and compared. Results showed a positive trend between storm size and the amount of released microfibers. As storm size increased, the amount of microfibers also increased exponentially. Results also showed a positive trend between storm size and size and amount of natural debris being filtered alongside the microfibers.

Effect of Aeration on Temperature of Compost
Lillian Moo, Washington-Liberty High School

The purpose of this experiment was to explore the effect of aeration on the temperature(°C) of compost. To investigate this, four buckets of compost were aerated (or mixed) at different intervals of time – Bucket 1 was mixed every day, while Bucket 3 was mixed every six days, etc. The temperature of each bucket was measured at the same time every three days to measure the effect of aeration on the temperature of the compost. The hypothesis was that if four compost bins are aerated at different frequencies with all other factors held constant, then the compost bin that is aerated the most will be the coolest while the one aerated the least will get warmest. This was because without aeration, oxygen would not circulate through the compost, increasing the temperature. While oxygen, when first introduced to compost, can increase temperature by causing the microorganisms to increase their activity, it also dispels excess heat – therefore, without any airflow, compost temperatures can rise exceptionally high. However, each bucket actually had an average temperature of approximately 18°C, which demonstrated very little difference between the different aeration cycles' effects. This was further explored with an ANOVA test, which confirmed with 95% certainty that the independent variable, or frequency of aeration, had no significant effect on the dependent variable, or the temperature of the compost. Research has shown that aeration should have an effect on temperature; however, within this experiment, it is possible that the different intervals of time between aeration were too similar. In order to see a significant effect, intervals as large as one week or two weeks between aerations may be necessary. Additionally, moisture content, materials, and outside climate may have caused the results to be less accurate.

The Effect of Growth Stimulants on Duckweed Growth
Elisabeth Coderre, Washington-Liberty High School

The purpose of the experiment was to determine if growth stimulants had a significant effect on the growth of duckweed. The hypothesis stated that if compost tea was added to the duckweed's environment, then more dissolved oxygen would be found, since compost tea has the benefits of both plant food and fertilizer. The research hypothesis was not supported by the data. The plant food averaged the most dissolved oxygen with 9.37 mg/L and the compost tea measured 9.06 mg/L of dissolved oxygen, which was still higher than the control group, which had 8.96 mg/L. The lowest amount of measured dissolved oxygen was in fertilizer group, at 1.01 mg/L. An ANOVA test was done to be sure the data was statistically significant, and the p-value was 1.69234×10^{-8} , which is less than the critical value of 0.05. This indicates that the data is overall statistically significant. Several t-tests were done as well, and all came back with p-values under the critical value of 0.05, which shows the data is significant. This rejects the null hypothesis: if a growth stimulant, such as compost tea, plant food, or fertilizer, is added to the duckweed then the same amount of dissolved oxygen will be found in all treatment groups and the control. The data showed a trend where growth stimulants with more nutrients had the effect of producing more dissolved oxygen from their plants. It is helpful in that we can see what happens when runoff is present, and if the runoff has positive or negative effects. Further experimentation including more trials to test if outliers are truly outliers or merely regular readings in a smaller group. The study is significant because it shows the effects of runoff on a globally grown plant, meaning the results are applicable to everyone.

Level of Contaminants in Arlington Public Schools' Water.
Henry Cummins, Washington-Liberty High School

The problem posed for this experiment is whether school drinking water is safe to drink compared with natural bodies of water. The dependent variable is the parts per million of contaminants in the water. The independent variable is the age of the piping systems of the schools. It was hypothesized that the school water would measure less naturally occurring minerals and less nitrates due to fertilization. Moreover, the school water would contain greater measurements of lead, fluoride, pH, hardness, alkalinity and residual chlorine than the measurements for the natural bodies of water due to fluoride's addition into our water systems and lead picked up through piping systems. The key finding is that fluoride levels are lower in schools than natural bodies of water. In conclusion, school-distributed drinking water does not have sufficient fluoride levels in it to properly prevent children from getting cavities, however, it has safe amounts of other harmful substances such as lead, chlorine and nitrites.

The Effect of Type of Biodegradable Plastic on Amount of Biodegradation in a Given Amount of Time

Kara Felker, Washington-Liberty High School

The purpose of this study was to determine the type of biodegradable plastic that degrades the fastest. The independent variable was the type of plastic the straws were made of (PP, rice-starch based plastic, PLA). The control group was non-biodegradable plastic straws. The constants were time for biodegradation (50 days), and conditions for biodegradation (type of soil, type of bucket, depth of bury). The dependent variable was the percent of mass loss that occurred over a 50-day period. The hypothesis stated that if different types of bio-based plastics are tested for an amount of degradation during a 50-day period, then rice-starch based plastics will degrade the most. Twenty straws of each kind were split into ten groups of two. Then the mass of each group was found, and they were then buried in soil and left to degrade for 50 days. After 50 days, the straws were dug up and a new mass was found from which the percent of mass loss was calculated. The data showed that rice-starch straws biodegrade the fastest. This supported the hypothesis. In conclusion, rice-starch plastics pose a promising solution to the plastic pollution problem. Future investment into the advancement of rice-starch plastics technology will help to keep the earth clean for generations.

Observations on Tidal Currents and Circulation in Urbanna Creek
Sierra Funk, Chesapeake Bay Governor's School

Along the Chesapeake Bay, 472 sewage treatment plants pump billions of gallons of wastewater into the Bay each day. A small wastewater treatment plant managed by Hampton Roads Sanitation District (HRSD) serves the town of Urbanna on the lower Rappahannock River in the Middle Peninsula region of Virginia. A study conducted by the Virginia Department of Environmental Quality (DEQ) estimated that the average flow of Urbanna Creek was 14.8 cfs (reported in cfs by DEQ), or $0.41\text{m}^3/\text{s}$. This number was never directly measured, but rather derived using stream flow measurements from the Great Wicomico River in Northumberland County measured by the U.S. Geological Survey (USGS). It is possible that this theoretical number is erroneous as no testing of the Urbanna Creek was ever conducted. The purpose of this study was to determine the actual flow rate of Urbanna Creek and the possible flaws of the DEQ's flow assumptions. Three transects of Urbanna Creek currents were measured by placing drogues in the water and measuring the distance traveled over time. ANOVA and t-tests were used to determine the statistical relevance of the data. Results show that Urbanna Creek's flow rate was significantly lower than the DEQ estimate, $0.16\text{ m}^3/\text{s}$, and very sluggish flow. This number completely changes how we should look at the creek. The Urbanna Wastewater Treatment Plant has been discharging 143% over the nitrogen and 620% over the phosphorus limit. Those limits were set using the DEQ's theoretical flow number from the Great Wicomico. This suggests that the limits on the amount of nutrient and sewage discharge should be lowered in order to accommodate the much lower flow of Urbanna Creek. If this does not occur, widespread eutrophication will develop.

Strength and Degradability of Starch Derived Polymers
Lillian Castro, Central Virginia Governor's School for Science and Technology

The purpose of this study was to explore the potential benefits of starch derived polymers in the production of bioplastics, specifically banana peels and tapioca starch. These starch derivatives, when compared to traditional plastic bags, supported the hypothesis that, if biodegradables derived from bananas and one composed of tapioca starch are tested for strength and biodegradability, then the one composed of tapioca starch will be the strongest and the one derived from bananas will biodegrade the most. Banana peels and tapioca starch were prepared into paste-like consistency and spread into pans. After baking the banana samples and drying the tapioca ones, 8 samples were cut off each bioplastic for testing both tensile strength and biodegradability. The samples were cut into 2 x 4 inch samples and were tested for degradability in soil and tensile strength. The means for degradability testing were 125.122, 40.915, and 37.461 grams. The means for tensile testing were 4.2749, 2.5384, and .0006 newtons (banana, tapioca, and plastic). Two separate single-factor ANOVA tests (alpha .05) revealed significance for both, degradability (p-value 1.78×10^{-12}) and tensile strength (p-value 2.39×10^{-11}). Post-hoc Tukey tests concluded significant differences between all degradability groups and all between the tapioca tensile groups. This research shows that banana and tapioca plastic are viable options for replacing traditional plastics in some settings, based upon their durability and degradability testing. Which in term could reduce the amount of plastic pollution in the world and allow for lower greenhouse gas emissions.

The Effect of Different Types of Filtration on the TDS of Water
Ellie Potts, Washington Liberty High School

This experiment observed the effect of different types of filtration on the TDS of freshwater. The hypothesis was; If the LifeStraw was used to filter water, then the TDS after filtration would be lower. TDS indicates the amounts of solids dissolved in water, this means bacteria, sediment, chemicals and other unwanted particles. For the experimentation itself, the LifeStraw, Iodine tablets and a homemade charcoal filter were tested for TDS against the control which was the unfiltered freshwater from 4 Mile Run. The water was filtered through each filter and a TDS meter was used to find PPM (parts per million). The results conveyed that the homemade filter worked the most efficient when filtering out contaminants, coming up with results containing the lowest TDS point with an average at 193.9 followed by the LifeStraw at 207 then the control being the freshwater at 300, and the iodine tablets having the highest TDS average at 352.9. Multiple T-tests were run to compare each independent variable and determine their statistical significance. Almost all of the T-tests ran, reported statistical significance or numbers lower than the standard 0.05 between independent variables with the exception of no filtration and Iodine. The hypothesis was proven incorrect by the outcome of the data. However, the research still proved that there are cheap and easy methods of filtration that result in the purifying of water.

The Effect of Rising Sea Surface Temperatures on the Intensity of Hurricanes in the Gulf of Mexico from 1996-2018

Caroline Krajicek, Washington-Liberty High School

Global warming is becoming more of a significant issue in our world and has many negative effects on the environment. For example, global warming increases the amount of heat in the atmosphere and surface temperature of the ocean, which may have a significant effect on hurricanes. The purpose of this experiment was to discover if rising sea temperatures affected the intensity of hurricanes in the Gulf of Mexico from 1996-2018. Data regarding surface temperatures, wind speed, atmosphere pressure, and date from the National Data Buoy Center was collected and analyzed based on year. Based on the data collected the null hypothesis (rising sea temperatures will have no effect on the intensity) was accepted because there was no significant effect on the intensity of hurricanes that were recorded between 1996 and 2018.

The Effect of Over-the-Counter Medications on the Heart Rate of Daphnia
Juliana Lomas, Washington-Liberty High School

The purpose of this experiment was to discover the short-term effects, if any, of pharmaceutical pollution. Many researchers only study the long-term effects and other aspects of pharmaceutical pollution such as antimicrobial resistance. Daphnia Magna were exposed to 4 different kinds of over-the-counter pain medication for 15 minutes. The medications used were acetaminophen, naproxen, Advil PM (containing ibuprofen and diphenhydramine), and Alka-Seltzer Cold and Flu Max (containing acetaminophen, dextromethorphan hydrobromide; doxylamine succinate, and phenylephrine hydrochloride). The heart rates were then recorded and analyzed to determine the effect of the medications on heart rate. Overall, the medications lowered the heart rate of the Daphnia. The control group had the highest average heart rate of 178.70 bpm. Daphnia treated with acetaminophen and naproxen had similar average heart rates of 156 bpm for acetaminophen and 150.75 bpm for naproxen. The Daphnia treated with Advil PM and Alka-Seltzer Cold and Flu Max had lower average heart rates of 144.40 bpm (Alka-Seltzer Cold and Flu Max) and 129.25 bpm (Advil PM). An ANOVA test was completed to see if results were statistically significant and the p-value was 1.204×10^{-17} , less than 0.05. This (in addition to T-tests with similar results) allowed the null hypothesis to be rejected, and as Advil PM caused the lowest average heart rate and each t-test completed with the group was found significant, the hypothesis was accepted. These results may suggest that medications in the water do have short-term/immediate effects on aquatic organisms' body systems but are not immediately harmful.

The Effect of Acid Rain on Macroinvertebrate Populations
Brady Krohl, Washington-Liberty High School

Acid rain is one of the leading causes of water contamination. Water contamination is affecting the whole country by killing aquatic animals and contaminating the water we drink. There are many ways to determine the pH of a water source. One of those ways is macroinvertebrates. Macroinvertebrates are an indication animal. Meaning depending on what macroinvertebrates are seen in that water source, the pH can be guessed. Different macroinvertebrates have higher or lower tolerance levels of pH. The purpose of this experiment was to determine the tolerance levels for brine shrimp in basic and acidic conditions. In this experiment, three different pHs were tested. An acidic pH, a basic pH, and water with no additives which is a pH of 7. My hypothesis was that the water with the pH closest to 7 would have the highest survival rate. My hypothesis was confirmed as the highest survival rate did come from normal water. This experiment was not statistically significant which may lead to different outcomes if performed again (refer to graph one). The brine shrimp in the normal water had very close ending populations to the acidic and basic conditions (refer to graph two). The reason why the experiment was not statistically significant is not yet known. It may be because of the saline levels, oxidation of the water, or light. With the increasing amount of acid rain and increasing pollution levels in water sources, macroinvertebrates will continue to adapt and increase their tolerance or die from high levels of pollution.

The Effect of Varying Antioxidants on the Survival Time of Brine Shrimp
Hanna Wirtu, Mills E Godwin High School

Antioxidants have become a new trend in today's society and is present in not only the food industry but the cosmetic industry as well. These antioxidants end up in local waterways, therefore disrupting the environment as well as the organisms living in it. The purpose of this experiment is to determine the antioxidant that allows brine shrimp to survive the longest. Brine shrimp were placed into bowls with various antioxidants and timed to see how long they could survive in the foreign environment. It was hypothesized that the brine shrimp placed in the vitamin C would have the longest survival rate due to the natural chemical makeup in comparison to the other antioxidants. The results revealed that this hypothesis was supported. T-tests were conducted and it was found that all of the data was statistically significant except for the 10% BHT antioxidant. This means that the data was due to the independent variable and not to chance. It is believed that vitamin C had the most positive impact due to it naturally being found in water systems and brine shrimp growing a tolerance to it over time. This research could lead to further studies such as the optimal amount of salt present in water and the optimal temperature for brine shrimp to live.

The Effect of Different Methods of Water Filtration on Turbid, Contaminated Water from a Variety of Different Water Sources.

Kaitlyn Cooper, Washington Liberty High School

Water pollution has devastated communities all across the world causing thousands of people to be displaced or exposed to chronic diseases such as cancer. In addition, numerous people around the world don't have access to filtration systems. The purpose of this experiment was to test different methods of filtration on a variety of water samples from lakes, rivers, bays, and the ocean to measure the effectiveness and difficulty for each method. Two types of filtration, activated charcoal and aluminum sulfate, were tested on water samples from 10 different water sources across the country. The hypothesis for this experiment stated that if different filtration methods are used on dirty water samples then the turbidity of the water will improve, there will be fewer contaminants and nitrates, and a lower pH reading with activated charcoal having a larger impact than the other method. Once collected, the water samples were tested for turbidity level, pH level, total hardness (mg/L), total alkalinity (mg/L), chlorine (mg/L), iron (mg/L), fluoride (mg/L), nitrites (mg/L), nitrates (mg/L), lead (mg/L), and copper (mg/L). The samples were then passed through each filtration method for 5 days. After 5 days, the samples were all measured once again for the same contaminants as noted above. The changes were observed and put into a raw data table where the results could be analyzed using Excel. Results suggested activated charcoal was a more effective method of filtration leaving the water samples with fewer contaminants, lower turbidity level, and a lower pH level after 5 days. However, the data was not statistically significant between the samples of both filtration methods, except for the nitrites (0.046) and copper (0.038) levels in samples filtered using activated charcoal. Both filtration methods improved the water quality. There was no statistically significant difference in the data between the activated charcoal and the aluminum sulfate, therefore, the null hypothesis was accepted.

The Effect of the Urban Water Cycle on Microplastic Counts: An Arlington Case Study
Charlotte Papacosma, Wakefield High School

The purpose of the experiment 'The Effect of the Urban Water Cycle on Microplastic Counts: An Arlington Case Study' is to determine if the microplastic count in a sample varies with key steps in Arlington's urban water cycle, as well as to conduct additional research relating to microplastic pollution and how individuals can do their part to reduce it. The urban water cycle, or the way water is sent from its source, through our homes, and eventually back into the environment, is designed to remove many types of pollutants from our water, and microplastics can be defined as any piece of plastic smaller than five millimeters. The hypothesis for the experiment is: If water samples are taken from key steps of the urban water cycle as well as a sample location that is not directly affected by the urban water cycle, then the tap water will have the lowest concentration of microplastics. This is because the portion of the cycle between when river water is filtered and when it comes out of our taps is a closed system, thus ensuring no outside pollution sources affect the composition of the tap water. The first step of this experiment was collecting two samples from each location. Then, a filter apparatus was constructed, and each sample was filtered through a 0.45 micron filter paper. The filter papers were then viewed under a dissecting scope and viewed in a row-by-row pattern so that an accurate microplastic count could be taken. After the results were reviewed and analyzed, it was found that the data did support the hypothesis, and the tap water had the lowest average microplastic count. The effluent was found to have the highest count, most likely due to dumping, laundering, and industry processes. Future repetitions of this experiment may be improved by collecting a larger, more varied set of samples, as well as using a less subjective method when counting the microplastics, in order to prevent miscounting.

The Effect of Natural Greywater Filtration Methods on the Survival Rate of Worms
Estee Ruiz, Washington-Liberty High School

The purpose of this study was to determine the effect of natural greywater filtration methods on the survival rate of worms. The independent variable was the type of filtration method. The experimental groups were rock filtration, sand filtration, coconut coir compost filtration, and smashed corn filtration. The control was the group of worms that received the unfiltered greywater. The dependent variable was the survival rate of the worms. The constants were the amount of compost given, the amount of sunlight given to each tub of soil, the amount of water given to each tub of soil, the number of worms to start within each tub and the type of worm in each tub. The hypothesis stated that if greywater is naturally filtered and then tested on worms, the group treated with the crushed corn filtration method will have the greatest survival rate or worms because of corn's absorption properties. Fifty containers were filled with 250 g of potting soil and five worms were placed in each container along with 10 g of sliced apples. Each level was placed into a funnel and 75 mL of each substance was placed into the corresponding containers; 10 containers for each level. The containers were checked two times during the five day period, and the number of worms alive was recorded. Once all the data was gathered, a graph depicting the information was made. The results showed the worms that received the grey water filtered by the corn and compost had the highest survival rate. These results supported the research hypothesis. In conclusion, the study suggests that the corn and coconut compost filtration methods have a more positive effect on the worms, compared to the rocks and sand.

Microfossils in Mammoth and Mastodon Dental Plaques as an Indicator of Diet
*Sarah Deloney, Massanutten Regional Governor's School I for Integrated Environmental Science
and Technology*

The purpose of this study was to identify types of microfossils in dental plaques from Mammoth and Mastodon teeth, in order to predict dietary patterns of species in different geographic regions. The majority of samples were collected from locations across Florida, including samples collected from sinkholes around the Aucilla River. Dental plaques from American Mastodon (*Mammuthus americanus*) and Columbian Mammoth (*Mammuthus columbi*) teeth were analyzed under a microscope for their microfossil contents. Identified microfossils were divided into three broad categories: tracheids, vessel elements, and phytoliths, of which clear examples were photographed for later reference, and analyzed as dietary indicators. The consistent presence of short cells from Pooid grasses indicates that swamp grass-consuming American Mastodons and pasture grass-consuming Columbian Mammoths both lived in damp areas, which encouraged the growth of Pooid grasses.

The Effect of Algaecide on Lake Renewal and Improvements in Water Quality
Elizabeth Smith, Chesapeake Bay Governor's School

Over the last ten years, a private lake in rural tidewater Virginia had been getting more and more opaque. The water had turned greener and the lakebed was no longer able to be seen from the personal dock that is in the larger section of the lake. Those who fish on the lake were concerned to see how much the water quality has declined, and the fish are also suffering due to the declining water quality. This study investigated the effects of an algaecide made by Citrine Plus on the quality of the water. The water's pH, dissolved oxygen (ppm), and turbidity (m) were monitored over the span of nine weeks with the algaecide being put in on weeks four, five, six, and eight. Over the span of the experiment, the algaecide was able to clear the lake of the excess algae and the turbidity diminished, dissolved oxygen increased, and the pH became less acidic. This small-scale study showed that unhealthy aquatic ecosystems have the ability to recover from human impacts.

Vegetation Density Preferences of Common Killifish (*Fundulus heteroclitus*)
Josie Worrell, Chesapeake Bay Governor's School

In this study, *Fundulus heteroclitus* or mummichogs were used in two experimental models to test whether they had a preferred vegetation density to connect climate change effects on aquatic species in the Chesapeake Bay, specifically related to habitat fragmentation and destruction. Climate change has caused global temperatures and sea levels to rise at an alarmingly high rate due to increasing CO₂ levels and greenhouse gases. The Chesapeake Bay is affected at a higher rate due to land subsidence and geographical factors. This will lead to higher fragmentation and vegetation loss rates due to the rising sea level and decreased marsh-surface elevation. This is alarming considering the Chesapeake Bay has a limited biodiversity and high wildlife abundance, which climate change can potentially change. These preferences can depict how mummichogs or other species may react to climate change and its effects. To identify these preferences, I used two experimental models of manipulating marsh vegetation density to observe the effects on mummichogs behavior. The statistical tests show no significance between a preferred vegetation density among mummichogs. However, there was a trend in the data suggesting mummichogs may prefer a moderately dense vegetation over higher and lower densities.

The Effect of Different Soil Sites on the Amount of Organic Carbon
Laura Neureiter, Finley Odar & Frances O'Malley, Arlington Career Center

Climate change is heavily impacted by the amount of carbon in the atmosphere. Carbon dioxide absorbs a tiny amount of radiation, but if there is too much carbon dioxide in the atmosphere, this absorption changes the climate. This experiment tested to see what type of soil stored the most carbon. The hypothesis stated that out of wetland, stream, forest, or suburban grassland sites, forest soil would have the most carbon stored because roots in trees would put carbon into the soil around them. The results can help people know which environments to focus on to help decrease the carbon dioxide in the atmosphere and slowly but surely win the war of climate change so that air quality can improve and prevent natural disasters from getting bigger. The hope was to make more people take action on this climate change matter. In each location, five soil samples were taken and mixed together to make sure each part of the destination was represented as a whole. All samples were put into a kiln, then calculations were made and recorded. Separate individual bags of different soil (wetland, forest, suburban grassland and stream) were sent off to a professional soil measuring lab to be tested for control. Once the results were calculated from both locations, the conclusion stated that the forest soil was able to sequester the most soil probably because the carbon went from the leaves to the roots of the trees and was put into the soil. Wetland soil was able to store the least soil, one reason may be that there were a lot of rocks in the wetland soil and rocks don't store carbon so that would have affected the results.

An Evaluation of Morgantown, Maryland's Coal-fired Power Plants Effects on Water Quality in
the Potomac

Beverley Arbogast, Chesapeake Bay Governor's School

The Potomac River is one of the major tributaries of the Chesapeake Bay. This study monitored six water quality variables (turbidity, sulfates, nitrates, phosphates, pH, and dissolved oxygen) near Morgantown Generating Station (MGS) – a coal-fired power plant - on the Potomac River for two months during the summer of 2019. The study had a sample size of six of each of my three locations. Two locations were on the same side of the river (one upriver and the other downriver from MGS) and the other site was on the opposite side of the river from the plant.

The Effect of Crop Type and Soil Grain Size on Water Quality in Small Streams
Cassidy Cooper, Chesapeake Bay Governor's School

This geospatial study observed the water quality of waterways located within a 1000m radius from farms that planted both corn and soybeans. This data was gathered from online databases from the years 2008 to 2017 in multiple locations spread across Virginia. Besides the crop type, soil type was also taken into account. During this experiment, we observed how five different grain sizes of soil affected the water quality when corn and soy were planted. The different farms all have similar topographies, and all perform yearly crop rotations. The locations for these farms were found using Landsat Imagery. The water quality of these areas was gathered during April, the month of their planting season; this data was collected from the Virginia Department of Environmental Quality. The geospatial analysis suggested that water may be affected by what crops are being planted and what type of soil is present. The analysis suggests that corn crops may contribute more nitrates to the local waterways than soybeans. With a denser grained soil, such as clay, and corn as the crop, nitrates and acidification were at higher levels than during a soybean season, with a thinner grained soil, like that of sand. Some trends in the graphs suggested that both crop type and soil grain size can have an impact on nearby water quality.

A Comparison of Copper Levels in Fish Livers and Gills for Two Separate Locations in Chesapeake Bay

Wyatt Engel & Kyle Pettigrew, Chesapeake Bay Governor's School

In the Chesapeake Bay, international shipping is prevalent with several major shipping destinations located within the bay such as Norfolk, Newport News, Washington D.C., and Baltimore. Not only is the Chesapeake Bay filled with commercial traffic, it is abundant with marine wildlife that call the bay their temporary home. This study investigated a correlation between copper-based anti-fouling paints on commercial traffic and the effect it has on the marine wildlife in the Chesapeake Bay. Two locations were chosen, one in a major shipping channel and another in a channel with less commercial traffic. Two popular species targeted by recreational fishing, Bluefish (*Scomberomorus maculatus*) and Spanish Mackerel (*Pomatomus saltatrix*), were used to obtain data on copper concentrations. Representatives of both species were obtained from both locations through licensed hook-and-line fishing. Their gills and livers were removed, frozen, and digested with nitric acid and analyzed for copper content with a spectrophotometer. Contrary to expectation, copper levels in gills were higher in fish from the area of low boat traffic, although the difference was not statistically significant. Liver concentrations were similar at both locations. Both species had similar levels. Males had statistically significantly more copper in their livers than females, although gill concentrations were similar. Therefore, according to our results, the anti-fouling paints appear to have little effect on Chesapeake fish and their daily processes.

Water Quality Differences on the Upstream versus Downstream Sides of Beaver Ponds
Avianna Hopewell, Chesapeake Bay Governor's School

The objective of this study was to see if beaver dams have the capabilities to filter water to make a significant difference between the water quality before and after passing through the beaver pond. If there is a significant difference and the quality of water has improved after being filtered, then people should stop tearing down beaver dams and stop the destruction of their habitats. After analyzing my data, there is a slight trend with temperature and nitrates that follow my hypothesis.

Field Study of Possible Water Quality Impacts of a Paper Mill on the York River
Channing Pitts, Chesapeake Bay Governor's School

The primary goal of this study is to determine the water quality in the York River and surrounding bodies of water. The WestRock Mill could be releasing harmful materials into the water that would pose a threat to the wildlife and the surrounding environments. The WestRock Mill sits on the Pamunkey River at the confluence of the York River. To the immediate North of the Pamunkey is the Mattaponi River. The Mattaponi River converges with the Pamunkey River to form the York. Water quality parameters including nitrates, phosphates, dissolved oxygen, and pH were tested in all three rivers at the surface. At the benthic depth, dissolved oxygen and pH results were collected. After testing, there were no significant traces of nitrates or phosphates in the Pamunkey or York Rivers if the WestRock Mill emitted these compounds.

The Effect of Algaecide on Lake Renewal and Improvements in Water Quality
Elizabeth Smith, Chesapeake Bay Governor's School

Over the last ten years, a private lake in rural tidewater Virginia had been getting more and more opaque. The water had turned greener and the lakebed was no longer able to be seen from the personal dock that is in the larger section of the lake. Those who fish on the lake were concerned to see how much the water quality has declined, and the fish are also suffering due to the declining water quality. This study investigated the effects of an algaecide made by Citrine Plus on the quality of the water. The water's pH, dissolved oxygen (ppm), and turbidity (m) were monitored over the span of nine weeks with the algaecide being put in on weeks four, five, six, and eight. Over the span of the experiment, the algaecide was able to clear the lake of the excess algae and the turbidity diminished, dissolved oxygen increased, and the pH became less acidic. This small-scale study showed that unhealthy aquatic ecosystems have the ability to recover from human impacts.

Vegetation Density Preferences of Common Killifish (*Fundulus heteroclitus*)
Josie Worrell, Chesapeake Bay Governor's School

In this study, *Fundulus heteroclitus* or mummichogs were used in two experimental models to test whether they had a preferred vegetation density to connect climate change effects on aquatic species in the Chesapeake Bay, specifically related to habitat fragmentation and destruction. Climate change has caused global temperatures and sea levels to rise at an alarmingly high rate due to increasing CO₂ levels and greenhouse gases. The Chesapeake Bay is affected at a higher rate due to land subsidence and geographical factors. This will lead to higher fragmentation and vegetation loss rates due to the rising sea level and decreased marsh-surface elevation. This is alarming considering the Chesapeake Bay has a limited biodiversity and high wildlife abundance, which climate change can potentially change. These preferences can depict how mummichogs or other species may react to climate change and its effects. In order to identify these preferences, I used two experimental models of manipulating marsh vegetation density to observe the effects on mummichogs behavior. The statistical tests show no significance between a preferred vegetation density among mummichogs. However, there was a trend in the data suggesting mummichogs may prefer moderately dense vegetation over higher and lower densities.

ENGINEERING

Deep Convolutional Neural Networks for Atomization Energy Prediction using Coulomb Matrices *Fareed Sheriff, Todd Allen Phillips Center for Medical Sciences at Godwin High School*

The purpose of this experiment was to determine whether the experimenter's model can achieve a lower error than the models described in the 2012 paper by Montavon et al. The rationale of this experiment was that determining how accurately a machine can predict atomization energy from a molecule's Coulomb matrix alone could improve the accuracy of deep learning-predicted atomization energies. The real-world implications of this were that improving the accuracy of deep learning-predicted atomization energies could save lives, be it through medicine to cure a fatal illness or through the flame-retardant fabric used in firefighters' suits, all of which use quantum chemistry. The hypothesis stated that the level of the IV with the lowest error of all of the levels will be the combination ResNet-ANN level. There was no control in this experiment because there was no level of the IV that acted as a baseline for the rest of the levels. The procedure for this experiment involved downloading quantum chemical data, programming and training a combination ResNet-ANN model, and compiling and analysing the results. The results showed that the lowest error was indeed achieved in the combination ResNet-ANN model. Calculating a more accurate atomization energy would have better aided in the creation of new medicinal drugs to cure a fatal illness or novel fabrics with a variety of uses.

The Effect of Room Dimensions on Sound Absorption *Amanda Appiah-Yeboah, Clover Hill High School*

This experiment was conducted to determine whether or not room dimensions, simulated by boxes, have an effect on sound absorption. It was hypothesized that out of no box, the 30 cm³ box, the 61 cm³ box, and the 91 cm³ box, the 30 cm³ box will have the highest amount of sound absorption. The boxes were lined with soundproof paneling and a phone producing the sound was placed in the box. A sound level meter that measures in decibels was placed in the corner of the box. An iPad was used to video record the reading on the sound level meter and then the sound level meter was removed from the box and placed at a distance away from the box. The sound level of the sound outside of the box was recorded. The sound level outside of the box was subtracted from the reading inside of the box to find the total sound absorption. The mean sound absorption for the 30 cm³ experimental group was 43.7 decibels (dB). The mean for the 61 cm³ group was 23.6 dB. The mean for the 91 cm³ group was 20.8 dB. The mean for the group with no box was 15.7 dB. The difference in mean sound absorption between each level was significant enough to reject the null hypothesis.

The Effect of the Shape and Material of a Solar Panel on Thermal Energy Generated
Ambica Sharma, Washington-Liberty High School

This experiment sought to determine whether a solar panel with a different shape and material could be constructed and tested to be as effective as a conventional flat galvanized steel based solar panel. Both the shape and material of the panel were varied in the experiment: flat was compared with corrugated surface, and the panel materials included aluminum, galvanized steel, and copper. Six solar panels were constructed: flat, aluminum; flat, galvanized steel; flat, copper; corrugated, aluminum; corrugated, galvanized steel; and a corrugated, copper solar panel. The hypothesis was that compared to the other five solar panels, corrugated, copper solar panel would show the most growth in thermal energy generated because of the presence of ridges in the corrugated surface allowing it to absorb more solar rays than a flat surface and that compared to aluminum and galvanized steel, copper is a better conductor of electricity and thermal energy. Each solar panel was constructed and sealed on top of a bread pan filled with water to measure the thermal energy generated based on the change in water temperature after 15 minute time intervals for 30 minutes. Each solar panel was placed under a desk lamp with a bright light bulb. All other experimental conditions were the same for all trials of each solar panel. The results supported the hypothesis: compared to other solar panels tested, the corrugated, copper solar panel generated the most thermal energy. The experiment showed that there are alternative designs that are more effective than the conventional design.

Christmas Under the Sea: Creating a Coral Sustaining Habitat
Shelbie Gray, Ocean Lakes High School

Every year, the density and populations of coral reefs continue to decline due to bleaching, global warming, and damage from humans. Without these ecosystems, fishing and tourist companies will shut down, and coastal towns and cities will be ravaged by storms due to the lack of the buffer provided by coral reefs. To combat this issue, scientists began creating coral restoration nurseries in the hope of rehabilitating and increasing natural coral populations. However, many designs of these nurseries are only capable of housing one species at a time and require lots of resources and time to prepare and set the nurseries. Thus the question of, "Could a low-budget coral sustaining habitat be created and maintain its structural integrity against different marine organisms and ocean currents?" was born. For this project, I worked closely with Will Ryan and the engineering team at S&S Precision. In order to work cohesively with Will and his team, I spent many days at my internship learning how the 3D modeling software worked and how I could use it to develop my senior project. I also had to learn about the biology and ecology of different coral species and how they performed in different nurseries to create a "catch all" for a variety of coral species. My findings were generally positive, although I had trouble accessing different articles because they required payment to be read and downloaded. However, my results were positive for my senior project and there is still even more to learn and develop in this field.

The Effect of Heating Thermoplastics on Tensile Strength
Annabel Puritz, Mills E. Godwin High School

Plastic gets thrown away often, which is harmful to the environment because the material takes a long time to break down. An experiment was designed to determine how applying heat to thermoplastic affects its strength properties. It was hypothesized that if high-density polyethylene (HDPE) was heated, it would have a higher tensile strength than polyethylene terephthalate (PET), low-density polyethylene (LDPE), and HDPE before it was heated. For this experiment, a tensile strength machine was constructed, which determined how much weight a piece of plastic could pull before it broke. PET, LDPE, and HDPE were the three plastics that were tested. Each type of plastic was also tested after being heated to determine if the heat increased or decreased the strength. The data proved that the tensile strength of PET plastic increased the most after being heated. Surprisingly, HDPE plastic changed the least, so the results did not support the research hypothesis. However, the tensile strength data for PET and LDPE significantly increased after being heated. It is likely that the PET plastic changed the most because the plastic shrank when it was heated, which made the plastic thicker. The LDPE plastic also shrank, which made the heated plastic slightly stronger. However, heat did not change the size of the HDPE plastic, which may explain why the data for that plastic was not significant. Several errors may have affected the data as well. For example, since the hanging scale was intended for heavier items, the weight may have been inaccurate.

The Effect of Different Types of Damping Systems on Buildings Affected by Vortex Shedding
Raphael Sanchez, Arlington Tech @ Career Center

The purpose of this study was to test different building dampers on how they reduce building sway from vortex shedding (an effect of wind). There were two independent variables tested. One independent variable compared different building dampers on their ability to reduce sway. A Tuned Mass Damper (TMD) and Tuned Liquid Column Damper (TLCD) were tested and compared to a building's sway with no damper, which was the control. The second independent variable was the wind speed. Wind speeds of 7.5 m/s and 12 m/s were tested to understand the effectiveness of building dampers at different wind speeds. One hypothesis was that the pendulum TMD would be most effective in reducing building oscillation. Another hypothesis was that the pendulum TMD would be most effective at both wind speeds. Results showed there was a significant difference in oscillation between a building with a damper and a building without one. However, the difference in the oscillation of a building with a TMD and a TLCD was insignificant. Thus, the hypothesis was rejected. The study suggests that a building will oscillate less if any passive damper is in place.

Using Python and OpenCV to Create a Real Time American Sign Language Gesture Translator
Holly Hinchy & Ella Bryant, Roanoke Valley Governor's School

There are numerous obstacles for American Sign Language (ASL) users in everyday life. Communication with those who do not understand their language is limited, and thus, frustration can arise between both parties. A more efficient method of communication is necessary to ease any difficulties that may occur. This project constructed an American Sign Language gesture translator that recognized alphabetical symbols using Convolutional Neural Networks (CNNs) and converted the letters to speech. In addition to this, the inverse was implemented; an input of a spoken letter was received, and the corresponding gesture was displayed on the screen. The software used in the creation of the project includes Tensorflow, Keras, OpenCV, and PocketSphinx, as well as their dependencies. The CNN undertook great amounts of training drawing from an ASL alphabet gesture library. Afterwards, images were run through the model; the image recognition training ran at an accuracy of approximately 95% accuracy but when tested with real world data it had roughly 4.5% accuracy. A speech recognition system required the dictionary to be limited to the English alphabet. Once the task was complete, the decoder system ran through inputted live speech. This process resulted in a fairly high success rate. In conclusion, this program is merely a basic step in achieving a fully functional American Sign Language translator. However, furthering the application of these methods may improve communication for hundreds of thousands of people to come.

Effect of Titanium Dioxide on Solar Cell Energy Output
Roshan Sarangi, Mills E. Godwin High School

The purpose of this research was to determine if coating a solar cell with a TiO₂ layer would increase the power output of the cell. In addition, another purpose was to determine which concentration of TiO₂ coating would be the most effective in increasing wattage output. The hypothesis studied stated that if a 1/mg/mL of TiO₂ was applied onto photovoltaic cells, then the most wattage would be produced. The experiment was conducted by obtaining six solar cells and coating each with either no coating, a 0.5 mg/mL concentrated coating, a 1.0 mg/mL concentrated coating, or a 1.5 mg/mL concentrated coating. The control of this experiment was a solar cell with no coating. After each cell was coated, the cells were placed under an even and constant source of light for equal amounts of time. After this, the wattage produced by each cell was calculated by multiplying the voltage produced by the amperage produced. The data collected from this research showed that a 1.0 mg/mL concentrated coating increased the wattage produced the most when compared to the control. The other two levels of the independent variable apart from 1.0 mg/mL and the control yielded a lower wattage when compared to the control. A t-test was conducted on the data and it was found that all data was significant. The 0.5 mg/mL and 1.5 mg/mL levels of the independent variable likely produced less wattage when compared to the control because the TiO₂ coating blocked the light from reaching the solar cell itself.

Engaging Everyone in Electrical Energy Conservation
Emma Gorman, The Mathematics and Science Academy at Ocean Lakes High School

Emissions from non-renewable gases pollute the atmosphere causing a Greenhouse Effect. Currently, renewable alternatives are expensive and also unreliable. In order to combat this growing environmental damage and resource deficit caused by excessive energy consumption and waste, lifestyle changes must be made on a personal level. The objective of this research project is to prove that educating the public about environmental issues and the effects of their specific actions regarding electrical energy usage will motivate them to take a more active interest in minimizing their resource wasting. Thus, a device, nicknamed the "WattBott", was constructed using an Arduino microprocessor and an ACS723 current sensor to measure the current emitted from a wall outlet when external devices were plugged into it. This was displayed on an LCD screen. Using this device, data was collected that displayed the amount of energy being consumed and how much money that energy costs. With this data and compiled research about global warming and environmental issues, a session was held with a total of 25 participants. The participants took surveys before and after being presented with the facts and data in a classroom style format, from which it was determined that because of the new information, the public felt 44% more motivated to unplug their electronics in order to help reduce the amount of energy they waste.

Are All Computer Languages the Same? Empirical Comparisons of Three Languages
Jinsun Lee, Douglas Southall Freeman High School

Each computer programming language has a different array of benefits and constraints. Thus, it is crucial for computer scientists and programmers to be familiar with the strengths and weaknesses of the most common languages. The main goal of the study was to compare three popular computer languages to determine their advantages and disadvantages. Three problems and their respective solutions were chosen from Leet Code, a cloud-based programming platform. C++, Java, and Python3 were compared with each other based on their task execution time in milliseconds and the amount of memory space used by the languages in megabytes. Java excelled in speed while C++ excelled in memory use overall.

The Effects of Wind Turbine Blades Shape on Energy Generated
Joshalyn Haight, Portsmouth STEM @ I.C. Norcom High School

The purpose of the experiment was to determine which blade shape was proven to generate the most amount of energy. The hypothesis of this experiment, which was if a 6-sided blade is used, then it would generate the most energy, was proven correct by the data. The hypothesis was tested using various shapes of wind turbine blades with a PVC stands in front of a fan. The blades turned a DC motor that was connected to a voltmeter. This experiment was chosen because of my interest in health science. Pollution caused by the use of nonrenewable energy sources can be reduced by using more renewable energy, which can increase the health of the community.

Raspberry Pi Mars Rover: The Electromagnetic Claw
Emil Ivanov, Ocean Lakes High School

The purpose of this experiment was to find out if it was possible to pick up different objects through the use of an electromagnet depending on the object's weight. This was an important study in the field of electrical and mechanical engineering as the research allowed for a more efficient method for space exploration involving space rovers. The hypothesis stated that if resistance was applied to the electromagnet, then the current would decrease, allowing the electromagnet to pick up objects of different weights based on how much resistance is applied. The skills and knowledge I had to develop included learning how to code using python and how to operate raspberry pi. My findings concluded a method, which utilizes an electromagnet to detect metallic objects of different weight. Previously, Martian rovers, such as the Spirit and Opportunity rovers, used multiple magnets to conduct this research. This method cuts down the weight of previously used Martian rovers, while making them function more efficiently.

Bio-Bike: A Novel, Injection Molded Cargo Bicycle Designed Using AI Based Generative Design
Charles Hamilton, Mills E. Godwin High School

Higher carbon emissions are a direct result of increasing populations in urban areas around the globe. To mitigate this risk, an innovative cargo bicycle was designed and tested with electric assisted pedaling and 200 kg cargo carrying capacity to serve as a transportation replacement for emission heavy transportation methods such as driving. Through an iterative design approach, a monocoque style frame and airless tire design was produced that was optimized to be manufactured using cost effective water-assisted injection molding out of a recycled PET plastic and glass fiber composite material. These non-traditional manufacturing choices pair together resulting in a truly innovative, environmentally friendly design. Artificial intelligence (AI) based generative design software was used to incrementally adjust the frame and wheel construction and optimize the bicycle's structural integrity as defined by the force specifications inputted to the software. This process resulted in a highly optimized, lightweight, strong design which was proven through finite element analysis simulations to have a cargo capacity of 200 kg while withstanding the forces of regular use. The estimated cost of manufacturing this bicycle was calculated to be 417% cheaper than other comparable cargo bicycles on the market, making this design a highly viable solution for today's emission and traffic issues in cities around the globe.

The Effect of Music Composition Software on Perceived Listenability
Will Duis, Central Virginia Governor's School

The purpose of this study was to determine whether or not the cost of algorithmic music composition software has a significant effect on its output. The results were collected through a survey from high school juniors and seniors. Participants were presented with two audio tracks each from a human composer and the software programs AIVA, DigiBand 1.8, and OrbComposer Artist S 1.5, which had no cost, a cost of \$49.95, and a cost of €149, or about \$165.50, respectively. Through an online survey, each participant ranked their perceived listenability for each of the tracks. A single-factor ANOVA of the ranking data showed significant differences with a p-value of .0139 and an alpha value of .05. A post-hoc Tukey test determined between which groups significance was held with a Dmin value of .84. The largest difference was between AIVA 1 and OrbComposer 1, and it did not support the research hypothesis, which stated that if algorithmic composition software is used to generate music, then listeners will rank its musicality as higher than the less expensive types, but less than music composed by humans. In conclusion, the free software AIVA had the highest results and was significantly more pleasant than OrbComposer, the most expensive software. This means that AIVA, as a free software, is easier to obtain and use to compose personalized music than the other software programs.

The Effect of Extreme Temperature on Shin Guard Efficiency
Randy Trost, Central Virginia Governor's School

The purpose of the study was to determine if temperature has an effect on the efficiency of Mercurial Lite shin guards. Six shin guards were separated into three groups of two and tested at varying temperatures. A ten pound dumbbell was released from a pendulum at a certain height and collided with a shin guard. The impact force was then recorded on the back side of the shin guard. A Single Factor ANOVA Test with an alpha value of .05 was used to determine if there was a statistically significant difference between groups. The Single Factor ANOVA test produced a p-value of .98, determining no significant difference among groups. The study did not support the research hypothesis, which stated that the cold shin guards would experience a greater impact force than the hot shin guards. The results of this study suggest that temperature does not have an effect on the efficiency of Mercurial Lite shin guards. Knowing that temperature does not have an effect on safety equipment, specifically shin guards, there is potential to improve player safety by examining other aspects of protection equipment.

The Effect of Household Recyclables on Heat Insulation Effectiveness
Tristan Adamek, Clover Hill High School

Despite many households recycling, the majority of these items never end up being recycled and simply end up as waste that oftentimes harms the environment. As a result, the question of how household recyclables can be reused in a cost-effective manner that improves both the quality of the environment and the lives of people arose. The research hypothesis stated that if exposed to the same conditions as the recyclable insulation materials, the R-30 insulation would insulate the most heat. To begin this experiment, the materials were collected before anything else, which included insulating materials (R-30 insulation, cardboard, egg cartons, PET water bottles, styrofoam) and construction materials (plywood, construction adhesive, etc.). Five boards were cut from the plywood and had one of the insulation materials attached to it. Then one of the boards was suspended in the air and heated up by a heat lamp. The surface temperature of the board was measured with a laser temperature gun and recorded, then that board was replaced by another after the heat lamp had cooled. This process was repeated five times for each board. The results found that the median surface temperature of the egg cartons was slightly lower (0.7 degrees Celsius) than that of the control, the R-30 insulation. As a result, the data did not support the research hypothesis. Through these results, it was found that there was a statistically significant difference in the data.

The Effect of Tennis String Tension on the Accuracy of a Backhand
Sia Chaudry, Clover Hill High School

The purpose of this experiment was to determine what string tension of a tennis racquet would produce the greatest accuracy in a backhand shot. The question addressed in this experiment was: what string tension could be used by the tennis audience to incorporate greater accuracy in their game? The experimental hypothesis stated that the lower the string tension in pounds, the lower the accuracy of the backhand would be. Four Wilson Ultra 100 Countervail racquets were strung at different string tensions that consisted of 40 lbs, 50 lbs, 55 lbs, and 60 lbs. A ball machine was placed at the center of the baseline on the tennis court. Ten target cones were used to outline a target area on the court on the same side of the ball machine. The side of the court opposite of the ball machine was positioned by the tennis player. Forty backhand shots were hit aiming for the target area. The percentage of how many backhands hit in the target area was calculated for each level of string tension, determining the accuracy of the backhand shot. The mean was 85.0% for 55 lbs string tension (control), 52.5% for 40 lbs string tension, 67.5% for 50 lbs string tension, and 72.5% for 60 lbs string tension. The 55 lbs string tension (control) racquet allowed for the greatest accuracy in the backhand shot with an average of 85.0% and the 40 lbs string tension racquet allowed for the least accuracy in the backhand shot with an average of 52.5%.

A Computer Vision Application to Identify Historic Buildings in Downtown Harrisonburg, Virginia
Mira Yoder, Harrisonburg High School

Computer vision is a field of machine learning that is increasingly being used in technology. In this paper, I describe the design of an application that uses computer vision to identify images of ten historic buildings in downtown Harrisonburg, Virginia, and provides the user with historical information about them. The application was developed in Javascript and HTML, and Google's Teachable Machine was used to build the machine learning model to identify the buildings. The application identified the buildings with an 81% success rate. This project introduces an interactive way that technology can facilitate the learning of the history of a particular place.

The Effect of Machine Learning on Reducing the Chance of Taking the Wrong Medicine
Caroline Colucia, Washington-Liberty High School

Taking the wrong medicine, an incorrect dosage, or on the wrong schedule can cause the medications to be ineffective in the human body and potentially dangerous. The hypothesis for this project stated that if Machine Learning is applied to the problem of taking the wrong medication, then it will substantially reduce unintentionally missed or incorrectly taken medications. This was because Machine Learning can be applied to reduce the frequency of human error. The null hypothesis for this project was: If Machine Learning is applied to the problem of missed medications, then it will have no effect on the number of missed or incorrectly taken medications. The three independent variables for this project were Ibuprofen (Advil), Acetaminophen (Tylenol), and Acetylsalicylic Acid (Aspirin). The dependent variable was whether or not the DeepLens camera can differentiate between the three independent variables. Fifty pictures were taken of Ibuprofen, Acetaminophen, Aspirin, and all three pills together and then labelled with its corresponding name using the Labelling application. The model was trained using TFRecord (TensorFlowRecord) and then a C270 HD Webcam was held above each tablet and presented a percentage of confidence based on the learning it was provided with. The results suggested that Machine Learning can be used to reduce unintentionally missed or incorrectly taken medications. The research hypothesis was supported because the object detection algorithm was able to detect Ibuprofen, Acetaminophen, and Aspirin in the frame. In addition, it was able to detect each pill with greater than 90% accuracy. One recommendation for further study would be to perform the same experiment with the same medication in different pill forms (gel caps vs. tablets or capsules vs. tablets). Another recommendation for further study would be to use research by pharmaceuticals or graduate students that provide models that have been trained.

Testing for the Effectiveness of Different Solar Tracker Designs
Wolfgang Ploch, Central Virginia Governor's School

The purpose of this experiment was to compare the power output capabilities of a prototype single and double axis solar tracker. An artificial light source, used to simulate the sun, was constructed with a rotating wood piece and a solar simulating bulb. The solar tracker was designed and constructed to rotate on one axis or two axes depending on the position of a switch. A photoresistor as a light sensor was placed where the solar panel would be positioned to simulate the solar panel's power output. Eight tests were conducted for each tracker orientation. The amount of time the tracker adjusted itself and the resistance of the photoresistor were used to determine the total power output for a simulated twelve-hour day, even though the tests lasted only around 10 seconds. A t-test was used to compare the power outputs for the two groups in watt-hours. The data was found to be significant as the t-test returned a p value of 9.959×10^{-9} , significantly less than the alpha value of .05. The double axis tracker provided more power which supported the hypothesis: if I use a double axis tracker, then it would produce more power than a single axis tracker even though it consumes more power to operate itself. These results can be used to engineer more efficient solar farms for harvesting solar power, which could replace traditional fossil fuel methods. This change could slow down or reverse the pollution of the environment that fossil fuels have caused.

The Effect of Common Building Materials on the Strength of a Wi-Fi Signal
Jonah Bierman, Washington Liberty High School

The purpose of this study was to determine the effect of different common building materials on the strength of a Wi-Fi signal. The Wi-Fi router and iPhone were placed on a hardwood floor, one yard away from each other with the iPhone facing the router. For each experimental group a box was constructed from a different material and placed on top of the router, covering all exposed sides. Using the iPhone app Wi-Fi Status, the strength of the wireless signal was read and recorded. Five trials were performed per experimental group. The experimental groups (plywood, aluminum, foam board and glass) were chosen because they are either common materials used for construction of homes and businesses or have similar properties to such materials. The independent variable was the material surrounding the router, and the dependent variable is the strength of the wireless signal. The control group was a reading of the signal strength without any excess material around the router. An ANOVA test was conducted to determine if the results were statistically significant. The ANOVA test returned a P-value of less than 0.05 ($7.8397E-10$) which allowed the null hypothesis to be rejected. The results supported the research hypothesis, and showed that aluminum caused the most attenuation of the signal.

The Effect of Mast Rake on Aerodynamic Efficiency of a Single-Sail Sailboat
Samuel Hartless, Central Virginia Governor's School

The purpose of the project was to determine if the mast rake, or mast angle, of a single sail sailboat, had an effect on its aerodynamic efficiency. Plastic models of 0, 5, 10, and 15 degrees were printed using a local school's 3-D printer and tested in a local university's wind tunnel. Two models were necessary for each mast rake so that both the propulsion and drag force could be collected. The drag force was then subtracted from the propulsion to find the net propulsion force. To determine if there was a significant difference between the net propulsion force, a one-way Analysis of Variance test was performed. The test was run with an alpha value of .05 and returned a p-value of 6.72E-7. Since the p-value was lower than the alpha value, the test suggested that there was a significant difference. To determine where the significance was present, a post hoc Tukey Test was run with a minimum difference value of .034. The pair of 5 and 15 degrees had a lower value of .009 which suggested there was no significance between the two. In conclusion, the research hypothesis, "If a sailboat's mast angle is set to 0, 5, 10, and 15 degrees, then the sail will be the most aerodynamically efficient at an angle of 10 degrees", was not supported by the data. In summation, the data suggested that make rake can significantly affect a sail's aerodynamic efficiency, ultimately leading to more success in boat races.

The Maximum Air Flow Rate through Different Sized 3D Printed Noses
Faith Smith, Central Virginia's Governor's School

The purpose of this study was to test how ranging interior nose diameters affect how much airflow is allowed into the nostrils. This experiment was conducted at a local high school in Central Virginia in December of 2019. Three different 3D noses were printed with ranging sizes of 33 mm, 36mm, and 39 mm. The noses were then drilled to create two different holes for nostrils and sanded down so that the walls were smooth. Five trials were completed to test the amount of water that could run through the noses, which would be compared to the amount of airflow. To do this, a ½ centimeter thick (3/16 inch) tube ran halfway into the nose, connected to a 242 Liter/hour (64 gallons/hour) pond water pump, and ran water through the nose for five seconds at a time. A one-way Analysis of Variance (ANOVA) and Tukey test was then run on the data points concluded. Compared to the predetermined alpha value .05, the data proved statistical significance with a p-value of .002226. Because of the statistically significant p-value, the research hypothesis, the greater interior nose diameter (39mm) would allow the most amount of airflow, was retained. In conclusion, the hypothesis, "If I create three different simulated depths of vestibules within the nose, then the largest depth will allow the most amount of airflow," was correct.

Studying the Lift/Drag Ratios of Experimental World War II Aircraft
Henry Hermes, Harrisonburg High School

Every aircraft ever produced can be characterized through three values: The coefficient of lift (CL), the coefficient of drag (CD), and the combined lift/drag ratio. These numbers represent the aircraft's performance at a specific airspeed in specific air conditions, and can be used in other formulas to mathematically predict the performance of the aircraft. These coefficients are calculated with experimental data, so lab work is required to find them. This paper describes the coefficients of lift and drag of several experimental German World War 2-era military aircraft, these aircraft being the Messerschmitt Me-163 Komet, the Dornier Do-335 Pfiel, and the Heinkel He-162 Salamander. Their CL and CD values were found through experimentation with scale models in the wind tunnel located in James Madison University's Thermo-Fluids laboratory, and were compared to a contemporary military plane, the American General Dynamics F-16 Fighting Falcon. The scale models were 3D printed at Harrisonburg High School based on CAD models sourced from users on GrabCad, a 3D file sharing site. The World War Two planes were found to have significantly lower lift and drag coefficient values than the F-16, but the values are still useful in their intended purpose of providing a single number to model complex dependencies of shape, inclination, and some flow conditions on lift and drag.

The Effect of Polyethylene Plastic on Compressive Strength of Asphalt
Samuel Hite, Central Virginia Governor's School

The purpose of this study was to determine if asphalt is a good means of disposal for polyethylene plastic. The study was conducted at a local engineering company during November 2019. Polyethylene plastic was mixed into groups of asphalt, obtained from a local company, and made into four groups of eight coupons, each with different percentages of plastic added. The percentages added into the groups were 0%, 5%, 10%, and 15%. A compression test with an Instron machine was performed on each coupon and the output data were converted in order to find the maximum compressive strength. The 0% group had the highest average strength at 11412.81 psi, next was the 5% at 7706.98 psi, then the 10% at 6211.86 psi, and finally the 15% at 5329.75 psi. A single factor ANOVA test determined significance, with a p-value of 2.5×10^{-11} compared to an alpha value of .05. A Tukey test with a Dmin value of 1486.6 then determined that the significance lay between all groups except the 10% and 15% groups. However, the compressive strength decreased as the percentage of plastic increased, demonstrating a negative effect on durability. This did not support the research hypothesis that compressive strength would increase as the amount of plastic increased. In conclusion, the addition of polyethylene plastic had a significant effect on the strength of asphalt. Exploring options that deal with low stress and weight would be a great potential use for recycling waste plastic in asphalt.

Comparing Human and Computer Analysis of Deceptive Text
Michael Kricheldorf, Central Virginia Governor's School

With human deception analysis in the context of investigations and court cases being marginally greater than chance, there is the possibility that computer algorithms can analyze deception significantly better than humans. The purpose of this experiment was to test how accurately classification algorithms can classify truthful, false, and deceptive statements, as compared with human classification. To test this, the researcher trained Support Vector Machine and Naïve Bayes classifiers written in Python with 1448 labeled statements provided by the Boulders Lies and Truth corpus and then tested them on 45 statements. The researcher tested human participants on their classification ability through a 50 question Google Form. The computer and human percent correct accuracies were recorded and then the researcher conducted a one-factor ANOVA statistic test. The human, Support Vector Machine, and Naïve Bayes average percent accuracies were 36.333%, 42.445%, 40.222%, respectively. With an alpha value of .05 and a p-value of .112, the data did not support the research hypothesis, “using a classification algorithm to classify statements will increase the percent accuracy of statements correctly classified as truthful, deceptive, or false, as compared with human statement classification”, and the null hypothesis was retained. Given time constraints, the program written for the classification algorithms was simple and only analyzed the statements on a surface level, but upon further research and a more complex analysis of individual statements, the designed program could be significantly better than humans at analyzing deception in statements.

Engineering a Small-scale Anaerobic Biodigester: Creating a Sustainable Source of Fuel for the
Nasaruni Academy for Maasai Girls
Stella Alexiou & Thomas Shulgan, Harrisonburg High School

With the need for a sustainable, legal source of fuel for an all-girls school in Norok, Kenya, our purpose was to create an anaerobic biodigester that would produce biogas, and, therefore, a sustainable source of fuel that uses cow manure as a feed. We conducted several tests to attempt to determine which conditions were best to produce flammable biogas. In order to do so, we tested several variables, such as time, temperature, and atmospheric conditions. Through our testing, we have determined the composition of the biogas we generated. Currently, this gas contains too little methane to be flammable and does not prove to be a viable source of fuel yet; however, the gas shows a strong promise for continued testing and was crucial in helping to determine which variables produce higher concentration of biogas.

The Comparative Stab Resistance of Different Chainmail Weaves
Jadelin McLeod, Harrisonburg High School

A wide variety of chainmail weaves have been used by different groups throughout history as protective armor. Because chainmail continues to be incorporated in modern protective garments, it is relevant to explore and compare the mechanical properties of different weaves so that modern designs can incorporate the weave best suited for its purpose. In this paper, the stab resistance of handmade chainmail samples representing two weaves (Japanese 4-in-1 and European 4-in-1) were compared. The numerical results from the tests were compared using two-tailed t-tests. It was concluded that European 4-in-1 had a significantly greater and more consistent stab resistance than Japanese 4-in-1.

The Effect of Various Cushioning Materials on the Pliancy of a Running Surface Over Time
Buck Arthur, Central Virginia Governor's School

The purpose of this study was to determine which foam would be most pliant and therefore the best at reducing impact forces if used in a running surface. The rationale for studying pliancy was preventing injury in runners. Three types of foam were tested: polyethylene, Ethylene-Vinyl Acetate (EVA), and polyurethane. The pliancy of each foam sample was determined by dropping a standard size basketball from a height of 2 meters onto the foam and recording it on video so that the basketball's specific rebound height could be measured with Tracker video analysis software. The foam samples were also subjected to mechanical wear via a pneumatic arm with a block on the end that would simulate a foot landing on the foam with significant force. Basketball rebound height data were recorded after 0, 500, 1000, 1500, and 2000 impacts for each foam sample. This data set was analyzed using a one-way Analysis of Variance (ANOVA) test and returned a p-value lower than .00001, which indicates a statistically significant difference between trials when compared to the alpha value of .05. A post-hoc Tukey test was conducted and revealed significant differences between foam samples at all stages of wear but not between all stages of wear within foam samples. The data did not support the research hypothesis, "EVA foam will be the most pliant over time." EVA foam produced the highest rebound height, polyethylene the second highest, and polyurethane the lowest, which suggests that polyurethane would perform best as a cushioned running surface.

Analysis of the Pressure Distribution of Differing Widths and Tensions of Backpacking Hammock Straps

Shayla Utzinger, Blacksburg High School

Recreation ecologist Dr. Jeffrey Marion has referred to recreation in national parks as the “principal internal threat to wilderness preservation” (Marion, Leung, Eagleston, & Burroughs, 2016). Since the creation of the National Wilderness Preservation System (NWPS), millions of acres of land have been set aside for the dual purpose of preservation and recreation (Wilderness Act, 1964). As the use of backpacking hammocking in protected natural areas has increased in popularity, research is needed on the impacts that hammock straps have on trees. This study will look at the pressure distribution of three different widths of backpacking straps hung at different tensions in attempts to determine how to backpack hammock with minimal impact on natural ecosystems. Utilizing high density foam wrapped around the trunk of the tree, this study was able to determine what parts of the tree receive the most pressure and which types of straps had the most impact. This study shows that the tension at which a hammock is hung has a considerable impact on the pressure of the strap into the tree trunk. This study finds that hanging a hammock between two trees with high tension utilizing a thin paracord rope will do the most damage to a tree trunk. This study suggests that the way to hang a hammock with the least impact would be loosely between two trees utilizing 1 to 2” straps. In the future, this research can be useful for land managers to implement better regulations in protected natural areas in order to minimize the impacts of backpacking hammocking.

Single-cell Analysis of Megakaryoblasts by Laser Ablation Electrospray Ionization Mass Spectrometry and Automated Image Processing with Object Recognition
Mahia Rahman, Washington-Liberty High School

Chronic myelogenous leukemia is a type of bone marrow cancer that is challenging to treat due to metabolic reprogramming. Targeting metabolic activities offers a wide range of therapeutic possibilities. Identifying the metabolites in each individual leukemia cell allows for a better understanding of metabolic reprogramming, potentially leading to the detection of control points that helps in diagnosis and improving therapeutic strategies. The purpose was to establish the necessary preliminary steps for single-cell analysis of Megakaryoblasts (meg-01) cells: bulk analysis and recognition of single-cells by image processing. The hypothesis was that the image processing and cell recognition program would successfully segment the images, identify objects, and color the cells based on metabolite intensities from a mass spectra. Bulk analysis was conducted using laser ablation electrospray ionization mass spectrometry (LAESI-MS). Cells were washed with phosphate-buffered saline (PBS). Eight common peaks were found in the PBS and meg-01 cell spectra, assumed to originate from the PBS. An image processing software was developed through Matlab. This program automatically segments the image, identifies the cells, and associates a false-color scale to the cells based on metabolite intensities from a mass spectra. When using the newly developed automated single-cell recognition software in tandem with the previously developed fiber LAESI-MS, there is potential to selectively analyze and associate entire mass spectra with identified cells. An automated image processing method for single-cell analysis was established. The performed bulk analysis allowed for collection of spectra from large cell populations to be used as a reference for single-cell analysis.

The Effect of Wire Direction on a Fog Harvester on Fog Water Collection
Melanie Garber, Clover Hill High School

In this experiment, the hypothesis tested was if the fog harvester with the vertical wires would produce a water droplet which would fall the fastest. This hypothesis and experiment were modeled after the growing water source concern in many countries and many climates. Fog harvesters work best in foggy areas, such as the mountains of Peru or California. Harvesters are used to collect microscopic fog droplets from the air and condense them until they fall into collection bins, harnessing a clean source of water. After gathering materials, special equipment was prepared to begin testing. Next, the experiment was set up with one of the three constructed fog harvesters, either with horizontal, vertical, or gridded wires, above the vaporizer. This allowed the stream of water vapor to be blown through the wires, massing into droplets over time. The effectiveness and speed of each harvester was measured by recording the number of minutes it took for the first droplet to form and fall off of each harvester. This was tested five times per level of independent variable and averaged out. The gridded control harvester, the horizontal, and the vertical harvesters lead to an average of 23.59, 24.67, and 22.9 minutes, respectively. At first sight, the hypothesis was supported by the data. However, an ANOVA test was conducted, and it was found that the collected data was statistically insignificant. Therefore, the null hypothesis was rejected.

Creating a Micro-Hydropower Downspout
Amelia Jones, TC Williams High School

In the U.S., hydropower only makes up 6% of all electricity produced in the country. The US averages 30 inches of rain per year, why not turn this water into energy? This project attempted to convert falling water into energy to create a sustainable source of energy . The goal was for the micro-hydropower wheel to fit into a downspout, convert falling water into energy using a motor, and the wheel to be fully rotational, using paddles or spoons on an axis. To assess whether it was successful, I measured the amount of volts conducted by the fan. My hydropower downspout was successful in every single one of my engineering goals. Through this project I was able to create energy with a fan and motor mechanism in a downspout. The average energy generated constantly was 0.032V.

The Effect of Coating Material on Radar Return
Jack Evans, Yorktown High School

This experiment was conducted to determine how using different coating materials affects an object's radar return. Radar return is utilized in many industries but has become vital in military aircraft design. Stealth aircraft gain a great advantage on the battlefield by attempting to retain the aspect of surprise. This experiment tested and compared the radar returns of five different everyday coatings: aluminum foil, plastic wrap, reflective paint, matte paint, and no coating. The coatings were each applied to spheres in order to minimize possible error due to relative orientation. The spheres were then suspended over a 24 GHz radar and the mode radar return strength was recorded to be used as radar return. While only eight trials were conducted, each trial summarized 200 samples of data taken from the radar. It was hypothesized that the sphere coated in aluminum foil would have the strongest radar return, as aluminum foil is often used for its reflective qualities. This hypothesis was supported, as the aluminum foil yielded the strongest radar return, followed by reflective paint, plastic wrap, no coating, and finally matte paint. The median, mode standard deviation, and logarithmic mean of the trials were calculated, as decibels are a logarithmic unit. Additionally, this data was found to be significant using a single factor ANOVA test. A stronger radar return for the aluminum foil covered ball means more of the signal emitted by the radar made it back to the radar. Conversely, the smaller radar return for the matte paint coated ball meant the paint has radar absorbing qualities. Additionally, the plastic wrap had a similar radar return to that of no ball, showing that it is essentially transparent to the 24 GHz waves. Each of these results are interesting and useful for different situations.

Automatic Power Factor Correction
Denitsa Dimitrova, Ocean lakes High School

America's electrical grid is an aging infrastructure. Although strides have been made in producing electricity more sustainably, the demand for energy has grown exponentially with recent technological advancements. The greater the demand, the more strain is inflicted upon the power grid, which causes vast inefficiencies - such as diluted voltage and power loss. Energy companies compensate for this loss with aggressive pricing for consumers. Most devices that use alternating current from receptacle sources (outlets) do in fact use more power than they are engineered to use, as evidenced by poor power factor ratings. Therefore, many residential and commercial buildings are unknowingly subject to fees for their low power factor. The immediate objective of this research project is to correct power factor through the automatic integration of capacitors into a simulated load, in order to test the device's potential to be used in residential and commercial areas. Power factor producing, power factor measurement, power factor correction, and display circuits were first individually created and later integrated in order to achieve this objective. The device tests the power factor of a resistive/inductive circuit, that with variable inductance produces different initial power factors, and how well the microcomputer responds to that value in incorporating capacitors parallel to the resistive/inductive circuit. On the basis of pass/fail criteria, the device provided the correct output each time. The results show that, with microcomputers, power factor correction methods can be used for more public use or on individual devices that are large sources of energy excess. Additionally, power factor correction, in alleviating America's energy demand, reduces carbon footprint.

The Effect of Different Building Materials and Internet Frequencies on WiFi Strength
Fardeen Bablu and Mike Dertke, Washington Liberty High School

This experiment studied the effects of different building materials on the signal strength of Wi-Fi. The purpose of this experiment was to determine how common building materials affect Wi-Fi signals to help optimize Wi-Fi networks. The internet is a crucial tool for modern life and wireless access to the internet is how most devices get online. However, current Wi-Fi technology struggles to adequately cover large areas and penetrate through walls. One solution to this problem is to place Wi-Fi routers in better places based on which materials will allow the signals to pass through. The building materials tested here were concrete, wood, drywall, brick and the control group was no material. Both 5GHz and 2.4GHz frequency Wi-Fi signals were tested on each material. It was hypothesized that if drywall was used to surround the router and the 5GHz frequency was used, then the speeds would be highest because drywall is made of gypsum which is a very soft mineral that Wi-Fi signals could readily pass through and 5GHz Wi-Fi signals are able to carry more data. Wi-Fi tested on concrete and brick were predicted to have lower speeds because these materials absorb Wi-Fi radiation, which would decrease Wi-Fi speeds. The hypothesis was supported by the data as the drywall had the fastest speeds for both 2.4 and 5 GHz and the 5 GHz test had higher speeds. The materials that blocked the signal the most, in increasing order were: concrete, brick, wood, and drywall. An ANOVA test determined that there was statistical significance in the data and thus the null hypothesis was rejected. Therefore, it was concluded from this study that drywall is the most ideal building material for optimized Wi-Fi speeds.

The Structure of a Quadcopter Drone under Crash Conditions
Henry Myers IV, Blacksburg High School

Drones are becoming more and more common for a variety of military and civilian tasks. They are able to both conduct military strikes and surveillance and assist in putting out fires, driving cars, and delivering packages. Many individuals in the civilian industry who seek to learn about drones or use a drone start with a rotary style drone simply because it costs less than a fixed-wing drone of the same size (Chandler, 2020). Many of the rotary style drones are used for tasks such as remote sensing, commercial aerial surveillance, commercial film picture-making, and package delivery (LaFay, "Popular Uses for Drones"). While these drones are very versatile, they often lack a proper structure due to the weight and open area needed for flight and break easily on impact either via landing or crashing. The following presents a deep understanding of quadcopter design and flight, three new quadcopter designs, and the results of stress testing due to a crash scenario. As discovered by the study the results prove that curvature to the structure and supports attached to the legs enable the quadcopter to absorb more shock from a crash compared to designs of similar dimensions and weight having a more rigid structure and design.

The Relationship Between Angles and Lamé Material on Fencing Hit Frequencies
Mary-Stuart Slack, Chesapeake Bay Governor's School

The experiment conducted was a test on the probability of a hit registering on a fencing lamés constructed with three different metals at three different angles of attack. The lamé is the metal vest fencers wear over their white jackets and attach via a cord to the box and reel, which completes a circuit. I had two hypotheses during this experiment. The first hypothesis was that lamés made with silver would register fewer hits than those made with copper or steel. The second hypothesis was that when the mannequin was positioned 90° to the fencer fewer touches would register in comparison to lamés positioned at 45° and 0°. In the end, there was statistical significance found between the different angles, specifically between 90° and 45° and between 90° and 0°. This significance was expected. In fencing, standing perfectly parallel to your opponent is a useless move, as you cannot push off your back foot hard enough to propel yourself forward. Standing at a 45° from the opponent is the common base position, perfect for controlling your movement up and down the strip. The test showing significance between 90° and the other two angles is further proof that twisting to stand perpendicular is a viable move to make in a match. Additionally, there was no statistical significance found between lamés; however, silver did register the fewest touches out of the three. While there it is nonsignificant, there is enough of a difference to warrant buying and using silver over other metals.

MATH: THEORETICAL & MODELING

The Effect of High-Level Programming Languages on CPU Execution Time
Avirat Raj, Mills E. Godwin High School

The purpose of the experiment was to determine which commonly used high-level programming language has the fastest CPU execution time in seconds. This would help in understanding which programming language is suitable for various forms of data analysis. A continuation of this experiment would test the effect of the fastest programming language on various analytic methods. The research hypothesis of this experiment was that if different high-level programming languages are used, then C would result in the fastest CPU execution time. There was no control in this experiment as each level of the independent variable had varying properties that could potentially cause a change in the experiment, thus rejecting the null hypothesis. There was no program that could efficiently compare against each level of the independent variable. The bubble sorting algorithm was implemented in each language in which a random array was generated and timed for how long the program took to sort. Each program was executed 100 times to gather and record enough data in seconds to have an accurate average. With 198 degrees of freedom and a probability of chance of 0.05, t-tests were calculated. The null hypothesis was rejected as all comparisons resulted in significant data. Java had the lowest average time, 1.869, while Python had the highest, 504.641. Additionally, Java had the least standard deviation, 0.17, while Python had the most, 22.87. Java being a general-purpose language specifies in having the fewest implementation dependencies. Additionally, Python is user-friendly by using dynamic semantics.

Quantifying Gerrymandering in Montgomery County: An Exploration of Cracking in Southwest Virginia

Cedric Christensen, Blacksburg High School

This paper studies the impact that the division of Montgomery County, a left leaning county in southwest Virginia, has on election outcomes in the 7th and 12th Virginia House of Delegates districts. To perform this analysis, this study uses vector representation to divide the 22 precincts of Montgomery County between the 7th and 12th house of delegates districts. To achieve this goal, this study pairs down the 2 million possible divisions of those 22 precincts by limiting the maps to those that fall within the proper population constraints and those which meet the standard of contiguity. With these standards met, the study was left with 1876 viable maps. Using a partisan voting index based on a combination of Lieutenant Governor and Attorney General elections, this paper finds that of possible maps under a 20% population constraint 90% produced two republican victories, while 10% produced one democratic and one republican victory. The map that was produced during the 2000 redistricting falls into the later category, with democrats favored in the 7th district based on the voting index used in this study. Additionally, this study finds that the map produced by the 2000 redistricting was 2 standards of deviations less competitive than other possible maps. These results were corroborated by repeating the methodology using a 30% population constraint, which produced similar outcomes for both partisan outcome and competitiveness. To further solidify the results of this study, it would be beneficial to repeat the analysis with Montgomery County divided into 3 districts, as happened during the 2010 redistricting, and to perform similar analyses on other politically heterogeneous counties that have been split in the state. Ultimately this study recommends a more stringent population constraint during the 2020 redistricting based on the population validity outcomes. In addition, this study recommends that lawmakers solidify a quantitative definition of fairness to incentivize accountability in the redistricting process. This study provides statistical significance to the body of knowledge by providing the public with a previously unstudied quantitative understanding of the impact of redistricting on voting efficacy in Southwest Virginia, in addition to providing a novel methodology that can be applied to other counties across the state and country.

Static and Emergent Shape Thinking in Contrast to Success in Calculus
Quinne Jimenez, Southwest Virginia Governor's School

Calculus is a foundational math applicable to the fields of science, mathematics, engineering, business, and economics. Fundamental to this branch of mathematics is the role of the function; without such, differentiation, integration, and limits would be naught. Static shape thinking and emergent shape thinking act as two cognitive branches of variable relationship perception of graphs. However, emergent shape thinking is vital to understanding functions, while static shape thinking provides an incomplete perception of graphs. The purpose of this research was to highlight students' comprehension of covariational reasoning by administering two tests, a functions test and a calculus test, to gauge their cognitive ability. The first section of the functions test (static shape thinking), as well as the second section of the functions test (emergent shape thinking), was directly compared to the calculus test which acted as the control of the experiment. The null hypothesis stated there is no advantage of emergent shape thinking over static shape thinking concerning success in calculus. The apparent trend was students that scored higher on both sections of the functions test tended to score higher on the calculus test. The two-variable t-test yielded a p-value of <0.0001 , thus presenting statistical significance between emergent shape thinking and calculus. This study furthers the field of math education research by adding the unique perspective of a high school researcher testing fellow high school students to understand their perception of functions. Future studies should include a larger sample size and utilize participant interviews in order to gain more insight into participants' mental actions.

Under What Circumstance Can the Enigma Cipher Machine Be Decrypted?

Diem-Mi Ribler, Central Virginia Governor's School/JFHS

The Enigma was an encryption device the Nazis used during World War II. The purpose of this study was to determine the circumstances under which intercepted Enigma messages could be decrypted without knowledge of the machine settings. A computer simulation of the Enigma was programmed and used to encrypt and decrypt messages. This simulator was also used as the basis for algorithms designed to crack the code. The machine itself employed a polyalphabetic cipher implemented through the use of three interchangeable rotors, a reflector, and a plugboard. Alan Turing and the codebreakers at Bletchley Park were able to crack Enigma messages when they contained some known plaintext using a plugboard deduction algorithm based on assumption and contradiction. This elimination algorithm was able to dramatically reduce the number of machine settings that needed to be evaluated. Turing's elimination algorithm was implemented in the Bombe machine used during the war. A computer program was written to simulate this process. The program was able to determine all rotor settings and the plugboard configuration in an average of one minute. When the known plaintext contained all the letters in the alphabet, it was found that the elimination method was always successful in determining all settings. When known strings contained fewer characters, the program could still decrypt these messages in some cases. Encrypted messages were tried with the same plaintext using various settings of the machine, and in some cases, the program was able to break the code while in others it was not. A sample of settings were tested to determine an estimate of the probability of cracking a message that contained a particular plaintext string.

What is the Simulated Effect of Time in Billions of Years on the Radioactive Decay Measured by the Remaining Parent Isotopes in a Hypothetical Rare Isotope?

Afrin Akhtar, Washington Liberty-High School

The intention of the experiment was to create a simulation of the 100 dice simulation for determining the half-life of isotopes. The 100 dice simulation takes a significant amount of time to complete thus leading to providing a reason to improve upon it. The simulation created was done with a computer program called code.org. A $\frac{1}{6}$ chance of becoming a daughter isotope was given to a set of 100 hypothetical parent isotopes. Then the number of parent isotopes and the number of times 1 billion years passed within the program was counted and the process was repeated. The half-life time determined by the time in billions of years is the time in which the number of parent isotopes was $\frac{1}{2}$ the original amount. It was hypothesized that the half-life time of every trial would be 4 billion years. The hypothesis was not accepted possibly due to not having a constant end time to the number of times the set of parent isotopes could be changed into a daughter isotope. Only $\frac{2}{3}$ of the trials conducted had the same half-life value as the probability.

The Effect of Cryptographic Hash Functions on Speed and Uniqueness

Nitin Kanuri, Mills E. Godwin High School

The role of hash functions is essential to the inner workings of modern cryptography and technology. With the emergence of newer and faster hashing functions, there must be a method to compare them and identify the most ideal hash. The purpose of this experiment is to test for the best hash function based on performance of speed and uniqueness. The uniqueness is an accurate self-derived reflection of the possibility of a collision. There are many reasons for the importance of the experiment, one being that for many companies, a breach in data protection could be unbearably costly. Modern customers invest in companies that provide as much security as possible. This experiment was conducted in the Spring Tool Suite 4 (Eclipse) software and written in Java using a Bouncy House implementation to code and run the experiment. The experiment was run on a Linux operating system. Twenty-five words used as the twenty-five trials were found using a random word generator. Four different cryptographic hash functions, the independent variables, were tested: MD5, SHA-256, Tiger, and Whirlpool. The code was written for the hash function to find the digest (encryption) and the time (milliseconds) taken to encrypt, for each word. The SHA-256 function is the control of the experiment as it sets the norm for hashing. The output of speed found is recorded as the millisecond/char which was the millisecond value divided by the characters of digest for the individual word. To calculate uniqueness: a random number generator of zero through nine was used and the number "1" was received, which is the basis for measuring the randomness and how likely a collision is going to occur. A hash collision is when two different inputs result in the same encryption. Using the output of the digest found in the console, the amount of "1" in the digest is found for each trial (shortened example: c11dc245f3, would result in a uniqueness value of 2 because there are two "1" digit characters). Using that uniqueness value received, the standardized uniqueness value was calculated by using the self-derived formula $x/(\text{chars of digest}) * 48$. The characters of digest are based on the output of each hash function (32 for MD5, 64 for SHA-256, 48 for Tiger, and 128 for Whirlpool). The standardized value was recorded to find the uniqueness of the hash function. The speed in milliseconds per byte and the uniqueness of each function are the two dependent variables that are tested for. The research hypothesis was that SHA-256 would be the fastest and the most unique hash function. The results proved that the data was precise. When testing speed, it was shown that most of the data was not due to chance and significant, inversely, for the majority of uniqueness aspect, the data was not significant. With this experimentation and future research, hash functions will grow so advanced that the probability of collisions and breaches will become close to impossible.

MODELING CHOLESTEROL LEVELS IN AMERICANS AGED 50–85

Jason Lu, Academy at Ocean Lakes High School

In the United States, high levels of cholesterol are correlated with many health-related problems, including cardiovascular problems, which is the leading cause of death today. This project focused on developing an accurate model of cholesterol level using data collected from the 2003-2006 National Health and Nutritional Examination Survey (NHANES) is possible using the programming language R in RStudio, an integrated development environment for R. A secondary goal was to compare multiple linear regression, lasso regression, ridge regression, and elastic net regression. The data was taken and split into a training and testing set, with the model being made through 10 folds of training. Using the testing data, the model was tested and root-mean-squared error, mean absolute error, and R-squared were recorded. The models themselves were more similar than not as the values of the error metrics are relatively close. While both high-density cholesterol and total cholesterol were modeled, it was not done accurately. The models did not have high R-squared values, meaning that the relationship between independent and dependent variables is likely not linear. The models provided insights into which variables contributed to higher cholesterol. Future studies could involve consideration of more variables.

How To Train Your Weak Side: Kinematic Analysis of Dominant and Non-Dominant Hand
Lacrosse Hand Shot.

Solomon Ralston, Charles J. Colgan Sr., High School

Most lacrosse players struggle to develop a non-dominant hand shot that is as effective as their dominant hand shot. The purpose of this research was to use kinematic analysis to determine the difference in shot speeds for dominant and non-dominant hand shots, identify which factors have the biggest influence on the difference, and model the shot speed difference as a function of these factors. Shots from 5 different lacrosse players were recorded using a Microsoft Kinect sensor with motion capture software and a radar gun to measure the shot speed. Feature values for 5 different predictor variables were calculated from the data. The data showed that there is a statistically significant difference in the shot speed for dominant and non-dominant hand shots, with an average difference of 10 mph. Correlation and linear regression analysis showed that Lever Length, Stride Length, and Hip Rotation were the most significant factors influencing shot speed differences. To predict the difference in shot speeds, many model methods were considered including Linear Regression, k-Nearest Neighbor (kNN), Neural Networks, and Random Forest regression models. Random Forest and kNN methods proved most effective, suggesting more complex relationships in the features. The best fit kNN model had acceptable residual errors with a mean absolute error of just over 4%.

Using Makeup Styles to Decrease Facial Recognition Software Effectiveness
Kathleen Carter, Chesapeake Bay Governor's School

Facial recognition is a growing technology that is increasingly invading people's privacy. Makeup is one of the subtler ways of helping defeat it and hiding a person's identity, although sometimes it can accentuate facial features and make a person more recognizable. This experiment tested a facial recognition software by attempting to use three different makeup styles compared against no makeup to thwart the software. The three styles are Dazzle, Basic, and SFX. In this study I used the three different styles on each of 15 participants to "trick" the software. The goal was to get the software to produce a low percentage or no match result. The Dazzle and Basic styles did little to interfere with the software but the SFX was able to defeat it almost half the time. This is most likely due to the fact that the SFX used prosthetics to alter the shape of each person's face.

MEDICINE & HEALTH

Investigating Amalgamations of NURF Knockdown and Chemotherapies Through Metabolic Deviations in Tumor Cells

Ashish Vaidyanathan, Mills E. Godwin High School

Experimentation was conducted to determine the presence of metabolic deviations as a result of nucleosome-remodeling factor (NURF) knockdown in combination with chemotherapies. Due to large levels of tumor relapse, a more thorough and permanent therapy was sought to improve prognoses of those afflicted with triple negative breast cancer. Genetic knockdown of NURF was induced through shRNAs and was used concurrently with doxorubicin, etoposide, and paclitaxel. It was hypothesized that the amalgamation of NURF knockdown and doxorubicin would result in the largest metabolic deviations as it has been known to cause the most sensitization in cell-autonomous assays. An amalgamation of no chemotherapy with a no knockdown cell line was used as the control. Results indicate that NURF knockdown does cause statistically significant differences in baseline OCR levels when used with the two topoisomerase II poisons, doxorubicin and etoposide. However, results regarding deviations in baseline ECAR levels remain inconclusive as a result of statistical insignificance. It is believed that NURF is recruited along with metabolic intermediaries and products to promote abnormal gene expression. Once NURF is inhibited and DNA damage is enhanced with the topoisomerase II poisons, the cells rely on other forms of epigenetic modification to sustain the abnormalities; consequently, there exists an increase in metabolic activity to produce intermediaries and products which are noted to be involved as epigenetic modifiers. Future research can be conducted in order to target metabolism in conjunction with NURF KD and chemotherapies in order to prevent any means of tumor relapse.

The Effect of Biomaterial Type on Performance Under Stress
Yasmine Groener, Mills E. Godwin High School

Several people are in need of organ transplants that they often cannot get. Research has been done to prove that the 3D-printing of organs, or bioprinting, may be a plausible solution to this problem. A study was done to test the effect of biomaterial type on performance under stress. Finding which biomaterial performs best would lead to more improved bioprinted organs. Organ transplants could be quicker, cheaper, and more accessible to patients. The independent variable of this experiment was the biomaterial type. There was no control because there is no standard biomaterial used for bioprinting. A hypothesis was formed that if agarose, chitosan, and alginate were tested under stress, then agarose would show the best performance. The biomaterials were gathered and tested using 30-gram weight that were placed on the samples of each biomaterial. For the 25 trials performed on each level, the samples were rated from 1-5 (1 being poor condition and 5 being good condition). From the medians, agarose was 5, chitosan was 3, and alginate 2. As a result of the median values, it was inferred that the biomaterial type did have an effect on the performance under stress. A chi-square test was performed with a df of 4 and the level of significance was 0.05. With this, the data was shown to be significant and the null hypothesis was rejected. Agarose was found to perform the best, which is likely due to its properties that mock soft tissue.

Investigating the Role of Thiamine in the Epileptic Activity of the *Drosophila melanogaster*
Samhita Vinay, Keertana Yalamanchili & Varshini Subramanian, Thomas Jefferson High School
for Science and Technology

Background: Epilepsy is a neurological disorder that is characterized by seizures (uncontrollable behavior). This disorder can occur at any age and affects more than 65 million globally. Epileptic behavior, which primarily occurs in humans, can be modeled using *Drosophila melanogaster* due to its genetic similarities. Methods: Bang-senseless mutant flies were used as they have been shown to exhibit seizure-like episodes due to a lower mechanical threshold for abnormal activity. In this study, a diet based on thiamine was used to investigate whether an increase in thiamine levels in the diet of *Drosophila melanogaster* would reduce epileptic behavior. Cost-effective webcam technology was used to record the movement of seizure-induced bang-senseless mutant flies that were fed with either standard or thiamine-enriched media. These recordings were analyzed using ImageJ, a computer program, where the movement of the flies was converted into a distance, duration, and speed. Results: The data were analyzed using three unpaired t-tests and a MANOVA test, and it was found that increased thiamine levels reduce SLA distance, but do not significantly affect SLA duration and speed, although a negative correlation between thiamine concentration and SLA speed was observed in BS *Drosophila*. Conclusion: Increasing thiamine levels in the diet of the BS *Drosophila melanogaster* reduces the behavioral intensity of seizure-like activity, but not the SLA duration or speed.

The Effect of IDDSI Testing on Milk Fat Type of Commercial Kefir with Applications for Dysphagia Patients

Charlotte Cunningham, Washington-Liberty High School

The purpose of this experiment was to determine if the percentage of milk fat in commercial kefir had an effect on kefir thickness, as measured by the International Dysphagia Diet Standardization Initiative (IDDSI) Framework, a scale to measure drink thicknesses and food textures. Despite kefir's known health benefits and use in hospitals, there has been no prior research found on the correspondence between the percentage milk fat in drinkable kefir and the IDDSI Thickness Level. The hypothesis was that the milk fat percentage in commercial kefir is related to a higher IDDSI Thickness Level because kefir made from higher milk fats would be naturally thicker. Two brands of commercial kefir and four levels of milk fat percentages were tested. To test the thickness of the various kefirs, 10 mL of each kefir was dropped from a syringe for 10 seconds and then the mean amount of remaining liquid was calculated, which determined the mean IDDSI Thickness Level, respectively. The mean thickness for the control (water) was IDDSI 0 and 0 mL, Lifeway 0% milk fat Kefir was IDDSI 1 and 3.3 mL, Lifeway 1% Lowfat Kefir was IDDSI 2 and 4.62 mL, Wallaby 1% milk fat Kefir was IDDSI 2 and 5.68 mL, Lifeway 3.25% milk fat Kefir was IDDSI 2 and 7.02 mL, and the Wallaby 3.5% milk fat Kefir was IDDSI 3 and 8.2 mL. The p-value from an ANOVA test was 2.4822×10^{-28} , which means that the null hypothesis can be rejected. In addition, the hypothesis was proven, as the percent milk fat of kefir positively corresponds to its thickness. These results show that if patients need to drink thicker liquids, then they should choose a kefir with a higher percentage of milk fat. These findings have applications for speech pathologists, dietitians, and Dysphagia patients, among other groups.

Improving Cancer Cell Sensitivity to Immunotherapy by Targeting Fatty Acid Oxidation
Jalen Wang, Mills E. Godwin High School

Immunotherapy has recently become a viable and a promising treatment option for several cancers including melanoma. However, the majority of patients fail to benefit from such a therapy due to cancer therapeutic resistance. The objective of this study was to identify a novel approach to sensitizing melanoma cells to immunotherapy. Carnitine palmitoyltransferase 1A (CPT1A) is a limiting enzyme of fatty acid oxidation (FAO), a key metabolic process in cancer cells that promotes fatty acid breakdown for energy production as well as therapeutic resistance. To test the hypothesis that inhibition of CPT1A-mediated FAO reduces the resistance of melanoma cells to the tumoricidal activity of antigen-specific T cells, CPT1A knockout of B16 melanoma cells was established using CRISPR-Cas9 technologies and confirmed by immune botting and quantitative polymerase chain reaction analyses. LDH assay was then used to determine percent cytotoxicity, and it was found that the absence of CPT1A did in fact reduce immune resistance of the tumor cells, yielding a much greater percent cytotoxicity for CPT1A targeted cells. Overall, the absence of CPT1A sensitized melanoma cells to the cytotoxicity of T cells. Therefore, the findings of the study suggest that inhibition of CPT1A or FAO may be exploited to improve immunotherapeutic outcomes.

Factors Affecting Flow Rate of Blood during Rapid Resuscitation
Netra Shah, Mills E. Godwin High School

The purpose of this study was to determine simple, yet effective ways to increase the flow rate of blood. During major transfusions, patients need blood fast and are given blood from the blood bank which is cold and concentrated. The blood does not flow fast to the patient and the patient may be harmed since they did not receive enough blood. The flow rate was increased by changing the temperature and hematocrit of blood. In this experiment, the blood was warmed and diluted and the time the blood took to flow through the tubing was measured. A flow rate was calculated for each trial. There were four IV levels and they were blood at 4°C(control), blood at 4°C and diluted, blood at 39°C and blood at 39°C and diluted. The research hypothesis stated blood at 39°C and diluted will have the fastest flow rate. Six t-tests were conducted for this data and they were all significant at a level of 0.001. The results supported the research hypothesis and showed a 170% increase by warming. There was a 232% increase by diluting the blood. There was a 366% by warming and diluting the blood. This concluded that the results were due to the independent variable and not chance. The flow rate of blood is inversely proportional to the blood's viscosity. The viscosity decreases when the blood's hematocrit decreases and when the blood's temperature increases. This research could lead to more use of these maneuvers to improve patient care during these emergencies.

Near-Perfect Melanoma Diagnosis with Optimized Feature Learning and Classification
Gwyneth Liu, Mills E. Godwin High School

The objective of this project is to investigate the effects of feature extractors and classifiers on the accuracy of a neural network in classifying melanomas and melanocytic nevi. As the most dangerous type of skin cancer, melanomas are often misdiagnosed by dermatologists for nevi. Early detection of melanomas is crucial for improving the five-year survival rate. Nine networks were constructed from concatenations of three possible feature extractors (GoogLeNet [G], ResNet-50 [R], and Inceptionv3 [I]) and three possible classifiers (k-Nearest-Neighbor [kNN], Naive Bayes [NB], and Support Vector Machine [SVM]). A bag of features algorithm was used as the control. Using images of melanomas and nevi from the HAM10000 database, the nine networks and the control were first trained and then tested to calculate the correct classification rate (CCR). It was hypothesized that R-SVM would yield the highest CCR. The results showed that R-SVM and G-SVM had the highest CCR. A t-test was performed on the results, showing that the results were significant for all 45 comparisons except the five cases of control vs. R-NB, R-NB vs. G-NB, R-SVM vs. G-SVM, R-SVM vs. I-SVM, and G-SVM vs. I-SVM. The results also showed that the classifier part of a network has a larger impact on the accuracy than the feature extractor part. SVM had the best performance likely because it is more suited for extreme cases. In addition, G-kNN, G-SVM, R-kNN, R-SVM, I-kNN, and I-SVM achieved results that surpass dermatologist performance, with G-SVM and R-SVM also achieving state-of-the-art results for melanoma vs. nevi classification.

The Effect of Different Wound Healing Agents on the Regeneration of Planaria
Rohan Kurup, Todd Allen Phillips Center for Medical Sciences at Godwin High School

The purpose of this experiment was to find the effects of different wound healing agents on the regeneration of planaria. Across the world, millions of people are affected by chronic ulcers and wounds. This results in billions of dollars spent annually to treat them and there are still no widespread solutions to combat this growing epidemic. In this experiment, bisected planaria were exposed to silver nanoparticles, curcumin, and *Ocimum tenuiflorum*. The control in the experiment was no wound healing agent. The length of both the anterior and posterior segment of each planaria was measured every three days and after 15 days the total growth was calculated. It was hypothesized that if silver nanoparticles were tested, they would be the least effective in the regeneration of planaria. The results revealed that on average, the planaria exposed to silver nanoparticles and *Ocimum tenuiflorum* grew the same amount, 0.5 millimeters more than the control, and 1.7 millimeters more than curcumin. As a result, the data did not support the research hypothesis. A t-test was conducted on the data and it was revealed that practically every t-test was statistically significant besides one. It is perceived that the results had this outcome because silver nanoparticles and *Ocimum tenuiflorum* helped spur the formation of neoblasts, while curcumin was toxic to the planaria. Lastly, further studies could investigate the effects of different wound healing agents on animals that are subject to similar wound healing effects as humans, like rats.

The Effect of Aconitum napellus Concentration on *Daphnia magna* (BPM)
Rose Yang, Mills E. Godwin High School

The purpose of this experiment was to examine the effects of Aconitum napellus on *Daphnia magna* heartbeats per minute (BPM). The levels of the independent variable were distilled water (control), 6c, 30c, and 200ck. Distilled water was used as the control because it lacked notable contaminants and was also used to dissolve the tablets, so it provided results that occurred due to the lack of a tablet being dissolved into the petri dish that the *Daphnia magna* resided in. The hypothesis proposed was: if the concentration of Aconitum napellus added is 6c, then the heart rate of the *Daphnia magna* will increase until the organism dies. The BPM was measured using a microscope with a total magnification of 50x and recorded on paper. The research hypothesis was proven incorrect and all the data was found to be statistically insignificant. Furthermore, the results had a high variability and exhibited a low level of preciseness. These results were likely due to an unreliable measurement technique of the *Daphnia magna* heartbeats per minute, the small amount of medicinal substance present within the homeopathic remedies used, as well as inconsistent life cycle stages the *Daphnia magna* were in when they were exposed to the Aconitum napellus and measured.

The Effect of Tampon Brand/Composition on Blood Substitute Absorption
Nadara Hudson, Clover Hill High School

The purpose of this experiment was to determine which brand of tampon would be the most absorbent. For millions of women worldwide, it is useful to know which brand of tampon is the most absorbent at a regular sizing in order to remain sanitary and safe during the menstrual cycle. The hypothesis stated that Playtex tampons would be the most absorbent. Thirty trials were performed for each level of the independent variable, which included a control of cotton fabric and four different brands of tampon; Playtex, Seventh Generation, Equate, and Tampax. The dependent variable was the amount of water that each tampon absorbed. To find the most absorbent tampon, different brands of tampons that were advertised at a regular sizing were left in an 100 mL graduated cylinder filled with water for thirty minutes, and the change in volume within the graduated cylinder was measured. The average amount of water absorbed by each tampon was 1.85 mL for cotton fabric, 20.09 mL for Playtex, 16.59 mL for Equate, 14.46 mL for Tampax, and 17.79 mL for Seventh Generation. The mean amount of water absorbed for Playtex tampons was highest. Therefore, Playtex tampons were the most absorbent. An ANOVA test determined that the F-calculated value (2170.69) was greater than the F-critical value (2.43), meaning that the difference between levels was statistically significant.

Epigallocatechin Gallate Blunts Inflammation Stimulated by Tumor Necrosis Factor- α in Liver Sinusoidal Endothelial Cells Under Varying Oxygen States
Emi Miyazaki & Lexi Nussbaum, Blacksburg High School

Liver diseases result in over 2 million deaths annually around the world. Among such diseases, non-alcoholic fatty liver disease involves liver inflammation and fat buildup in liver cells. Nutraceutical products, such as green tea, have been researched extensively for health benefits to reduce such diseases. Epigallocatechin Gallate (EGCG) is a catechin found in green tea leaves, and previous studies have shown EGCG to have potential anti-inflammatory effects. However, the effects of EGCG on inflamed cells in a low oxygen (hypoxic) state, which acts as an added stressor, are not fully understood. This experiment modeled the effects of EGCG on inflamed liver sinusoidal endothelial cells (LSECs) in both normoxic and hypoxic conditions using an in vitro technique. LSECs were put into a state of inflammation using tumor necrosis factor alpha (TNF- α). The effects of EGCG were analyzed in an adhesion assay to measure cell adherence and qPCR to measure VCAM-1 (an adhesion molecule upregulated by TNF- α) expression. EGCG decreased cell adherence and VCAM-1 expression in both normoxic and hypoxic conditions, but hypoxia was not found to have an effect on inflammation or the success of EGCG. While these results suggest the potential for EGCG to be an anti-inflammatory agent, future work should analyze a variety of adhesion genes and assess the effect of the duration LSECs spent in hypoxia.

The Effect of Zinc Sulphate on Cholera Infections, as Represented by *Escherichia coli*
Kathleen Salmon, Central Virginia Governor's School for Science and Technology

The purpose of this research was to discover if zinc sulphate would be successful in inhibiting the growth of *Escherichia coli*, modeling *Vibrio cholerae*, in search of a cost-effective treatment for enteric diseases highly prevalent in underdeveloped countries. The *E. coli* was cultured in tryptic soy broth and incubated for at least 48 hours at 37°C. Even lawns of bacteria were then created upon tryptic soy agar and filter discs, containing water or concentrations of zinc sulphate solution, were placed onto the center of the petri dishes. This was done in 10 trials with four groups each (control, 1M, 2M, and 3M). The zones of inhibition were measured in millimeters 24 hours later, after incubating at 37°C. The mean diameters expressed that the 3M group was the most effective in inhibiting bacterial growth, with efficacy decreasing by concentration (M = 23.7mm, 21mm, 16.2mm, and 2.2mm, respectively). A single-factor ANOVA revealed a significant difference within the data ($p = 9.5 \times 10^{-21}$, $\alpha = .05$). A post-hoc Tukey test showed that this difference was between every group except the 2M and 3M groups ($D_{\min} = 2.94$). The research hypothesis, that the 3M zinc sulphate solution would create the largest zones of inhibition because it possesses the greatest chemical concentration, was partially supported. The greatest concentrations of zinc sulphate (2M and 3M) were the most inhibitory, but these solutions were not statistically different. Zinc sulphate's success in inhibiting *E. coli* could present a cost-effective alternative for gastrointestinal pharmaceuticals inaccessible in underdeveloped countries.

The Activation of Somatostatin Interneurons adjacent to a Cortical Malformation
Shrinidhi Kittur, Todd Allen Phillips Center for Medical Sciences at Godwin High School

Malformations during cortical development (MCDs) account for a third of childhood epilepsy patients. The increased c-Fos expression during the resulting seizures can allow for immunohistochemical identification of the protein and thus, neuronal activity in different types of cortical neurons can be studied; Somatostatin, an inhibitory interneuron, was hypothesized to show the most activity. To mimic MCDs in experimental groups, freeze lesions were given to mice expressing fluorescent proteins in cells with active c-Fos while “sham” lesions were given to control groups. The brain slices were immunohistochemically stained for different proteins, and the colocalization, or overlap, of the cFos protein was studied. It was found that cFos had high colocalization percentages of 94.45% and 98.20% with NeuN, marking neurons, and 97.62% and 94.28% with GAD, marking inhibitory interneurons; a t-test confirmed there was no statistical difference between cFos and GAD/NeuN positive cells, implying that the initiator was neuronal and inhibitory. When Somatostatin and another inhibitory neuron, Parvalbumin, were stained for, it was revealed that Somatostatin did indeed have a higher colocalization percentage with cFos: 88.32% of cFos in the microgyria region and 84.64% of cFos in the paramicrogyral region. A T-test confirmed the statistical significance of the data. Therefore, Somatostatin interneurons are activated at higher levels during a seizure and can be regarded as the initiators of malformation-associated seizures, supporting the hypothesis. The implications of this study can be profound; Somatostatin-expressing cells can now be targeted by anti-epileptic medications in future studies to lessen the burden of epilepsy in patients.

The Effect of Caffeine on the Growth of the Gut Microbiome
Jad Saleh, Central Virginia Governor's School

This study was conducted to determine if the compound caffeine can effectively inhibit the growth of bacteria. The purpose behind this is to discover new sources of medication to combat the emergence of antibiotic resistant bacteria. To model the gut microbiota, the bacteria *E. coli*, *L. acidophilus*, *C. freundii* and *B. cereus* were used. Half of the groups grew in the presence of caffeine while the other half grew under normal conditions. All groups were cultured in nutrient broth, except for *L. acidophilus* which was cultured in MRS broth, and were grown at 37°C for five days. On day three, one milliliter of a 0.1 Molar caffeine solution was added to the experimental groups. Each group had a total of 10 trials, the groups with the most bacteria present to the least were *E. coli* (No Caffeine), *C. freundii* (No Caffeine), *B. cereus* (No Caffeine), *B. cereus* (Caffeine), *C. freundii* (Caffeine), *E. coli* (Caffeine), *L. acidophilus* (Caffeine) (M = 1.80×10^5 , 2.06×10^4 , 2.04×10^4 , 1.54×10^4 , 1.53×10^4 , 9.92×10^3 , 5.96×10^3 , respectively). Three ANOVAs were conducted for pathogenic bacteria vs. probiotic bacteria, overall growth of all bacteria, and gram positive vs. negative, which indicated significance between all groups ($p < .001$, $\alpha = .05$). A Tukey test for all the groups netted a Dmin value of 7120.38, demonstrating differences between experimental and control groups. The results of this study suggested that caffeine has an inhibitory effect on bacterial growth, which means it may be used as an alternative to treat antibiotic resistant bacteria.

The Effect of Athletic Exertion on Blood Sugar over Time
Nicholas Hoelting, Mills E. Godwin High School

The management of blood sugar for people who have Diabetes is extremely important. Athletic exertion makes it easy to mismanage blood sugar, which can be life threatening. The research hypothesis for this experiment was "If someone exerts themselves for a longer period of time, then their blood sugar will be affected more significantly than it would if they had done a shorter workout." This hypothesis was tested by gathering Diabetic people at a local gym and doing a workout, then having each participant report their blood sugar reading every hour, on the hour, from 11:00 A.M. to 6:00 P.M. that day. This was done on a day with no workout, which is the control, a day with a 30-minute workout, and a day with a 60-minute workout. The data collected showed that blood sugar was affected more on the day with the longest workout. The calculated t values were 3.157, 0.000, and 2.810, making the first and last values statistically significant. These two values were the calculated t values for no workout vs. 30-minute workout and no workout vs. 60-minute workout. The results of this experiment were most likely caused by the need for oxygen created by working out for a long period of time which causes blood sugar to drop, along with the endorphins released during exertion. This research could be used to keep blood sugar maintained during and after sporting events, and could reduce the amount of blood sugar related emergencies. This experiment could be extended by testing blood sugar at different times of day, and experimenting with different types of exertion with even more trials.

GENETIC BASIS FOR PERSONALIZED MEDICINE-WHY MEDICATIONS DON'T HAVE THE SAME
RESPONSE IN ALL PEOPLE?

Ameya Sinha, Yorktown High School

Prescription drugs are important tools in maintaining and improving the health of individuals with chronic diseases, like diabetes, heart disease, hypertension and arthritis. Most prescription drugs interact with signaling pathways involved in important biochemical functions that are controlled by proteins. However, gene mutations cause improper formation, absence, or dysfunction of proteins essential for the action of these drugs. These mutations not only affect drug efficacy and toxicity but can also make prescription drugs dangerous because different people respond differently to these drugs. Since heart disease is the leading cause of death, with about 1 in 4 people dying of heart disease in the United States, the objective of this experiment was to evaluate how genetic mutations in protein formation cause different people to respond differently to cardiac medications like Aspirin and Clopidogrel (which are anti-platelet drugs), and Warfarin (an anticoagulant). This study was conducted by identifying the gene and the rsID (reference SNP cluster ID) of the alleles and determining if mutations leading to allele changes are in the exon or intron. Changes to the amino acid sequences secondary to the mutations were recorded. Differences in protein properties as a result of change were recorded and analyzed. It was also determined how alleles leading to mutations in the exons versus introns affected the drug response. To compare effects of genetic mutations the Fisher Exact Test for comparisons between exon and intron mutations was performed and P values <0.05 were considered statistically significant. The study showed that 154, 109, and 123 mutations affected the use of Aspirin, Clopidogrel and Warfarin respectively. For all drugs most, exon mutations were clustered on 2-3 specific genes (G6PD & CYP2C19 with Aspirin, CYP2C19, CYP2B6, & P2RY12 with Clopidogrel and CYP2C19 & VKORC1) with Warfarin). Exon mutations led to major differences in the efficacy and toxicity of all three drugs (statistically significant differences between exons vs introns noted in toxicity of Aspirin and Clopidogrel; and efficacy of Clopidogrel). This study of the effects of genetics on drugs used in the treatment of heart diseases could be a step forward in understanding the best drug and its optimum dosage to increase patient safety and personalize treatment in the future.

The Effect of an Activity Done Before Bed on the Quality and Quantity of Sleep
Rory McAndrew & Gillian Doherty, Washington-Liberty High School

The purpose of the experiment was to learn which activities done before bed could improve the average female adolescent's sleep. The hypothesis stated that meditation would have the strongest positive effect on the quantity and quality of sleep (as well as dream percentage) of the subjects. Consent forms were signed by the forty participants before involvement in the experiment. Each day for five days, the participants did an activity for twenty minutes, and then proceeded to go to sleep one hour after the activity was finished. The following morning, surveys were filled out with information about each participant's sleep, and all of the surveys were collected at the end of the experiment. The data collected did not support the research hypothesis. The null hypothesis of the experiment, which is that the activity (reading, meditating, or showering) done before going to sleep has no effect on the subject's sleep quality and quantity, was accepted. The data collected at the end of the experiment did not support existing theory and research. Based on the p-values and other statistics, there was no relationship between the activity done before bed and the quantity and quality of sleep or dream percentage. However, this contradicts the existing knowledge that each independent variable level in the experiment has a positive effect on the brain and sleep when incorporated into the sleep-wake homeostasis. Because of this difference between the results and current theories, there were most likely errors in how the experiment was conducted.

Does Physical Activity Affect Anxiety Levels in Teens
Ashleigh Lovelace, Central Virginia Governor's School

The purpose of this study was to determine whether the amount of physical activity an individual performs influences the individual's level of anxiety and to discover methods to positively impact the mental health of teenagers. The study was conducted through an online survey. Participants, who were all teenagers from the same high school, answered questions that measured their self-reported anxiety level on a scale of 1-5, and they reported the amount of exercise they had completed in the past week. Through a correlation and linear regression test, the p-value was determined to be .38 and the correlation value to be $-.179$. As the p-value was less extreme than the alpha value of .05 and the correlation value was less extreme than the Pearson correlation value of .38, it was concluded that there was no significant relationship between the two variables. The data did not support the research hypothesis that stated, "If an individual participates in at least seven hours of physical activity per week then they will experience lower levels of anxiety." The results of this study suggested that physical activity has no impact on anxiety in teenagers. As physical activity has been shown to not impact anxiety, it is imperative to further study what influences mental health.

Ear Canal Shape and Its Impact on Sound Transmission to the Eardrum at Various Frequencies
Andrew Qi, Central Virginia Governor's School For Science and Technology

The purpose of this study was to examine the effects of ear canal shape on the ability of sound transmission by providing data at a wide range of sound frequencies. The broad data generated from this study could serve as the first step in corrective ear surgeries, artificial intelligence sound reception, and adaptive hearing aids. Data was collected at frequencies ranging from 50 to 17,500 Hz, the limits of the human hearing range, from a speaker. The sound was passed through 3-D printed ears to a Vernier sound probe that measures sound intensity. All tests were performed in a sound resistant box. The test objects included 3-D printed ears with four variations: one control, one interior region pinched canal, one middle region pinched canal, and one exterior region pinched canal. Test results were statistically evaluated by a two-way analysis of variance (ANOVA), which determined that there was a strong interaction effect between my variables of ear canal shape and sound frequency, giving a p-value approaching 0 compared to an alpha value of .05. Due to the strong interaction effect, 13 one-way ANOVA tests and post-hoc Tukey tests were used to determine the significance between ear canals at each frequency, resulting in significance among each individual frequency between ears. Additionally, the pinched middle canal overall performed the best, and at one point had a 10% boost in sound transmission compared to the control ear. However, various ears performed better at each frequency, and the pinched exterior canal had the highest performance at 15,000 Hz, with a 27.3% boost in transmission compared to the control. The research hypothesis that the pinched interior canal shape at the highest frequencies would perform the best in sound transmission was partially supported; it performed the best at 17,500 Hz, but the second best at 15,000 Hz. In summary, ear canal shape significantly affected sound transmission, and this can better human health and productivity.

Association of IL-33 Polymorphisms with Reported Reaction Severity to Urushiol
Katelyn Collett, Southwest Virginia Governor's School

Skin reactions to plants containing urushiol are the most common allergic reaction in the United States affecting over 50 million people each year and each person's body reacts differently to it. If a person's reaction intensity could be predicted based on their genetic code, then extra safety measures could be implemented to prevent exposure to urushiol. A survey on reaction intensity was administered and collected saliva samples were analyzed via DNA extraction, PCR, restriction digest, and gel electrophoresis to identify the polymorphisms of rs7044343 for the IL-33 gene. IL-33 is known to enhance irritating skin reactions when it is released upon tissue damage or death, while some rs7044343 variants are associated with the regulation of IL-33 production, for instance the CC variant is associated with higher IL-33 serum levels leading to more severe reactions to urushiol. A Chi square statistical analysis was completed to evaluate the association of the reported intensity of reactions to urushiol and rs7044343 genotypes. The resulting p-value 0.56, compared to the set significance level of 0.05, means that the reaction level to urushiol was not statistically associated with the variants identified in the population tested in the current study. This project was completed with a small sample size and in a short time frame which limited the study to self-reporting reactions to urushiol as well as limited methods for sample analysis. If a larger population could be evaluated and the time permitted direct DNA sequencing for each participant, then the genotypes could be specifically identified allowing for a more powerful statistical analysis of the proposed genotype:phenotype association. These avenues will be pursued in future studies.

The Effect of Screen Time on Neck Range of Motion
Cooper Donovan & Kyle Wilson, Washington-Liberty High School

The purpose of the experiment was to discover whether screen time affected neck flexibility. The hypothesis of the experiment was that if people spend more time looking down at their personal devices, then there will be a decrease in range of motion in the neck because constantly looking down puts a strain on the neck muscles. For the experimentation process, the neck range of motion of each participant was measured using an inclinometer placed on specific points of the participant's head while performing a certain motion. This hypothesis was rejected given that the data collected was found to be statistically insignificant. As a result of this, the null hypothesis, that neck flexibility is not affected by screen time, was accepted. The data was most likely statistically insignificant due to the low number of participants in the experiment. Additionally, age may have played a factor in the inconsistency of the results between each experimental group. Every subject that was tested was between the ages of 14 and 17 years old, typically defined as teenage years. This proximity in age helped maintain constancy in the experimental groups, but since the average age was so young, the results may be difficult to project on the adult population. Perhaps with adult participants, the effect of screen time on neck flexibility may have been amplified. In conclusion, the experiment revealed that neck flexibility may be affected by average daily screen time, but more experimentation would be needed to prove that for a certainty.

Impact of Folic Acid on RNA Methylation and Gene Expression - Implication of Folic Acid
Influence on Autism Spectrum Disorder
Eric Xie, Blacksburg High School

Genetic disorders have continued to be a major issue that has yet to be solved. These disorders have a far greater impact than many people today realize. The fraction of people with mutations that are linked to genetic disorders is around 20 percent. This project further explores the processes behind genetic diseases and attempts to answer by what means and to what extent environmental factors have an effect on the development of them. This is done through the analysis of how two factors are affected by varying folic acid concentrations: RNA methylation and gene expression. To thoroughly compare the differences caused by folic acid on these two variables, computational analysis was performed on the datasets. Two-sample t-tests were used for the comparison of all data. Comparison of gene expression levels under each concentration of folic acid did not indicate any significant differences overall or specifically for genes related to Autism spectrum disorder (ASD). However, a significant difference was seen in gene expression between genes related to ASD and the overall expression level. Analysis of the amount of RNA methylation showed that, overall, each amount under each concentration of folic acid was significantly different, but in genes related to ASD, the values were not statistically significant. The project concludes that there is a likely significant difference between genes related to ASD and those that aren't in terms of these two processes. Furthermore, folic acid concentration does not have an effect on gene expression, but it does on methylation level for genes not related to ASD.

The Effect of Various Cooling Fabrics on Temperature Reduction in a Simulated Heated Environment Modeling the Human Body
Emily Wills, Clover Hill High School

The purpose of the experiment was to determine the effect of different cooling methods on the core and surface temperatures of saline bags. It is important to test these effects because cooling towels could potentially help prevent heat illness. The hypothesis stated that the cooling towel would be the most effective cooling method, which was supported in respect to the surface temperatures, but not the core temperatures. Three saline bags were heated to 43°C, which then had their respective cooling methods placed on top of them (cooling towel, washcloth, no towel). Ten mL of water were spritzed onto each group, and a fan that was 1.5 meters away, was set to the lowest setting to induce evaporative cooling. After 30 minutes, the towels were removed from the saline bags and measurements were immediately taken. The means for the core temperature were 35.0 for no towel, 36.8 for the cooling towel, and 38.7°C for the washcloth. The means for the surface temperature were 34.9 for no towel, 34.0 for the cooling towel, and 35.1°C for the washcloth. The hypothesis was not supported; instead, the control group (no towel) was the most effective cooling method.

The Effect of pH on the Dissolving of Two Specific Pills
Jazmin Johnson, Patrick Henry High School

People want to feel better faster so they can get back to their normal daily lives when they are not feeling the best. The purpose of this study is to investigate the connection between the liquids that people drink with Tylenol Extra Strength and Advil Liquid Gel and how fast they can dissolve so that they can enter the bloodstream. Using lemon juice as the substitute for stomach acid and a timer, this study analyzed everyday drinking liquids and how fast they can dissolve two specific pills — then measured the results against each other to find the drink that would dissolve the pills the fastest. The Sprite and lemon juice were found to play the most significant role in dissolving Tylenol Extra Strength pill the fastest. As for the Advil Liquid Gel, the Crystal Geyser Water and lemon juice were found to play the greatest role in dissolving them. This study definitively answers the question regarding the correlation between everyday drinking liquids with two specific pills and how fast they can dissolve so that they can enter the bloodstream. Further studies are needed to establish other pills that can be tested and what specific drink dissolves these pills the fastest, so people can feel better faster.

The Effect of Various Dilutions of the Homeopathic Drug Arnica montana on the Regeneration of
Dugesia tigrina
Ankita Adhvaryu, Mills E Godwin High School

The experiment endeavored to determine the effect of various dilutions of the homeopathic drug Arnica montana on the resulting regeneration of planaria. Hundreds of millions of homeopathy users exist worldwide. A large percentage consider homeopathy practitioners to be their primary care doctors; however, considering recent reports accusing homeopathic medicine of causing severe symptoms, it is no longer definite that homeopathy is a harmless practice. As a result, it is essential that the consequences of homeopathic treatments be reevaluated. The study exposed planaria to various dilutions of homeopathic Arnica montana (6c, 12c, and 30c). It was hypothesized that if various dilutions of arnica are used to treat cut planaria, then the group receiving no treatment (the control) would show increased regeneration in comparison to planaria receiving any type of treatment. The average regeneration length was calculated for each planaria group. The results revealed that no Arnica treatment resulted in the greatest planaria growth, supporting the hypothesis. T-tests were performed on the data and it was found that the data was overall significant, except for 30c Arnica vs. 12c Arnica and 12c Arnica vs. 6c Arnica. The experiment concluded that all tested dilutions of Arnica were detrimental to the normal healing process of planaria. These results are most likely due to a faulty dilution process that resulted in inconsistent Arnica concentrations, leading the Arnica montana plant's toxic nature to affect the test subject. In the future, the premise of this experiment can be applied to determine how various types of homeopathic treatments affect injured patie

The Correlation Between Depression and Anxiety Screenings
Mehtap Yercel, Academy at Ocean Lakes High School

Alarmed by a high rate of increase in the prevalence of mental health disorders in teenagers, many healthcare providers have adopted the use of mental health screenings to promote awareness and early detection of these conditions. Included among those are the PHQ-9 and the SCARED Questionnaires, screenings that are used to recognize symptoms of depression and anxiety, respectively. This experiment investigated a correlation between these two screenings to understand if both needed to be given to patients at the same time, or if one could be given out based on the results of the other to increase the efficiency of well-visits. It was hypothesized that if a patient answers positively for anxiety through the SCARED Questionnaire, then they would also answer positively for depression through the PHQ-9 Questionnaire, but not vice versa. To test this hypothesis, these screenings were given to adolescent patients between the ages of 12 and 18 who visited a local pediatric clinic for well-visits. Pre-collected and de-identified data from visits spanning three months was analyzed using the Phi-Coefficient to reach a conclusion. The null hypothesis was rejected based on the calculated Z-value of 3.513 at a 95% confidence interval, indicating a significant correlation between the two screenings. However, based on the high number of patients who presented with anxiety but not depression, it was concluded that, until further research is done, both screenings are necessary for well-visit evaluations to conduct a thorough examination of mental health disorders.

The Effect of Hydraulic Force on the Efficiency of Oxygen-Rich Blood Pumped by the Cardiac Muscle

Haasita Akkala, Mills E. Godwin High School

Hydraulic force, a physics concept on pressure, has recently emerged as a key principle in the mechanics of the cardiac muscle, or heart. It suggests that the relative sizes of the atrium and ventricle affects the pressure and efficiency of blood that is pumped. Valuable implications of hydraulic forces testing include potential new therapies for heart failure, benefit scientists who create artificial organs to potentially reconsider the dimensions by which they create, and learning if the current human heart structure is the most evolutionarily efficient. In this experiment three ratios of the atrium to ventricle were tested: 1 to 1, 1 to 2 (control), and 2 to 1. A model of the left atrium and ventricle was created with balloons and straws and was used to simulate properties of a human heart. For each of the 25 trials, the model was pumped once and the resulting "blood" was measured with a graduated cylinder. This method was then repeated for the other two levels of IV. The results indicated that the 1 to 2 ratio had the highest mean and the 2 to 1 ratio had the lowest mean but the highest standard deviation. Further statistical analysis using t-tests revealed that all the levels of IV were significant. These results supported the initial hypothesis that if the hydraulic force in the left ventricle and atrium is changed, then the control ratio of hydraulic force will be most effective in pumping oxygen-rich blood. Research supported these results by explaining that pressure from the veins helps the atria push blood to the ventricle but changing the size of the atrium interferes with this process.

The Effect of Ethylenediaminetetraacetic Acid and Vitamins on Chelating Calcium
Shriya Das, Mills E. Godwin High School

The purpose of this experiment was to determine the effects of different vitamins with Ethylenediaminetetraacetic acid, also known as EDTA. In recent years, research using EDTA to treat cardiovascular disease has become increasingly common. An egg was massed and exposed to either three grams of EDTA, three grams of EDTA with Vitamin A, three grams of EDTA with Vitamin B12, or three grams of EDTA with vitamin D3 for seven days and was then massed again. Each level had a total of twenty-five trials. The control of the experiment was three grams of EDTA without a vitamin. It was hypothesized that vitamin B12 with three grams of EDTA would chelate the most calcium compared to other vitamin and EDTA combinations. The results conveyed that EDTA with vitamin D3 chelates calcium the best with an average reduction weight 0.2 grams more than Vitamin A and 0.05 grams more than Vitamin B12. A t-test was conducted and found that the data for vitamin A versus the control was significant whereas the data for vitamin B12 versus the control and vitamin D3 versus the control was not significant. The results were not supported by the hypothesis. It is believed that the results are due to the short time frame of the experiment and because the EDTA and vitamins were still reacting with the eggshell. This research could lead to further studies determining the effects of different testing time durations, or a combination of multiple vitamins on calcium chelation.

Deletion of the Akt2 Kinase Reveals Sex-Specific Roles in Allergic Inflammation
Aditya Kotha, John Randolph Tucker High School

Not much is known about the similarities and differences between PKB alpha (Akt1) and PKB beta (Akt2) in the signaling pathway of IL-6 in mast cells that are IgE activated for allergic asthma. For this reason, the purpose of this research experiment was to compare and contrast the roles of Akt1 and Akt2 in the signaling pathway of IL-6 in mast cells that expressed allergic asthma. The experiment tested the hypothesis that “The Akt isoforms, Akt1 and Akt2, have different functions in the IL-6 production by mast cells regarding asthmatic allergic inflammation” because of how they function in various diseases. An enzyme-linked immunosorbent assay (ELISA) test, manufactured by BioLegend, was used to measure the amount of IL-6 produced by mast cells that had both Akt1 and Akt2 and that lacked either Akt1 or Akt2. The data revealed that Akt1 and Akt2 have similar functions in males, and that Akt2 has significant functions in females. It was concluded that if a male was to not express one of the Akt isoforms, the other Akt isoform would still be functioning and carrying out the same functions as the absent Akt isoform; however, if a female was to not express the Akt2 isoform, then the mast cells would experience abnormal IL-6 production. Therefore, sexual dimorphism was present in the signaling pathway of IL-6, which may help explain why females are more prone to asthma and suffer from asthma with much more severity than males.

Triangulating Fluoxetine into a Novel Macular Degeneration Therapy via Biochemical, In Vivo & Big Data Approaches
Meenakshi Ambati, Albemarle High School

The dry form of age-related macular degeneration (dry AMD) affects nearly 200 million people worldwide. There is no FDA-approved therapy for this disease, which is the leading cause of irreversible blindness among people over 50 years of age. Vision loss in dry AMD results from degeneration of the retinal pigmented epithelium (RPE). RPE cell death is driven by accumulation of Alu RNAs, which are noncoding RNAs in the human genome. Alu RNA induces RPE degeneration by activating the NLRP3-ASC inflammasome. I report that fluoxetine, an FDA-approved drug for treating clinical depression, inhibits activation of the NLRP3-ASC inflammasome in RPE cells and macrophages, two critical cell types in dry AMD. I also demonstrate that fluoxetine, unlike several other antidepressant drugs, inhibits RPE degeneration in an in vivo model of dry AMD. Finally, I present a Big Data analysis of a health insurance database of 25 million Americans, in which I identified a dramatic reduction in the development of dry AMD among patients with depression who were treated with fluoxetine. Collectively, these studies triangulate to link fluoxetine as a potential drug repurposing candidate that could become the first therapy for a major unmet medical need that causes blindness in millions of people in the United States and across the world.

The Effect of Chemicals on Eroded Tooth Enamel's Change in Mass
Sarah Newman, Yorktown High School

The purpose of the experiment is to discover which chemical improves enamel density in wisdom teeth. This is applicable because tooth decay is the second most common health disorder other than the common cold. Some may expect fluoride to solve this problem, but high levels of fluoride have been proven to lower IQ, particularly in young males (n.a, 2014). Also, a large percentage of people do not have access to cosmetic dental care or any dental care. In the experiment, 10 wisdom teeth were cut in half. The mass was found. The teeth were placed on a metal tray. 15 ml of lemon juice was poured over the teeth. This sat for 4 minutes. The teeth were removed from the juice. The control (no chemicals) was placed in Petri dishes. Next, 8 grams of calcium nitrate was mixed with one milliliter of water and brushed onto the corresponding teeth for 2 minutes. These steps were repeated for zinc nitrate and potassium phosphate and then repeated every 3 days for 4 weeks. The teeth were rinsed off, to remove chemical build-up and reweighed. Data collected during the trials was the increase in tooth mass. Descriptive statistics were calculated. In addition, a one-way ANOVA test was conducted. The data shows the medians are close in numerical value to the means, which highlights fairly consistent data. The ranges had low numerical values. This shows little variation in the data. The standard deviations were all low. This demonstrates the individual data values are numerically close to the mean. In the one-way ANOVA test, there is a P-value of 0.964497, which is greater than .05. This illustrates that there is not a significant difference between data in different treatments. The null hypothesis that chemicals do not have an effect on eroded enamel is accepted. Some bias may have been caused by the chemicals' consistency, as the texture of the chemicals was different when each was combined with water. The calcium nitrate was a coarse grainy powder, zinc nitrate was solid crystals. The potassium phosphate was a fine powder. This resulted in varying consistencies. It was observed that the thinner the powder, the more sticky, thick, and cohesive it was during experimentation. In future testing, chemicals with the same consistency could be used. If the experiment was continued, items such as foods, beverages, or other substances may be used to determine the effects of erosion and remineralization of tooth enamels.

Discovery of Novel Exosomal miRNAs for Lung Cancers: Development of a Biomarker Panel for Rapid Identification of Lung Cancer by Blood Tests
Perisa Ashar, Maggie L. Walker Governor's School

Lung cancer is the leading cause of cancer death, taking about 156,000 American lives annually, while CT scans and x-rays are expensive and time-consuming. MicroRNAs (miRNAs) are small non-coding RNAs that participate in gene-silencing and can be dysregulated in cancer. Exosomes circulate our blood stream, contain miRNAs, and participate in cancer progression and metastasis by transferring bioactive molecules between cancer cells in the local and distant tumor microenvironments, essential for cell-cell communication. This project aimed to develop a novel exosomal miRNA panel and discover the efficacy of exosomal miR-375 as biomarkers for lung cancer. Small RNA libraries of patients' serum were quantified by qRT-PCR, sequenced and pre-processed. Novel miRNA with their default parameters and their abundance changes were identified. A heat-map displayed the expression of miRNAs with p-values <0.05 and fold changes

>1.5, serving as the biomarker panel. This process was completed for Stages I-III of squamous cell carcinoma (SCC), lung adenocarcinoma (LUAD), and small cell carcinoma (SCLC). Per the bioinformatic analyses, miR-1306-5p, miR-374a-5p, miR-374b-5p were selected for lab polymerase-chain-reaction (PCR) validation in LUAD exosomes. Laboratory PCR confirmed that miR-374a-5p and miR-374b-5p were downregulated in advanced stages of the exosomes of LUAD serum samples and cell lines, while miR-1306-5p was upregulated. This project also showed for the first time that exosomal miR-375 was elevated in SCLC and LUAD human serum samples, regular and starved cancer cell lines, and surrounding growth media solutions (vs. benign and SCC samples), per PCR. Discovery of these novel, circulating exosomal miRNAs can be used for rapid identification of various lung cancer types through simple blood extraction tests, while miR-374a-5p and miR-374b-5p can be utilized as promising therapeutics for LUAD.

Assessing the Effectiveness of Dietary Enzyme Supplements on In Vitro Digestion of Dairy and
Gluten Substrates

Alayna Loveland, Chesapeake Bay Governor's School

The human digestive system is extremely complex and has recently become one of the major focuses of current science. Knowing how one's digestive system behaves and what makes it function to its full potential is important because obtaining the understanding of the power this system holds could lead to being more content. Modern food is immensely different from the food that humans evolved with and recently this difference has led to the involvement of our immune and digestive systems. Two major intolerances that have become more prevalent in today's society are intolerances to lactose and gluten. This study investigated whether dietary enzyme supplementation is truly effective and if the two solutions actually work through examining the digestion of 2% and whole milk with and without a lactaid supplement and lactose-free milk, as well as white bread with and without a gluten cutter supplement and gluten-free bread through an in vitro experiment.

MICROBIOLOGY & CELL BIOLOGY

The Effect of Natural Antifungal Agents on *Candida albicans* Inhibition *Marianne Tan, Mills E. Godwin High School*

The purpose of the experiment was to test the use of plant oils as substitutes for clotrimazole medication against *Candida albicans*. In suitable conditions, the fungus can cause cutaneous candidiasis, a widespread and potentially lethal infection for immunocompromised individuals. With cases of off-target toxicity from azole drugs and an emerging drug resistance of *C. albicans* in immunocompromised patients, the use of natural antifungal agents has increased. It was hypothesized that if lemon oil, peppermint oil, and tea tree oil are used in comparison to clotrimazole to inhibit the growth of *C. albicans*, then they will show weaker inhibiting effects than the drug. Clotrimazole cream was used as a control to determine if the plant oils could exhibit the same antifungal efficiency as the drug. The inhibitory effects of each antifungal agent were measured using a zone of inhibition test, which revealed that clotrimazole medication was more effective than all three plant oils, the peppermint oil being the most effective plant oil. A t-test and standard deviation test were performed, showing that the data was significant and precise for all antifungal agents. This implied that the results were due to the independent variable and that the research hypothesis was supported. The results suggested that plant oils are ineffective substitutes to clotrimazole medication in stopping the growth of *C. albicans*. Further studies may show the minimum inhibitory concentration needed for plant oils to be effective against *C. albicans*, its synergistic effects, and their effects compared to other antifungal medications.

The Effect of Antibacterial Cleaning Disinfectants on Bacterial Growth
Harleen Kaur, Mills E. Godwin High School

Disinfectants are used daily without the basic understanding of their true effectiveness. This project is the result of antibacterial cleaning disinfectants on bacterial growth. The initial idea was to compare the true efficiency of antibacterial disinfectants. It was hypothesized that if cleaning disinfectants that are meant for tougher substances/surfaces are used, then the ring around the disk containing the cleaning product will be bigger. In conducting the experiment agar filled petri dishes were used to hold 30 microliters of K-12 *E. coli* and cardboard disks. The 100 cardboard disks were pre-soaked in 4 different IV levels (antibacterial hand sanitizer, antibacterial cleaning spray, antibacterial dish soap, and water (control)) and pushed into the agar before the K-12 *E. coli* was put in. All 100 petri dishes were placed in an incubator at 37 degrees Celsius. The results were conducted 27 hours later by measuring the area between the disk and the bacterial growth with a centimeter ruler. The results revealed that the dish soap has a greater impact on bacterial growth than the cleaning spray, hand sanitizer, and water. Overall, the data for the effect of antibacterial cleaning disinfectants on bacterial growth is statistically significant with the exception of the hand sanitizer, implying that the results of this part of the experiment were most likely due to the independent variable. The dish soap was the most effective because it contained a chemical called triclosan which prevented bacterial invasion.

The Effect of Different Types of Water Treatments on the Concentration of *E. coli* (in bacteria per mL)

Natalia Chahil, Washington-Liberty High School

The purpose of this experiment was to find the effect of different types of water treatments on the concentration of *E. coli* (in bacteria per mL) grown in water. The hypothesis was, if ultraviolet light is most effective at decreasing the amount of *E. coli* then the concentration of bacteria in water will decrease because UV lights will kill the bacteria entirely by damaging their DNA. The hypothesis was not supported by the data. The ultraviolet light had a decrease range of 100-100,000 of bacteria per mL of the 4 out of the 8 trials and the other 4 trials saw an increase in the range of 100 of bacteria per mL and one saw no change. While the UV lights did decrease large concentrations of bacteria, there was also growth of bacteria in more trials compared to the other water treatments. Chlorine tablets had a decrease range of 100-100,000 of bacteria per mL of the 6 out of the 8 trials and 2 of the trials saw an increase of 100 bacteria per mL. The activated carbon/charcoal filter had a decrease range of 100-100,000 of bacteria per mL of the 7 out of the 8 trials and 1 trial had an increase of 100 bacteria per mL. Chlorine tablets were most effective because the data showed how each trial had significant drops of *E. coli* concentrations compared to the other treatments. The experiment was conducted during an approximate 4-week period. Each trial (container of distilled water) was inoculated with *E. coli*, then incubated for 11 days. Each trial was measured using coliform test strips which measured the concentrations of *E. coli* exponentially. Taking all safety precautions, eight trials were treated with a UV light (SteriPen), another eight trials with a charcoal filter, and another eight trials with half a tablet of Chlorine Dioxide. Soon after, the data was collected from each trial using the water test strips and was compared to the same trials prior to treatment. A key finding showed

that a major experimental error occurred by incubating the *E. coli* in water for a very long period of time. This error caused the water treatments to be less effective because of the high toxicity of the bacteria concentrations found in the water. These results indicate how fast bacteria multiplies and how ineffective water treatments are in dealing with these high concentrations of bacteria. Another key finding from the experiment showed that treating contaminated water with chlorine tablets can be more effective at killing the bacteria in the water. This is a significant conclusion given that this method can be utilized in rural areas as well as in developing countries to reduce the chances for their population from getting sick from water borne diseases.

The Effect of *Acinetobacter calcoaceticus* RAG-1 on Oil Spills
Amulya Chowdhory, Mills E. Godwin High School

The purpose of this experiment was to explore the potential that microorganisms possess to rehabilitate bodies of water after an oil spill. When the 2010 BP Deepwater Horizon spill occurred, 205.8 gallons of oil and 225,000 tons of methane ended up in the Gulf of Mexico. Only 25% of the oil was cleaned up and many birds, turtles, marine mammals, fish, invertebrates, and plants were harmed. (Center of Biological Diversity). The hypothesis was that if *Acinetobacter calcoaceticus* RAG-1 is introduced to 2 μl of motor oil, then, after 72 hours, the oil will be the most degraded. The control was no oil because it represents a healthy ocean without any oil spills. The levels of the independent variable were 0 μl , 2 μl , 4 μl , and 8 μl . While experimenting, each sample included the bacteria, nutrient agar, and the oil. The samples were then placed in a water bath shaker for 72 hours and then, the degradation was measured by looking for an oily sheen and emulsions. The mode of the control was no and the modes of 2 μl , 4 μl , and 8 μl were yes. Four chi-squares were conducted, one for each level of the independent variable. The control, 2 μl , and 4 μl levels were found significant, but the 8 microliters level was not found significant. This may be due to the fact that 8 μl was the largest level and the microorganisms may not have been able to degrade that size.

The Effect of SODIS on Bacterial Growth of Pond Water
Nikhil Amin, Mills E. Godwin High School

The purpose of the experiment was to study how solar disinfection, or SODIS, through ultraviolet radiation, affected bacterial reduction in pond water. The testing of various times is beneficial by analyzing the level of efficiency the process is disinfecting at and comparing solar disinfection to other treatment methods. The research hypothesis stated that if pond water is exposed to ultraviolet-A rays as a form of solar disinfection for 36 hours, then its bacterial concentration will reduce the most. The experiment was conducted testing the transmittance of pond water samples with 0, 12, 24, and 36 hours of ultraviolet-A radiation. The control was zero hours, as it consisted of samples with no radiation. The samples were measured using a spectrophotometer to observe the transmittance of light to investigate the water quality, turbidity, and difference in transmittance of light as the concentration of bacteria decreases. After the transmittance of each sample was recorded, the data was statistically analyzed. The results indicated that with 36 hours of radiation, the quality of water was highest with an average transmittance of 93.708%. The low standard deviations represented that the data had high precision. In addition, six t-tests were conducted at a degree of freedom of 48 and a level of significance of 0.05. The inferential statistics results showed that comparisons were statistically significant, and the probability of error was less than 0.05. Based on the findings, the constant flow of ultraviolet-A radiation caused a significant decrease in bacterial concentration over time.

Comparative Analysis of Genetic Mutations In A Sex Differentiated Cohort of Patients with
Glioblastoma

Liala Sofi, Roanoke Valley Governor's School

Glioblastoma multiforme (GBM) is one of the most common and aggressive brain tumors in adults. Significant advances in understanding the molecular pathology of GBM have created opportunities for innovative treatments such as immunotherapy. Survival rates differentiate between genders of patients with GBM, however, there is paucity of data and knowledge of factors that would impart survival advantage. This inspired an in-depth look at differences in genetic makeup between genders with GBM. It was hypothesized that there would be significant differences in genetic mutations and their correlation with survival rates in female patients with GBM compared to their male counterparts. Data mining from The Cancer Genome Atlas was done for patients in the Pan Cancer study. One hundred and eight females' and one hundred and fifty-eight males' top ten genetic mutations were then recorded along with their mutation frequency. This data was further analyzed on the basis of gender and survival time. Six genes were highly expressed in males which were not highly expressed for females, four genes were highly expressed in females which were not highly expressed for males, and fourteen genes were similar between the two. Functions of each of these genes were then identified as controlling cell growth, division and migration. A Kaplan Meier survival analysis was performed to find a correlation between survival rates and genetic mutations. Two novel genes were identified that led to poorer prognosis amongst female patients compared to their male counterparts: SPTA1 and DNAH2. Two novel genes were identified that led to poorer prognosis amongst male patients as well: SYNE1 and TTN. This research is instrumental to future therapeutic development of precision medicine for female and male GBM patients.

The Effect of Neurofascin on Microglial Morphology
Victoria Bui, Mills E. Godwin High School

Microglia are cells residing in the central nervous system which are essential to the brain's development and protection, as they react to any threats to the brain, including trauma or morphological change. However, during multiple sclerosis, it is possible that multiple sclerosis causes microglia to attack healthy tissue. The purpose of this study was to determine if neurofascin, a protein found in microglia, regulates microglia shape. The outcome of this study may be beneficial towards further possible treatment options to prevent the development of multiple sclerosis or decrease damage to the brain during this disease. The hypothesis was that if the tissue samples lack neurofascin, then microglia would extend fewer processes when compared to normal tissue, as neurofascin mediates morphology in non-microglial cells. The independent variable groups were the wildtype, or control, and "knockout." This was to compare morphologies, measured by density, between cells with and without neurofascin. Immunohistochemistry was performed on archived mouse brain sections on slides using an antibody directed against IBA-1 in a ratio of 1:1000 and a secondary antibody in a ratio of 1:500. The slides were viewed through a microscope and images. Images were analyzed utilizing the ImageJ program. The mean density was 0.05828 cell area/convex hull area for the control and 0.06418 cell area/convex hull area for the "knockout." The t-test performed showed the data to be insignificant. It is possible the results are due to confounding variables, such as an insufficient number of cells analyzed and variability of antibody labelling.

The Effect of Spices on Microbial Activity
Margot Sellgren, Washington-Liberty High School

This project is about the effect of spices on antimicrobial activities to see whether at home remedies actually aid in curing infectious diseases. The independent variables are cinnamon, clove, and cumin. They were testing on a sample of *Staphylococcus Epidermidis* which is found on human skin. There were 16 trials for each independent variable and one trial for the control. All testing was done with goggles and gloves. They were left for five days, observed, and then the zone of inhibition was measured. Five days later, some of the spices had been effective and some had been disastrous. Cinnamon had done nothing and there was zero inhibition of the bacteria, nor growth. The zone of inhibition of the cinnamon trials was 0 mm. Cumin had spurred the growth of the bacteria and seemed to support its life. The average diameter of the cumin spores was 32.09 mm. Clove had almost completely inhibited the bacteria. The average zone of inhibition of the clove trials was 39.14 mm. This data could be used to further antibiotics and medical research for practical, natural ways to cure illnesses.

Immune Reconstitution Kinetics Following Unrelated Donor Stem Cell Transplantation Predict
Graft Versus Host Disease

Bennett Clark, Mills E. Godwin High School

The purpose of this study is to determine how different patterns of immune cell reconstitution affect development of chronic graft versus host disease (cGVHD) in patients receiving hematopoietic stem cell transplant. Recent studies have shown that there is a relationship between lymphocytes (a group of immune cells that trigger the onset of cGVHD) and another type of immune cell, monocytes. However, in order to determine the extent and variability of this relationship further research needs to be conducted. It was hypothesized that on average a patient with greater monocyte growth will have greater lymphocyte growth and be more likely to develop cGVHD. Twenty-three hematopoietic stem cell transplant (HSCT) patients from 2015 through 2019 participated in this study. Each patient's blood counts were measured on most days for a complete blood count with differential, over approximately 100 days. Using MS Excel, patient cell growth was modelled as a function of time and a polynomial trendline was fit to the resulting data. Data was separated based on development of cGVHD. Overall, the data showed that the average cGVHD patient had early monocyte growth that was surpassed by lymphocyte growth. Additionally, the non-cGVHD group of patients had significantly less lymphocytes than the cGVHD group at day 60 ($p=0.0181$). High levels of variation were observed between patients. For continued study different subsets of immune cells like T cells or B cells could be studied individually to better isolate the different effects they may have on the development of cGVHD.

The Effect of Synthesized Agents on Prevention of *Rhizopus stolonifer*
Laasya Konidala, Mills E. Godwin High School

Rhizopus stolonifer is a pathogen indicator for post-harvest diseases in agricultural fruit products, accounting for biodeterioration through its strong hydrolytic enzyme system. Within the presence of micro-wounds, the polymorphic spore exudes synthesized enzymes towards cutin degradation. The pathological damages catalyze economic instabilities within poverty-driven regions, and thus, the purpose of the experiment was to analyze synthesized auxins on the host tissue maceration through antifungal metabolite production, employing hyperspectral imaging. ImageJ, an automated microscopy technology, evaluated temporal area increases through primary conidial germination on the focal plane, and mapped the specimen on cellular digital atlases. 2,4-D, NaOPP, DHA-S, and H₂O (control) were diluted to a 1.0 Molar concentration and micro-pipetted upon 108 grape samples, 27 per level of the independent variable. *R. stolonifer* was cultured and the samples were infected with a spore solution to examine their interaction with synthesized agents, through image analysis, mass alteration, and visual scaling. The fungal infection decreased in all experimental groups extrapolating a similar trend of H₂O to NaOPP to 2,4-D to DHA-S for each measurement technique. Evidently, data supported the research hypothesis in the potential for DHA-S to replace conventional fungicides, and rejected the null hypothesis in that there would be no significance with the implementation of synthesized chemicals. The physiological observations were supported with DHA-S's influence on fungal gene expression, through potential inhibition of the cytochrome P450, preventing ergosterol conversion, and lack of C-terminal KETYY sequence, depicting limited alpha-subunit functionality. DHA-S also induced widespread hypersensitivity response through elicitor oligosaccharides and a series of plant defense enzymes: SOD, POD, and PAL.

The Effect of Artificial and Natural Sweeteners on the Growth of *Escherichia coli*
Haleigh Earsing, Central Virginia Governor's School

The purpose of this experiment was to determine the effect of artificial and natural sweeteners on the growth of probiotics. *Escherichia coli* was used as a model bacterium for probiotics and grown in various treatments of nutrient broth (N = 12). The control was traditional nutrient broth, while the experimental groups contained 7 mL of nutrient broth with 12 mL of the treatment solution. Treatment groups were grown for 2 days and represented cane sugar (.4% cane sugar), a natural sweetener (.2% stevia), and an artificial sweetener (.1% aspartame). For data collection, the number of colonies were counted after each treatment was diluted to 10⁻⁵ onto pre-plated nutrient agar and incubated for 3 days. Averaging each group resulted in sugar having the highest colony count, followed by plain, stevia, and aspartame (M = 14.417, 12.833, 6.833, and 0.5). A one-way ANOVA was conducted and indicated a statistically significant difference between the groups ($p < .01$, $\alpha = .05$). A post-hoc Tukey test was performed and indicated a difference between the groups of aspartame and plain, aspartame and sugar, and stevia and sugar. The research hypothesis, that if aspartame is added to *E. coli*, then there will be fewer colonies when compared to the *E. coli* cultured in stevia, was not supported. The results suggest aspartame negatively affects the growth of gut probiotics. Moreover, individuals with diets high in artificial sweeteners may experience stomach issues and have less beneficial bacteria present in their guts.

The Effect of Light on Biofilm Growth
Adam Stievater, Washington-Liberty High School

The purpose of this experiment was to find the effect of light on biofilm growth. The research hypothesis was that biofilm would grow better under light than in the dark, because biofilm is photosynthetic. The null hypothesis was that light would have no effect on biofilm growth. Biofilm was sampled from the Thomas Jefferson Memorial and inoculated onto 40 petri dishes. Half were grown under a grow light and half were grown inside an opaque box. The petri dishes were inoculated for 8 days and then the growth was calculated using ImageJ image processing software. When biofilm was grown under no light, the mean growth was 2.298 cm², the range was 6.319 cm², and the standard deviation was 1.004 cm². When biofilm was grown under a grow light, the mean growth was 4.714 cm², the range was 2.743 cm², and the standard deviation was 0.990 cm². The error bars do not overlap, and a T-test performed on the data returned a p-value of 5.2611×10^{-18} . These imply statistical significance in the difference between the two means, which rejects the null hypothesis and accepts the research hypothesis. Therefore, it can be concluded that biofilm grows better under a grow light compared to in a dark box

Comparing Various Wastewater Disinfection Methods on the Elimination of *Escherichia coli*
Darel Snead, Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine what wastewater disinfection treatment most effectively eliminates colonies of *Escherichia coli*. In order to increase the potability of treated water, *E. coli* was used as a model organism for indigenous wastewater bacteria, cultured within 100 ml of tryptic soy broth for one week. Then the groups were administered with chlorination, copper silver ionization, and UV radiation treatments and compared to the control of no treatment. To determine the effectiveness of the treatments, serial dilutions of each treatment were plated onto petri dishes of tryptic soy agar and the number of colonies were counted over the course of 21 trials ($M = 0, 0, 4.22 \times 10^8$, and 6.34×10^9 CFU/mL respectively). For each treatment, pre and post-test analyses were conducted with a t-test, demonstrating significance for all groups ($p < .001$, $\alpha = .05$). A one-way ANOVA found there was significance in the post-treatment number of colonies between treatment groups ($p < .001$, $\alpha = .05$). A Tukey test ($D_{min} = 6.62 \times 10^8$) determined there was significance between the control and all other treatments but not between treatments which did not support the research hypothesis that UV radiation would be the most effective treatment method on the mortality of *E. coli*. In conclusion, the results suggest that while all treatments were effective at reducing the number of *E. coli* colonies, UV radiation was the least effective. Furthermore, if wastewater treatment facilities use UV radiation when sterilizing wastewater, it should be used in conjunction with other treatments.

The Effect of the Type of Milk on the Mass the Milk Curdles
Mackenzie Anonick, Clover Hill High School

The experiment, the Effect of the Type of Milk on the Mass the Milk Curdles, was carried out to discover which type of milk curdles the most to assist in processes such as cooking. The hypothesis for this experiment was that goat milk will curdle the most and buttermilk will curdle the least. 15 samples of 65 milliliters of skim milk, whole milk, 2% milk, goat milk, and buttermilk were left to sit for 116 hours. After this, the curds from each sample of milk were strained and the mass of the curds was determined. The average mass of the curds was 55.76 grams for skim milk, 49.50 grams for whole milk, 61.53 grams for 2% milk, 0.062 grams for goat milk, and 62.46 grams for buttermilk. An ANOVA test was calculated for this experiment. It was shown by the test that there was a statistically significant difference in the data and the null hypothesis was rejected.

The Division Decision: The Cdc13 Protein and Cell Size Control
Claire Morton, Blacksburg High School

How cells regulate and maintain their size is fundamentally unknown. Failure to maintain a consistent cell size has been associated with cardiac disease, brain disease, musculoskeletal disease, and cancer. The objective of this research is to understand whether the Cdc13 protein in fission yeast is an indicator of cell size. The concentration of Cdc13 decreases at cell division but rises as cells grow. This project addresses whether Cdc13 accumulates as time passes (time-dependent accumulation) or directly responds to cell size (size-dependent accumulation). Predictions about time- and size-dependent accumulation were made using a computational model and experimentally tested using live cell imaging and western blot procedures. The live cell imaging demonstrated increasing concentrations of Cdc13 with cell size and time. The western blot indicated a short protein half-life which, according to the model, suggests size-dependent rather than time-dependent accumulation. This project concludes that Cdc13 concentration increases dependent on cell size. Because Cdc13 is increasing in concentration as the cell grows and is known to induce cell division, it has the potential to act as a sensor to measure cell size and trigger division at the correct size. Many fission yeast proteins' functions are conserved in complex organisms, which may suggest similar size control mechanisms in human and animal cells.

Colloidal Silver for the Treatment of Urinary Tract Infections.
Grace Loos, Mills E. Godwin High School

Colloidal silver's effects on antibiotic-resistant *Escherichia coli* were investigated to determine if colloidal silver was an effective antibiotic that could combat the growing societal crisis of antibiotic resistance. The Kirby-Bauer Disk Diffusion Test was performed by placing antibiotic sensitivity discs impregnated with variable colloidal silver concentrations onto a uropathogenic *E. coli* culture and, subsequently, measuring the diameter of the zone of inhibition. The negative control, no colloidal silver, and the positive control, gentamicin, provided an overview of colloidal silver's antibacterial effects compared to an antibiotic. It was hypothesized that if gentamicin is placed in the center of an *E. coli* colony, then the diameter of the zone of inhibition would be the largest. The research hypothesis was supported by the data because gentamicin's diameter was the largest at 2.01 cm compared to colloidal silver's largest diameter at 0.11 cm. T-tests were performed on the data and implied that the data was statistically insignificant except for five t-tests in which colloidal silver was compared to gentamicin. Colloidal silver's ineffective bacterial inhibition could be because its weak positive charge could not damage the negatively-charged cell membrane and its low surface area-to-volume ratio decreased the amount of destructive reactions that occurred on the particles' surfaces; thus, the cell was not lysed. In the future, the strong positive charge and high surface area-to-volume ratio believed to inhibit bacteria could be studied through ionic colloidal silver and silver nanoparticles to understand the causes of silver's bacterial toxicity.

The Effect of Water Temperature on the Bioluminescence of Dinoflagellates *Pyrocystis fusiformis*
Chris Leffler, Miles E. Godwin High School

The purpose of this experiment was to determine the effect of different water temperatures on the bioluminescence of dinoflagellates. It was hypothesized that the dinoflagellates in the warmest 23.9-degree water would glow the brightest. Bioluminescent bays that are large parts of the economies for some places have started getting darker, it's yet to be determined why, so tourism must be restricted most of the time which hurts the economy. This experiment will see how global warming and other increases in temperature will affect the bays. It will also help predict if global warming will increase the frequency of red tides. Dinoflagellates were put in temperature-controlled water for a day, their bioluminescence was measured using a hand-held photometer held 5 centimeters away when the container is swirled. There is no control because there is no temperature considered average for water, but the 23.9-degree water is above the 22-degree average of ocean temperature. The results

The Correlation Between Catalase Concentration in Various Organisms and Lifespan
Dzenita Gazic and Rita Rizkallah, Wakefield High School

Given the presence of catalase in various organisms, it was reasoned that catalase could possibly be a predictor of cellular health and thus, serve as an indicator of overall longevity due to its vital role in mitigating oxidative stress. In this experiment, the catalase concentration of various organisms was identified and correlated to the lifespan of the organism. The catalase concentration of tissues from apple, potato, yeast, and chicken liver was determined by using a standard curve measuring the percentage of oxygen gas produced in the presence of hydrogen peroxide. It was found that yeast tissue released the most amount of O₂ at 18.33%, indicating 11.08% of catalase by concentration. However, in spite of chickens having the longest average lifespan of 84 months out of all the organisms tested, liver tissue only showed a modest amount of O₂ of 18.02%, suggesting a catalase concentration of 9.51%, much less than hypothesized. Our results showed that catalase is not a good predictor of cellular health, as the correlation between catalase concentration and lifespan was not as positive as predicted.

The Effect of UVB Light on *E. coli* in Water
Ryan Gallagher, Central Virginia Governor's School

The purpose of this experiment was to determine the effectiveness of UVB light as a method to eliminate *E. coli* from water. Water samples were collected from a local river in a gallon water jug and divided into four groups of ten 10mL samples. Each group was then exposed to a Zilla Slimline Desert 50 UVB T8 Fluorescent Fixture for a designated amount of time (30, 60, and 120 minutes), with a control group that was not exposed. A LaMotte™ Total Coliform Test Kit was then used to test for and determine the levels of *E. coli* left in the water samples following exposure to the light. A one-way ANOVA (alpha .05) resulted in a p-value of 1.127×10^{-3} determining a statistically significant difference between groups. A post-hoc Tukey Test (Dmin .414) revealed the difference was between the 30 and 60 minute groups and between the 30 and 120 minute groups. The research hypothesis, "If *E. coli* is exposed to UVB light then the minimum amount of time it will take to eliminate the bacteria will be 60 minutes" was not supported. While there was a decrease in the levels of *E. coli* in the 60 and 120 minute groups, the bacteria was not eliminated. The study found that different levels of UVB exposure influences levels of *E. coli* but does not eliminate it from water. With more research and improvements in methods, UVB could potentially become an effective method for purifying water.

Stability of the Serine Hydrolase Inhibitor AA74-1
Dasol Lee, Blacksburg High School

The Plasmodium parasite causes malaria, a devastating infectious disease that caused 405,000 deaths in 2018 (World Health Organization [WHO], 2019). While inside a red blood cell, Plasmodium spp. uses numerous proteins from the host cell as food. Acylpeptide hydrolase (APEH) is one of the first known hydrolytic host enzymes that collects in the parasite and is necessary for asexual reproduction (Elahi et al., 2019). When added to a culture with parasite-internalized APEH and erythrocyte APEH, AA74-1 (an APEH-selective inhibitor) was found to inhibit the erythrocyte APEH but not the internalized APEH (Elahi et al., 2019). The interesting result led to the central question behind this research project: why was the internalized APEH not inhibited by AA74-1? Based on the theory that AA74-1 is inactivated before it reaches the parasite-internalized APEH, this research determined whether the Plasmodium falciparum aminopeptidase PfA-M1 is able to hydrolyze AA74-1. This research found that both PfA-M1 and crude *P. falciparum* lysate did not inactivate AA74-1. It also tested for differences in pH and found that pH did not play a significant role in inhibition of APEH by AA74-1.

Isolating the Periplasmic Region of GacS(39-164) from *Pseudomonas aeruginosa*
Cameron Gilmore, Blacksburg High School

The two-component signal transduction system, composed of a GacS histidine kinase and a GacA response regulator, indirectly controls the virulence of many gram-negative bacteria. Although the overall system has been modeled to great detail, little is known about the periplasmic domain of GacS. This region is responsible for the reception of extracellular signals. Here, I explore the viability of isolating the sequence GacS 39-164 and expressing it as an independent construct using Gateway cloning. Results indicated that GacSperi remains stable once separated from the rest of the system. This knowledge unlocks new opportunities for research. Site specific testing may be done on the periplasmic region of GacS which could prove useful for circumventing current barriers in research.

The Effect of Antibacterial Teas on *Staphylococcus epidermidis*
Lauren Thomas, Washington-Liberty High School

The purpose of this experiment was to study the zone of inhibition (cm) caused by antibacterial teas on *Staphylococcus epidermidis*. The hypothesis stated that if three different common household teas are tested on *Staphylococcus epidermidis* bacteria, then green tea will be the most effective in killing the *Staphylococcus epidermidis* bacteria because of the (-)-epigallocatechin-3-gallate antibacterial catechin it contains which may inhibit the growth of bacteria. Pomegranate, mint, and green tea were the three independent variables with the control being sterilized distilled water. Pomegranate tea inhibited bacteria growth at an average of 2.2 cm, mint tea inhibited bacteria growth at an average of 2.0 cm, green tea inhibited bacteria growth at an average of 1.5 cm, and the control inhibited bacteria growth at an average of 1.1 cm, this data did not support the hypothesis. An ANOVA test was conducted in order to determine if the averages were significantly different. The calculated p value was 0.927, which is over the critical value of 0.05, and therefore the data was not significant. Additionally, seven T-tests were conducted, all seven groups were above the critical value of 0.05 and the null hypothesis was accepted. The results show that mint, green, and pomegranate tea have no effect on the growth of *Staphylococcus epidermidis*. These results indicate that antibiotics which use a form of pomegranate, green tea derived from the camellia sinensis leaf, or mint derived from the spearmint leaf are ineffective. These results also show that body scrubs or body products used to cleanse the body which use pomegranate, green, or mint ingredients may be ineffective. Especially, in natural or organic body cleansing products which primarily do not use chemicals to aid in the cleansing process.

The Effect of Different Minerals on *Escherichia coli* K-12 Growth.
Katherine Rynes, Washington Liberty High School

Escherichia coli K-12 was treated with iron, sulfur, copper and a constant variable of nothing to determine which element would impede the most growth. The experiment was performed as a Zone of Inhibition experiment in a Petri dish. The research hypothesis predicted that iron would perform the best because it is a metal and could be overdosed easily and kill the bacteria. Levels of the IV were administered through a thin paper disc into the inoculated Petri dishes. After 96 hours, the zones of inhibition were measured and recorded in terms of growth. If the Petri dish showed a zone of inhibition, the area of inhibition was then subtracted from the total area of the Petri dish, as to display growth of bacteria rather than decline. Sulfur had the lowest mean of 708.44 mm², and aside from the full growth of the control group, iron had the most bacteria growth of 1261.58 mm². Copper had a mean zone of inhibition of 1140.23 mm². The null hypothesis stated that there would be no difference in growth between the *E. coli* groups treated with any of the elements. The null hypothesis was rejected after an ANOVA p-value of 0.0012 was calculated, which supports a statistical significance in the data. As well, the data rejects the research hypothesis, because against copper and sulfur, it repels bacteria growth the least. However, it cannot easily be said sulfur is the most effective in killing *Escherichia coli* K-12, because it has a high standard deviation of 670.16 mm², which suggests bad data. Copper has a standard deviation of about half: 341.91 mm². However, a significant difference exists between the two, as sulfur performs much better than copper, by about 400 mm².

The Effect of the Source of Contaminated Water on Bacteria Content after Filtration using Plant Xylem

Keira Taylor and Emily Dick, Washington Liberty High School

This experiment was conducted to determine if plant xylem could be effective at filtering out bacteria found in contaminated water. The hypothesis stated that if water was passed through a conifer tree xylem tissue filter, then bacteria in water would be filtered out, because the microscopic holes that connected the cells would not allow bacteria to pass through. The hypothesis was partly supported based on the results because there was a significant decrease in bacteria growth in water tested after filtration, but there was still bacteria in the water. The results allowed several conclusions to be drawn. Firstly, since there was a decrease in bacteria growth between the groups of water before filtration and after filtration, this indicated there was some effectiveness of the xylem in removing the bacteria in contaminated water. However, there was still a substantial amount of bacteria after filtration, which indicates there was still bacteria that went through the xylem, or there was bacteria in the plant xylem, and while it stopped some bacteria from the water, bacteria was added since it was filtered through a conifer tree branch.

The Effect of the Type of Antibiotic on the Presence of *Micrococcus luteus*
Gaston Finger and Grace Gent, Washington-Liberty High School

This experiment was designed to address the current health issue of antibiotic resistant bacteria and specifically examined the effect various topical antibiotics had on bacteria. In this experiment, Petri dishes were covered in bacteria (*Micrococcus luteus*) and then three different antibiotics ointments were applied to three groups of Petri dishes. After the incubation time, the areas of inhibition were measured and recorded, then compared to the ones of the control. The results of this experiment were favorable as each level had its own independent and unique results. The hypothesis, that Neosporin would result in the largest inhibition areas because it contained the most active ingredients, was accepted. Furthermore, the results came in the order expected with Polysporin having the second largest area of inhibition and bacitracin having the smallest. The null hypothesis was also rejected because an ANOVA test revealed distinctions between the independent variable levels. Additionally, the standard deviations of the data sets did not overlap for separate levels, giving more reliability to the data. Therefore, it was concluded that more active ingredients in a certain treatment cause greater negative effects on bacteria.

The Effect of Different Antibiotics on the Growth of Bacteria
Siri Saligrama, Mills E. Godwin High School

The purpose of this experiment is to find the effect of various antibiotics/antibacterials on *Escherichia coli* bacteria. The research hypothesis states that the hybrid antibiotic containing ciprofloxacin and oregano oil would kill the most *Escherichia Coli*. This experiment is important to the world because it could improve the effectiveness of antibiotic treatment. The independent variables in this experiment are ciprofloxacin, oregano oil, and a hybrid antibiotic that is a mixture of ciprofloxacin and oregano oil. A phosphate buffer solution is used as the control. To place the antibiotics on the petri dish, tweezers are used to dip the sterilized zone of inhibition disks in the antibiotic and place it on the bacteria-filled petri dishes. A ruler is used to measure the zone of inhibition in centimeters. The ciprofloxacin is found to be the antibiotic that kills off the most *Escherichia Coli* as it has an average zone of inhibition of two centimeters. The control has killed the least amount of bacteria as it has an average zone of inhibition of 0.2 centimeters. T-tests show that each group is significantly different at a 0.05 level of significance. The hypothesis that was formulated is not supported in this experiment. The results of the experiment are most likely caused by an antagonist effect where the receptor molecule is blocked. Future experiments can be done based off of this one, such as testing out different antibacterials combinations, or working with different strains of bacteria.

The Effect of Light Intensity on the Cyanobacterial (*Synechocystis nigrescens*)
Poly- β -hydroxybutyrate (PHB) Bioplastic Production
Vaibhavreddy Maru, Mills E. Godwin High School

An experiment was conducted to investigate how different light intensities affect Poly- β -Hydroxybutyrate production by cyanobacteria. Plastic has played a major role in environmental pollution due to the toxic chemicals in plastics that lead to increased global warming and poisoning of animals. PHB is a biodegradable plastic that can replace plastics and is applicable in various industries such as medicine and clothing. However, its production cost is very high, therefore ways to optimize production in the most cost-efficient way possible are being investigated. Most of the cost is due to the carbon source. Therefore, the use of CO₂ as a carbon source is one possible answer to this problem as it is very cheap. This experiment explores light intensity as one way to optimize bioplastic production while using CO₂ as the carbon source. Cyanobacteria was cultured in three agar plates and were put in a cardboard box with 150 g of CO₂. Then, a 240 lumen LED desk lamp was placed in one of the boxes 40 cm away from the agar plate and 5 cm away from the agar plate in a different box to represent 1,500 lux and 9,600 lux respectively. This was calculated using the formula $\text{lux} = \text{lumen}/\text{m}^2$. After 68 hours, 25 samples were taken and stained using Sudan Black B. Each sample was given a rating between 1 (lowest) – 5 (highest) based on how much blue was present in the sample. It was hypothesized that the cyanobacteria grown in 0 lux will produce the most PHB. The results revealed that the *S. nigrescens* grown in 0 lux had the highest median (5), 1,500 lux had a median (2), and 96,000 lux had the lowest median (1). A chi-square test was performed to determine the significance of the results, and it revealed that all the observed results were significant. Due to these results, the research hypothesis is supported. One explanation for these results is that the cyanobacteria placed under high intensity of light went into photoinhibition which limited the amount of substrate able to use for fermentation. It was also found in previous studies that elemental sulfur can be used as an electron acceptor in the dark and that it plays a role in converting stored carbohydrates into PHB. A source of error is that this data is qualitative and using dry cell weight, IR spectroscopy or flow cytometry to quantify the data would be an improvement. For further research, the effectiveness of PHB in different industries can be investigated.

PHYSICS & ASTRONOMY

The Effect of Magnetic Shielding Geometry on Focality for Transcranial Magnetic Stimulation
Chirayu Nimonkar, Mills E. Godwin High School

Transcranial magnetic stimulation is a growing field that holds the potential to revolutionize neuroscience research and medicine. To fully realize the capabilities of this technology, every aspect of the treatment must be optimized. This investigation aimed to determine the effects of magnetic shielding geometry on the focality of the stimulation area. A hybrid geometry was developed and hypothesized to yield the highest focality of the tested geometries. Using Sim4Life finite element simulation software, a spherical model was stimulated with a figure-8 coil with a V-shape, parabola, and hybrid flat-U shield above the head. Stimulation with no shielding was also measured as the control to compare the results with the shielding. The raw Sim4Life files were post-processed in MATLAB to retrieve the percentage of the sphere that was stimulated above a threshold, which was a representation of the focality. The hybrid geometry had the highest focality (0.793% stimulated) followed by the V-shape, parabola, and control. The observed results supported the hypothesis because the hybrid geometry yielded the highest focality. Multiple t-tests showed that each comparison was significant, and therefore shielding geometry influences focality. The findings from this experiment are similar to other studies that found shielding has a significant impact on focality. The hybrid geometry, which was designed to incorporate the best characteristics of the parabola and V-shape, had the highest focality as it redirected more magnetic fields into the desired region. To optimize performance, further research into magnetic field interactions and other shielding characteristics would be needed.

The Effect of Visible Light-based Methods on the Identification of Galaxy Mergers
Erum Vohra, Mills E. Godwin High School

This experiment aimed to investigate the benefits of stellar velocity data on the identification of galaxy mergers. Galaxy mergers are commonly identified with the use of visible-light photographs, which provides an external view of a galaxy, obscuring other information. Using stellar velocity, movements within a body can be identified, allowing a more nuanced classification of galaxies. In this experiment, the formulated hypothesis was if stellar velocity is used to identify galaxy mergers, then it will identify mergers more accurately. Data from the Sloan Digital Sky Survey's Mapping Nearby Galaxies Program were collected and assembled into a training dataset. This data set was fed into Uber Ludwig, a machine learning program that creates algorithms based on data points. Once the algorithms were created for the two levels of the independent variable, stellar velocity and optical photographs, the algorithms were tested with a prediction set of data points. The results indicated that the stellar velocity algorithm was more accurate relative to human classification. The results of the experiment were tabulated and analyzed with a chi-square test, which showed that both of the levels of the independent variables were significant when compared to the expected distribution. Stellar velocity was the more accurate model because it allowed invisibly merging galaxies to be identified, as coalesced galaxy mergers can still have irregular movements within a galaxy. This experiment can be applied to more closely study star formation rates and the interaction of dark matter.

The Effect of Meteor Impact Location on the Energy Transmitted
Cameron Sharma, Mills E. Godwin High School

The Earth's geological, evolutionary and biological history has been shaped by the collisions with celestial bodies such as asteroids and comets. Their contributions can also cause destruction, as in the case of Chicxulub impact when dinosaurs and 75% of the species became extinct. Fortunately, such catastrophic events are rare. However, less-damaging though devastating impacts such as Tunguska and Chelyabinsk happen frequently. The purpose of this experiment was to study the effect of a meteor's strike location on the amount of damage done to a terrestrial planet such as Earth. This experiment comprised a physical model and three software simulations. The model was built in a pool using a pneumatic actuator and a large latex balloon with an iridescent surface. The wave propagations on the balloon surface were captured using high speed underwater cameras and analyzed with artificial algorithms. The simulations were a combination of custom written computer code and an off-the-shelf module. In the first simulation, an impactor was modelled based on the published parameters of the Chicxulub impactor. Numerous mathematical models have been built to estimate the mass, diameter and the energy of the asteroid at the time of impact. The estimated values of these parameters vary widely. The values of the parameters were interpolated in this research. The simulator was coded in Python. The second simulation was done in MATLAB to study the wave propagation around the globe. The third simulation was performed with iSALE, a third-party module. It modeled the effect of the impact. The results supported the hypothesis that when different terrains were tested, the impact on an aquatic location had the greatest energy dissipation and therefore the least damage. The t-tests failed to discard the null hypothesis. Future work could be extended to more precise algorithms and physical equipment.

The Effect of Different Materials on Sound Diffraction
Sarah Craft, Clover Hill High School

The purpose of this experiment was to find out which material diffracted the most sound. The rationale behind the experiment was that by diffraction of sound waves it would help circulate sound better in rooms such as auditoriums and classrooms. The hypothesis was that wood would diffract the most sound. The levels of the independent variable were plastic, styrofoam, wood, and cardboard. The control was the medium of air for the sound waves to pass through. All of the materials were cut to be 27.6 by 13.3 centimeters long. Then they were placed between two electronic devices; one which played a recording of a guitar note, the other which had an oscilloscope app to measure the sound waves in decibels (dB). Each of the different materials and control was given 20 trials and then the data was compared. The means were -11.85 dB for the control, -16.71 dB for the plastic, -22.45 dB for the styrofoam, -22.21 dB for the wood, and -16.51 dB for the cardboard. The data showed significant differences between the levels of the independent variable so the null hypothesis was not supported. The hypothesis for the experiment was not supported for the styrofoam was able to diffract the most sound rather than the wood.

The Effect of Materials Inside a Baseball Bat on The Distance the Ball Travels
Anthony LoBosco, Clover Hill High School

The purpose of this experiment was to determine the effect of the materials inside a baseball bat on the distance the baseball traveled. Knowing what allows the ball to travel farther allows for Major League Baseball (MLB) to adjust the rules to the best possible outcomes. To measure the distances with each bat, the balls were placed on a tee and hit. An app called BlastVision was used to calculate the distances the balls traveled with each bat. The five levels of independent variable were control, corked bat, saw-dust bat, hollow bat, and bouncy ball bat. The distances were recorded in a data table, and this process was repeated until each level had 30 complete trials. The control bat (no drilling or filling) produced a mean distance of 49.71 meters (m). The bat that was filled with the cork led to an average distance of 65.86 m. The saw dust filled bat generated an average distance of 48.95 m. The bat that had bouncy balls inside of it caused the ball to travel 44.98 m on average. The hollowed out bat's trials resulted in the ball traveling an average of 50.56 m. 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 a statistically significant difference between two of the levels of independent variable because the F value was greater than the F Critical value. The experimental hypothesis of this experiment was that the bouncy ball filled bat would cause the ball to travel the furthest. This was not supported.

The Effect of Different Dome Shapes on the Strength of Domes of Eggshells
Samantha Graham, Clover Hill High School

The question that was addressed in the experiment was which shape of dome would hold the most mass. The purpose of the experiment was to determine the most mass-holding dome shape that could be applied to architectural designs. The hypothesis was that if a large mass was applied to the peak of a duck egg, then, the duck egg would hold the most mass before breaking. Ten trials of three different species of egg, duck, chicken, quail, and a control, a dome that was 3D printed, were measured for the eggs' circumference with a tailor's centimeter measuring tape. The circumference measurements for all of the eggs were recorded into a data table. The eggs were placed in between the measuring device and set amounts of water were added to a container that was placed on top of the measuring device. Set amounts of water were added to the container until the egg that was being tested broke. The water that was present after the egg broke was measured on a digital kilogram mass scale and was recorded into a data table. The data regarding the circumference and mass that were needed to break the egg were used to calculate the breaking force per unit circumference and were displayed in Newtons per centimeter (N/cm). The highest of the means was the dome that was the 3D printed level, which was 9.4 N/cm, while the duck egg level's mean was 2.3 N/cm. The chicken egg level's mean was 2.4 N/cm and the quail egg level's mean was the lowest and was calculated to be 1.2 N/cm. The experimental and null hypotheses were rejected. From the experiment and the ANOVA tests that were conducted, the domes that were 3D printed were found to hold the most mass at the egg's breaking point and the quail eggs were found to hold the least mass at the egg's breaking point.

The Effect of Simulated Martian Crustal Compounds on the Attenuation of Ionizing Radiation
Drew Flint, Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if Martian sediments had a significant effect on the attenuation of ionizing radiation and to examine if different sediments and their depth altered the amount of radiation attenuated. Four simulated Martian materials were tested: Olivine sand, calcium chloride, Kaolin clay powder, and ferric iron oxide at four depths: two, four, six, and eight centimeters. A Vernier probe measured the ionizing particles that passed through the materials during trials, and the data was recorded. Sixteen two-sample t-tests ($\alpha = .05$) revealed significant difference between each testing group and the control; no p-value exceeded 8.65×10^{-88} . A two-factor Analysis of Variance (ANOVA) with replication ($\alpha = .05$) indicated a significant difference between the type of shielding material ($p = 1.12 \times 10^{-9}$), depth of the shielding material ($p = 2.07 \times 10^{-23}$) and indicated an interaction effect between the variables was present ($p = .004$). A post-hoc Tukey test suggested an inversely proportional relationship between the depth of the shielding material and the intensity of the ionizing radiation transmitted through it. On average, groups of ferric iron oxide and Olivine sand attenuated more radiation than the other materials. The research hypothesis that ferric iron oxide at an eight centimeter depth would attenuate the most radiation was partially supported. Results from this study can be used to determine the ideal location on Mars for settlement to maximize protection from space radiation by utilizing natural crustal materials.

The Effect of String Tension on Ball Accuracy and Speed for Different Skill Levels of Tennis Players
Megan Knight, Central Virginia Governor's School

The purpose of this study was to determine whether string tension had a significant effect on ball accuracy and speed for different skill levels of tennis players. Four skill levels were tested each with eight participants excluding the highest skill group, which had three. Three different string tensions were used in this study: loose, medium, and tight. Each participant hit around 15 forehands and 15 backhands with each racquet. Accuracy was measured by percentage of balls that landed in the court and ball velocity with a radar gun. A ball machine fed the balls to the participants. Three two-way ANOVA tests (with replication) revealed the interaction effect of different string tensions for accuracy and speed with beginner, intermediate, and advanced tennis players. These tests revealed a p-value of .953 for accuracy, a p-value of 1.00 for forehand velocity, and a p-value of .518 for backhand velocity. Three one-way ANOVA tests for professional tennis players revealed a p-value of .900 for accuracy, a p-value of .808 for forehand velocity, and a p-value of .581 for backhand velocity. Because all p-values were higher than the alpha value of .05, the results of this study did not support the research hypothesis that tighter string tension would result in ideal performance for lower skill levels and that looser string tensions would result in ideal performance for higher skill levels. The results of my study suggested that racquet string tension does not affect ball velocity and accuracy across skill levels of tennis players.

The Effect of Temperature of the Impulse Created by a Baseball
Adam Lee, Central Virginia Governor's School

The purpose of this experiment was to determine whether different temperatures had an effect on the impulse created by a baseball, due to a longstanding controversy in Major League Baseball (MLB). Conducted at a local high school, impulse testing was used to represent a baseball coming in contact with a bat. Three different groups of baseballs were tested at different internal temperatures. There was a cooled, heated, and control group. A video analysis was conducted in order to determine the impulse created on each drop. Each baseball was individually dropped onto a piece of wood from a 3.7 meter ladder. The video analysis consisted of using a software that provided the inbound velocity, rebound velocity, and time, which was used to find impulse. The average impulse for the heated group was 1.462 N*s.

The Effect of Padding Materials on Linear Forces in Football Helmets
Gavin Cooper, Central Virginia Governor's School

The purpose of this study was to reduce the concussion effects of a large magnitude impact to the head by changing the type of padding material in a football helmet. The effects of the padding type on the large magnitude impact were investigated through the hypothesis that if the interior padding of a football helmet was changed to Styrofoam, memory foam, or ethylene vinyl acetate (EVA) then, Styrofoam would be the most effective at reducing the forces of impact received to the head. The three padding samples were each tested eight times by striking the helmet at the front and right side with a 2 kg mass suspended from the ceiling by a rope. An accelerometer collected the data and measured the integral for the change in z-axis acceleration over a period of time at impact. A single factor ANOVA test, using an alpha value of .05, determined significance, with a p-value of 9.03E-09 at the side impact location and a p-value of .02 at the front impact location. A post-hoc Tukey test was conducted using a Q_t value of 3.58 and a D_{min} value of .22 for a side impact location and .15 for a front impact location. A statistically significant difference was identified between the EVA padding group and both the Styrofoam group and the memory foam group. Although the results did not support the research hypothesis, they did suggest the EVA padding group had the greatest effect on reducing the linear forces at impact.

The Effect of App Color Scheme on LED Blue Light Irradiance
Angelica Bain, Washington Liberty High School

The purpose of this experiment was to investigate how different applications' color schemes, such as dim and dark modes, affected the amount of blue light energy emitted from the LED screens of smartphones. It is well established that there are negative health effects (ocular, cognitive, and immunological) from overexposure to LED light, specifically in the blue wavelengths, so factors that affect the dosage of LED light are important. The hypothesis stated that if different color schemes of smartphone applications were tested for the amount of blue light relative irradiance using a laboratory-grade spectroradiometer, then the unaltered versions of the applications would emit the most relative irradiance (w/m^2) at the blue light wavelengths. Based on the results of this experiment, the null hypothesis stating that different color schemes of smartphone applications have no statistically significant differences in the amount of blue light relative irradiance was rejected. This was supported by conducting an ANOVA test which resulted in a p-value of 2.64×10^{-36} , which falls far below the needed 0.05 to indicate that the independent variables had an effect on the dependent variable. The data strongly supported the hypothesis because the unaltered application screens emitted over 300% more light in the targeted blue wavelengths as measured by relative irradiance. According to these findings, dark modes do have a significant impact and should, therefore, be a part of blue light mitigation best practices. Established medical research on the immunosuppressive impact of blue LED light underscores the importance (especially during the COVID-19 pandemic) of objectively effective blue light mitigation.

Analyzing the Relationship Between Brine Viscosity and Anti-Icing Viability Across Multiple Snow Cycles

Adam Downs, Southwest Virginia Governor's School

Brine application during cold weather is vital to road safety because of its ability to reduce the freezing point of water on roadways. However, salt has negative impacts on the surrounding environment and infrastructure. When added to salt, organic alternatives such as beet pulp have shown to produce better results than salt alone. This could be a result of the naturally higher viscosity of these solutions compared to regular brine allowing the solution to resist being removed from paved surfaces during plowing. The research question asked if increasing brine viscosity increased snow removal resilience. Three solutions were created by mixing water, glycerin, and salt and classified by their relative viscosities to create a low, medium, and high viscosity group, all with freezing points below water. One fluid ounce of each solution was spread over its own three pavement patches and three patches were left uncovered. Two inches of snow were applied to the surface of each patch and placed under a press. Ice was then cut and removed until four ice sections measuring two inches square remained on each patch. The force required to remove each section was measured and recorded. The snow application and removal processes were repeated twice to allow calculation of approximate instantaneous rate of change about the middle application. Sample group means were 0.61, 1.53, 1.37, and 0.08 pounds per removal for the control and low, medium, and high viscosity groups, respectively. An ANOVA test of the mean rates yielded an f-statistic of 0.283, indicating no statistically significant differences between groups and failing to reject the null hypothesis because it was greater than the critical f-value of 0.05. This could mean viscosity does not affect brine resilience, indicating that organically derived anti-icing products are effective for a different reason. Further research must be done regarding this to provide a more definite answer.

The Effect of a Baseball's Rotational Tilt on the Total Air Pressure Along the Top, Left, and Right Side of the Ball

Andrew Wittman, Clover Hill High School

The purpose of this experiment was to test how the tilt of the axis upon which a baseball rotated affected the pressure on different sides of the ball. This could be applied to how a pitch in baseball would move when it is thrown. In order to obtain a desired pitch movement, a pitcher could intentionally throw a ball that rotates upon a certain angle. The experimental hypothesis stated that the side that contrasted the flow of air in the tunnel would experience a greater pressure reading, as the two flows of air, that of the boundary layer of the baseball and the wind in the tunnel, would collide and create drag. Therefore, in many instances the left side was expected to read a greater pressure, as the ball was rotating clockwise when seen from above. The experiment was performed by spinning a baseball in a wind tunnel using a metal rod. While the baseball rotated, air was being blown at it by a leaf blower. There were four levels of the independent variable, a 90° axis, a 60° axis, a 30° axis, and a 0° axis, and measurements were taken on the right, left, and bottom sides. In most trials of the experiment, the right and left measurements were very similar, contrary to the experimental hypothesis, and the bottom side varied independently. Therefore, the data did not support the experimental hypothesis, which could be partially due to the fact that there was a high variance in many of the levels. The conducted ANOVA test did not allow for the null hypothesis to be rejected.

An Exploration of Amateur Astronomy: Astrophotography and Spectroscopy
Dillon Bass, Yorktown High School

This project is an investigation of the limits of amateur astronomy in two specific fields: astrophotography and spectroscopy. The project was performed with an amateur telescope, a camera and some other basic photographic equipment in a high light pollution area. The goal of the project was to perform real astronomy in subpar conditions and show that space is not only reserved for advanced scientists, even in an increasingly light polluted world. In the astrophotography half of the project the main objective was to take clear pictures of the night sky, specifically the Orion Nebula, and also other objects like planets and star clusters. Various techniques were learned and applied in order to capture maximum detail and combat light pollution. The data was collected in the form of many long exposures up to 30 seconds in length. A major limitation was the inability of the mount to track the sky along the correct axis and the mount's inaccurate tracking. Both of these factors shorten exposure time and therefore decrease the detail of the data. The photos were stacked and processed in Photoshop to increase total exposure time, contrast, and color. The result of this process was pictures of celestial objects that revealed faint stars below 10th magnitude, gas clouds in Orion, the rings of Saturn, and more. The second half of the project used spectroscopy and stellar spectra to attempt to determine the type and temperature of various stars. A diffraction grating was added in front of the camera in order to capture the component wavelengths of light that made up the stars' spectra. This data was collected with shorter exposures because bright stars were used as targets. A software program was used to analyze spectra by comparing them to a professional database and Wien's law was used to determine an approximate temperature for each star. By this method, the approximate stellar classification of a range of stars was closely predicted and accurate temperatures were found for some stars within the limitations of the technology used. Overall, the project proved that astrophotography and spectroscopy are possible even in bright environments with limited amateur gear.

Examining the Efficacy of Wearable Lenses on Blue Light Filtration
Malak Elsherbiny, Charles J. Colgan Sr. High School

Background: Blue light ranges in wavelength from 400-450 nanometers and offers advantages to humans such as increased attention span and improved mood. However, it can also induce eye damage, such as macular degeneration, and may disturb sleeping patterns as well. To combat this phenomenon, researchers have found that some wearable eye lenses can be used to prevent long-term retinal damage. The purpose of this experiment is to compare the efficacy of 3 different wearable lenses, as well as the Koala Web Browser filter, on blue light filtration. It was hypothesized that the BluTech lens will filter blue light most effectively compared to the Orma Crizal Previncia and Independence Anti-Reflective Coating Lens. Method: Three different lenses used in this experiment: BluTech, Orma Crizal Previncia, and Independent Coating lenses. Two light sources were used and the standard intensity of light, measured in lux, for each device was determined (7.98 lx from the laptop and 77.4 lx from a cell phone). For each device, the various lenses and the Koala App were used to test the amount of blue light that was filtered from the electronic device. Filtered light was assessed using a photometer. Results: Contrary to the initial hypothesis, the Orma Crizal Previncia lens filtered the highest amount of blue light from both the cellphone (72.51 lux), and the laptop (2.85 lux) compared to the other 2 lenses and the App filter. This may have been due to the larger tint on the lens contributing to a higher filtration value. Conclusion: This research may be of great value to the field of ophthalmology; however, more trials will be needed to truly identify the most efficient lens for retinal health.

PSYCHOLOGY

The Effect of Learning Preference on Academic Performance.

Zaid Contractor, Mills E. Godwin High School

The effect of learning preference on academic performance was explored in order to investigate how cognitive nourishment can affect educational learning. Over time, education has significantly developed; however, numerous institutions exist that do not provide education correctly. In this study, high schoolers completed academic achievement assessments on two subjects. The VARK Inventory had notable importance in this experiment as the post assessments were altered with respect to the learning preference categorization. The pretest group served as the control group as it could be accurately compared to the other assessment types. It was hypothesized that a kinesthetic learning preference would result into greater academic assessment score and performance. The analysis of the results revealed that the aural and the read/write post assessments had the highest average score for the subjects Geometry and World History, respectively. T-tests were performed on the data; no assessment comparisons were statistically significant for the subject Geometry. Contrariwise, the pretest versus the aural, the read/write, and the visual post assessment comparisons were statistically significant for the subject World History. The aural, the read/write, and the visual; all in comparison to the kinesthetic post assessment were statistically significant, too. Given, it was believed that the subject World History had greater effect on the variability of learning environments possibly because not all participants were currently taking Geometry, but all were indeed taking World History. This research could certainly lead to further exploration of factors like assessment format or even teacher qualifications that may affect the overall learning process.

The Effect of "Mario Kart Tour" on Reaction Time
Joey Chen, Godwin High School

This study was conducted to discover the effect of a fast-paced video game on reaction time. Many people of all ages can suffer from slow motor skills, whether from birth or throughout adulthood. It was inferred that videogames can help improve your reaction time, which can improve your motor skills. This research is important because it will benefit people that have slow motor skills while simultaneously improving hand-eye coordination. The control for this project will be playing "Mario Kart Tour" for 0 minutes because people aren't used to playing video games, especially since "Mario Kart Tour" came out towards the end of 2019. The levels of independent variables concerning the experiment include playing "Mario Kart Tour" for 0 minutes, 10 minutes, 20 minutes, and 30 minutes. A research hypothesis was formulated stating that if "Mario Kart Tour" is played for 30 minutes, then the reaction time will decrease the most. Participants were asked to play "Mario Kart Tour" for 30 minutes in total while taking a reaction time test at 10 minute intervals starting at 0 minutes. The results showed that playing "Mario Kart Tour" did have an impact on reaction time. The data was not statistically significant except when 0 minutes is being compared to 30 minutes. It can be determined that the majority of the data was due to the independent variable. The reason for error in the experiment is most likely due to chance. Overall, playing "Mario Kart Tour" showed improvement in reaction time for the participants.

The Effect of Physical Activity on Stress
Mark Chen, Godwin High School

The purpose of this experiment was to find the effect of different amounts of physical activity on stress. Recently, physical activity has been used to mitigate, cope, and reduce stress. Human test subjects were asked to jog for 10, 20, and 30 minutes. The test subjects took surveys after each level was completed. The control that was used in the experiment was the results of a survey taken prior to experimentation. It was hypothesized that 20 minutes of physical activity would reduce the most stress. The test subjects took a survey prior to the experiment to be used as a control. Then the experiment began and after each level the test subjects took a survey to be compared to the control. The results revealed that 20 minutes of physical activity reduced the most stress, then 30 minutes, and lastly 10 minutes. A chi-square test was done on the data and it revealed that the data was not significant for all of the levels. The results did support the research hypothesis which was that 20 minutes of physical activity will reduce the most stress. It is believed that the results are due to the fact that physical activity is a known stress mitigator and reducer. 20 minutes may have just been the best amount of time for physical activity to reduce stress the most. This research could lead to further studies that investigate higher amounts of time doing physical activity along with different types of physical activity being done.

The Effect of Birth Order on Introversion and Extraversion
Hannah Ahmed, Mills E. Godwin High School

The purpose of this experiment was to investigate the possible correlation between birth order and introversion and extraversion. There is an abundance of societally influenced beliefs and ideas about birth order and its effects on aspects of individuals' personality. These may not always be true and differ from person to person. This experiment sought to find a basis for the relationship between order of birth and level of introversion or extraversion. Several researchers have concluded various combinations, and some have also found the lack of a consistent relationship. For this experiment, 30 firstborns and 30 lastborns were asked to complete a questionnaire, Adam Grant's Test, to determine if they leaned towards introversion or extraversion. The independent variable was birth order and its levels were oldest and youngest. The dependent variable was introversion or extraversion. There was no control because there is not a definite agreed trait that each birth order will always exhibit. It was hypothesized that there is no consistent effect of birth order on introversion and extraversion. A chi-test was done on the data and it revealed that the data was not significant. The results showed that both birth orders were equally ambiverted and oldest siblings were less likely to be extraverted. Although not significant, the results supported the research hypothesis. It is assumed that the results are due to the many variables that play a factor in growth and development.

The Effect of Age on the Emotional Stroop Test
Matthew Magtoto, Mills E. Godwin High School

The purpose of this experiment was to determine the effect age had on Stroop test times. This was to further the knowledge of the varying emotional state and motor skills between various age groups; more specifically, depression developing through age and motor skill deficiency in elders. It was hypothesized that retirees would take a longer time on a sad Stroop test as opposed to a neutral one and that their times would be higher than the younger groups. A participant that fit into one of the three groups (in-school, working, and retired) was given a 15-question neutral Stroop test, followed by a sad variant. Both tests were timed and recorded. After 25 participants for each age group were tested, descriptive and inferential statistics were performed on the data. Of the three levels, there was no control, as there is no basis for varying ages. Multiple t-tests were performed on the data, comparing the neutral and sad times for each group and the times for each variant among all of the groups. The data supported that there is no significant difference between the test variants between each age group, but there is a difference when comparing test variant times among all of the groups. In addition, two ANOVA tests were performed and supported that the times between all groups had a significant difference between them. Overall, the results supported that individuals do not develop depression through age and younger ages have better motor skills.

The Effect of the Influence of Internet use on Parents' Perception of Pediatric Care
Isabella Grice, Mills E. Godwin High School

The purpose of this experiment was to find the effect of the influence of internet use on parents' perception of pediatric care. The rise of medical information available on the internet has altered the patient/physician relationship, more specifically, the parent/ child-pediatrician relationship. A survey was given to 100 parents at two different pediatric practices. The survey asks how likely they are to use the internet for medical information for their child on a scale of 1 to 4 (1 being the least likely and 4 being most likely). The surveys were then collected and scored. There was no control in this experiment. It was hypothesized that if parents use the internet to find medical information then they will be more likely to second guess their pediatrician's recommendation. The results showed that parents are more likely to use the internet for their child's medical information but are not as likely to bring their findings up with their doctor. A t-test was performed on the data, and none of the data was found to be statistically significant. The result did not support the research hypothesis. It is believed that the results found are since parents recognize that the internet should be used to decide if a doctor's visit is necessary, but not to second guess their pediatrician. This research could lead to further studies that investigate what specific information parents are looking for on the internet and also how doctors perceive parents' use of the internet.

The Effect of Colored Light on Peripheral Vision
Arya Suram, Mills E. Godwin High School

The purpose of this experiment was to find the effects of different colored lights on the peripheral vision of a person. The findings of this project could help in protecting individuals' lives since it could be implemented into different vehicles, thus creating less of a chance for a crash to occur. The light would help enhance the eyes of the driver to be able to see sharper out of the corners of their eyes. In order to perform this experiment, a group of 25 people was assembled and, using a measuring device, their peripheral vision was measured on their dominant eye. It was hypothesized that red light would allow for the widest range of peripheral vision by their dominant eye. The control in this experiment was white light since it is the color of light commonly found in buildings. After conducting the experiment, the results were recorded and showed that green light had a wider range of peripheral vision amongst the test subjects' dominant eyes. On average, peripheral vision range obtained from green light was 3° more than white light, 7° more than red light, and 8° more than blue light. A t-test was performed, and it concluded that the data was not significant and that the results did not support the research hypothesis. It is believed that the results are due to the fact that the intensities of each color varied since blue light ended up being one of the darker colors between the four while green light was one of the brighter ones. The intensity of the color was important since it is easier to see in lighter environments compared to darker ones. This research, however, could then lead to testing different intensities of the color green to figure out which one would allow for the widest range of peripheral vision.

The Effects of Anxiety on Teens
Shamyah Price, Portsmouth STEM @ I.C. Norcom High School

The purpose of this experiment is to inform teens and parents about anxiety and how to treat it and what can help. The hypothesis states If teens have anxiety then their grades and life at home and school will be affected, which was tested with a survey in Google Forms and sent to 50 students at I.C Norcom High School. The hypothesis was proven correct. About 28% of teens said that anxiety affects their ability to sleep or concentrate. Teens also said school was their main cause for anxiety/stress. Parents and teens must find ways to treat teens with anxiety.

The Effects of Perceived Positive and Negative Emotions on Consumer Intention to Share Viral Content

Saighuhan Senthilkumar, Ocean Lakes High School

The empirical evaluation of viral marketing holds numerous benefits to the businesses and companies that seek to employ it. A properly administered viral marketing campaign has the potential for a business to reach a large number of people with a relatively small initial investment through taking advantage of peer to peer communication networks, making the return on investment much higher than a traditional marketing campaign. Effective viral marketing, however, requires a company to first have a clear understanding of the successful parameters that contribute to the content being shared. Many studies have been conducted on the aforementioned aspects of viral marketing, yet there exists a gap in the literature with regards to the emotions present in viral content and its role in consumers sharing content. This study seeks to fill in this gap by asking individuals to recall viral content that they saw and relate their experience through the use of critical incidents. In order to study this gap, three surveys using the Pleasure-Arousal-Dominance model were designed and evaluated the critical incidents of the participants. Administered through Amazon MTurk, these surveys allowed for analysis into the motivations behind forwarding viral content based on emotion.

Young Adult Opinions on Academic Dishonesty
Samantha Elam, Central Virginia Governor's School for Science and Technology

The purpose of this study was to obtain the opinions of college graduate students on the severity and frequency of partaking in various methods of cheating and compare them to determine if there is a correlation. This data was gathered via an online survey designed by the researcher to have participants rate both frequency and severity on a scale in fifteen different scenarios, answer other categorical questions (such as GPA, gender, and presence of an honor code), and allowed for them to leave a direct comment if they desired. After the data from the surveys were received, the researcher assigned numerical values to each scaler (ex. Not Cheating = 1, Trivial Cheating = 2, etc.) and found the means. Running linear regression tests between the severity and frequency of all 15 scenarios revealed two significant p-values of .003 and .0479, which were below the alpha of .05. This demonstrated significance in two of the fifteen scenarios, supporting the research hypothesis of, "If students find cheating behavior to be more trivial, then that cheating behavior will occur more frequently and be better accepted among a student community". In summary, this study collected student opinions, as both a scaler unit and as direct quotes, on the frequency and severity of cheating based on their own beliefs and experiences. This study can be used and replicated by educators to help demystify the mindset of students in universities everywhere.

The Correlation Between the Big Five Personality Traits and Political Ideology
Hana Floge, Central Virginia Governor's School

The purpose of this study was to determine if there was a relationship between the Big Five personality traits and political ideology. The study was conducted at a local high school during November and December of 2019. Thirteen high school participants were recruited and sent a survey with two sections: personality and political ideology. The survey provided each person with a personality score and political ideology score, which were then placed on a cumulative scale. A correlational analysis was used to examine the data. Using an alpha value of .05, the correlation analysis returned a correlation coefficient of $-.224$ for the scores overall, a correlation coefficient of $-.204$ for the Agreeableness trait, and a correlation coefficient of $-.302$ for the Openness trait. None of the correlation coefficients met the .05 alpha value requirement for a correlation coefficient of $.553$. Because of this, the research hypothesis, that individuals having the highest average score on the Openness aspect of the Big Five personality traits will have a preference for liberalism, was not supported. The results suggested that there is not a strong relationship between the Big Five personality traits and political ideology. These results are important to understanding the factors involved in the formation of political beliefs, and this knowledge could contribute to improving the political climate.

Does Nature Influence Problem-Solving Abilities?
Brooke Spencer, Central Virginia Governor's School

The purpose of this study was to determine whether or not testing environments had an effect on problem solving abilities. The study was conducted online using a ten question Algebra 1 test from the website JLab during 2019. High school participants were asked to complete this assignment both indoors and outdoors once a week over the course of four weeks, and email their results to the researcher upon completion. Their results were scored and recorded by taking their percentage score and time completed in seconds. The average indoor test score was 81.8% over the course of nine minutes and eleven seconds, while the average outdoor test score was 76.8% over six minutes and fifty-five seconds. A two-way ANOVA with replication, with an alpha value set at .05, revealed a p-value of .306 for the environments, and a p-value of .356 for the interaction effect. These insignificant p-values did not support my research hypothesis, stating that if students are required to take a math quiz both indoors and outdoors, the students will receive higher scores in a quicker time in the outdoor environment. In summation, different testing environments had no significant effect on problem-solving abilities. The results suggest that alternate methods of educational environments aren't necessary for overall academic success.

Impact of Word-of-Mouth on Marketing
Aleesha Mays, Central Virginia Governor's School

The purpose of this study was to demonstrate the effect of consumer-based marketing strategies on the success rate of products. The study included faculty members from a local high school. The participants were separated randomly into three groups based on positively-skewed, negatively-skewed, and equally balanced review ratios and asked to watch an advertisement, read online reviews, and rate the likelihood to recommend and buy a product on a scale through a Google Form. To analyze the data, two one-factor ANOVA tests ($\alpha=.05$) for the likelihood to recommend and likelihood to buy the product were performed. The ANOVA for the likelihood to recommend the product presented a p-value of .036, which indicated significance. A post-hoc Tukey test with a D-min of 3.108 revealed the significance lay between the positively skewed ratio group and the equally balanced group. The ANOVA for the likelihood to buy the product presented a p-value of .631, an insignificant value. The data for the likelihood to recommend the product supported the hypothesis of positively skewed review ratios affecting the success rate of a product, while the data for the likelihood to buy the product did not. In conclusion, this study supported the idea that consumer-based marketing can affect a product's success rate, which encourages the marketing community to contribute more to the economy by helping to better understand consumer choice.

The Effect of Age on an Applicant's Chance to be Hired
Hollins Pierpoint, Central Virginia Governor's School

The purpose of this study was to determine whether age bias is present in the food industry. The study was conducted at local restaurants around the same region in Virginia. The participants, who were all hiring managers, were required to fill out a survey that asked them demographic questions, and to choose the résumé they would personally hire. The difference among the résumés was the amount of experience they held, which represented the age of applicants. A chi square goodness of fit test was used, and it found that the p-value was .03 with the set alpha value of .05. Due to this, there was a statistically significant difference among the three different age groups used: oldest, youngest, and middle-aged. The research hypothesis, which stated that "If participants are given three résumés with different ages (middle age, millennial, and older), then they will most often choose the middle aged applicant for the job" was not supported because the youngest applicant was chosen most frequently. In conclusion, the study conducted shows that there is age bias while hiring in the food industry. These conclusions show us the presence of age bias, and the many forms it takes on as well as bringing about awareness to employers and employees.

The Relationship Between Parenting Style, Academic Performance, and Student Psychological Health

Cynthia Lam, Central Virginia Governor's School

The purpose of this study was to determine whether or not parenting style affected psychological health, self-esteem, or GPA. Participants were recruited from two local high schools. Data were collected by a Google Form consisting of four parts to determine GPA, anxiety and depression level, self-esteem level, and parenting style. A linear regression test was used to determine if there was any relationship between three different parenting styles (authoritative, authoritarian, and permissive), and the anxiety and depression level, self-esteem, and GPA of participants. Authoritative parenting and anxiety and depression yielded a negative correlation with a p-value of .0076 and were thus significant with the set alpha of .05. All other parenting styles and factors relations were insignificant. The research hypothesis was that authoritative parenting would result in lower levels of anxiety and depression, higher GPA, and higher self-esteem, with authoritarian parenting resulting in higher levels of anxiety and depression, lower GPA, and lower self-esteem. As such, the research hypothesis was only partially supported. The data suggested that as parenting becomes more authoritative, anxiety and depression levels decrease. Therefore, it can be concluded that authoritative parenting is capable of being a deterrent to the development of mental health conditions. The conclusions from this study can be used to describe the impact of parenting on the psychological health of children and enlighten parents on how their actions can lessen or heighten the severity of mental health conditions.

The Effect of Suppression vs Recollection on Intrusive Thoughts
Michaela White, Central Virginia Governor's School

This research was intended to determine the impact of suppression versus recollection on the generation and magnitude of intrusive thoughts. The study was performed at a local high school, using twenty students who were divided into two groups. They were instructed to either suppress or recall a certain word, and write down the times each day when they thought of the word in the following week; this was repeated the second week with a different word. After two trials, each participant completed a questionnaire to determine their inherent nature to suppress and generate intrusive thoughts. Using a paired t-test, and an alpha of .05, the p-values of Group One and Two were .070 and .11; with the groups' scores factored in, the p-value for Group One was .069 and Group Two, .12, Finally, the p-value for suppression overall was .36, and the p-value repression overall was .43. Therefore, the research hypothesis, which stated that if I told students a word with an accompanying trigger and then asked them to either suppress it or remember it over the course of a week, then the group that was told to suppress it would remember it more, was not supported, because there was no significant difference between any of the tests. This study suggests that suppression and recollection have little to no impact on intrusive thoughts. The study of intrusive thoughts is important to understanding and improving mental health.

Does Decision Making Differ According to International Socioeconomic Status?
Angelica Thompson, Central Virginia Governor's School for Science & Technology

The purpose of this study was to examine and analyze differences and relationships between socioeconomic status and motivational factors with a first world and a third world country. A total of 52 participants from the United States and the Philippines filled out a basic online survey regarding underlying motivational factors. Each answer corresponded with a level of Maslow's hierarchy. Each level was assigned a number one to four, based on their place on the hierarchy. A person's score was determined by adding up their answers and finding the mean. Each country's score was determined by finding a mean score of all of its participants. The mean score for the United States was 2.611, while the mean score for the Philippines resulted in 2.487. A two-sample t-test with an alpha value of .05 revealed a p-value of .146. This showed the data were not significant, however both countries mean scores revealed that they fell under the same level of hierarchy. The research hypothesis, which stated that if the subjects fell under the same socioeconomic status, then the subjects would mostly correspond to a common level of Maslow's Hierarchy of Needs regardless of where they lived (More Developed Countries or Least Developed Countries), was supported. In conclusion, socioeconomic status had no significant effect on motivational needs based off of Maslow's hierarchy. In the future, this can be further studied to understand underlying financial effects of motivational needs.

The Effect of Incentives on Students Performance Level and Motivation
Melanie Bowling, Central Virginia Governor's School

The purpose of this study was to see how external motivators affect the internal motivation and performance level of students. This study was conducted at a local elementary school in Virginia within the age group of eight to nine year olds. Three different classes with the same math teacher took three different quizzes where different incentives were offered: an incentive for completing a study guide, incentive for scoring above an 85, and no incentive. Students were given a study guide a week before each of the quizzes. A two sample t-test was conducted for each incentive group comparing who completed the study guide and who didn't. Results showed that there was a statistically significant difference in the incentive group where students had to score an 85 or above (alpha = .05, p-value = .04), but there was no significant difference in the other two groups. After completing the quizzes, students completed a survey assessing their motivation levels. Results from the survey showed that students had the highest motivation when they had to score an 85 or above. It was concluded that students work harder when they have to achieve a certain score; however, the research hypothesis, "If I offer incentives for performance level and preparation, then the student's performance level will be higher when I offer incentives for preparation," was not supported by the data. By continuing to show students that preparation will improve their results, the education system will improve because students are left successful and encouraged.

The Effect of Sight-Reading on Conditioned Reflexes
Philip Naveen, Mills E. Godwin High School

The purpose of the experiment was to explore the effects of musical study on conditioned reflexes. The musical study includes a specific notation, which has been around for centuries and is still in use today. Many studies support the thesis that musical training improves pitch recognition, but this paper focuses on its effects on visual tasks. Musically trained and non-musically trained individuals, who were regarded as the control, were given an inquiry to complete. The inquiry required participants to decode hidden text with a translation key. The participants were timed as they took the inquiries and were scored for accuracy. The accuracy scores were discarded because they showed only a subtle change. The times recorded to complete the inquiry were further analyzed because they showed a substantial change. A t-test was conducted on the times taken for completion and all the data was significant. It was statistically supported at a 0.05 level that the musically trained group performed the inquiry faster than the control. A solution to the results was that musical study caused the musically trained group's brain activity to increase in the occipital, temporal, and parietal lobes. These lobes are partially responsible for touch, memory, and sight. An extension of this investigation would be done with functional magnetic resonance imaging (fMRI) to gain a visual record of multiple areas of the brain.

The Effect of Media Influence on Political Views
Sarah Culver, Central Virginia Governor's School for Science and Technology

The purpose of this study was to evaluate how media bias influences a person's political opinions. To conduct this study, each participant was given a non-biased article about a political agreement that is relevant today, which was followed by a survey. Then they were given an article in favor of the opposite opinion they showed, followed by the same survey a second time. The participants were separated into demographic groups: Male, Female, Democrat, Republican, and politically identified as "Other". The test used to analyze these data was a 2-sample paired t-test. The p-value for each group was found by using the data provided in the surveys. The data came from the differences in the before-and-after opinions of the participants when asked 2 questions. The p-values were significant when compared to the alpha value of .05 in the Female, Democrat, and Other groups for both questions. According to the data, the research hypothesis, "If an individual is presented with biased sources, then more than 50% of the time Democrats will be influenced from in favor of the Paris Climate Agreement to against it, Republican will be influence from against to in favor, and politically neutral will be influenced either way as a result of the biased information" was supported. As a result, this study was found to be significant, as 3 out of the 5 groups proved to be statistically significant. Today, individuals are constantly shown persuading political media in an attempt to convince them to vote for a politician. This study can relate to this by determining how much an individual may possibly be influenced as a result of the media. By conducting this study, it was found that the media does have an impact on selective demographic groups' political opinions.

Trainer Rubik's Cube to Improve Pattern Recognition
Talon Booth, Southwest Virginia Governor's School

The Rubik's Cube is widely regarded by the general public as the most difficult puzzle on the market. With well over 43 million possible combinations, and thousands of memorizable algorithms for solving it, this intricate toy has confused some of the greatest minds of this generation. However, if the Rubik's Cube could be made simpler to solve by changing the way people approach solving the cube, then more people, whether novice or adept at solving Rubik's Cubes, could learn to solve the cube or possibly solve it faster. This project aimed to create a 3x3 puzzle cube that allowed for easier pattern recognition by negating unnecessary pieces for the first two layer solve steps. A pre-existing template was modified and reoriented to create the blueprint for three dimensionally printing the cube's pieces. Once printed and assembled, the final cube was roughly 373.3cm³ in volume and was painted with a Rubik's Cube's color scheme, except the yellow layer was left uncolored. The 3-D printed cube was found to be statistically slower on average than the three 3x3 puzzle cubes it was tested against, largely due to design error. Despite the insignificant results for faster solve times the practicality behind trainer Rubik's Cubes for certain solve steps was still evident. If more research addressed the steep learning curve for solving Rubik's Cubes, then more people could be incentivized to solve them for mental exercise.

Gender-Based Confidence Gaps in Mathematics Within Advanced Students
Solace Church, Southwest Virginia Governor's School

STEM (Science, Technology, Engineering, and Math) careers have always been dominated by males. Even as gender equality improves, women are still underrepresented in STEM careers. In order to increase the number of women in these careers, their confidence in math and science needs to be improved. This study was completed in order to find out how this confidence gap in STEM fields could be reduced between males and females. The research question asked if there was a gender-based confidence gap regarding performance on a math assessment, even within exceptional students. Previous studies showed that males were, in fact, more confident than females on math assessments. To eliminate the confidence gap, different circumstances must be tested. Because all participants are students at an advanced science and math school, they perform exceptionally well in these topics. This study explored whether or not this change in environment would eliminate the confidence gap. Sixty students signed informed consent forms, were given a math assessment, and rated their expectations of their performances. The number (1-5) the student selected as their confidence level correlated with how many of the five questions they believed they answered correctly. The average score for each gender was calculated. Males had a mean confidence level of 3.36667 ± 0.19466 , and females had a mean confidence level of 2.7 ± 0.22565 . Based on these results, males were significantly more confident (p -value = 0.0146) than females. Although all students had above average math capabilities, the confidence gap in mathematics between males and females was not eliminated.

The Effect of Generally Accepted Quality of Classical Literature on the Self-Esteem of Student
Writers in Regard to their Own Work
Taylor Rudisill, Southwest Virginia Governor's School

Self-esteem is a person's perceived self-worth and can be affected by several different variables, both positive and negative. Modern media is seen as one of the biggest factors when it comes to lowering self-esteem, especially that of adolescents. Based on this, it would stand to reason that all forms of media, including non-digital media such as classical literature, would cause self-esteem to fluctuate. Over three sessions, thirty-three participants were given Rosenberg self-esteem scales to fill out, meant to measure how a person perceived their writing ability. The first session acted as a control group, as no excerpts of literature were given to participants. During the second session, participants were given an excerpt of a piece of literature either indicated as good quality or poor quality, then were given a second self-esteem scale. During the final session, participants read a final excerpt of literature of the opposite quality of the first excerpt they were given and a final self-esteem scale. Scores from the scales were put through a matched pairs test in the JMP program and a p-value of 0.2067 was found which is greater than the alpha value of 0.05, therefore no significant difference was found to indicate a correlation between self-esteem and classical literature. Further research would need to involve a larger variety of literature over more sessions and with a more accurate scale. Based on results, it is possible that fluctuation of self-esteem is not caused by the media itself, but by the culture surrounding it.

Is There an Association Between People with Morning Versus Evening Chronotype and Variants of the HCRTR2 Gene?

Nadine Shannon, Southwest Virginia Governor's School

Varied sleep rhythms, temperaments, and attentiveness throughout the day influences performance for all humans, whether in work, school, or sports. These can be affected by chronotypes, because people with morning versus evening chronotypes have differing body rhythms and preferences. One of numerous factors, specific gene variants have been associated with people having certain chronotypes. One gene of interest is the HCRTR2 (hypocretin receptor 2) gene that is involved in the regulation of the hormone hypocretin, which, in turn, regulates wakefulness and arousal. In this study, a specific variant of the HCRTR2 gene, a base change from adenine to guanine on rs2653349, was examined for association with morning/evening chronotypes. In light of results from previous genome wide association studies, this study looked for an association between the presence of the G-allele and participants with morning chronotypes. Participants were given questionnaires to determine their morning or evening chronotypes before providing saliva samples for DNA analysis involving DNA extraction, PCR to amplify the gene region of interest, restriction digestion, and gel electrophoresis. The results showed 9 of the 13 participants identified as having an evening chronotype had a homozygous genotype for the G-allele, while 2 of the 6 identified as having a morning chronotype had a homozygous genotype for the G-allele. Using a Chi-square test of independence for analysis, the presence of the G-allele between chronotypes was not found to be significantly different ($p=0.1407$). While this study showed no significant difference in this variant's association with morning/evening chronotypes, further studies could be performed on other relevant alleles of the HCRTR2 gene or additional genes thought to influence circadian sleep rhythms, and similar studies could be conducted with a different or larger sample.

The Effect of Pre-Election Polling on Primary Voters
Brook Smith, Southwest Virginia Governor's School

Pre-election polling in America is routinely used to try and predict the results of major elections. As polling grows more and more common, however, many Americans are beginning to grow skeptical of the role of polling in the election process. Although polls do tend to accurately predict results a majority of the time, there are growing concerns that polling itself may be influencing the electorate through the bandwagon effect. The goal of this research was to analyze whether access to pre-election polls influences voter behavior. Participants were split into two groups (n=26 per group), one showed a poll and one not shown a poll, and participants in each group were asked to cast a vote in the 2020 Democratic Presidential Primary. In the group shown a poll, Bernie Sanders got the most votes with 28% of the vote, and in the group not shown a poll, Joe Biden and Elizabeth Warren got the most votes with 24% of the vote each. A chi-squared analysis was done, and the p-value was $p=0.2492$, suggesting that there is not a link between access to pre-election polls and voter behavior. However, there was apparent bias introduced by the use of real candidates in an election that not all participants would have chosen to vote in. Future research could still be done, especially using fictional candidates to eliminate bias, to confirm these results.

The Effect of Gender on the Stroop Task
Laura Nowalk, Washington-Liberty High School

The purpose of this experiment was to determine if there was a difference between boys and girls when performing the Stroop color-word test to demonstrate that girls would have higher overall scores than the boys due to greater processing and verbal capabilities. In the experiment, 20 boys and 20 girls were tested, using 3 different Stroop task designs to collect the data. Points were tallied out of 20 words per design, with each subject completing each of the designs. The summative data collected for the experiment are a mean score of 19.0 and a standard deviation of 1.60 for the girls, and a mean score of 18.7 and a standard deviation of 2.16 for the boys. These results show that the girls have a better overall score than the boys, but the T-Test, which produced a value of 0.61, indicates that the difference between the genders is not statistically significantly different enough to support the hypothesis. In addition to the results showing no significant statistical differences between genders in the Stroop task, they similarly do not support the idea that there are differences between genders in the speed of functions in the anterior cingulate cortex of the brain.

The Effect of Lifestyle Changes on Maintaining Sobriety in Addicts
Riya Chawla, Todd Allen Phillips Center for Medical Sciences at Godwin High School

Opioid addiction has been considered a major epidemic in the US for the past twenty years. The data collected in this experiment will be relevant to medical professionals who are investigating correlations between lifestyle behaviors and successful sobriety. The implications of the data gathered may benefit societal understanding of opioid addiction treatment. The purpose of this experiment was to find the effect of lifestyle changes on maintaining sobriety in addicts. The researcher hypothesized that if given a choice of five lifestyle changes, then the majority of recovering addicts will identify diet change as the most effective for maintaining sobriety. At a detoxification medical clinic, 104 recovering addicts were requested to complete a survey, and there was a 76% completion rate. The survey contained questions about demographics and lifestyle changes. Addicts completed this survey while participating in their therapy sessions. There is no control because all patients made at least one behavioral lifestyle change to maintain sobriety. Since lifestyle change is part of the treatment process for recovering addicts, it would not be wise to have a group of patients to compare to. Therefore, a control group was not necessary. Spiritual practice was shown to be the most effective to maintain sobriety in addicts, and the data is valid and significant as shown in the chi-squared test. Diet change was not shown to be more effective than spiritual practice. This may have been because spiritual practice is easily available and allows addicts to self-reflect, which is a proven benefit of treatment.

Improving Accessibility to Mathematical Gesture Coding Systems for Early Childhood Educators
Ellen Habteyonas, Blacksburg High School

Speakers frequently use gestures along with their speech but are often unaware of the information that these gestures communicate. Hands and whole-body movement indicate related or unrelated information through a variety of gestures. The use of gestures in teaching in early childhood classrooms holds great significance as children at a younger age are impacted on a greater scale through the use of gestures. Children use gestures as a different path to overcome the limits and barriers of language even if their speech and behaviors do not align. Understanding the impact of gestures in a classroom provides teachers access to another means of communication with their students and improved learning environments. This paper is situated in context with Vy Gótskys zone of proximal learning, its connection to mismatched gesturing and increased specified teacher response gestures to the mismatch. Currently, there is limited literature available about coding systems for gestures, especially ones that aren't centered around video recorded observations. This paper aims to create a coding system that is more accessible to early childhood educators to help improve their awareness of gestures occurring in early childhood.

The Effect of Age on the Ability to Remember Dream Details on a Scale of 1-5 over a 14 Day Period.

Marlena Gutshall, Washington Liberty High School

The purpose of this experiment was to determine if age has an effect on a person's ability to remember dream details. This was tested to develop a better understanding of what makes certain people remember their dreams better than others. The number of dream details remembered was tested by distributing a survey that asked how many details each participant remembered on a scale of 1-5, to 36 participants of 3 different age groups. Each participant filled out the survey each morning for 14 consecutive days. The age groups that were tested were ages 10-20, ages 21-50, and ages 51+. The hypothesis for this experiment stated that if 3 age groups were tested for their ability to remember dream details, then the 21-50 year old age group would be able to remember more details, because adults of these ages tend to get better, longer, and deeper sleep, allowing them to stay in the REM sleep stage longer than seniors or minors. The REM sleep stage is the stage of sleep in which dreams occur. Therefore, longer and deeper sleep during any given night will allow more dreams to occur, which increases the likeliness of a dream to be remembered. After all the data was collected and averaged, a summative data table and line graph was created. The lines on the graph, that represented the levels of independent variables, were very similar and showed no immediate or obvious result. An ANOVA test was conducted, a p-value of 0.9869 was calculated which is greater than 0.05. Therefore, the null hypothesis was accepted, and the alternate hypothesis was not supported. The error bars for the experiment also verified and corresponded with the findings of the ANOVA test, showing that there was no need to conduct a t-test. The results for this experiment showed that age has no effect on the ability to remember dream details.

The Effect of Stance on Performance
Ardenne Sklavos, Mills E Godwin High School

The purpose of this experiment was to find the effect of various stances on the amount of time to complete a word search. Students completed the word search on four separate days and the variables included sitting, standing, superman pose, and the fetal position. On each different day, the participants would hold one pose for a minute, then would complete the word search. The control was sitting, as this is the main position held throughout the day and does not spread the body or compact somebody. It was hypothesized that if participants hold the fetal position, then they will complete the word search slower than the other independent variable levels. The results revealed that the fetal position resulted in the longest average duration of completing the word search. A chi-square test was done on the data and it revealed that the data was significant, and the results supported the research hypothesis. It is believed that the results are caused by the lowered confidence levels when adopting a close-bodied stance and the raised levels of confidence when adopting an open-bodied stance. This research could lead to further studies that investigate exactly how much this could affect humans' daily lives and whether it is worth practicing.

The Effect of Pod-Based E-Cigarettes on Sleep and Cognitive Function
Michaela McCormack, TC Williams High School

Insufficient sleep, especially during adolescent development, interferes with daytime functioning increasing sleepiness, depressive mood, and risk-taking behavior. This study determines how learning and memory are affected by sleep and risk-taking, specifically in the form of pod-based e-cigarettes (vaping) in both humans and in a *Drosophila melanogaster* model. Human subjects will complete a demographics survey, wear a Fitbit for seven nights and take two cognitive tests: a concussion baseline test measuring reaction time and short-term memory and a balance test assessing spatial awareness and long-term memory. Risk-taking vaping data was obtained from the 2019 Alexandria City Risk Assessment Survey. Wingless *D. melanogaster* were given two cognitive tests: an olfactory avoidance test for short term memory and a spatial orientation test for long term memory. Vaping usage was tested using Imidacloprid, a neonicotinoid insecticide. Similar to nicotine it is an agonist of the nAChR receptor. Comparisons will be drawn between the short-term and long-term memory results in both subjects. Prototyping is complete, and experimentation is in progress. Analysis of human and fruit fly data is expected to show a modest decrease in cognitive ability with sleep deprivation. Furthermore, nicotine/ neonicotinoid exposure is expected to negatively impact both short and long-term memory.

The Effect of Sleep and Caffeine on GPA and SAT Scores
Jacob Singer and Will Torg, HB Woodlawn High School

Do you get enough sleep? Recently, awareness of sleep and how sleep duration and quality affect social and mental health has been on the rise. Perhaps that if it is shown that sleep is linked to test scores and GPA, students would be motivated to get more and higher quality sleep. We investigated the effect of sleep and caffeine on GPA and SAT scores. To measure sleep quality and duration, we used a modified shortened version of the PSQI (Pittsburgh Sleep Quality Index), which generates a numeric value to represent the quality of sleep each participant received. All information received was self-reported anonymously by the participants. It was hypothesized that both lower sleep quality and decreased sleep duration would lead to a lower GPA and SAT scores. Our hypothesis was partially confirmed, as both decreased sleep duration and quality leads to both lower GPA and SAT scores. However, caffeine had no significant correlation with GPA and SAT scores. This project provides useful information on how sleep can affect both short term and long term academic performance, and on the importance of sleep in general.

Do Personality Traits Correlate with Musical Preferences?

Yamierelys Nieves Lopez, Caroline High School

It is important to see if stereotypes are actually true and certain people listen to certain kinds of music since so many stereotypes are made about people because of their music preferences. The words of a type of song can connect to a person on a personal level, which can give clues as to what he thinks about and what personality he has. To test whether personality traits correlate with musical preference, questions about one's personality and music preference were asked to the subject. The survey asked the participant to take a Myers Briggs test to find his or her personality type and rate a certain type of music from one to five. It was found that there were a few positive and negative correlations and that each of the 4 personality dimensions had at least one music genre that had a significant p-value. Therefore, in some cases it is safe to assume one's music preference based on their personality.

The Influence of Birth Season, Seasonal Allergies, Age, and Seasonal Affective Disorder on
Favorite Season

Madeline Garrett, Chesapeake Bay Governor's School

The purpose of this study was to determine if there was any correlation between age and birthday to which season a person chose as their favorite. It also looked to see if later life experiences, such as Seasonal Affective Disorder (SAD) and allergies, could possibly affect that choice. There were four major hypotheses for this study. The first hypothesis was that people will choose a season as their favorite if their birthday is in it. The second hypothesis was that people over the age of 40 will be more likely to choose autumn and winter as their favorite season, while people under the age of 40 will be more likely to choose spring and summer. The third hypothesis was that people with allergies will be less likely to choose the season that their birthday is in if they experience allergies during that season. The last hypothesis was that people who suffer from SAD will be less likely to choose the season that their birthday is in if they experience Sad during that season. The predicted outcome of this survey was that the majority of people would choose the season that their birthday is in versus any other season.

How the Chameleon Effect Influences Cooperative Behavior
Meghan Gilmer, Chesapeake Bay Governor's School

The chameleon effect is the unconscious tendency to imitate the behaviors of others in a social setting. This study explored whether a person was more likely to choose to cooperate with a potential partner when he or she was being secretly mimicked by that potential partner. The experiment had groups of confederates and test subjects participate in a cooperation game modeled after the famous prisoner's dilemma. In some cases, the participant was mimicked by the confederate, and in other cases he or she was anti-mimicked, before being given a chance to cooperate with that confederate. The use of mimicking behavior is known to increase trust and attraction, and thus it was predicted that this would also make an individual want to cooperate. It was found that those who were mimicked were approximately 50 percent more likely to cooperate than those who were anti-mimicked.

The Effect of Witnessing an Emotional Event on an Eyewitness's Ability to Recall Central,
Peripheral, and Misleading Details
Daysianna Green, Chesapeake Bay Governor's School

This study was designed to test possible factors that could cause an eyewitness to become less reliable. It deliberately builds on previous studies to investigate if emotional charging has an influence on eyewitness accuracy/ reliability in recalling central and peripheral details, as well as the effect of misleading information on recall. Charge of emotion, central vs. peripheral details, and the concept of misleading information were all analyzed to determine the influence each factor has on eyewitness accuracy/reliability. This study is different from previous studies because it includes an emotionally charged variable, memory of central vs. peripheral details, and a misleading component, whereas others have only studied these factors individually. In this study, participants were split into two different groups which witnessed either an emotionally neutral or emotionally charged film. Afterwards, they were asked a series of questions pertaining to central, peripheral, and misleading information. The results suggest that emotional experiences may improve eyewitness recall for central details but diminish recall of small peripheral details. The data also suggests that recall might be weakened by attempts of attorneys to lead an eyewitness astray with misleading information.

Key Factors that Affect the Failure and Duration of a Romantic Relationship
Alyrica Kelley, Chesapeake Bay Governor's School

The purpose of this study is to determine if there are key factors that affect the failure and duration of a relationship. These factors included infidelity, abuse, money issues, communication problems, distance, trust issues, lack of effort, loss of feelings, frequent arguing, or control issues. A sample of 104 participants were given identical surveys to complete. These participants were ages 16 and up, and have had a relationship of at least two months. My hypothesis was that there would be factors that have a significant effect, and there will be a noticeable trend among couples. This study was done to attempt to predict the outcome and duration of relationships based on these factors, as well as to help people identify issues that could be the downfall of their relationship. The results showed that other people's infidelity and money issues were the best factors to predict the duration of a relationship. These factors allowed a model of predictability to be created which can estimate the expected duration of a relationship.

The Relationship Between Myers Briggs Personality Type and Music Preferences
Yamierelys Nieves Lopez, Chesapeake Bay Governor's School

It is important to see if stereotypes are actually true and certain people listen to certain kinds of music since so many stereotypes are made about people because of their music preferences. The words of a type of song can connect to a person on a personal level, which can give clues as to what he thinks about and what personality he has. To test whether personality traits correlate with musical preference, questions about one's personality and music preference were asked to the subject. The survey asked the participant to take a Myers Briggs test to find his or her personality type and rate a certain type of music from one to five. It was found that there were a few positive and negative correlations and that each of the 4 personality dimensions had at least one music genre that had a significant p-value. Therefore, in some cases it is safe to assume one's music preference based on their personality.

The Relationship Between Age and Perceptions of Facial Attractiveness
Zoe Wilson, Chesapeake Bay Governor's School

This study investigated whether people's perceptions of facial attractiveness become more flexible or malleable as they get older due to the influence of cultural and societal experiences. Because their cultural experiences are more limited, younger people under the age of 20 might have smaller variability in their perceptions that are strongly influenced by evolved predispositions. As people age, however, evolutionary preferences may affect their perceptions less and less as cultural and societal experiences have more and more influence. A survey was created with 20 portrait pictures of equal numbers of male and female photos. Participants were asked to rate the attractiveness on a scale of 1-7 for four facial features and overall. Results gathered from the survey were analyzed with the regression test and the F-test. The regression test revealed that female participants' ratings of both male and female photos usually changed significantly with age, but male participants' ratings usually did not. Females' ratings also became more variable with age in almost every category, and the F-test sometimes gave a statistically significant p-value. Males' ratings did not usually become more variable with age, and often became less variable. This could imply that for females there is a transition as age increases: perceived attractiveness shifts from being based on evolutionary preferences to being based on cultural and societal experiences. The male ratings could signify that males' perceived attractiveness may be less influenced by cultural and societal experiences.

STATISTICAL ANALYSIS & INFERENCES

The Effect of Differences in Daily Media Coverage on the Sentiment Analysis of Information
Amelia Murphy, Washington-Liberty High School

The purpose of the experiment was to determine the effect of differences in daily media coverage on the sentiment analysis of information. The hypothesis that was investigated was; “all of the media platforms will cover the major news events differently because of the varying standards of each medium”. To complete this project the procedure is listed as followed. The four media platforms that were tested were New York Times, Twitter, Buzzfeed, and Washington Times. Each media platform was investigated for 15 days straight. The top news stories were gathered from each platform and were then inserted into the sentiment analyzer software. Additional qualitative data was collected to collect and reveal bias that was found in each article. The conclusions that were found were that each media platform covered each daily news story different from each other, and the hypothesis was supported. Although the averages were not too different from each other, they were undeniably not the same. This was most likely due to the fact that each platform all had very different platforms that they were disseminating their articles to, and they wanted their stories to appeal with how the reader would normally interpret them. Additionally, The Washington Times had the lowest sentiment analysis average, concluding that the data that put out was significantly more negative than the others.

The Effect of Teachers' Average Annual Salary on SOL Pass Rates in Virginia
Nabela Rahman, Wakefield High School

Teachers continue to play a crucial role in society by nurturing the minds of the youth and educating future generations. However, in the US, many teachers remain underpaid and the extent to which they receive little money is not well known. The SOL test is a required assessment for all students in grades 3-12, enacted by Virginia Public Schools. To many, the SOL scores dictate how much information students obtain in the classroom and the quality of teaching. The purpose was to determine if teachers are underpaid in Virginia and if income status is a factor in students' education. This was done by comparing the teachers' salaries and the 2017 SOL pass rate for each county in Virginia. The hypothesis was if the teachers receive a higher income, then there would be a higher SOL pass rate for that particular county. The independent variable was the average annual teacher salary in each of the 94 counties. The dependent variable was the SOL pass rate. The experiment was performed by collecting data from the website Virginia Department of Education. First, all the average annual teachers' salaries and the SOL results were obtained and recorded onto Excel Spreadsheets. Next, the averages were calculated. The counties were separated into groups based on the averages of the salaries and SOL pass rates. Finally, to determine if the hypothesis was accepted or rejected, statistical tests were done, specifically, an ANOVA test and a correlation test. The p-value was 5.34×10^{-142} , therefore, the null hypothesis was rejected. The r-value was 0.4 meaning there is a weak, positive correlation between the two variables. The hypothesis was accepted.

The Relationship Between Emotions in Tweets and the Number of Favorites the Tweet Receives
Abigail Swanberg, Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if emotions in tweets affected the number of favorites the tweet received. The data was gathered using a Python library called Tweepy. Tweets were categorized into two groups based on whether they had pleasant active or unpleasant active words in them. The mean for the pleasant active tweets was .019 favorites per followers and the unpleasant active was .023. After running a two-sample t-test on those groups, there was a p-value of .749. This value is compared to an alpha value of .05, which means there was no statistical significance in the data. Therefore, the research hypothesis, "if I analyzed tweets by individuals associated with a brand that contain different emotions, then the tweets containing pleasant-active emotions will receive the most favorites" was not supported. The results of this study imply that the emotion in a tweet has no effect on the number of favorites it receives. The findings of this study can change how brands present themselves on social media.

The Effect of Carbon Monoxide Pollution on Rates of COPD
Rose Haron, Washington-Liberty High School

The goal of this experiment was to determine if a correlation exists between, one, COPD and carbon monoxide emissions, and two, COPD and smoking rates in rural and urban areas. This is relevant to examining causes of COPD, which presents a global issue. COPD is caused primarily by smoking but can also be affected by air pollutants. Because air pollutants, specifically CO, are higher in urban areas due to fuel combustion, it was assumed that non-smokers would be at a higher risk for COPD in the urban areas. For this experiment, a total of six linear regressions were run using excel software. These regressions were used to identify the significance of the correlations between COPD and its causation factors. It was hypothesized that CO would have a significant correlation with COPD, when smoking rates were taken into account, in urban areas. It was also hypothesized that the correlation between COPD and CO in urban areas would be stronger than in rural areas, because there is a higher prevalence of CO in urban areas. The results for this experiment supported the hypothesis. The correlation between CO and COPD was significant with a p-value of 0.008. The regression between COPD and CO combined with smoking rates was also significant. COPD in urban areas had a stronger correlation with CO than COPD in rural areas. The results also showed insignificant correlations between smoking rates and COPD in both rural and urban areas, with both regressions having p-values greater than 0.05. Because the results showed significant correlations between CO and COPD in urban areas, the null hypothesis was rejected.

Does School Size Affect Cross Country Runners' Time
Michael Rafferty, Southwest Virginia Governor's School

The researcher tested to find whether or not the size of a school affected the times of cross-country runners. It was hypothesized that the larger schools would perform better due to the size of their teams. Larger teams mean more people to run against, and rivalries can help improve skill. Using a combination of three websites, MileStat.com, VHSL.org, and Athletic.net, the researcher collected 5 times from 5 runners from 5 schools of ascending size, starting at Class 1 and ending at Class 5. Only 4 times were able to be collected from all the runners from the class 4 school except 1, resulting in 121 total times being collected. The alternate hypothesis is that, after the ANOVA test, a difference in the means will exist. The null hypothesis states that there is no difference in the means. The times for each school were averaged and were as follows: Class 1, 1081.048; Class 2, 1105.652; Class 3, 1135.3; Class 4, 1087.248; Class 5, 1076.852. Time is represented in seconds. An ANOVA and Tukey-Kramer test were performed on these means and a statistical difference was shown between Class 3 and Class 5, Class 3 and Class 4, and Class 3 and Class 1 with p-values of 0.0002, 0.0007, and 0.0066 respectively. These results rejected the null hypothesis and an explanation was proposed to fit this new data. Perhaps the coaches of the smaller schools were able to devote more time to each individual runner and the teams of the larger schools were able to create rivalries due to their size. Class 3 schools would perform the worst because they're large enough to where the coaches cannot help everyone, and small enough to where rivalries cannot form. With this explanation in mind, this information could prove useful to any coach in charge of a solo sport. It will allow them to optimize how they train their athletes, leading to a better performance overall.

Correlation Between Diabetes and Increased Tendency Toward Hyperopia Compared to
Non-Diabetics

Gavin Wheatley, Southwest Virginia Governor's School

The Correlation Between Diabetes and the Increasing Tendency Toward Hyperopia Compared to Non-diabetics (DITTcH) study was designed to provide evidence of whether or not diabetes correlates to increased rates of farsightedness compared to the population. Many different studies have found conflicting results on the subject, and there have been many tests to try and isolate the different effects of diabetes to see if the reason for the relationship could be identified. In the DITTcH study, de-identified medical records were studied, and prescriptions were recorded for diabetics and non-diabetics. Subjects were also divided into groups by age. Additional factors that were controlled were location, the business that the data was obtained from, and patients with surgeries that altered their prescription were removed from the data. The data was not significant because the p-values found ranged from 0.2471 to 0.8878, which means that these values are greater than alpha, whose value is 0.05. Therefore, we failed to reject the null hypothesis and there is not enough evidence to support that diabetes correlates to increased hyperopia rates compared to the population. It is acknowledged that there were some project weaknesses and improvements that need to be made in order to get results that are significant and useful. Future study improvements would include use of a larger population size. They may measure the effects of the medical history of the patient or their genetics on hyperopia. Or studies could be done to determine how patients' prescriptions change when they are diagnosed with diabetes. Correlations between such factors and hyperopia, if they exist, could be used to help produce a new solution to corrective vision that is not expensive or risky.

Islamophobia in Political Discourse: A Comparison Between the United States and France
Sasha Halfon-DeLay, Blacksburg High School

Islamophobia is greater than ever in the United States and Europe, and much research has been done on the issue. Many scholars have discussed rhetorical ways in which Islamophobia manifests. Edward Said's depthful review of the notion of 'orientalism', or Patty Hillyard's book introducing the idea of 'suspect community' which has been expanded to Muslim communities by Pentazis & Pemberton, Meeteren & Oostendorp, and Beydoun, are a few examples. The main objective of this study is to analyze and compare how Islamophobic rhetoric appears in political discourse in the United States and France. Each country has unique attributes that makes its specific discourse surrounding Islam and Muslims slightly different from the other. The analysis uses existing discourses and theories of Islamophobia in order to interpret and generalize the specific instances of Islamophobia that are uncovered. Various news sources, quotes by politicians, and party platforms were searched for Islamophobic rhetoric using specific key terms such as 'terrorist,' 'Islam,' or 'values'. The discourse-analysis that was performed confirmed that many of the current theories hold true. However, it was found that many instances of Islamophobic rhetoric present themselves in coded forms, such as with France's 'Lawless areas' and commitment to Secularism, or the United States' Islamophobia through a reiteration of peace. This paper hopes to add to existing knowledge by illuminating specific instances and trends in each country of study, providing a more grounded approach to highlighting Islamophobic discursive trends. Comparing each country will provide context and can help to draw conclusions about the sources of, and factors that affect Islamophobic rhetoric.

The Diffusion of Information: The Impact of Sentiment and Topic on Retweets
Colin Berry, Yorktown High School

Although there are several studies that have examined the spread of information based on the positive or negative content of the information, there are many human emotions that are difficult to categorize into simple positive or negative categories. This study examines the diffusion of information that has been categorized into six sentiment categories (including happiness, sadness, anger, fear, surprise and disgust). The hypothesis is that there will be differences in the diffusion rates of tweets considering six different sentiments and four different topics (including climate change, 2020 elections, gun control and crowdfunding). The results show that both sentiment and topic influence the diffusion rate of tweets. Although the results for all four topics combined show that angry tweets are more likely to be retweeted than happy tweets, the results by topic reveal the importance of examining differences across topics. For both the 2020 election and gun control topics, angry tweets are significantly more likely to be retweeted than all other sentiments. However, for both the crowdfunding and climate change topics, both happy and angry tweets are equally likely to be retweeted. Further, happy tweets are significantly more likely to be retweeted than tweets with sad, fear or disgust sentiments for both the crowdfunding and climate change topics, while there were no significant differences in the diffusion of these sentiments in the 2020 election and gun control topics. All of the results in this paper are robust to dropping outliers and to dropping retweets by bot accounts. Overall, the results suggest that the broad categories of positive and negative sentiment are too aggregate to really explain when information is likely to be diffused through retweets. The six sentiments examined in this study impact the diffusion of information in different ways across the four topics that are considered in this study. These results may help to explain why prior diffusion studies have found conflicting positivity and negativity bias results - given the differences that this study documents across topics; it may be that the negative and positive outcomes were driven by differences in the topics that were considered across these studies. Equally important, because so many people get their news and information from social media services, it is important for both the sender and receiver to understand that some information may diffuse faster and wider than other information, depending on the topic under consideration.

Measuring the Efficiency of Central and West African Ports Using Data Envelopment Analysis
Michael Flynn Mann, Clover Hill High School

The purpose of this analysis was to assess the efficiency of thirteen central and west african ports using the DEA-CCR and DEA-BCC models using data from 2017. These ports play an important role in the future economic growth and development of this region. It is essential that the ports are up to the efficiency standards of the rest of the world in order for them to process containers on time. The analysis was conducted at a private residence using Microsoft Excel and a DEA solver extension. The results expressed that two of the ports were operating efficiently under the DEA-CCR model, and seven under the DEA-BCC model. The two ports that are efficient under the DEA-CCR model are relatively efficient compared to the rest of the ports. The seven that are efficient under the DEA-BCC model are efficient in terms of resource utilization. Three of the ports are running at optimum size. Of the 13 ports, three exhibit constant returns to scale, eight exhibit increasing returns to scale, and two have decreasing returns to scale. The hypothesis stated that the port that has the input values with the highest numbers would be the most efficient. The efficiency results indicate that the hypothesis was not supported. The port of Pointe-Noire had the highest total input values with a sum but was only the sixth most efficient port with 50.2% efficiency. Pointe-Noire also exhibited decreasing returns to scale which means that it has too many inputs for the scale of the output, and it should decrease its input values to run at optimal size and efficiency. This, however, depends on the actions that the Port Authority of Pointe-Noire and the Government of the Republic of Congo tak

A Statistical Investigation of the Accuracy of Astrological Predictions about Personality Traits and
Weekly Horoscopes

Helen Laguerta, Chesapeake Bay Governor's School

Astrology suggests personality and future can be predicted based on the location of the sun, moon, and planets during a person's lifetime. Zodiac signs are categories people are placed in based on when they are born. The first part of this research project was to discover if there is correlation between astrology's predictions of people's personality traits and their real personality traits based on a score from the IPIP-NEO personality test. The second part was to discover if horoscopes can accurately predict a person's future. This was done by having volunteers try to identify which of three horoscopes was their correct horoscope for the previous week for their zodiac sign. In the end, my results were statistically nonsignificant. The correlation between the predicted personality and real personality was weak and the results of the horoscope study were no better than chance. Astrological predictions appear invalid and are not to be trusted. There is no scientific empirical evidence that the predictions are accurate.

ZOOLOGY

The Effect of Turmeric on the Regeneration of *Girardia tigrina* Paul Yang, Mills E. Godwin High School

The purpose of this experiment was to determine the effects of different amounts of turmeric on the regeneration of the planarian *Girardia tigrina*. The topic of cell regeneration in regenerative medicine holds potential to improve the healing speed of wounded tissue. One hundred bisected planaria were placed in 6mL of spring water and topically exposed to four different amounts of turmeric: 0mg, 5mg, 10mg, and 15mg over the course of two weeks. The lengths of each planaria then were measured using Logger Pro after 0 days, 7 days, and 14 days. 0mg of turmeric, the control, was chosen as a standard of comparison to determine differences between planaria that received did and did not receive treatment. It was hypothesized that if varying amounts of turmeric were administered to planaria, then 15mg would result in the most regeneration. The regenerated lengths of the planaria were analyzed in t-tests. Planaria that received 15mg and 10mg both showed regeneration, but data was statistically insignificant when t-tests were conducted vs. 0mg (control). The results could possibly be attributed to an optimum amount of turmeric to yield the maximum regeneration, since planaria in groups 5mg and 15mg showed less regeneration. Additionally, since planaria primarily rely on stem cells to regenerate and turmeric stimulates neural stem cell growth, a general conclusion could possibly be made that turmeric was beneficial towards planarian regeneration. Shown in the results, the mean regeneration values for groups 5mg(1.636mm), 10mg(1.760mm), and 15mg(1.660mm) were all greater than the control, 0mg(1.576mm).

The Effect of Colored Light on Moth Behavior
Smera Shanmugan, Godwin High School

The purpose of the experiment was to determine the effects of different colored lights on moth behavior. Every year, millions of insects die from the exposure to artificial light. This attraction to artificial lights that insects have is very dangerous for both them and humans. Polyphemus moths were exposed to 3 watts of white, blue, and orange light. The moths were observed for 30 seconds each and the light bulb that each moth was closest to was recorded. The control for the experiment was the white light. A hypothesis that was formulated for the experiment stated that moths would have the most photo-taxis response towards white light. It was shown through the results that moths had the most photo-taxis response towards white light while the blue light had the second most. A chi-square test on the data showed that the results were significant. The research hypothesis was supported by the results. The results are believed to have been from the way the moths are able to process the different wavelengths of colored light. Further studies could use the results of this experiment to determine the color of light that is least harmful for moths and other insects.

The Effect of Geomorphic Habitat Features on Benthic Organism Abundance
Lillian Watson, Washington-Liberty High School

The macroinvertebrate index is used as an indicator of water quality health. When conducting surveys for calculating the index, sampling of only a high current or low current region could lead to inaccurate indicator results. The purpose of the investigation was to study the effects of geomorphic features, specifically current flow, in a body of water on the number of organisms present. The areas of high/moderate current flow were hypothesized to have higher species abundance than areas of low current flow where there is less sediment turnover, leading to greater pollutant deposition, and thus being a less habitable region. The results of the experiment had a higher average species for the low current sampling sites compared to the moderate/high current sites. There were high standard deviations between the two groups and an ANOVA statistical test had a p-value greater than the critical value of 0.05, meaning the results were not statistically significant. The results of the investigation did not support the hypothesis and were not consistent with current research due to low precision in the results.

The Effect of Water Temperature on the Hatching of *Artemia franciscana*
Madeleine Day, Washington-Liberty High School

Due to the fact that oceans are warming from the absorption of atmospheric heat, it can be assumed that marine life will also be affected by this warming. In order to examine and predict how marine life would be affected, brine shrimp were placed into containers of water of different temperatures. This was measured through how many brine shrimp hatched in a sample from each container. The prediction for this experiment was that if the temperature of water in a habitat is changed, then the most brine shrimp will hatch at 26°C because that is the temperature in which brine shrimp typically hatch. The different temperatures tested were based on predicted ocean warming over the next 100 years, with each level of temperature representing a difference of 33 years, and the current ocean temperature. These temperatures were 26.6°C, 27.3°C, and 28°C. All other factors of the organisms' environment remained stable (salt content, pH, etc.) throughout each trial of the experiment. Each container was given three days for all cysts to hatch, then data was collected. The data found that the average number of brine shrimp in a 1 mL sample of 26°C water was 5.2, 26.6°C 35.1, 27.3°C 24.4, and 28°C 24.2. From this it can be concluded that brine shrimp hatch best at 26.6°C and slowly decline in hatching rates after this. Therefore, brine shrimp will most likely not be affected by rising temperature; however, other marine life forms could be, and this should be further tested. The standard deviations for all of the experimental trials was high and could mean there was a high level of error in the experiment.

Oil Sorbents and their Impact on Oil Collection and *Dugesia tigrina* Survivability
Thomas Ackleson, Washington-Liberty High School

Oil spills are an ever-increasingly relevant subject in our current and future society. The way contained freshwater oil spills are often cleaned by the use of oil sorbents. This experiment was conducted to identify an oil sorbent type that not only cleaned a simulated oil spill, but excelled at protecting the environment it was deployed in. The common oil sorbents of straw, clay, and polypropylene were tested on their ability to absorb oil in freshwater. In addition, each sorbent was tested on the morbidity rate of *Dugesia tigrina* that it produced. After a period of two weeks (14 days), measurements were taken for the oil and water remaining in each trial for each sorbent, as well as the survival rate of *Dugesia tigrina* for each sorbent type. It was predicted that the straw sorbent (natural and organic) would yield the highest survivability and lowest oil collection. It was also predicted that polypropylene would produce the highest morbidity for *Dugesia tigrina* and the highest rate of oil collection. Data was collected and converted into graphs and charts for analysis. Results showed that straw produced the highest survivability and oil collection rate but also collected a high amount of water. Clay and polypropylene fared similarly to each other in terms of morbidity and oil/water collection. The initial hypotheses were both partially rejected; some aspects of each were accurate. Potential implementation of formulae and computer/theoretical modeling was discussed, as well as the use of software to identify ideal sorbent types.

The Effect of Radiofrequency Radiation on the Regeneration Length of *Dugesia dorocephala*
John Mario Kiely, The Mills Edwin Godwin Todd Allen Phillips Centre for Medical Sciences

This project intends to determine the effect of radiofrequency radiation on the regeneration length of *Dugesia dorocephala*, also known as planaria. The prevalence of devices that emit radiofrequency radiation such as mobile phones and laptops provides the need to study its effect on human health. Three radiofrequency levels (0, 800, & 1600 megahertz) were used to imitate a control group, a mobile phone, and a laptop. Seventy-five planaria were divided into three groups, measured, and bisected. They were then exposed to one of the three sources of radiation for ten days and measured again. It was hypothesized that a higher radiofrequency level would cause the planaria to regenerate less. The results demonstrated that the planaria's regeneration percentage decreased by two percent as the megahertz level increased (98%, 96%, 94%). The t-tests performed on the data conveyed that all three comparisons were significant, allowing the results to support the hypothesis. The results are attributed to higher radiofrequency levels, which affect the growth of cells and, as a result, the regeneration length of planaria. Planaria are a regenerative organism that simulates human skin. Therefore, the effects of radiofrequency radiation on planaria may apply to human exposure.

The Effect of Diet Composition on the Mortality of *Gryllodes sigillatus* Nymphs
Angela Oandasan, Clover Hill High School

The purpose of the experiment was to determine the effect of diet composition on the mortality of decorated cricket nymphs. Raising insects as livestock could be a better alternative to raising conventional livestock because of their nutritional value and because rearing systems have less of an impact on the environment. Finding an inexpensive waste material to produce cricket feed that also results in low mortality would increase efficiency of rearing facilities and provide more of a use for human food waste. The hypothesis was that if decorated cricket nymphs, *Gryllodes sigillatus*, were fed diets composed of either vegetable, fruit, or meat food wastes, then nymphs fed on vegetable wastes would show the lowest mortality. The control diet was chicken feed. Twenty cricket pens were used to hold the 100 cricket nymphs used for the experiment. Each IV was given 5 pens which each held around 5 crickets. Water was replaced as seen necessary, and the 10 grams of the prepared diets were replaced every 3 days over the span of 3 weeks. The initial number of crickets in each pen was recorded before data collection, and the number of dead crickets in each pen was recorded daily and subtracted from the number of surviving crickets. A percentage of surviving crickets at the end of the 3 weeks was then taken. The average percentage of surviving crickets was 8% for the control, 0% for vegetables, 14% for fruit, and 9% for meat. Crickets fed the vegetable diet showed the highest mortality, so the experimental hypothesis was not supported. The null hypothesis of no significant difference was tested using an ANOVA test, and the null hypothesis was not rejected. The results of the experiment contradicted past experiments possibly due to how the independent variable was measured. It would be more beneficial to test diet composition on how efficiently an organism converts food, which would require chemical analysis, to determine lifespan.

The Effect of Cadmium on Embryonic Development of *Danio rerio*
Sarah Spradlin, Roanoke Valley Governor's School

Danio rerio (zebrafish) embryos are beneficial to study because they are transparent, model human's physiology, and are easy to care for. They can model neurological diseases and toxicity of heavy metals. It was hypothesized that if zebrafish embryos were exposed to varying concentrations of cadmium, then embryonic development would be hindered, as measured by eye diameter, head length, girth, tail length, and egg diameter. A 10 ppb stock solution was made with 0.0050 g of cadmium nitrate tetrahydrate and 500 mL distilled water. This stock solution was then diluted into 0 ppb, 5 ppb, 10 ppb, 15 ppb, and 20 ppb concentrations of cadmium nitrate and embryo rearing solution. These concentrations were transferred to Petri dishes and five zebrafish eggs were added. The embryos were observed and imaged daily. The data was analyzed using one-way ANOVA for growth and the Chi-Square test for hatching rate. For the one-way ANOVA test, p values were only under 0.05 for more than one time period for head length and girth, therefore only these two groups were statistically significant. The Chi-Square test suggests at least one group was significantly different than another for hatching rate. Cadmium effects the development of zebrafish embryos in the areas of hatching rate, head length, and girth. The hypothesis was supported. Cadmium hindered the hatching rate of zebrafish eggs and affected the growth of the head and girth.

Effect of Gender and Age on Metabolic Rate of *Drosophila*
Ashley Stage, Central Virginia Governor's School

The purpose of this study was to identify how gender and age affect the metabolic rate of *Drosophila melanogaster*, and potentially humans. Respirometry was used to measure the metabolic rate of *Drosophila* through their carbon dioxide output. Respirometers were placed inside of a chromatography chamber containing a water and eosin Y solution. Two groups of *Drosophila* of different age categories were divided by their gender for each trial and placed inside the respirometer. The flies' respiration rates were recorded by measuring the distance the solution travelled up each respirometer. A one-factor ANOVA compared the average distance traveled which ranged from 0.06 to 0.588 centimeters. The test reported a p-value of 1.57×10^{-4} , which is lower than the alpha value of .05, indicating significant differences in the data. A post-hoc Tukey test revealed there was a significant difference between both male groups and the control and the old males with both female groups. The research hypothesis, which stated: "If I record the metabolic rate of male and female *Drosophila* of various ages, then the metabolic rate will decrease as age increases and the male fruit flies will have a higher average metabolic rate" was partially accepted as males did significantly respire more, but age did not have an effect. In conclusion, males have a higher metabolism than females, but age has no effect, so gender influences on human metabolism could cause weight regulation to be more difficult for females.

The Effect of RNAi on *Caenorhabditis elegans* in OP50-Seeded NGM-lite Plates
Landen Tomlin, Central Virginia Governor's School

The purpose of this study was to determine if wild-type *C. elegans* being fed RNAi, silencing the gene could affect their phenotype without mutating their genotype. Silencing the gene without mutation could mimic the appearance of mutated *dpy-13 C. elegans*. There were three groups: wild-type, RNAi, and *dpy-13*, each with 10 trials. The wild-type and *dpy-13* acted as control groups; the RNAi was experimental. All groups were plated on NGM-lite agar cultured with *E. coli* OP50 as a food source for two days. In the experimental group, worms two days old were replanted onto the same agar and food source was seeded with RNAi and allowed to grow for three days. They were measured by taking pictures with a stereomicroscope and analyzing the images with the program ImageJ. The worm length and widths was statistically significant from a one-way ANOVA, which determined ($p < .01$, $\alpha = .05$). The Tukey test then revealed significance between the wild-type and RNAi for the lengths. The research hypothesis was partially supported, if the RNAi feeding strain is implemented into *C. elegans*, then the size of *C. elegans* will become short, similar to the original *dpy-13*. The results of the study suggested that by giving RNAi as a food source that the phenotypic effect of a mutated gene can be imitated.

The Effect of Taurine on the Heart Rate of *Daphnia magna*
Rebecca Qiu, Maggie Parkhurst, Roanoke Valley Governor's School

In recent years, the consumption of energy drinks has become a prevalent habit, especially amongst the younger generations. Many of these drinks, such as Red Bull, contain an amino sulfonic acid called taurine. However, there is little to no significant scientific research surrounding the interaction of taurine on the human heart and its effects. This study utilized *Daphnia magna* as a model organism due to its transparency and susceptibility to cardio active drugs known to influence the human heart to observe the interaction of taurine on heart rate. It was hypothesized that the exposure of taurine on *Daphnia magna* would result in an increase in heart rate, with the highest concentration of taurine yielding the most significant increase in heart rate. The effects of taurine on the heart rate of *Daphnia magna* were quantified by calculating the heart rate in beats per minute using the Tap to bpm iOS application after submerging the crustacean in 0.5%, 0.25%, 0.125%, and 0% taurine solutions for three minutes. Each level had ten trials each, for forty total trials. Exposure to the taurine yielded a significant increase in heart rate from a mean of 216 bpm at 0% to a mean of 367 bpm at 0.5%. A One-Way ANOVA statistical analysis test yielded a p-value of 1×10^{-21} , thus rejecting the null hypothesis. A Tukey Post-Hoc test was then performed and showed a statistically significant difference between all four of the trials. These findings indicate that taurine may have an augmented effect on cardiac function.

The Effects of Oxybenzone, Octinoxate, and Zinc Oxide on the Heart Rate of *Daphnia magna*
Ellie Peterson, Central Virginia Governor's School

The purpose of this study was to determine the effects of sunscreen chemicals on the heart rate of *Daphnia magna* as a model for humans. Concentrations of 1 mg/L were created for zinc oxide and oxybenzone, along with 1 uL/L of octinoxate, and a control group of spring water. The heart rate of eight *D. magna* was measured before introducing a total of 15 organisms to each chemical. Using the average heart rates before and after exposure to each chemical, a single factor ANOVA was performed. The ANOVA returned a p-value of 1.02×10^{-6} with an alpha value of .05, which indicated significance. Therefore, a post-hoc Tukey test was performed with a Dmin value of 70.87. A significant difference was shown to be between the zinc oxide and oxybenzone test groups. This partially supported my research hypothesis, which stated if *Daphnia magna* organisms are exposed to sunscreen ingredients, oxybenzone, octinoxate, and zinc oxide, then their heart rate will increase more with oxybenzone and octinoxate than with zinc oxide. Based on these results, it is indicated that oxybenzone and zinc oxide are potentially harmful to humans and the environment.

Openness Factor and Large Mammal Use of Highway Underpasses: An Observational Study of
State Mitigation Techniques

Christian Shushok, Blacksburg High School

Virginia drivers are often wary of deer on roadways because collisions with deer at high speeds are relatively common in the state. These crashes can not only kill the animal but can also incur thousands of dollars in damage to vehicles and put the life of the driver at risk. One proposed solution to the problem of deer-vehicle collisions is to implement wildlife underpasses. Wildlife underpasses are tunnels and culverts that allow wildlife to cross underneath the roadway rather than over it. One parameter by which tunnels can be built is by taking into account the total openness factor in which the length times the width of a tunnel is divided by its height. This study hypothesized that a larger openness factor would correlate to higher rates of wildlife usage. Using remote motion sensors trail cameras, multiple tunnel sites were monitored for wildlife presence both in and around the structures. After data analysis, there was little significant relationship found between openness factor and wildlife usage. This study also found a complete absence of deer using the structures, and low rates of other wildlife usage. This study is not large enough to definitively establish that these structures are inadequate; however, its lack of wildlife documentation raises questions about tunnel effectiveness along Interstate 81 and Highway 460 in Southwest Virginia.

The Facility of *Gromphadorhina portentosa* to Grind Microplastics
Morgan Ralph, Southwest Virginia Governor's School

Microplastics, which are plastics smaller than five millimeters, are increasingly polluting the environment and harming natural ecosystems. There is little research involving the use of insects, specifically cockroaches, in the breakdown of plastics. *Gromphadorhina portentosa* is a unique insect on the island of Madagascar, where it acts as a decomposer. As the abundance of microplastics arise in the environment, some research is looking towards cockroaches for solutions. The research focus here was on the possibility of *G. portentosa's* facility to grind and degrade microplastics into a less harmful form. The study was designed to have three groups of *G. portentosa* placed in three different tanks be exposed to a homogeneous diet. The diet consisted of dextrin, casein protein, salt, yeast, banana chip, glass beads, and biodegradable or nonbiodegradable plastics. Group 1 was given the diet with biodegradable plastics, Group 2 was given the diet with nonbiodegradable plastics, and the Control was given a diet without the plastics. The cockroaches were fed the diet through three trials for 2 weeks. Frass from each group was collected after each trial, analyzed using a Dinolite Microscopic Imager, and photographs were taken from each trial. A Wilcoxon Non-Parametric Test was performed to compare the plastic sizes found in the frass. A p-value of 0.2731 resulted, which is higher than 0.05, so there was no evidence to support that *G. portentosa* can grind microplastics through their digestive processes. Additionally, a 2-Way ANOVA Test was performed to examine the variances in Trial 1 and Trial 3, as time elapsed between them. It yielded a p-value of 0.0067, indicating a significant difference between diet consumption levels between the beginning and the end of the experiment. This study sheds light on how a key species of cockroach will respond to the growing amount of plastic pollution. Additional studies involving the use of this cockroach could focus on ways to improve their likelihood of digesting and degrading the plastics.

The Effect of Ozone on the Health of Honeybee Hives in the US
Ben Portner, Washington-Liberty High School

The goal of this study was to identify a possible link between ozone concentration and honeybee colony loss through the use of cross-sectional statistical analysis. Honeybees are vital pollinators for many crops, notably almonds, cherries, and blueberries. However, worldwide, bee populations have been declining at an alarming rate since the early 50s. This study investigates whether ozone plays a role in bee decline. Ozone is a destructive air pollutant, and in addition to ozone being documented as a gas harmful to humans and other animals, several studies have shown negative effects on plants. Some such effects arise from the interference between ozone and the floral aromas those plants produce. The data used was gathered from the EPA's tests of ozone concentrations, and the USDA's annual survey of honeybee colonies across the country. Using Microsoft Excel, multiple tests were conducted, including a Pearson r correlation, several ANOVA tests and t-tests. Variation in ozone and colony loss was not random, and while the relationship between the two trended in the predicted direction, this correlation was weak. A combination of these results has led to the conclusion that ozone likely has an effect on honeybee colony health, though this influence is small, and does not constitute a major explanation of why bee populations are declining. The conclusion of the study suggests a number of practical conclusions, such as changed policies at regional levels concerning agricultural practices and particular crops being grown. In summary, this study has derived useful information on the topic of honeybee decline by performing statistical tests on national multi-year data.

Oil Sorbents and their Impact on Oil Collection and *Dugesia tigrina* Survivability
Thomas Ackleson, Washington-Liberty

Oil spills are an ever-increasingly relevant subject in our current and future society. The way contained freshwater oil spills are often cleaned up and mitigated is by the use of oil sorbents. This experiment was conducted to identify an oil sorbent that not only cleaned a simulated oil spill but excelled at protecting the environment it was deployed in. The common oil sorbents of straw, clay, and polypropylene were tested on their ability to absorb oil in freshwater. In addition, each sorbent was tested on the morbidity rate of *Dugesia tigrina*. After a period of two weeks (14 days), measurements were taken for the oil and water remaining in each trial for each sorbent, as well as the survival rate of *Dugesia tigrina* for each sorbent type. It was predicted that the straw sorbent (natural and organic) would yield the highest survivability and lowest oil collection. It was also predicted that polypropylene would produce the highest morbidity for *Dugesia tigrina* and the highest rate of oil collection. Results showed that straw produced the highest survivability and oil collection rate but also collected a high amount of water. Clay and polypropylene fared similarly in terms of morbidity and oil/water collection. The initial hypotheses were both partially rejected, though some aspects of each were accurate. The potential implementation of formulae and computer/theoretical modeling was discussed, as well as the use of software to identify ideal sorbent types.

Investigation of Different Concentrations of *Ginkgo biloba* on *Danio rerio* Memory Development
in the Prevention of Alzheimer's Disease
Mrunal Kute, Mills E. Godwin High School

Alzheimer's disease, a highly prevalent health issue in the 21st century, affects approximately 1 in 10 people over the age of 65 in the United States and there is one new case every seven seconds. However, the limited treatments presently available often ensue in adverse side effects for patients. On the other hand, *Ginkgo biloba*, a promising, modernized plant-based medication, has consistently shown to improve and alleviate symptoms of Alzheimer's at a more efficient rate than current remedies. Hence, the purpose of the research was to analyze how different concentrations of *G. biloba* impact *Danio rerio* (zebrafish) memory development where *D. rerio* were used as a neuroanatomic vertebrate model for the human brain. Based on the levels of the independent variable, a research hypothesis was formulated that if Experimental Group C was administered 1.5 mg/L of *G. biloba* extract powder, then the memory development among the *D. rerio* would be greater than Experimental Group A (received 0.5 mg/L), Experimental Group B (received 1.0 mg/L), and the Control Group (received 0.0 mg/L). To test the dependent variable, *D. rerio* memory development, T-maze testing methods were utilized, where *D. rerio* demonstrated either "Observed" or "Unobserved" Memory Development. Based on the chi-square test performed, the qualitative data was statistically significant, indicating that there was less than a 0.5% chance that the results were due to chance. As hypothesized, Experimental Group C demonstrated the highest cognitive development in comparison to the other levels of the independent variable. It is thus concluded that the results occurred due to *G. biloba*'s blood-thinning properties and the herbal treatment's neuroprotective effects against the proteins involved in the promotion of Alzheimer's disease.

The Effect of Memory Conditioning on *Dugesia dorotocephala* Memory Retention
Abhinav Mara, Mills E. Godwin High School

The purpose of this experiment was to investigate the effects of various training periods on the memory retention of *D. dorotocephala* after they regenerate a new head. Due to the memory and regenerative capabilities in *D. dorotocephala*, there is a possibility that they are capable of inheriting memories. Research on this topic can provide insight into memory mechanisms and whether the removal or addition of memories manually is possible in order to help people with memory-related problems. *D. dorotocephala* were trained to associate a rough surface with food during their training phase. A cathode was added to speed up the learning process. *D. dorotocephala* were tested for memory retention by timing how long it took them to surpass a rough terrain to eat food as the planaria's thigmotaxis fore to repel from rough surfaces. The different training periods were 0 days (control), 8 days, 10 days, and 12 days. A research hypothesis was formulated that the *D. dorotocephala* trained for 12 days will start feeding the fastest. The results showed that the *D. dorotocephala* that were trained for 12 days did start feeding the fastest at 160.56 seconds on average which supported the hypothesis. A t-test was performed, and it revealed that only the independent variables 10 days vs. 12 days were not significant. It is believed that the extended training phase increased the probability of inheriting the memory and this proved that epigenetics is possible. This research could lead to further studies of memory transfer through RNA mechanisms.

To Breathe or Not to Breathe: Can Prenatal Exposure to Inhaled Pollution Adversely Impact Health Outcomes in *Drosophila melanogaster*?

Arman Lateef, Tony Bright, and Gabriel Ralston, Charles J. Colgan Sr., High School

Main Objectives: Air pollution is a serious, global problem that threatens successive generations of all living organisms. The objective of this project was to engineer a pollution chamber with measurable levels of particulate pollution and assess the following: 1) Does prenatal exposure to particulate matter (PM) affect the lifespan, physical structure and learning capacity of *Drosophila melanogaster* (fruit fly) offspring?; 2) Can wearing a Vogmask and/or prenatal supplementation with folic acid mitigate the harmful effects of particulate pollution on these health outcomes? **Methods:** Flies were exposed to pollution in a controlled chamber using the exhaust from a STIHL Echo-One trimmer. An air pollution monitor recorded PM 2.5 levels. The offspring, or F1 generation, were assessed for health impacts. Five parental groups were used: 1) No exposure to pollution; 2) Pollution only, no mask, no folic acid; 3) Pollution and mask only, no folic acid; 4) Pollution and folic acid only, no mask; 5) Pollution, mask, and folic acid. **Longevity** - After 6 hours of pollution exposure, 5 male and 5 female flies in each pollution exposed group were transferred to an incubator, with unexposed flies. Their offspring's lifespan was monitored. **Physical Structure** - Flies in each offspring group were anaesthetized and their prominent physical characteristics (body shape, body color, and wing anatomy) were observed, photographed and studied for mutagenic effects. **Learning** - After a short period of starvation, flies were introduced into the choice chamber and could either migrate towards a chemoattractant (fruity mint) or sucrose. Flies were expected to learn the value of nutrition for survival and eventually migrate towards sucrose. After 10 minutes, the number of flies in each chamber was recorded. **Results:** Pollution exposure of parents decreased *Drosophila* offspring lifespan by 13% and caused mutagenic effects such as vestigial and curved wing structure. *Drosophila* exposed to prenatal pollution did not demonstrate expected olfactory behavior possibly because they had an impaired sense of smell, potentially due to the genotoxic effects of pollution. Protecting the parental generation with a Vogmask did not diminish the effect of pollution on lifespan, physical structure or learning. However, providing prenatal folic acid supplementation significantly improved offspring lifespan. **Conclusions:** Pollution has a profound impact on human health for successive generations, and this cannot be mitigated by wearing a mask. Prenatal vitamin supplementation may offer some protection from the detrimental health effects in offspring, but it cannot replace breathing in clean air.

MIDDLE SCHOOL SECTIONS

ANIMAL HEALTH

The Effect of Increased Obstacles within the Subterranean Environment of *Solenopsis invicta* on Colony Growth.

Cameron Piehota-Abbott, Thomas Jefferson Middle School

The purpose of this study was to investigate *Solenopsis invicta* activity and ant colony growth in a subterranean environment with varying amounts of obstacles. The independent variable was the percentage of rocks in the container that the ants were housed in. The experimental group included an ant farm with sand and 25% rocks, 35% rocks, and 50% rocks. The control group was an ant farm with 0% rocks. The dependent variable was ant activity within the farm. The constants were the type of ant, sand, and light. The hypothesis was: if *Solenopsis invicta* are exposed to 35% of rocks in the farm, then the colony will have more activity in order to overcome those obstacles. Multiple ant farms were constructed. The displacement method was used to create an ant farm with 25% rocks, 35% rocks, 50% rocks, as well as a control group with 0% rocks. The ants were placed in the ant farms and their activity was measured through downward vertical expansion in the ant farm. The results showed that the 35% experimental group had the highest final mean growth out of all the experimental groups. In conclusion, the study suggests that *Solenopsis invicta* do communicate to advance the colony when obstacles are in the way.

The Effect of the Moss Type on the Reoxygenation of Anoxic Waters
Anna Mohanty, Williamsburg Middle School

The purpose of this experiment was to determine the reoxygenation success of a dead zone, by using various moss types (Riccia Fluitans, Forest Moss, and Sphagnum Moss). Dead zones catastrophically impact an ecosystem, killing millions of marine species. They often cause mass killings of marine life, and at an extreme rate. As pollution rates rise, dead zones have become more common. There are over 166 recorded dead zones between the Chesapeake Bay and the Gulf of Mexico alone (the largest one globally being in the Gulf of Mexico spanning roughly 7,000 square miles). They are caused mainly in households by over fertilization, so when the excess nutrients congregate from sewers, it is dumped into our water bodies, creating a damaging state of anoxia. This experiment was carried out by planting Riccia Fluitans, Forest moss, and Sphagnum moss into separate containers. In each of the containers there was a purposefully created dead zone from mock fertilizer runoff. The oxygen levels were compared daily to the starting anoxic conditions. By the end of a two-week period (it was a shortened time period to represent the quick time between the creation of a dead zone, and its mass killing of marine life), each moss type was expected to surpass the starting oxygen levels. The anticipation or hypothesis was that Riccia fluitans would produce the most oxygen over the time period. This is because Riccia fluitans has the highest concentration of chloroplast out of the independent variables. Therefore, it will be more efficient in photosynthesis. This hypothesis was supported by the range of oxygen levels after the two-week period.

The Effect of Type of Liquid on the Heart Rate of Daphnia
Inés Kapur, Thomas Jefferson Middle School

The purpose of this study was to see which of three common drinks has the most effect on the Daphnia heart rate. The independent variable was the type of drink which were coffee, alcohol, and coca-cola. The dependent variable was the Daphnia, a shrimp-like organism that has a clear exoskeleton so the heart is visible. The control group was spring water, the substance where the Daphnia lives. The hypothesis was if the daphnia is soaked in coffee, then the heart rate of the Daphnia will have the highest heart rate. The study used a microscope to measure the heartbeat of Daphnia soaked for ten minutes in the three liquids (coffee, alcohol, and Coca-Cola) and compared them to the heart beats of Daphnia in spring water. The results showed that alcohol increased the heart rate the most, followed by Coca-Cola. Coffee slowed down the heart rate. These results rejected the hypothesis. One reason the hypothesis was rejected may be because the drinks affect humans and Daphnia differently or that the Daphnia's heart rate is not increased by caffeine but by sugar. In conclusion, the study suggests that the Daphnia's heart rate is not increased by caffeine but by sugar.

The Effect of Taurine on the Heart Rate of *Daphnia magna*
Maggie Parkhurst and Rebecca Qiu, William Byrd High School/ Roanoke Valley Governor's
School

In recent years, the consumption of energy drinks has become a prevalent habit, especially amongst the younger generations. Many of these drinks, such as Red Bull, contain an amino sulfonic acid called taurine. However, there is little to no significant scientific research surrounding the interaction of taurine on the human heart and its effects. Due to its transparency and susceptibility to cardio active drugs known to influence the human heart, this study utilized *Daphnia magna* as a model organism to observe the interaction of taurine on the heart rate. It was hypothesized that the exposure of taurine on *Daphnia magna* would result in an increase in heart rate, with the highest concentration of taurine yielding the most significant increase in heart rate. The effects of taurine on the heart rate of *Daphnia magna* were quantified by calculating the heart rate in beats per minute using the Tap to bpm tool on the iPhone after submerging the crustacean in 0.5%, 0.25%, 0.125%, and 0% taurine solutions for three minutes. Each level had ten trials each, for forty total trials. Exposure to the taurine yielded a significant increase in heart rate from a mean of 216 bpm to a mean of 367 bpm. A One Way ANOVA statistical analysis test yielded a p-value of 1E-21 and Tukey Post-Hoc test showed a statistically significant difference between all four of the trials, thus rejecting the null hypothesis. These findings indicate that taurine may have an augmented effect on cardiac function.

ANIMAL HEALTH

The Effect of Temperature and Dew Point on 5k Running Times

Penelope Kim, Moody Middle School

The purpose of this experiment was to discover if dew point and temperature can affect result times for a 5-kilometer race. This information could help runners and race organizers understand and predict changes in performance due to the weather. Dew point is the temperature at which the air gets saturated with moisture. The hypothesis for this experiment was if the temperature and dew point increased, then the race times increased. The data from a total of forty-three races in Richmond, Virginia at Deep Run Park between 11/3/18 and 11/2/19 were collected from the parkrun website. Also, the weather data were obtained from the Weather Underground website for the dates of these races. Since the weather is different throughout the year, there were many different temperatures and dew points. The mean race time was calculated using Excel. The data of the race time versus dew point graphed on a line plot and a scatter plot showed that the dew point and temperature were at least somewhat correlated to racing times an R squared value of 0.13 for dew point versus mean race time and an R squared value of 0.1404 for temperature versus mean race time. In comparison, the relative humidity was also collected for each of the dates and showed no correlation to race times at all with an R squared value of 0.0003. There was no control because the weather was not able to be manipulated in this setting to create a control dew point. Overall the data collected supported the hypothesis that running times would be affected negatively by increased dew point and increased temperature. The findings suggest that runners and race organizers would benefit from checking the dew point, in addition to temperature, on race day, as it may affect the performance results.

The Effect of different concentrations of pure nicotine vs. vaping liquid used in E-cigarettes on the heart rate of the *Daphnia magna*.

Nitya Kumar, George H. Moody Middle School

Nicotine obtained from the tobacco plant *Nicotiana tabacum* is the primary source of smoking tobacco and is highly addictive. The use of ENDS (electronic nicotine delivery system) or E-Cigarettes is the most commonly used tobacco product among U.S. middle (5.3%) and high school students (16%). Smoking nicotine is causally related to a higher level of resting heart rate and exerts its detrimental effects on cardiovascular disease at least partly via increasing resting heart rate. *Daphnia*, also known as water fleas, are very tiny planktonic crustaceans. Measuring the *Daphnia* heart rate is the most common test done using this organism. The hypothesis of the experiment was if the different concentrations of pure nicotine and vaping liquid are tested on *Daphnia magna*, then the heart rate of the *Daphnia magna* will increase. Five trials for each concentration was conducted. The average heart rate of *Daphnia magna* in spring water (control) after 5 trials was 190 beats/min. The average heart rate in vaping liquid nicotine concentration of 3 mg/ml, 6mg/ml and 12 mg/ml was 217, 242 and 226 beats/min respectively consistent with prior experiments. The average heart rate of the 3 % pure nicotine, 6% pure nicotine, and 12 % pure nicotine was 172 beats/min, 139 beats/min, and 14 beats/min respectively. At 12% pure nicotine the *Daphnia magna* immediately succumbed to the toxic concentrations. Thus, the experiment hypothesis was not supported, probably because the pure nicotine was very toxic to *Daphnia magna*. Since E-cigarettes are becoming increasingly prevalent, especially amongst the youth, it is important that further studies to study the deleterious effects of nicotine should be undertaken.

The Effect of Different Colors of Light on the Volume of Brine Shrimp Migration
Addison Kofron, Moody Middle School

The purpose of this experiment was to test the colors of light that brine shrimp are attracted to the most. Brine shrimp have an attraction to light, but scientists do not know which colors of light brine shrimp have the greatest level of attraction. The hypothesis in this experiment is that if brine shrimp are exposed to different colors of light, the brine shrimp will move in greater numbers to blue light. Based on research, brine shrimp are attracted to blue and green colors of light. Therefore, the hypothesis suggests that brine shrimp will be more attracted to blue light than other colors of light. To conduct the procedure and test this experiment, brine shrimp were placed in a pyrex dish. There were six different pyrex dishes covered by black construction paper. Each pyrex dish had a color of light shown on the one-quarter opening of the pyrex dish. The colors tested were red, yellow, green, blue, white, and no light as a constant. The light was displayed over the pyrex dishes, revealing the colors of light brine shrimp are attracted to the most. The number of brine shrimp that moved towards the different colors of light were counted and analyzed. The results indicated that brine shrimp moved in greater numbers towards the white light. The mean movement for the color white was one hundred and eighty-one. The control group of no light provided the least amount of brine shrimp with a mean of four. After analyzing the data, the data showed that the hypothesis for this experiment was not supported. Although the brine shrimp had an attraction to the blue light, the data revealed that the brine shrimp were most attracted to white light.

The Effect of Fly Sprays on House Flies
Camden Meacham, Sabot at Stony Point

Horse fly spray is frequently used at many equine facilities. Horse fly spray can cause problems though, horses can be allergic to them and they can be dangerous to everyone involved when inhaled. This experiment was conducted to determine whether or not horse fly spray has any effect whatsoever on fly protection. Three sets of about ten flies were tested by counting how many went to a food source when there was no spray, store-bought fly spray and homemade fly spray when the flies were with the food source. The hypothesis was that store-bought fly spray would be more effective at deterring flies than homemade and no fly spray. The results showed that actually homemade was the most effective fly deterrent, and fly spray does actually deter flies from going to a food source. The results showed that one fly landed on the food source with homemade fly spray, store-bought had two flies land on the food source and control had seven flies land on the food source. The data shows that fly spray makes a significant difference.

The Effect of Video Games on Heart Rate and Blood Pressure
Julian Bessenger-Vose, Sabot at Stony Point

The objective of this experiment was to find the effect of videogames on heart rate and blood pressure. This would be beneficial to people who play video games a large amount to see if they would be negatively affected by video games. The hypothesis was that playing video games would increase heart rate and blood pressure significantly. The hypothesis was rejected because the difference was very small between the average starting and finishing heart rate and systolic and diastolic blood pressure. There was a difference of 3.4 beats per minute for the heart rate, a difference of 2.67 mmHg for the systolic blood pressure, and a difference of 0.66 mmHg for diastolic blood pressure. It was concluded that Portal is not a very intense game, and there would be a more significant change in heart rate and blood pressure if a fast-paced video game was used in the testing, such as Counterstrike, which was shown to raise heart rate and blood pressure in a test during a different study.

The Effect of the Time of Day on the Number and Type of Mammals
Charlie Dantzker, Williamsburg Middle School

Understanding mammal populations and movement is important for wildlife conservation. Previous research shows that most mammals are nocturnal. The purpose of this experiment was to understand mammal activity in relation to the time of day at a suburban site in Arlington, VA. For this experiment, an IR (infrared) trail cam was used to capture instances of mammals on a backyard path connecting a private yard to unfenced forested parkland. Instances of mammals observed via the trail cam was used as a measure of mammal activity. The dependent variables were 1) the type of mammals, and 2) the number of mammals. The independent variable was the time of day. Data was collected for 28 days. The study hypothesis of higher mammal diversity at night was supported by the data. Key results included: 1) five total mammal species were observed: deer, fox, squirrel, cat, and dog; 2) the highest mammal diversity was observed at night, and 3) low diversity was observed at both dawn and dusk. This type of data showing mammal activity can play an important role in gaining a better understanding of local wildlife presence and activity. This knowledge, in turn, is important for wildlife conservation, including habitat preservation, habitat restoration, and ecosystem management.

The Effect of a Static Magnetic Field Generated by Neodymium Magnets on Regeneration in the
Planarian *Dugesia tigrina*
Alexia Sawwa, Ronald Wilson Reagan Middle School

Planaria, commonly known as flatworms, have the remarkable ability to regenerate due to pluripotent stem cells called neoblasts, which can be reprogrammed to replace any cells that are needed to create an adult worm. Flatworms in the class Turbellaria are found in almost all aquatic habitats where they hide under rocks, leaves, and debris to avoid light. The purpose of this project was to assess the effects of magnetic field intensity emitted from rare earth neodymium magnets on the regeneration of the Tubellarian *Dugesia tigrina*. *D. tigrina* were exposed to three different magnetic strength intensities: 282, 521 and 895 Gauss. Planaria were cut midway between the anterior and posterior end of the animal in four groups: bisected with no magnets and bisected and exposed to surface field strength of 282 Gauss, 521 Gauss, and 895 Gauss. The control group, left uncut and untreated, was further divided into two additional groups with no magnets and with magnets of the highest strength (895 Gauss). It was hypothesized that increasing the magnetic field intensity would have a negative impact on the regeneration and growth rate of *D. tigrina*. However, it was found that all *D. tigrina* exposed to the magnetic field had an increased regeneration rate, which contradicted the hypothesis. A possible explanation for this result is that the magnetic field generated by high strength magnets stimulates growth and regeneration in *D. tigrina* by stretching their bodies.

The Effect of Runoff Nitrate Fertilizer on the Population Growth of *Daphnia magna*
Sivani Nemani, George H. Moody Middle School

The purpose of this experiment was to evaluate what concentrations of nitrate fertilizer were the most toxic to *Daphnia magna*. Nitrates are essential for plant and animal growth and nourishment. However, an overabundance of nitrates can result in negative health and ecological effects. Excess nitrates in water sources leads to hypoxic conditions and blocks sunlight from entering the water. This process is called eutrophication, which causes water sources to lose its primary functions and prevents it from sustaining life. The research hypothesis was that if *Daphnia magna* were exposed to 10mg of nitrate fertilizer, then their population growth would decrease the most significantly. Varying concentrations (0 mg, 1 mg, 5 mg, and 10 mg) of nitrate fertilizer were added to the living space of *Daphnia magna* and their population growth was recorded. The 10 mg of nitrate fertilizer affected the *Daphnia magna* the greatest, having an average end population of 0.9 *Daphnia magna*. The 1 mg of nitrate fertilizer affected it the least with an average end population of 22 *Daphnia magna*. This data rejected the null hypothesis, which showed that the results of this experiment were significant. Higher amounts of nitrate fertilizer reduced population growth the greatest because *Daphnia magna* tend to reproduce based on their surroundings. The healthier their environment, the more they reproduce, but the more toxic it is, the less they reproduce. Because of the lack of reproduction in the experimental groups with nitrate fertilizer, it is concluded that the addition of nitrates made the living space of the *Daphnia magna* toxic.

CHEMICAL SCIENCE

The Effect of pH in Liquids on the Erosion of Chalk

Ava George, Thomas Jefferson Middle School

The purpose of this study was to test different pH levels of liquids on the erosion of chalk. The independent variable was different pH levels in liquids. The experimental group included: vinegar (pH: 2.4), orange juice (pH: 3.75), and lemon juice (pH: 2.5). The control group was water (pH: 7.0). The dependent variable was the length of the chalk after it was immersed into the liquids. The constants were: type of chalk, color of chalk, original size of chalk, amount of liquid used, ambient temperature, amount of time chalk was immersed into liquids, and temperature of the liquids. The hypothesis was: If chalk is immersed in vinegar, then chalk will erode more significantly when put in a liquid with a high acidity. One 7.7 cm piece of chalk was immersed into a clear plastic cup for twenty minutes, with 250 mL of orange juice in it. When the timer was done, the chalk was carefully removed with gloves from the orange juice, it was measured with a ruler (cm), then the results were recorded. These steps were repeated using the other three liquids: distilled white vinegar, Kirkland purified water, and Turkey Hill lemonade. Then all steps were repeated for four more trials (five trials for each liquid, for a total of twenty trials). The results showed that vinegar eroded chalk the most out of the four liquids. These results proved the hypothesis. One reason the hypothesis was accepted may be because vinegar has a pH level of 2.4, which is more acidic than the other liquids and acidity caused the chalk to erode more. In conclusion, the study suggests that the more acidic the liquid, the more it will erode chalk. Based on the findings of this study, one study that should be done is to test how to get acids in liquids to have a smaller erosion rate on chalk to help reduce the erosion rate of acid rain on statues and other buildings.

The Effect of the Amount of Time Crumb Rubber Soaks in Saltwater on Lead and Chemical Levels Found

Elizabeth Adams, Dorothy Hamm Middle School

This experiment searched for the difference in the chemical levels, primarily lead, of a water solution after crumb rubber soaks in it for differing lengths of time. To complete the experiment, crumb rubber samples were collected from a nearby turf field and placed in a saltwater solution. The water solution represents sweat because the athletes who utilize the turf fields release bodily fluids during use. Over a 14-day period, the samples were tested at different time intervals, and the findings were recorded and analyzed in this experiment. Artificial turf has been known to contain carcinogens, therefore, the research done in this project is important as it concerns the safety and wellness of patrons of artificial turf fields. The experiment found no traces of lead, though it did find a difference between the beginning chemical levels of the water and the levels at the conclusion of the experiment. Specifically, the alkalinity levels, or the ability of the water to neutralize acids and maintain a balanced pH level, decreased significantly over the two week period. The levels of copper in the solution changed as well, increasing over the course of the experiment, thus demonstrating that the crumb rubber does indeed impact the chemical balance of the water solution.

The Effect of Different Types of NSAID Pain Relievers on the Time they Take to Dissolve In Simulated Stomach Acid

Sam Daunt, Ronald Reagan Middle School

Pain-reliever companies tout that their drug will dissolve the fastest, but which pill actually dissolves the fastest in the stomach? Two years ago, after receiving a bone marrow transplant, I was advised to have a fast-acting pain-reliever/blood thinner with me at all times. This inspired me to test these claims, because so many people in the world take these drugs and need to know which one will work the fastest. This project looks at the four most common brands of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) and their ability to dissolve in simulated stomach acid. The different brands of NSAIDs (independent variable) were tested in simulated stomach acid and a stopwatch was used to see how long it took each of the pills to dissolve (dependent variable). My hypothesis was that Bayer, a form of aspirin, would dissolve the fastest in the acid because of its powdery texture and new technology it utilizes. My hypothesis was supported by my data, and Bayer was far faster than the other NSAIDs tested. This study will help and inform all those who take these medications and wonder which one will be fastest acting in an emergency.

The Effect of Bromelain on the Mass of Different Types of Food Waste
Nadyah Ahmed, Thomas Jefferson Middle School

This study was performed to determine whether or not Bromelain, a proteolytic enzyme, could break down and reduce the mass of food waste. The independent variable was the type of food waste. The experimental group included: banana peels, raw meat scraps, and egg shells in a Bromelain and water mixture. The control group was the same group of food waste in water. The dependent variable was the difference between the starting mass and the ending mass. The constants were the Bromelain tablet, the amount of water, and the amount of time that the waste was in the Bromelain mixture and the water. The hypothesis was: if food waste is put into a Bromelain and water mixture, then the mass of the waste will decrease. Six containers were each prepared with one-liter of water, then a Bromelain tablet was placed into three of them. Each type of food waste was submerged in the liquid for six hours and then the waste was removed and left to dry for 18 hours. The starting and ending weight of the waste were recorded, and the process was repeated for five trials. After analysis the results suggested that food waste with Bromelain lost more mass than food waste without Bromelain. One reason the hypothesis was accepted may be because the Bromelain broke down the protein in the food waste. Another reason may be because there were not many errors that would affect the results of this study. In conclusion, this study suggests that Bromelain can be used to breakdown proteins in food waste.

Not So Crystal Clear: Do Different Sugars Affect the Mass of Rock Candy?

Haley Baasansukh, Swanson Middle School

The purpose of this experiment was to see if different sugar crystal sizes found in different types of sugar would affect the mass of the product. This experiment consisted of testing the different types of sugar on the mass of the rock candy produced by creating a supersaturated solution and a seed crystal for the sugar crystals to grow onto during crystallization. The hypothesis that was tested was, if the Demerara sugar is crystallized, then it will have the highest mean. The four levels that were tested were granulated sugar, light brown sugar, cane sugar, and Demerara sugar. The crystal sizes for each level were as listed, granulated sugar 450 to 650 μm , light brown sugar 270 to 420 μm , cane sugar 500 to 750 μm , and Demerara sugar 800 to 1,200 μm . The hypothesis was tested by producing ten different rock candy samples for each different sugar type. The motivation for this project was fueled by the interest in how crystallization works from a supersaturated solution. From the data collected, it was concluded that the Demerara sugar had the lowest mean with 8 grams and that cane sugar had the highest mean with 33 grams. The Demerara sugar and cane sugar were the levels that had the least variability among all of the levels, meaning that the data was consistent throughout all ten trials. The data does not support the hypothesis that was tested.

The Effect of Acids on the Degradability of Polyvinyl Chloride in UV Light
Shreesh Kalagi, George H. Moody Middle School

PVC is short for polyvinyl chloride (U.S National Library of Medicine, 2017). This material has the special ability to break its molecules down under UV light, and the name of this process is “photolysis” (Liu, 2013). As of 2018, the global demand of Polyvinyl Chloride was 59.1 billion United State dollars (Wood, 2018). Not only is that number significant, but the amount of waste produced mirrors that of its sales. With the world’s land-fills taking more and more space, it is time to start thinking of solutions. Since this idea is such a big problem, it would help immensely to rid the world of these plastics, even if only by small percentages. Because of these ideas, the project was conducted in hopes of finding a clean way to dispose of PVC products. This project was conducted with the hopes that it could also help those at home to reduce the amount of waste in their home made of polyvinyl chloride on their own. While in the comfort of their own home, people would be able to save the world in small actions such as degrading un-usable polyvinyl chloride products. The hypothesis made was, if hydrochloric acid was used in the degradation of polyvinyl chloride samples that have undergone photolysis, then the samples would have displayed a maximum decrease in mass. After the tests were completed, the data was recorded and assessed. Under the ultraviolet light, hydrochloric acid performed the best with a mean percentage of mass decrease at 0.33%. With this statistic, it was proven that the hypothesis was supported. The findings of this experiment can be explained by the fact that UV light can weaken PVC samples. After samples are weaker, they are corroded with the different acids. One error that could be fixed was that the UV light bulb was a little too close to the samples and started making the liquids evaporate. To fix this, simply move the light bulb slightly further away.

The Effect of Sodium Chloride on Albumin Denaturation Time
Niranjana Marri, George H. Moody Middle School

Denaturation in a protein is where the tertiary and secondary structures are destroyed, and the hydrogen bonds get disrupted. Heat is the safest and simplest way to denature proteins. If a NaCl concentration is added to albumin, then it can denature albumin faster than just heat alone denaturing albumin. If sodium chloride can help with the quickening of albumin denaturation, then it will change the way eggs are cooked. 80 mL of water should be heated on a stove in a heatable container. Once the candy thermometer reads 70 degrees Celsius, the hot water was carefully poured into a glass transparent container. The experimenter quickly measured 4g of salt and added it to the hot water. After, the researcher then added one egg white, then timed how long it took the albumin to denature. Once the albumin showed any sign of denatured protein the experimenter stopped the timer. Any information and data was recorded. The experimenter repeated this experiment for the rest of the IV levels and control. The IV levels are, 4g, 6g, and 8g. No sodium chloride was added to the control. Ten repeated trials were done for the experiment. Over the course of ten trials, the control container had an average time of 3.07 minutes. The container with 4g of salt took the longest time to denature with a time of, 3.30 minutes. The container with 6g of sodium chloride added took 3.1 minutes to denature. The last container with 8g of salt added had an average time of 3.23 minutes. The control container took the least time to denature. The hypothesis failed, salt cannot help destruct the tertiary and secondary structures. The salt did not affect the denaturation process whatsoever.

The Effect of Conditioner Brand on the Tensile Strength of Hair
Natalie Xie, George H. Moody Middle School

Conditioner replaces essential oils to hair that shampoo washes out. It is necessary for keeping hair moisturized and healthy. When hair is exposed to harmful conditions, the outermost layer is weathered down. A rough texture or dulled shine suggests that the hair has been damaged. Heat damage is particularly detrimental towards hair, as dry hair is fragile. However, prolonged heat exposure is also one of the most common hairstyling techniques. The purpose of this experiment was to test which conditioners are the most effective. The hypothesis for this experiment was if the L'Oréal conditioner was used, then the hair would have the highest tensile strength. Five groups of hair, each with fifteen twenty-centimeter-long strands, were separated from the virgin Peruvian hair extensions. Four groups were either submerged in three fluid ounces of Aveda Damage Remedy Conditioner, L'Oréal Paris Elvive Total Repair 5 Conditioner for Damaged Hair with Protein and Ceramide, Garnier Fructis Damage Eraser Conditioner for Distressed or Damaged Hair, or Dove Damage Therapy Intensive Repair Conditioner. The last fifteen strands of hair were set aside. After three minutes, the hairs were taken and held rinsed under lukewarm tap water for thirty seconds. Then, each individual hair was blow-dried with a Revlon hair blow-dryer for ten minutes and clamped in a Conair 1-1/4 inch hair straightening iron for twelve seconds. The tensile strengths were found by tying the hairs to a hook scale, finding the force required to make them snap, and converting that to tensile strength. For the control, the average tensile strength was $1.94E-03$ N/m². The average tensile strengths of the Aveda, L'Oréal, Garnier Fructis, and Dove conditioners were $3.31E-03$, $2.50E-03$, $2.56E-03$, and $3.06E-03$ N/m², respectively. The hypothesis was not supported, as the Aveda brand resulted in the strongest strands of hair.

The Effect of Aeration on the Decomposition of Vitamin C
Krishi Chand, George H. Moody Middle School

Oxygen takes up 46% of the earth's crust, making it almost half the whole area, which also helps keep all living organisms alive, including human beings. Oxygen was discovered about 1772 by a Swedish chemist, Carl Wilhelm Scheele, who identified it by heating using many other elements. Vitamin c, an acid, is presented in various types of foods, especially fruits and vegetables, such as orange's, spinach, tomatoes, etc. It helps to heal swollen and bleeding gums, loose teeth, hemorrhaging under the skin, and slowed healing of wounds. The Purpose of this experiment was to see if oxygen (aeration) affects the levels of vitamin c in a product of food. Before the experiment was started, safety was considered using an apron, gloves, safety goggles, closed toe shoes, and parental supervision. The Materials that were used to conduct the experiment were Iodine, disposable cups, H₂O, Starch Solution, Vitamin C tablets, juice, and syringes. During the experiment, it was observed that when iodine was added to a type of juice that has been aerated, the amount of iodine that was supplemented to the aerated juice was less than the amount given to the juice that was not given oxygen. After the juices were aerated for 24 hours, there was a decrease in vitamin c from the juice(s) that were not aerated and the ones that were. The hypothesis ended up being somewhat true. The vitamin c in the product(s) did decrease, but a couple of them did not significantly decrease. If the products were left to aerate for longer though, there would have been a chance that they could have. The experiment had the same results as many other scientist's experiments.

The Effect of Acidity of a Liquid on Tooth Erosion and Discoloration
Daniel Lim, George H. Moody Middle School

Beverage consumption rates had soared since the past century. 2004 total consumption of these drinks for every man, woman, and child was approximately 68 gallons per year (Reddy et al, 2016). Along with the increase in beverage intake, tooth erosion had also become an issue. Tooth erosion was when the acids in the beverages lowered the pH in the mouth, eroding the enamel. The purpose of this paper was to study two hypotheses- the effects of acidity on erosion and the effect of tooth erosion on discoloration. The researcher created three different levels of acidity; high-level acidity with a pH of 2.9, low-level acidity with a pH of 3.9, and freshwater as a control group with a pH of 7. Three eggs were lowered into each different acidity level for one hour. Afterward, 24 surveys were conducted, comparing the differences between each egg's level of erosion. The researcher used t-tests and ANOVA to confirm the proposed hypotheses. The researcher found out that the outer membrane of eggshells in the high level of acidity condition was mostly damaged (mean = 8.21), the low level of acidity moderately damaged the outer membrane of eggshells (mean = 5.00), and the control group barely affected the outer membrane of eggshells (mean = 1.42). The same was true for the second hypothesis. In the high acidity conditions were mostly discolored (mean = 8.13). The eggshells in low acidity condition were moderately discolored (mean = 4.71), while the eggshells in the control condition were barely discolored (mean = 1.75). Based on the results of the statistical analysis, both of the hypotheses were confirmed. A limitation of this research was that the experimental procedure was unable to mimic the movement of the beverage inside the teeth.

The Effect of Alternative Sugars on the Rate of Yeast Respiration
Monona Zhou, George H. Moody Middle School

Carbohydrates are different types of sugars, starches, and fibers, produced by photosynthesis, which usually contain carbon, hydrogen, and oxygen. Glucose and lactose are two examples of carbohydrate sugars. The living organism that is going through the process of aerobic respiration in this study, is yeast. The hypothesis was if the sugar used was sucrose, then the rate of yeast respiration would be the highest. The importance of the experiment is to help widen the scientific knowledge in the field of biochemistry, by informing people how sugars are different from one another and the impact different molecular compounds can have on yeast respiration. The procedure started with mixing fifty milliliters of water, five grams of yeast, and five grams of sugar together in an Erlenmeyer flask. Then, stretching a balloon over the top of the same Erlenmeyer flask. The Erlenmeyer flask, containing the yeast, sugar, and water mixture, was shaken for one minute and then left alone for two hours. After two hours, the balloon was removed from the Erlenmeyer flask, the circumference and height of the balloon were measured, and then the volume of the balloon was calculated. The mean was 0 cm³ for the No Sugar level, the mean was 156.49 cm³ for lactose, glucose had a mean of 2854.77 cm³, the mean was 2806.38 cm³ for sucrose, and for Artificial Sugar, the mean was 2592.95 cm³. The hypothesis of this experiment was not supported by the research conducted. The hypothesis had stated that sucrose would cause the most fermentation. However, the research had proved that glucose caused the most amount of fermentation with an average balloon volume of 2854.77 cm³. The composition of different sugar molecules has different amounts of carbon that is released when the molecules are broken down by the yeast.

The Effect of Different Metals on Saltwater Corrosion Rates
Shubha Anand, George H. Moody Middle School

Metals have been used for shipping and entertainment purposes for years. Saltwater causes metals to corrode and potentially damages them. The purpose of this project was for the researcher to investigate which metal would corrode the quickest when submerged in saline water and test the resulting pH level of the water. The hypothesis of the researcher is: If iron is placed in saltwater, then it will corrode the quickest out of all the variables. The researcher assembled required materials and found a clean environment to work in. Using a sanitary glass bowl, they measured 950 mL of water into it. Then, the researcher poured 35 grams of salt and stirred until completely dissolved. Uniformly cut strips of the independent variable were placed into a test tube and submerged in saltwater for two weeks. Ten samples of each metal were tested. Each day, the researcher took a ruler and measured the corrosion. On the last day, pH strips were submerged in the water for five seconds and recorded. The average corrosion of the metals was as follows: Iron averaged 7 millimeters of rust, zinc measured 0.3 millimeters, brass and aluminum measured 0.4 millimeters and 0.2 millimeters respectively. Conversely, none of the copper strips developed any corrosion. In measuring the pH of each metal, iron and aluminum measured an average pH of 6, while brass, zinc, and copper readings measured an average of 8. Based on the corrosion amounts, the data showed that copper, which had developed no corrosion, is the most reliable metal. Before it can be concluded that copper is the most reliable, real seawater will need to be used first.

The Effect of the Type of Liquid on the Amount of Oxygen Isolated through Electrolysis
Avery Park, Dorothy Hamm Middle School

Electrolysis is the chemical decomposition produced by passing an electric current through a liquid or solution containing ions. The scientists believed that researching electrolysis could lead to future discoveries of using the process as a clean energy source. The main purpose of this experiment was to discover which of four substances (water, red Gatorade, 2% reduced fat milk, or water with salt) would isolate the most oxygen molecules during electrolysis. The experimentation of electrolysis could one day contribute to professional research. Through electrolysis, both hydrogen and oxygen gas can be isolated and used in a hydroelectric turbine to produce clean energy. This clean alternative to carbon fuel could reduce carbon emissions and greenhouse gases in the atmosphere. Out of the four substances, the scientists predicted if a direct current was sent through water, the amount of oxygen isolated would be highest. A simple test lasting two minutes was done on every liquid, and six trials were conducted for each substance. A 9-volt battery was used to send an electric current into the substance through a brass conductor. The results of each individual trial varied slightly for each of the independent variables, but the average of the recorded data did not support the hypothesis. The results showed that if electrolysis was used on water with salt, the highest amount of oxygen would be isolated compared to the three other liquids.

The Effect of Household Substances with Varying pH Levels on the Removal of Carpet Spills
Alan Tobin, George H. Moody Middle School

The most common substances that get spilled in houses are liquids like juice and water which all have varying pH levels. Additionally, when these liquids are spilled on carpets, it is difficult to clean them. Many people use carpet stain removers, but they have harmful chemicals. Therefore, other people use cleaning materials like common household substances which are typically healthy. The student, in order to test which common household substance was the best, conducted an experiment to test it by using bleach, vinegar, rubbing alcohol (referred to as alcohol), baking soda, water, and air. The experiment was done with the student first taking grape juice (stain) and spilling 0.25L of grape juice onto an IKEA Polypropylene carpet/rug. Then, the student let the stain settle for 2 minutes and took a brush and put 0.25L of the household substance on the stain and scrubbed it. Lastly, after scrubbing for two minutes, the student rated the effectiveness on a scale of 1-10. The student then repeated the procedure 7 times for each of the levels of IV. After conducting the experiment, it was found that bleach performed the best with alcohol and vinegar coming in second place, baking soda coming in third, water coming in fourth, and air coming in fifth. It was also found that as the pH level becomes extremely high or extremely low, the substance does a better job at cleaning the stain. Furthermore, it was noted that bleach and vinegar left a disturbing smell in the air. Lastly, it was found that substances with Chlorine and Sodium Hypochlorite performed better. In the end, it was concluded that bleach was the most effective substance, while alcohol was a good replacement if a person disliked the smell bleach and vinegar omitted. It was also concluded that more acidic and alkaline substances were better at cleaning.

The Effects of pH on the Rate of Corrosion
Parvathi Pranavasruthi Tadi, George H. Moody Middle School

Corrosion can cause all types of industrial plants to close, it wastes resources, and costs lots of money to get rid of it. Cars, bridges, and machinery are all objects that are vulnerable to rusting. For example, in December of 1967, the Silver Bridge corroded and collapsed. The purpose of the experiment was to determine how the different levels of acidity, or pH, affects the rate of corrosion and the temperature will rise. The research hypothesis was if lemon juice is added onto steel wool, then the rate of corrosion would be quicker and would radiate more heat. Steel wool was submerged for thirty seconds in different water-based solutions: distilled water, black coffee, vinegar, lemon juice, and orange juice. The temperature rise for each solution was recorded for ten minutes and the observations were made. The results indicated that the vinegar trial, with a pH of 2.4, had the most temperature rise, with a difference of 7.3 degrees Celsius. The distilled water, with a pH of 5.8, had a lowest temperature difference, one of 2.2 degrees Celsius. The lemon juice had a temperature difference of 6.7 degrees Celsius. Orange juice ended at 27.1, with a temperature difference of 5.4 degrees Celsius. Black coffee had a difference of 3.4 degrees Celsius, meaning at 600.0 seconds, it was at 25.1 degrees Celsius. Lemon juice's end temperature was 28.4 Celsius, meaning it had a difference of 6.7 degrees Celsius. Steel often doesn't corrode at a pH high than 8 but corrodes quickly at acidic pH's. The research hypothesis was not supported because it was not the lemon juice with the most difference, but it was the vinegar.

The Effect of Climbing Chalk Particle Size on Absorbency
James Spencer, Sabot at Stony Point

Climbing chalk is a vital part to most climbers. Climbing chalk is important for the safety of climbing, especially outdoor climbing, because it is more dangerous, this is because chalk increases the friction between your hands and the rock. The experiment included the testing of different particle sizes of chalk. The hypothesis was that the fine chalk would absorb the most water and chunky would absorb the least water. The scientist is confident that the fine chalk was absorbed the most because of the surface area. There are 2 figures, figure 1 contains the results of all the trials. Figure 2 contains the averages of all the trials. The experiment was re-performed at a greater level of accuracy, to confirm the initial results. The averages of the results were that the fine chalk absorbed the most with an average of 166 millilitres, and chunky and street chalk having the same average of 182 millilitres.

The Effect of Sugar on the Freezing Point of Homemade Ice Cream
Nainika Sompallie, George H. Moody Middle School

Sugar can be found in many foods, including ones that are primarily considered healthy. There are many types of sugar, and sucrose which is also known as table salt is the most common. Some of the foods and drinks that sugar is added into include ice cream, and liquids such as lemonade. The sugar dissolves into the food or drink and changes its overall taste or even its properties, such as freezing point. The purpose of this experiment was to determine the effect of sugar on the freezing point of homemade ice cream. The hypothesis presented was that if more sugar is added, then it would take longer to freeze. In this experiment, a small bag, filled with milk, vanilla extract, and a varying amount of sugar was placed in a larger bag filled with ice and salt. It was shaken until the ice cream hardened. This was done multiple times and was completed for 0 grams of sugar, 10 grams of sugar, 20 grams of sugar, and 30 grams of sugar. The results indicated that it took ice cream with more sugar added longer to freeze up. The mean for ice cream with 0 grams of sugar was only 154 seconds, while it was 399.3 for 30 grams of sugar. Those results proved that sugar slowed down the freezing process. This conclusion supported the hypothesis that if more sugar is added the ice cream would take longer to freeze. There is a direct correlation between the amount of sugar added and the amount of time it takes for the ice cream to freeze.

The Effect of Different Oils on Oil Paint Drying Time
Matilda Frantz, Sabot at Stony Point

Oil paint has been used all around the world for centuries, used by countless artists to make countless masterpieces. Oil paint thinners, which include linseed, sunflower, safflower, and walnut oil, are used to aid artists in creating their paintings, as they can be used to thin paint to make it more spreadable. They can also be mixed with paint and applied to canvas as a base on which other colors can glide and spread more smoothly. The information that this experiment provides could help painters decide which oil paint thinner is the best option for them, whether they are looking for a slower drying paint that allows for a longer window in which the art can be edited, or a faster drying paint, which allows for a finished product sooner. This experiment was conducted to find which oil paint dried the fastest when mixed with cold pressed linseed oil, walnut oil, safflower oil, and sunflower oil. The control for this experiment was paint samples that were not mixed with any other oil. The hypothesis was that linseed oil would have the fastest drying time. The results of this experiment showed that linseed oil had the fastest drying time with an average of 7.55 days to be completely dry, compared to the control (10.05 days), walnut oil (8.05 days), safflower oil (12.25 days), and sunflower oil (10.75 days). In conclusion, the hypothesis was supported by the results.

The Effect of Different Filters on the Speed of UV Beads' Color Change

Emily Yang, George H. Moody Middle School

The purpose of this experiment is to determine the significance of different filters blocking out the UV rays. UV rays can burn our skin and cause cancer, damage our eyes, and destroy our cells. Although most UV is already blocked by Earth's ozone layer and atmosphere, some UV light still gets through (Scherrer, 2015). The beads act like us and our skin, since when exposed to UV light, they change colors. The cups of beads were then put under the UV flashlight without a filter for the control. A stopwatch on 0.00sec was started as soon as the UV flashlight was on the beads. When the beads turned to a bright color, the stopwatch was stopped to record the speed of the color change. The filters, including sunscreen, glass, plastic saran wrap, and no filter (control) were used as the levels of independent variables. The UV light measured how productive the filters were by putting beads in the place of a human. The beads had special photochromic dyes that react to UV light. The sunscreen had the longest time because it was designed to reflect, absorb, and scatter UV rays, while others weren't specifically designed to do so. Also stated was that research in many epidemiological studies have seen an association between sunscreen use and skin cancer.

The Effect of Type of Sleep Medication on Its Solubility
Freya Matheson, Thomas Jefferson Middle School

The purpose of this study was to determine the solubility of sleep aid medications in water. The independent variable was the kind of sleep medication used. The experimental group included: Unisom SleepMelts (diphenhydramine 25mg), BasicCare Doxylamine Succinate Tablets (Doxylamine 25mg), Tylenol PM Extra Strength Caplets (500 mg acetaminophen, 25mg diphenhydramine), Aleve PM Caplets (diphenhydramine 25mg, 220mg NSAID), Benadryl Ultratabs Antihistamine Allergy Medicine (diphenhydramine 25mg), and Natrol Melatonin Fast Dissolve Tablets (Melatonin 5 and 10 mg). The dependent variable was how many grams of solute dissolved per 100 grams of the solvent. The constants were the amount of medication used, the amount of water used, the temperature of water used, the type of cup used, and the amount of time each medication was given to dissolve. The hypothesis was: if Unisom Sleep Tabs are used, then they will have the highest solubility. All medications were given six hours to fully dissolve and were then left alone for 24 hours in order to evaporate all excess medications. They were then weighed in grams. The results showed that Natrol Melatonin tablets were the most soluble. These results rejected the hypothesis. In conclusion, this study suggests that Natrol Melatonin is more soluble than other OTC sleep medications.

The Effect of Different Types of Metal Containers on the pH of Drinking Water
Sriyutha Morishetty, George H. Moody Middle School

In Ayurvedic practice, it is believed that drinking water stored in copper vessels overnight and consuming it every morning will detoxify and cleanse the digestive system as well increase the absorption and intake of essential nutrients. The purpose of this experiment was to determine the effect of different metal containers on the pH of drinking water. It was hypothesized that "If water is stored over a period of time in steel, silver, and copper vessels, then the water stored in the copper vessel will have the highest pH." The steel, silver, and copper containers represented the levels of independent variables. The pH of the water in each container was measured using an electronic pH meter and recorded at zero, four, eight and twelve-hour intervals. Upon observation and analysis of the experimental data, it was concluded that water stored in copper containers has the highest change in pH, making the water more alkaline compared to the pH of the water stored in silver and steel containers. The pH of the water in the copper containers ranged from 7.06-8.03 during the 0-12-hour intervals. The varying degrees of change in pH of water stored in copper containers may be due to its intrinsic physio chemical properties. The natural alkaline water, created through storing water in copper containers, has shown to deliver significant positive impacts on health and overall well-being. This experiment was conducted to aid in reintroducing the ancient, and often forgotten, Ayurvedic practice of consuming water from copper containers to the modern scientific community.

The Effect of Different Metal Electrodes on Hydrogen and Oxygen Production from Water Electrolysis

Owen Eklund, Sabot at Stony Point

A Hofmann Voltmeter uses DC power, two metal electrodes, and sodium bicarbonate to split the molecules of water into hydrogen and oxygen molecules. However, there is little research on what type of metal electrode is the most efficient in electrolysis. This experiment was conducted to test the effect of three different metal electrodes (Platinum, Brass, and Stainless Steel) on hydrogen and oxygen production from the electrolysis of water and sodium bicarbonate in 15 minutes. The experiment used a Hofmann Voltmeter and a 12-volt DC power source. The Hofmann Voltmeter was filled with a water-sodium bicarbonate solution. Each test ran 15 minutes and the water level of the solution was measured before and after each test, giving the amount of hydrogen and oxygen produced during each test. The hypothesis states that the platinum electrodes will create the most hydrogen and oxygen after 15 minutes of electrolysis. The results from the experiment found that the stainless steel electrodes evolved the most hydrogen and oxygen in each of the five trials performed using the stainless steel electrodes. The platinum electrodes created the second most hydrogen and oxygen, however the results show that the platinum created a more constant amount of hydrogen throughout five tests compared to the stainless steel electrodes.

The Effect of Concentration of Sodium on Spherification
Dillon Humphrey, Sabot at Stony Point

Spherification is the process whereby liquid can be formed into spheres. They are made out of different types of liquids combined with sodium alginate, and then put into a bath of calcium chloride. Spherification is mostly used in cooking, the spheres are added to the top of foods and desserts and it is also a way that fake caviar is made. This experiment was conducted to find the best ratio of sodium alginate to water for the strongest gel ball. The testing for this experiment was done by pressing a vernier force sensor on the spheres that sat on a counter. The force that it took to cut the spheres was recorded in logger lite and then the max force was recorded in a google sheets table. The data from this experiment did not support the hypothesis that as the amount of sodium alginate in the ratio of sodium alginate to water increases the amount of force in Newtons needed to break the spheres increased. 0.5g sodium alginate to 100g water was the most effective ratio at being the strongest. This ratio averaged the most amount of force to cut. When the data was looked at in terms of variability 0.3g sodium had the least amount of variability making the average for 0.3g sodium most likely accurate. Though when you look at 0.5g and 0.6g sodium they both have a bunch of variability meaning the averages for the two might not be as accurate as the average for 0.3g sodium.

The Effect of Short-Term Olivine Sequestration on the Concentration of Carbon Dioxide
Lorenzo Mazzeo, Sabot at Stony Point

Olivine is a mineral that absorbs carbon dioxide. Scientists believe it may be useful to slow down the effects of climate change. The study was conducted to see how well olivine could absorb CO₂ in a short time period. If climate change gets to an almost irreversible point this experiment will tell us if olivine will be able to sequester enough CO₂ to save us from some of its devastating impacts. In this experiment, olivine was placed inside an airtight bottle filled with CO₂, and measurements were taken with a Vernier carbon dioxide sensor to see if there was any change in the concentration of CO₂ from the start of the experiment to the finish under three conditions. The conditions tested were no olivine (control), olivine sand, and chunks of olivine crystals. Both the olivine sand and crystals proved to make a statistically significant difference in comparison to the control with T-test p-values of 0.0314 and 0.0029, respectively. Olivine has the ability to sequester CO₂, (meaning it can absorb it).

The Effect of Different Types of Salt on the Efficiency of Melting Ice
Nithya Ravula, George H. Moody Middle School

The United States used nearly 50 million metric tons of salt in 2007, with 37% of that going toward road de-icing. Different types of salts can be used to melt ice. Potassium chloride is a naturally occurring mineral salt which comes from rock and sea salts. Rock salt is a naturally occurring rock salt formed from the evaporation of seas located inland. Sodium chloride, otherwise known as table salt, is found through saltwater, mainly acquired through the process of evaporation. Lastly, calcium chloride is mainly used as a drying agent and for ice control on roads. This experiment can be useful to the community during the snowy season as many people must go to work every day, and the roads must be clear for them to depart and arrive safely and this can only be done when the ice has melted on the roads. The purpose of this experiment was to find which type of ice melts the most ice in a given amount of time. For this investigation, the research hypothesis was that if table salt was used, then the most amount of ice would be melted. This hypothesis was supported by the fact that NaCl (or sodium chloride/table salt) is the most commonly used road salt. Since table salt is the most commonly used road salt, it most likely melts the most ice in the given amount of time. Four different types of salt were placed on 30 grams of ice and given time to melt. The amount of ice melted was then measured in grams and averaged. The potassium chloride had an average of 2.82g of ice melted. Rock salt had an average of 3.02g. Table salt had an average of 1.1g. Calcium chloride had an average of 1.06g. The control group, no salt, had an average of 0.98g of ice melted. Therefore, the research hypothesis was not supported by the results of the experiment as rock salt was the type of salt which melted the most ice.

The Effect of Lawn Fertilizers on the Amount of Chemicals in Water
Guthrie Bowers, Sabot at Stony Point

Pollution is a growing problem in our society and this experiment was designed to gather knowledge about the effect of lawn fertilizers on water as fertilizers are big water pollutants. The project focused on three metals and they were; lead, fluoride, and iron. Lead, unlike the other two metals, has no health benefits whatsoever. Lead accumulates in the bodies of water organisms, even when only very small concentrations of lead are present. Lead is a cumulative toxic chemical and negatively affects multiple body systems and is especially harmful to young children and their brain and nervous system development. Adults are also at risk of high blood pressure and kidney damage by exposure to lead. The problem is that when fertilizers are applied to the ground they can cause run-off into a body of water and it contaminates the water. Several common lawn fertilizers were tested to determine what impact fertilizers had on the amount of contaminants that were increased in the water. The data showed that lead, fluoride, iron, and pH were positive in the tests over a short period of time (30 minutes).

The Effect of Preparation Method on the Glucose Concentration of Rice
Aria Merrill, Thomas Jefferson Middle School

This study was designed to test the effect of various preparation methods impact on the starch content of rice, thereby minimizing the risk of hyperglycemia in diabetics. The independent variable was the preparation method used to prepare the rice. The experimental group included: washing rice prior to cooking, soaking rice thirty minutes prior to cooking followed by thorough washing, and frying the rice in coconut oil before cooking. The control group was boiling the rice in water without wash or additives. The dependent variable was the glucose concentration of the rice. The constants were the type of rice and the amount of rice cooked. The hypothesis was: If rice is fried with coconut oil prior to cooking, then the least amount of glucose will be found in the resulting rice. In this experiment, the researcher prepared rice in three different ways known to reduce starch content. This was followed by the addition of the enzyme amylase, which converted the starch to glucose. This glucose concentration was then tested using test strips and a colorimeter to determine the color distance of the resulting test strip from the original test strip. The results showed that rice soaked and washed prior to cooking resulted in the lowest glucose concentration. One reason the hypothesis was rejected may be because soaking allows the starch within the rice to surface, which is stripped away through washing. Another reason may have been because the rice was broken up far more following the washing process causing it to soften and become significantly more fragile. Rice grain size could potentially play a role in the amount of starch found in rice. In conclusion, the study suggests that soaking and washing the rice prior to cooking is preferable to the control variable or any other form of starch reduction methods.

Levels of Ascorbic Acid in Different Juices
Aanandi Parashar, Hidden Valley Middle School

Vitamin C (Ascorbic acid) is a water-soluble antioxidant which cannot be synthesized by the human body and requires daily intake. This study aims to determine the level of ascorbic acid in different types of juices using DCPIP (Dichlorophenolindophenol). The hypothesis was that if the juice is freshly squeezed then it will have the most vitamin C. Independent variable was the type of orange juice dependent variable was the number of drops of DCPIP and vitamin C solution (1%) was the control. Levels of vitamin C, a reducing agent, were measured in freshly squeezed orange juice, Tropicana orange juice, orange flavored Gatorade, and orange flavored Vitamin Water. DCPIP, an iodine containing solution, was the indicator for this redox reaction. Two ml of each juice was taken in a test tube and drops of DCPIP were added. The number of drops used to reach the endpoint reflected the amount of vitamin C in each juice. The first tint of blue indicates oxidation of all the ascorbic acid and is the end point of the reaction. Each titration was repeated five times. The average number of drops of DCPIP used to titrate freshly squeezed orange juice was the most (5.4) while Gatorade required 0.03125 drops on average indicating that it contained the lowest amount of ascorbic acid. In conclusion, the hypothesis was correct, freshly squeezed orange juice had the most vitamin C (0.1687g). The titration of vitamin C concentration using DCPIP is a reliable method to measure the amount of this useful antioxidant.

The Effect of the Color of Fabric on the Ultraviolet Rays
Noor Long, Williamsburg Middle School

In this experiment, the Ultraviolet Light Ray dosage is tested by the color of cloth to see the impact the color has. This procedure was adopted to find out more information about what is safe to wear and relates to skin cancer prevention. The variables would change due to testing of the experiment twice, first with ultraviolet detecting beads, and secondly with a UVA sensor. The constants helped throughout testing by ensuring that the experiment mostly flowed without error. The IV can be changed throughout anyone's research, and variations in this experiment have occurred with different independent variables but also different dependent variables. This particular experiment is rather simple in its terms of testing the variables. The key results include the means and range. The mean or average for the clear Ziploc Bag, (29.23 mW/m²) is similar to the means of green, (28.97 mW/m²) and blue (29.10 mW/m²). The ranges were from 3.16 to 0.27 mW/m². The range varied, especially towards the end, where the experiment was conducted mostly without any recurring flaws, like in the first three levels of IV. After conducting five trials, at each color of the fabric, it was determined that the results mostly support the hypothesis. It was found that the hypothesis is correct. The trend showed that the darker cloth did indeed block out the ultraviolet light rays. However, the data also showed signs that the yellow fabric also reflected rays as well. That means that while the hypothesis was supported, it did not counter in the factors that lead to the yellow fabric performing best and reflecting the ultraviolet light. The darker colors of fabric absorbed most of the UV rays, leading to the beads not really being affected. During the second testing, the data also showed signs that it didn't affect the sensor either. The results of the experiment could be explained by the fact that the UV light passed through the cloth with some difficulty, especially according to the color and density of the cloth. The lighter colors, like green and yellow let in more UV light than the darker colors, like red or orange. A possible reason for this result is that the cloth made a dent upon the reflection of UV beads, taking into consideration that the UV Light was reflected, and affected the data in another way.

The Effect of the Different Types of Common Nails on the Measurement of Corrosion After an Extended Period of Time

Mia Naglieri, George Henry Moody Middle School

Corrosion is the degradation of a material due to a chemical reaction with the environment. When a metal is exposed to a wet environment, the metallic nature of the metal is changed into a nonmetallic form becoming solid corrosion products. Corrosion is one of the most damaging naturally occurring events in the world. Corrosion degrades critical infrastructure, which leads to many accidents. It is estimated that corrosion costs the United States economy nearly 300 billion dollars per year. Roughly one-third of the cost could be reduced by the application of corrosion-resistant materials. The purpose of this experiment was to determine the effect of different types of common nails on the measurement of corrosion. No metal is immune to corrosion, but through the research from this experiment, people could determine the nail least susceptible to corrosion. The data did not support the research hypothesis that stated that if bright steel common nails, galvanized common nails, and zinc common nails were used, then the galvanized common nails would corrode the least. Ten nails for each level of IV were weighed on a scale and placed in 10 separate cups filled with a saltwater mixture and left alone for 15 days. On day 16, all the nails were removed from each cup and weighed on the scale again. After all the weights from the experiment were recorded, each nail's final weight was subtracted from its original weight to determine the mass of the corrosion. The results indicated that the zinc common nails exhibited the least mean corrosion (0.028 g), which was less than both the bright steel common nails (0.050 g) and galvanized common nails (0.034 g), and therefore would be the most effective to prevent corrosion. In conclusion, the zinc common nails would have the most effect on decreasing corrosion rates.

The Effect of Types of Lactose-free Brands on the Amount of Lactose Prevalled by Glucose Test Strips

Lydia Hudgins, George H. Moody Middle School

In this experiment, the main focus was to determine the best brand of lactose free milk for those who do not possess the ability to hydrolyze the lactose into glucose. Lactose intolerance has been becoming more common over the years, making lactose free milk influential. The hypothesis is "If different types of consumer bought lactose-free products are tested, then the glucose test strips will respond negatively to traces of lactose." Four different lactose free brands and one regular milk brand were each poured into ten different containers, representing trials for the independent variable. The liquids were all tested with strips before and after adding the lactase enzyme to the solutions. The experimenter used glucose test strips to concentrate the amount of glucose in the solutions of lactose free and regular milk. The regular milk was used as a control to compare the data, and see what the lactose milk readings should appear as. Results from the experimental groups varied, while the control had a very different effect than the lactose free solutions. The averages for lactose free milk before the lactase was added were between 430 mg/d and 850 mg/d. While the averages after adding lactase was between 727.5 mg/d and 1180 mg/d. The ranges were very different for regular milk. Before adding lactase it was 0 and after lactase was added it was 187.5. The brand 365 showed the smallest increase before and after adding lactase, proving it is the best brand to buy. The hypothesis is not supported because there were small traces of lactose in these milks, but not enough to do harm on the individual.

The Effect of Liquids with Different pH Levels on the Moisture Created in Wood
Nivriti Vanga, George H. Moody Middle School

Wood is an abundant material that is produced from trees, and it is used to construct building, furniture, etc. Wood moisture content is the moisture in the wood and is measured using a wood moisture meter. pH is the level of acidity or alkalinity of a liquid. The levels of the independent variables in this experiment are air (control), lemon juice, black coffee, water, baking soda and water solution, and bleach. These common household items have different pH levels and will be used to see if the moisture content of wood changes once it is placed in each level of IV. This experiment was chosen to see how the moisture content of wood would change once it was soaked in each liquid. If blocks of wood are placed in different liquids for thirty minutes and then left to dry for another thirty minutes, then the bleach will leave the biggest percentage of moisture in the wood block overall. A 3cm x 3cm x 3cm block of wood was placed in a cup filled with 6 ounces of a liquid. These were left to sit for thirty minutes and then the wood was placed on paper towels and left to sit in front of a window for 25 minutes. The wood moisture content was then found using a wood moisture meter and this was repeated 10 times for each liquid. The safety precautions taken were handling the bleach with gloves and being careful when testing the wood moisture of the wood using the moisture meter since the wood is wet. The wood kept in bleach had the highest wood moisture content and the control (air) had the least wood moisture of the independent variables. The wood moisture mostly rose as the pH of the liquids raised. This was mostly seen throughout the experiment, but the black coffee had a higher moisture content than the water. Overall, the hypothesis was correct, and it proved that the bleach had the highest wood moisture content of all the levels of the independent variable.

The Effect of the Type of Fat on the Diameter of Chocolate Chip Cookies
Myra Clark, Williamsburg Middle School

Research has been conducted to find the cause of avocado chocolate chip cookies not spreading in the oven while being baked. The research objective was to prove the cause of cookies made with avocado directly replacing butter not expanding (spreading) in the oven while being baked. To test the conclusions of other experiments, an experiment was conducted. The experiment that was conducted was to find the effect of the type of fat in chocolate chip cookies on the diameter of the cookies. The experiment results concluded that cookies with butter (the control) as a fat have the greatest mean diameter, whereas cookies with avocado as a fat have the least diameter. The chocolate chip cookies with avocado in them as a butter substitute did not spread out, because the composition of an avocado is quite different from the composition of fattier substitutes such as margarine or shortening. In an avocado, the lipid molecules are not quite high enough to let the avocado melt, like shortening, margarine, and butter do. There is too much water in the avocado, so the proteins just will not let the avocado melt. This concludes that cookies with avocado used as a butter substitute will have a lesser diameter than if a fattier substitute is being used, including margarine and shortening.

The Effect of the Type of Soap on the Efficiency of the Surfactant.

Thanvi Parupati, George H. Moody Middle

Soap is a surfactant that is used to remove dirt and grime from the skin. It has had a long history, first appearing around 2800 BC in Ancient Babylon. Surfactants are used to reduce surface tension in liquids causing them to be able to spread easier. Surfactants are used in soap to be able to clean efficiently. When the surfactant is placed in water the hydrophilic side moves to the outer side creating a sphere-like shape called the micelle. While the hydrophobic side moves to the middle of the sphere. Since the hydrophobic side attracts oil and grime, the soil from the surface moves to the center of the micelle trapping it. The purpose of this experiment was to determine the effect of the type of soap, Dove, Aveeno, Johnson's Baby Wash, Dial, or no soap on the efficiency of the surfactant. The research hypothesis was that if Dial soap was used, then Dial soap would be the best surfactant. A paper clip was placed on a paper towel slightly bigger than the paperclip to cause it to be able to float because of surface tension. A drop of soap was added and timed until the paperclip sunk. The procedure was being timed by a timer to measure the seconds until the paperclip sunk. The results indicated that the Dial was the quickest to lower surface tension with a mean of 1 second and 91 milliseconds. The control, adding no soap, was the longest to lower surface tension with a mean of 24 hours, 56 minutes, 52 seconds, and 34 milliseconds. There was no correlation between the data. The data supported the research hypothesis. However, before it can be concluded that Dial was the best surfactant the experiment should be improved to fix any possible errors.

My Cup of Tea
Daisy Maxwell, Swanson Middle School

A nice, long sip of your favorite hot tea can calm you on the most stressful of days. But it never stays as hot as we want it, for as long as we want it! So how can we choose the best insulating material to keep our precious drinks warm? In this experiment, five materials, aluminum, paper, plastic, and glass, were tested to see which one could keep the hot water inside the warmest after 30 minutes, measured in degrees Celsius. The best performing material, in terms of the average temperature was paper, 35.45 degrees Celsius, followed by plastic, 32.75, then glass, 32.1, aluminum, 31.35, and finally ceramic, 29.7. The hypothesis was that ceramic would be the best insulator, but this was not supported by the data. However, the type of ceramic can make a huge difference on the results, and since the ceramic cup used in this experiment was sealed with glass, and essentially inherited the bad properties of both ceramic and glass, it is understandable why the ceramic cup performed so badly in this experiment, but may be an excellent insulator otherwise.

The Effect of Different Chemicals on the Reduction of Grease
Manushi Nepal, George. H Moody Middle School

A degreaser is a cleaning solution used to remove grease and oil from hard surfaces. There are three main types of degreasers: solvent-based, natural, and aqueous. Grease is a lubricant used to lubricate moving surfaces without being compressed under pressure. The purpose of this experiment was to see what type of degreaser would work best in reducing grease from a surface. The research hypothesis constructed for this experiment was if a 2.5-centimeter wide circle of grease was exposed to different degreasers, then the Pine-Sol would reduce it the most. To test one variable, a tube of Danco's Silicone Faucet Grease was opened and a circle of grease was squeezed out into each dish. The diameter of each circle was measured to be 2.5 cm. The four independent variables of this experiment were Pine-Sol, Krud Kutter Parts Washer/Degreaser, Citrus Magic Natural Orange Heavy Duty Cleaner/Degreaser, and Kroger Grease Cleaning Ultra Concentrated Dish Soap and water. One of these was poured into a measuring cup to measure 15 mL and then was poured into the Petri dish with grease in it. A lid was placed on top and the dish was shaken for 10 seconds to expose the solution to the grease properly. After pouring out the remaining solution, a metric ruler was used to measure the diameter of the grease circle in order to observe the change. This was repeated 14 more times for each variable. The results of the experiment showed that Pine-Sol reduced the grease the most, supporting the research hypothesis. Citrus Magic reduced the diameter of the grease the least, proving it to be the most ineffective of the four solutions. This experiment concluded that the formulation of chemicals in degreasers affects soils in different ways. Depending on the type of degreaser, it will be more effective at cleaning certain soils.

The Effect of Method of Food Preservation on the Shelf Life and Quality of Strawberries
Achsah Bisrat, Thomas Jefferson Middle School

This study was conducted to determine the effect of different methods of food preservation on the shelf life and quality of strawberries. The independent variable was the method of food preservation: drying, freezing, sweetening, and ascorbic acid (Vitamin C). The experimental group included the strawberries that were dried, the strawberries that were sweetened (sugar), the strawberries that were frozen, and the strawberries that got ascorbic acid (Vitamin C). The control group was the strawberries that received no preservatives. The dependent variable was the length of time before the strawberries began to decompose, as seen in visual discoloration, change in mass, and change in smell. The constants were the type of strawberry, the amount of additive, and the ripeness of the strawberries at the beginning of the experiment. The hypothesis was that, if the strawberries were frozen, then they would stay fresh for the longest time. Over a period of 1 week, 4 groups of 5 strawberries (dried, sweetened, controlled, and ascorbic acid) were kept at room temperature, while 1 group of 5 strawberries (frozen) was kept in a freezer. Results showed that the frozen strawberries had the least amount of lost mean mass. Thus, the results supported the hypothesis. In conclusion, though these methods may be efficient, the temperature the strawberries were kept in, played a key role in the decomposition rates of the

ECOLOGY & EARTH SCIENCE

The Effect of a UV Clarifier on the Hue and Saturation of Water Containing *Chlorella vulgaris*
Samantha Stewart, Thomas Jefferson Middle School

The purpose of this study was to discover if the presence of a UV clarifier adversely affected the color saturation and hue of water with *Chlorella vulgaris*, a common type of green algae. The independent variable was the presence of the UV clarifier. The control group had no UV clarifier. The dependent variable was the color saturation of the water, found using a colorimeter. The constants were the amount of water, the starting amount of algae, the water temperature, the location of the experiment, the type of algae, and the time in which the hue and saturation were measured. The hypothesis was: If the UV clarifier is put into the water, then the saturation and hue will decrease. Fifty milliliters of *Chlorella vulgaris* was poured into each of two bins containing six liters of water and were left for two days untouched under a heat lamp. The UV Clarifier was built during this time. The color of the water from each bin was recorded. The Clarifier was then placed in one bin, and the other one remained untouched. Two more bins were set up, and the two day process began again, but with four bins. Two days passed and the Clarifier was moved to one of the two newer bins, and the color was measured again. This process was repeated two more times, for a total of three trials. The data were converted from RGB to HSV, and graphed. The results showed that if a UV Clarifier is used, then the hue and saturation of water with *Chlorella vulgaris* will increase. These results rejected the hypothesis. In conclusion, the study suggests that a homemade UV Clarifier does not adversely affect the hue and saturation of water containing *Chlorella vulgaris*.

The Effect Of Various Types of Fertilizer on Eutrophication
Saanvi Gandham, George H. Moody Middle School

Eutrophication, although overlooked, is a serious issue that affects multiple sources of healthy water, but using the right type of fertilizer can help reduce the severity of this problem. Eutrophication is the process in which water overproduces due to excessive nutrient enrichment. Using fertilizer that does not have as much nitrogen and phosphorus content can help solve part of the problem. This research study describes the impact of different fertilizers on eutrophication in freshwater and which types of fertilizer inflict the worst water contamination, which will inevitably lead to eutrophic conditions. The hypothesis was, "If organic, inorganic, water-soluble, and slow release fertilizers are dissolved in freshwater, the freshwater samples with inorganic fertilizers will present the most eutrophication (nitrates/phosphates)." This hypothesis was chosen because according to the research, inorganic fertilizer contains a generous amount of nitrogen and phosphorus, and inorganic fertilizer has been blamed for freshwater eutrophication in previous studies. Nitrogen and phosphorus kits were used to measure the dependent variable(contamination). The data demonstrated that the freshwater samples containing inorganic fertilizer showed the most phosphorus contamination with 10 mg/L, and showed even more nitrate contamination(83 mg/L). Water samples containing slow-release fertilizer had the same phosphorus contamination(10 mg/L) but ultimately showed less nitrate contamination(32 mg/L). The other experimental groups varied but altogether showed less contamination than the samples with slow-release fertilizer. Thus, the data collected supported my hypothesis that freshwater samples with inorganic fertilizer would present the most eutrophication. In conclusion, this research project conveys that alternate solutions exist to which type of fertilizers can be avoided to keep the environment nature-friendly.

The Effect of Type of Sunscreen on the Hatching Viability of Brine Shrimp
Harriet Shapiro, Thomas Jefferson Middle School

The purpose of this study was to find the effects of mineral versus chemical sunscreens on the hatching viability of brine shrimp. The independent variable was the type of sunscreen. The experimental group included two mineral sunscreens [ThinkSport Safe Sunscreen SPF 50 (ThinkSport) and Neutrogena Sheer Zinc Oxide Mineral Sunscreen (Neutrogena)], and two chemical sunscreens [Coppertone Sunscreen Lotion Broad Spectrum SPF 50 (Coppertone) and Aveeno Broad Spectrum Lotion Sunscreen SPF 50 (Aveeno)]. The control group had no sunscreen. The dependent variable was the number of brine shrimp hatched. The constants were the amount of sunscreen, the amount of water, the Sun Protection Factor (SPF) of the sunscreens, the number of brine shrimp cysts, and the salinity of the water. The hypothesis was: The brine shrimp cysts not exposed to any sunscreen will be the most likely to hatch. The experiment was conducted by filling five glasses each with a solution of half a liter of salt water and 0.05 ml of the corresponding sunscreen. The glasses were centered under three incandescent bulbs and 50 brine shrimp cysts were placed in each. Every 12 hours for 72 hours, the number of hatched brine shrimp were recorded, and at the end of the three days, the water and brine shrimp were disposed of through the drain. The results showed that the control group (no sunscreen) allowed for most cysts to hatch while Aveeno did not allow for any. The results supported the hypothesis. In conclusion, the study suggests that while all sunscreens are at least somewhat harmful to the environment, those containing oxybenzone are especially so.

The Effect of Micro-plastics Derived from Tea Bags on the Mortality Rate of *Daphnia magna*
Richa Dhakal, Thomas Jefferson Middle School

This study was conducted to discover if microplastics, derived from tea bags, would have an effect on the health of *Daphnia magna*. The independent variable was the number of Tetley tea bags, minus the tea. The experimental group included: 1 tea bag, 2 tea bags, 3 tea bags, and 4 tea bags. The control group was water with no tea bags. The dependent variable was the number of *Daphnia magna* alive after an experimental period of 5 days. Lastly, the constants included the amount of water, number of *Daphnia magna*, containers, environment placed in, and the temperature of the water. The hypothesis was: If 3 *Daphnia magna* are placed in water boiled with 4 empty tea bags, their mortality rate will be 66% (2/3). 100 mL of spring water was boiled with the set number of tea bags according to trial number. The water was then allowed to cool and was placed into twenty 100 mL containers. The tip of the pipette was cut off by 4 millimeters, and 3 *Daphnia magna* were extracted and placed into the container. Lastly, *Daphnia magna* were stored in a dark, cool area to stimulate their natural habitat. After 5 days, the *Daphnia* were analysed and recorded. The data demonstrated that the *Daphnia magna* placed in water boiled with four tea bags produced the highest mortality rate; therefore, the hypothesis was accepted. In conclusion, this study suggests that although tea bags are efficient, the microplastics found in them can be lethal to aquatic organisms.

The Effect of Eco-friendly Plastics on the pH of Water.
Cheyenne Klapper, Thomas Jefferson Middle School

The purpose of this study was to investigate which type of eco-friendly plastic affected the pH of water the most. The independent variable was the type of eco-friendly plastic. The experimental group included: Reusable, Recyclable, & Biodegradable Thank You Bags and ProGreen compostable bags. There was no control group. The dependent variable was the pH of the water before and after exposure to water. The constants were the temperature of water, the amount of water, wait time, and the size and amount of each eco-friendly plastic. The hypothesis was: If biodegradable plastics and bioplastics are exposed to water, then the pH of the water with biodegradable plastics (Reusable, Recyclable, & Biodegradable Thank You Bags) will change the most. Five red solo cups were used to test the pH of each eco-friendly plastic. Water was boiled and poured into the cups, which contained the eco-friendly plastic. The pH of the water in each cup was measured and after five days the pH was measured again. The results showed that Reusable, Recyclable, and Biodegradable Thank you bags impacted the water's pH the most. These results supported the hypothesis. In conclusion, the study suggests that biodegradable plastics change the pH of water the most and could cause potential harm to the environment.

The Effect of Type of Worm on Vermicomposting Cardboard
Dylan Tallis, Thomas Jefferson Middle School

The purpose of the study was to determine what type of earthworm is the most efficient at vermicomposting cardboard. The independent variable was the type of earthworm. The experimental groups were the *Eisenia hortensis* and *Lumbricus terrestris*. The control group was the *Eisenia fetida*. The dependent variable was the weight loss of the cardboard. The constants were the amount of soil, the amount of cardboard, and the amount of earthworms. The hypothesis was: If the earthworms are fed greasy cardboard, then the *Eisenia fetida* will vermicompost it the fastest. The researcher carried out the experiment by putting equal amounts of cardboard, dirt, and a source of nitrogen into three containers with each type of worm. Then she waited for 10 days and then weighed the remaining cardboard and found the difference in weight. She conducted the experiment twice for better results and recorded them in a graph. The results showed that the *Eisenia hortensis* and *Lumbricus terrestris* vermicomposted the cardboard the fastest. These results contradict the hypothesis. In conclusion, the study suggests that vermicomposting cardboard works and when looking for a better way to get rid of your pizza box, you should vermicompost it with either *Eisenia hortensis* or *Lumbricus terrestris*.

The Effect of Different Decontaminators on the Acidity of Pond Water
Smriti Murali, George H. Moody Middle School

The purpose of the experiment was to find the effect of different decontaminators on the pH of pond water. Scenarios in which clean water was not accessible would not be an issue because a working method for cleaning water would be available. The method of cleaning water was water purification, the process of different contaminants being removed from water. Some methods of water purification work better than others. Some methods were boiled water, Brita filter, and chlorine tablets. The methods typically were commonly used and affordable for people to purchase. The hypothesis was if the Brita filter was used, then the pH of the pond water would be closer to seven. Filters had no side effects, therefore, filters appeared to be the best. Five liters of pond water was separated into four different containers and purified by the different decontaminators. After filtration, the containers were separated into twenty cups and the pH of the cups was taken. The pH was taken using the digital pH tester. The boiled water had the pH closest to seven and purified the water best. The mean of the boiled water was 7.08 pH. The hypothesis was not supported by the results because the Brita filter reduced the pH of the water. The boiled water's pH was closest to seven and was the safest method to drink. Therefore, boiled water was the better choice and steps must be taken to help countries get access to clean water.

The Effect of Filtration Materials on the Turbidity of Stream Water
Alessandra Dinarte, Thomas Jefferson Middle School

The purpose of this study was to find the most effective material to filter water. The independent variable was water filtration material. The experimental group included: sand, chlorine drops, and iodine solution. The control group was stream water. The dependent variable was the turbidity of the water. The constants were stream water, cups, the amount of water, the TDS meter, area of the experiment taking place, and time of measurement. The hypothesis was: Sand will filter the most sediment from the stream water. The experiment to test this hypothesis had 20 trials, 4 for each independent variable (Chlorine, Iodine, and sand), and 1 for the control group (stream water left untouched). After an hour, the results were measured with a TDS (total dissolved solids) meter. The study suggests that when coming across the situation when filtering water is needed, sand would be the best and most practical option. The hypothesis was supported because sand indeed filtered the most sediment from the stream water.

The Effect of Salinity Levels on *Daphnia magna* Survival Rates
Sarah Eichorn, Thomas Jefferson Middle School

The purpose of this study was to find out how salinity levels affect the survival rate of *Daphnia magna*. The independent variable was the level of salinity. The experimental group included: 20% salinity, 15% salinity, and 10% salinity. The control group was 3.5% salinity. The dependent variable was the number of *Daphnia magna* that survived in each trial. The constants included the amount of water in each tub, the original number of *Daphnia magna* in each tub, the type of salt, and the location. The hypothesis was: *Daphnia magna* in the tub of highest salinity (20%) would have the lowest survival rate. To create this experiment, the researcher added 1 liter of water to 20 different tubs and used a formula to create different salinity levels. Next, 10 *Daphnia* were added into each tub and left to sit for one week with a pellet of food. When the week had finished, the tubs were cleaned up and the *Daphnia* were placed in a separate tub to live out their lifespan. The results showed that none of the *Daphnia* survived. These results rejected the hypothesis. In conclusion, the study suggests that any time an organism is placed in an environment they are not used to, the introduction must be done gradually otherwise they will not adapt fast enough, and they will just die instantly. For example, the percentage should be increased by a percentage a day so as to ensure that the environment does not change too rapidly, which would allow the *Daphnia* to have time to adapt to the change in salinity. The *Daphnia* supplier suggested that to have ensured they lived throughout the experiment these steps should have been taken.

The Effect of Various Secondary Microplastics on Zoanthus species
Natalia Zeballos, Thomas Jefferson Middle School

The purpose of this study was to test the effects of secondary microplastics on the damage to Zoanthus species. The independent variable was the different secondary microplastics. The experimental group included: 5 mm pieces of tires in water with Zoanthus sp. in it, 5 mm pieces of synthetic clothing in water with Zoanthus sp. in it, and 5 mm pieces of a plastic cup in water with Zoanthus sp.. The control group had no microplastics. The dependent variable was the severity of coral damage, as measured by a researcher created visual scale. The constants were the amount of coral, type of water, water quantity, amount of microplastics, and coral food. The hypothesis was: If tires are placed in water with Zoanthus sp., then coral would suffer the most damage. The researcher cut pieces of various materials in order to turn them into microplastics. Then the microplastics were placed in containers with coral. Lastly, the researcher recorded their observations in order to place them in a scale. The results showed that no damage was done. These results neither rejected nor accepted the hypothesis. In conclusion, the study suggests that there are many things that rely on coral as well as many things coral relies on.

The Effect of Population of Natural Filter Feeders on Nitrates in the Chesapeake Bay
Mae Seward, Thomas Jefferson Middle School

The purpose of this study was to determine the effect of natural filter feeders on one key indicator of pollution (nitrate) in the Chesapeake Bay. The study was conducted by using direct water sampling techniques. The water samples were collected in and around the Great Wicomico River and surrounding Chesapeake Bay in Virginia in an area where a multi-year, large-scale oyster restoration project is ongoing and in an area close by that does not have such oyster reefs. The independent variable was the location in the Bay. The experimental group included three distinct locations in the Bay and a tributary where there is an active oyster restoration program. The control groups were locations in the Bay where there were no active oyster restoration programs in place. The dependent variable was the nitrogen level. The constants were tides, water temperatures, and wind. Nitrate levels were measured by using a water nitrate testing kit (NECi Superior Enzymes Standard Range kit). The results were compared against each other for nitrate levels at each site. The hypothesis was that the presence of a large oyster population—based on the locations of large scale oyster restoration reefs—will result in a decrease in the level of nitrates present in the Chesapeake Bay. The results showed that in a location with a large oyster reef in a tributary that is sheltered from the open water of the Chesapeake Bay, the nitrate level in the water was significantly lower than in a similar located tributary with similar water conditions that did not have a large oyster reef. These results indicate that the hypothesis is generally sound and this result is backed by evidence from other studies of the impact of oysters on nitrate levels. In conclusion, this study adds to previous research that shows that oysters can be effective filters for nitrates in the water, specifically in the Chesapeake Bay.

The Effect of Different Water Pollutants on the Germination of Radish Seeds
David Ku, George H. Moody Middle School

As the environmental problems are on the rise, the influences of various causes of water pollution were studied to overcome the problems. The purpose of this experiment was to find out which water pollutants had the worst influence on the germination of radish seeds among four different water pollutants – acid rain, disposal of personal care and household chemical products, fertilizer runoff, and oil from leakage. The hypothesis for this experiment was that: If acid rain pollution is used as a water source to germinate radish seeds, then there will be fewer germination than four other pollutants, soapy water, fertilizer runoff, and oil-contaminated water used as the water source. Water with vinegar which was adjusted to pH 4, soapy water with one liter of water and 5 mL of liquid detergent which was proportionally regular to the usage of water and detergent for normal washing machines, water with one liter of water and 5g of Miracle-Gro fertilizer runoff, water with one liter of water and 5mL of regular gasoline which would be the same ratio of water to pollutants as the soapy water were prepared to represent four different water pollution. Five water sources including tap water as control were applied to each of the Petri plates which each had 30 radish seeds in it and observed daily. The number of germinated seeds was recorded until 6 days or until no more seeds germinated. The hypothesis was rejected because only 50% of radish seeds were germinated in the oil-contaminated water source and 76.67% of radish seeds were germinated in acid rainwater source. Furthermore, this experiment indicated that the oil-contaminated water source delayed the seed germination time comparing to four other water sources. Therefore, the results of this study indicated that oil-contaminated water pollution would have the worst influence on the germination of radish seeds as quantitatively and timely.

The Effect of Lowering pH on the Growth Rate of Freshwater Rosette Family Plants
Abhay Sumesh, George H. Moody Middle School

The purpose of this experiment was to examine the growth of aquatic rosette family plants, when grown in varying levels of acidity. The plants used in the experiment were *Echinodorus parviflorus* and *Anubias barteri*. Cabbage and agave also belong to the rosette family and could benefit from this study. The hypothesis for this study was, if the plants are kept in water under a pH of 7.2, then their growth rates would decrease. In this experiment, the plants were placed in three tanks, each having a pH of 6.2, 6.8, and 7.2 respectively. The growth rate of the plants were measured over a period of one month at 5 day intervals. The plants that were at a pH of 6.8 were the fastest growers, showing that moderate application of acid is beneficial to the plant growth. There was algal development in the control group (7.2 pH) and in the group with 6.2 pH, which could have contributed to the arrested development of the plants in those groups. The hypothesis was not supported due to the fact that the plants did best in the Tank A with pH of 6.8, whereas the hypothesis stated that the plants would grow slower in acidified water. Increasing the acidity any further, however, adversely affected their growth.

The Effect of Sunscreen Composition on Radish Plant Growth
Evelyn Scally, Dorothy Hamm Middle School

This experiment was conducted to examine how different compositions of sunscreen affect the growth of daikon radishes. Coral reefs around the world are suffering from the effects of several chemical ingredients, and marine plants conducting photosynthesis have started to die. Radishes, which also conduct photosynthesis, were used to demonstrate that effect. Some sunscreens are now banned from beaches due to containing certain chemicals, such as Oxybenzone, that cause negative side effects in marine life. The hypothesis studied was if water without sunscreen would allow radish plants to grow the highest. The rationale was that adding sunscreen to the water would produce an effect on the plants from the added chemicals of the sunscreen. Every four days, a sunscreen mixture was created for each of the levels of the independent variable and the plants were measured. Two days in between, regular water was given to the plants to keep the soil moist enough for growth. After following the procedures, the total growth that occurred in each plant during the 16-day period was recorded. The control group, the group with no sunscreen added into the water, had the highest average growth, supporting the hypothesis. Every other group experienced less growth due to the sunscreens added. According to the data found, radish plants grow higher with reef-safe sunscreens. This data supports the existing research on sunscreen and coral reefs.

The Effect of the Species of Tree on the Amount of Carbon dioxide Absorbed and Stormwater Intercepted.

Ophelia Tulchinsky, Dorothy Hamm Middle School

The purpose of this study was to look at the effect of tree species on the amount of carbon dioxide absorbed and the amount of stormwater intercepted. Due to the threat of global warming, carbon dioxide absorption and stormwater interception are becoming large problems. Trees absorb carbon dioxide through photosynthesis and help slow water down so it doesn't become runoff. iTree Design, an online simulator, was used to collect data in order to compare carbon dioxide absorption and stormwater interception of five different species of trees. The species that were selected were red maple (*Acer rubrum*), red pine (*Pinus resinosa*), eastern red cedar (*Juniperus virginiana*), southern magnolia (*Magnolia grandiflora*), and white oak (*Quercus alba*). Red maple absorbed the most carbon dioxide (2,012 kilograms) and intercepted the most stormwater (204, 452 liters). Eastern red cedar absorbed the least carbon dioxide (128 kilograms) and intercepted the least amount of stormwater (31,756 liters). The results could indicate that species of tree could have an effect on the amount of carbon dioxide absorbed and stormwater intercepted.

The Effects of Sunscreen Chemicals on Algae Concentration
Nathan Torres, Thomas Jefferson Middle School

This experiment tested the effects of zinc oxide on zooxanthellae algae to investigate it as an alternative to oxybenzone-containing sunscreens. The independent variable was the chemicals zooxanthellae algae had been exposed to, as well as its concentration. The experimental groups were oxybenzone at 1 ppt, 1 ppm, and 1 ppb, and zinc oxide at 1 ppt, 1 ppm, and 1ppb. The control group was unadulterated seawater containing zooxanthellae. The dependent variable was the concentration of algae measured by parts per thousand, parts for million, and parts per billion. The constants were the sea water used, which will be collected from the same place at the same time, the amount of water used, the amount of zooxanthellae added to each tank, the temperature of the water, and the exposure to UV light. The hypothesis was : 1ppm of zinc oxide will be less harmful to zooxanthellae than 1 ppt of oxybenzone. The researcher first began the experiment by cutting 1 inch in diameter hole with the total 21, then proceeded to label each of 21 graduated cylinders with their dilutions. The researcher made the dilutions, added the zooxanthellae algae, and put them into the tubes. Once that was complete, the researcher turned on the two UV lights covering them equally then waited 24 hours to use a secchi stick to see the turbidity of the water to guess the amount. The results of this study were inconclusive because there is not enough data to accept or reject the original hypothesis. In conclusion, the study suggests that the researchers experiment was not adequate in time and concncentration either or/ and sunscreen, algae and water.

The Effect of Water Temperature on the Efficiency of Oil Spill Extraction using Ferrofluid
Abhinav Tadinada, George H. Moody Middle School

Oil spills in an ocean are one of the most detrimental man-made disasters on earth. These devastating catastrophes, which occur either by human error or an accidental leak, affect many living organisms in a multitude of ways. The purpose of this experiment is to find out if water temperature influences the efficiency of extraction using a nanotechnology method where oil is magnetized by mixing iron filings. The iron filings are ferromagnetic and will turn the oil into a magnetic fluid called ferrofluid. The magnetized oil can then be separated from the water using a magnet. This experiment was conducted at 5 different water temperatures, ranging from 10 degrees Celsius to 30 degrees Celsius, to test the efficiency of extraction. The hypothesis was that the method will be most effective in 15 degrees Celsius water. The results of this experiment were analyzed, and it was concluded that the cleanup method was most effective in 15 degrees Celsius water as hypothesized with an 82.50 % average rate of oil extraction. This method performs better in colder temperatures as the magnetic field will be stronger and the resistance of paramagnetic particles is low in the ferrofluid, making it easier to attract. Therefore, this oil spill clean-up method is most effective in colder temperatures and can be further improved on to help solve a major world crisis. Further study on more aspects such as how waves and the salinity of the water affect this procedure or if this method affects wildlife in the ocean will help us understand the feasibility of this nanotechnology method.

The Effect of Different Sources of Water on pH of the Water
Eloise Minnigh, Williamsburg Middle School

The purpose of this experiment was to determine the pH value of three types of unfiltered water — river water, creek water, and rainwater — since the pH value of water can significantly affect the environment and ecosystems. If the water is too acidic, it can lead to reduced growth rate and reproduction in fish over time. It can also cause acidosis in cattle. If animals die due to acidic waters it could damage the food web, which in turn would affect the environment. On the other hand, overly alkaline water can also negatively affect the animals that live in the water and drink it, negatively impacting the environment. In this experiment, water was collected from each of the different sources in the same area over the course of a week. For each of the sources, the pH value of the water was tested and recorded. It was expected that the river water would have the highest pH value, because the increase in acid rain causes the breakdown of carbonate rocks, and those chemicals flow down into the river. Testing confirmed that the river water had the highest pH mean value; whereas, the creekwater had the lowest mean pH value. The levels of variation were very low; therefore, the data are most likely reliable. The river water had the highest variation, and the rainwater had the lowest variation. The hypothesis for this experiment was supported. The river water did prove to be the most alkaline source of water in that specific area.

The Effect of Epsom Salt Concentration on Stalactite Growth
Nora Brakman, Sabot at Stony Point

Many limestone caves exist around the world, and the vast majority of them have existed for millions of years (if not more). However, a lot of these caves could be affected and/or damaged by the growing problem of acid rain. This could change the mineral concentrations of the water that seeps into the caves, and cause stalactites, stalagmites, and other formations to grow at different rates or even dissolve. The purpose of this experiment was to predict how different concentrations of minerals will affect stalactite growth, as represented by different concentrations of epsom salt, 250 grams per liter (g/L), 450 g/L, and 650 g/L. After three weeks, the stalactites growing on the strings were measured with a ruler and massed on a triple beam balance. The stalactites of the 250 g/L concentration had an average length of 4.2mm, and an average mass of 1.68g. The stalactites of the 450 g/L concentration had an average length of 20.8mm and an average mass of 1.405g. The stalactites of the 650 g/L concentration had an average length of 13.1mm and an average mass of 1.45g. The data shows that higher concentrations of epsom salt do not produce stalactites of a greater length or mass.

The Effect of Urban Environments on Nitrogen Dioxide Emissions
Emerson Rose, Sabot at Stony Point

When exposed to environments with high concentrations of nitrogen dioxide in the air, the functions of the human respiratory system are at risk. The purpose of this analysis is to compare urban environments in Virginia, to see which has the highest mean of nitrogen dioxide over the months of November and December. Also, days were split into 8-hour periods to see which part of the day has the highest concentrations of nitrogen dioxide on average. Data were looked at from four different locations in Virginia: Richmond, Washington DC, Roanoke, and Hampton. Each of these locations has monitors provided by the Environmental Protection Agency that access and record amounts of nitrogen dioxide in the air every hour of every day. The data shows that Washington DC on average had the highest amount of nitrogen dioxide in the air over November and December at 14.75 ppb. Hampton on average had the least amount of nitrogen dioxide in the air over November and December, at 4.86 ppb. Around late November and December, each location has the highest amount of nitrogen dioxide in the air. For every location, the time period 9:am - 4:pm had the lowest amount of mean nitrogen dioxide. For Roanoke and Richmond, 5:00 pm - 12:00 am had the highest mean of nitrogen dioxide (10.51ppb and 10.26 ppb respectively). For Washington DC and Hampton, 1:00 am - 8:am had the highest amount of nitrogen dioxide (16.88 ppb and 5.93 ppb respectively).

The Effect of the Ocean's pH level on the Change in Weight of an Oyster Shell
Lauren McDonald, Williamsburg Middle School

Plastic pollution in the ocean's was first observed in the late 1960's to 1970's by a group of scientists researching plankton. Since then researchers have been studying in depth about changes in the pH level as well as its effect on marine life. In this experiment it was hypothesized that if the ocean's pH level is a 2 then the oyster shell will change in weight the most because the ocean water will be the most acidic resulting in the oyster shell breaking down. To test this oyster shells were placed in ocean water of different pH levels to test if the pH level had an effect on the shell with the IV's being 2pH, 5pH, and 8pH. It has been found many times that the ocean's increasing pH level has had a great effect on marine life. In the experiment the oyster shells were tested over a period of one month. After the month had passed the oyster shells were weighed and the change in weight was calculated. It was found that the hypothesis was supported and that the lower the pH level the greater the effect. Plastic pollution is a serious problem in our oceans and needs to be changed.

The Effect of Detergent Levels on Hydrothermal Geysers
Ryan Cohen, Thomas Jefferson Middle School

The purpose of this study was to find the effect of detergent levels on hydrothermal geysers. The independent variable was detergent levels. The experimental group included: slightly contaminated water (5% detergent concentration) and moderately contaminated water (10% detergent concentration). The control group was water with no detergent added. The dependent variable was the eruption rate of the geysers and the duration of each eruption. The constants were building materials used for each geyser, liquid amounts used in each geyser, and heating temperature for each geyser. The hypothesis was: If moderate levels of detergent are used in each geyser, then the geyser will erupt more frequently, and the time between eruptions will decrease. The geyser was built using a lab flask, a rubber stopper, glass tubing, a plastic container, duct tape, plumbers' putty, and a drill. Once the plumbers' putty had dried, detergent was added to water to make 0%, 5%, and 10% concentrations, and these concentrations were added to the geyser for each trial. Once the geyser was ready to test, it was placed on a hot plate and the hot plate was turned on to the highest setting, and the time was measured for each eruption. The results showed that the geyser erupted more frequently with lower concentrations of detergent, and the hypothesis was rejected. In conclusion, the study suggests that human pollution decreases the eruption rate and damages hydrothermal geysers.

The Effect of Increasing Levels of Carbon Dioxide in the Air on Environmental Temperature and Global Warming

Sanjana Anem, George H. Moody Middle School

Carbon dioxide is a greenhouse gas that is produced by burning carbon, organic compounds, and fossil fuels. Scientific data has proven that carbon dioxide is the leading cause of global warming, the gradual heating up of the planet's atmosphere, due to human industrialization. Carbon dioxide prevents heat from leaving the earth's atmosphere known as the greenhouse effect. The objective of this project was to determine the effect of increasing levels of carbon dioxide in the air on environmental temperature and global warming. This project was performed to inform the general public as the environment continues to negatively change and become warmer due to industrialization. Based on studies showing that carbon dioxide increases global warming, it was believed that if there were higher carbon dioxide levels in the air, then warmer temperatures would follow. Three fish tanks of equal volume were filled with different sources of carbon dioxide. The first tank was filled with normal air, the next tank was filled with air from a person's lungs, and the last tank was filled with car exhaust. The tanks were then sealed and brought to the same temperature using incandescent lamps. Once the lamps had been turned off, the temperature inside the tanks was recorded every 10 minutes for 1 hour. The results supported the research hypothesis. This is because the normal air tank cooled the fastest with a median temperature of the averages of 25.13°C while the car exhaust tank cooled the slowest with a median temperature of the averages of 30.56°C. This experiment proved that higher levels of carbon dioxide would result in slower cooling rates and warmer temperatures. It also supported the evidence stating that carbon dioxide increases global warming's effects on the world and its atmosphere.

The Effect of Nano-silver on the Quality of Belle Isle Water
Yana Shah, George H. Moody Middle School

Nano-silver is a particle that most people don't know about but is affecting human, animal, and plant life on a daily basis. The purpose of this experiment was to analyze and assess how Nano-silver is affecting freshwater quality and how that water quality affects life in freshwater. Nano-silver is used in so many of our everyday products such as makeup, laundry machines, toothpaste, and much more. Once this Nanoparticle goes into the sink which eventually leads to freshwater rivers, the river filter does not separate this silver out causing it to stay in the water and affect the ecosystem. It is suggested that if the amount of Nano-silver added increases, then the quality of the water will decrease. For this experiment to take place, water was collected from Belle Isle and was split evenly into 40 cups. Every ten cups had a different amount of Nano-silver added for each independent variable. After the Nano-silver sat in the cups for a week the Total Alkalinity, pH level, General Hardness, and Nitrites were tested. The mean, median, and mode results in this experiment show that every time a greater amount of Nano-silver was added, the water quality became worse. Nano-silver is a particle used to kill bacteria which is why so many products use it but when that particle gets in the water, it kills the bacteria in the river too decreasing the quality of water. This particle is having a negative impact on the water ecosystem and further study is suggested.

The Effect of Different Concentrations of Nano Silver Particles on the Survival of *Daphnia magna*
Sowmya Narra, George H. Moody Middle School

For millions of years on Earth, nanoparticles have existed and have been used by humans. Nanoparticles are currently used in various fields such as electronics, medical applications, cosmetics, and environmental processes (Świdwińska-Gajewska, et al. 2014). One nanomaterial that is having an early impact in healthcare is nano silver. These nano silver particles are toxic to bacteria and fungi. *Daphnia*, commonly called water fleas, are a freshwater zooplankton found in ponds and lakes all over the world. *Daphnia* can be found in freshwater lakes, ponds, and rivers all over the world. Nano silver particles affect freshwater organisms like *D. magna*, the environment, and if exposed to a sizable quantity, even humans (Truong, et al. 2017). The purpose of this experiment was to determine the effect of nano silver particles on the environment and freshwater organisms such as *D. magna*. It was hypothesized that if the freshwater organism, *D. magna*, was subjected to different concentrations of nano silver, then, none of the *D. magna* would be able to survive at a concentration level of 25 ug/L. Three trials were conducted for each level of IV (5 ug/L, 10 ug/L, 25 ug/L) and the control (0 ug/L). 3 disposable cups were set up for each level of IV and stock solutions were prepared. The dilutions were made using the colloidal silver and added to the disposable plastic cups filled with pond water. The condition of the *D. magna* (alive or dead) was recorded at the 2 hour, 4 hour, and 6 hour marks. After all data had been collected, precautions were taken, and the remaining *D. magna* were disposed of carefully. The results indicated that none of the *D. magna* were able to withstand the highest nano silver level (25 ug/L) after 6 hours. The data collected supports the research hypothesis that none of the *D. magna* would be able to resist the toxicity of the highest level of nano silver concentration being tested (25 ug/L). The data supports the research, because it shows that indeed, the higher the level of concentration, the less chance of survival for organisms like *D. magna*.

The Effect of Different Methods on the Efficiency on Purifying Dirty Water
Iresha Choudhary, George H.I Moody Middle School

There are many ways to purify dirty water, but the real question is which way is the safest and most effective. For example, boiling water is a very common and well-known way to purify water. Some of the lesser-known ways are filtration and chlorination. The purpose of this experiment was to learn which purification process was most efficient in purifying the water enough to make it drinkable. The hypothesis was, if the chlorination method is used to clean water, then the water will be purer than using other methods. Boiling was tested with 100 ml of water that needed to be purified. The water was poured into a clean pot. Then the pot was put on top of a stove and boiled at medium for 1 minute. Next, the water was tested with a water testing kit. It was tested for iron, copper, pH, alkalinity, nitrite, nitrate, chlorine, and total hardness of the water. As for Filtration, a coffee filter was needed. The filter was filled with 100 ml of sand, and put over a beaker — 100 ml of dirty water was poured through the filter. Chlorination requires 2ml of manufactured dilute sodium hypochlorite, into the dirty water. The major findings were that boiling was able to get rid of the copper ppm, chlorine ppm, and made the water less acidic. Chlorination did the same, but unfortunately, increased hardness and chlorine ppm, Filtration did not do much to clean the water. Still, the process was able to make the water look safer qualitatively. The data and results did not support the hypothesis since chlorination was not the process that had the best results.

The Effect of PM2.5 Levels on Mortality Rates Due to Respiratory Illnesses.
Sania Jain, George H Moody Middle School

The impact of growing air pollution on human health has become a major concern worldwide. Studies of human populations exposed to high concentrations of fine, inhalable particulate matter (PM2.5) show a significant impact on human health including breathing issues, respiratory abnormalities and eventually, damage to lung tissue which can sometimes lead to premature death. In this study, the effect of mean annual PM2.5 exposure (micrograms per cubic meter) on the age-standardized death rates (ASDR) per 100,000 world standard population was modeled. The hypothesis was that higher levels of PM2.5 would cause higher mortality rates due to respiratory illnesses. The results showed significant differences in the mortality rates for the three different levels of PM2.5 studied. For low (<20 $\mu\text{g}/\text{m}^3$) and medium (between 20 and 40 $\mu\text{g}/\text{m}^3$) PM2.5, no correlation was observed between PM2.5 levels and ASDR. For high levels of PM2.5 (more than 40 $\mu\text{g}/\text{m}^3$), the correlation of PM2.5 levels with ASDR was very strong.

How Soil Changes the pH of Neutral Water
Olivia Plimpton, Swanson Middle School

The objective of this research experiment is to learn about the pH of soil acidity and basicity and how the pH of soil is really important for the successful growth of plants. I set up this experiment to test the pH change when neutral water was mixed with garden soil, potting soil, compost, red clay soil, and sand to determine which soils are more basic or acidic. The most accurate results would come from testing the soil directly, but in order to test the pH of a solid, the solid has to be dislodged or mixed with a liquid. I mixed 1892.71 mL of water to about 512 grams of soil. I measured the pH of the mixture and determined if the pH of seven from the neutral water went up or down when the soil was added. My results showed how many standard soils used for plant growth are similar in pH and do not have much effect when it comes to changing the pH of neutral water. The mean from the results of garden soil, potting soil, compost, and red clay soil was around 6.5. Sand has a slighter higher average pH of 6.95. In the future when this experiment is performed, I plan to add less water to test the soils. Having viewed the results, I have determined that the water may dilute the soil, changing results, so a mixture with more soil than water may have different results.

The Effect of the Material of Dew Nets on Water Collection
Soumya Khadye, George H. Moody Middle School

The purpose of this experiment was to determine the most dew net efficient material for harvesting fog. Fog harvesting, a method of condensing dew within the air to potable water, became an essential source of water for numerous countries on a global scale. Within arid countries such as Chile, a scarcity of rainfall occurs, the humidity within the air serves as the single source of water. Furthermore, dew nets provide a source of potable water to those countries with polluted water sources. Therefore, dew nets are imperative to aid such countries, as the moisture in air may condense into a replenished source of water. The independent variable of this experiment was the material of the dew net, as the dependent variable was the amount of water collected in milliliters after being bombarded with mist. This experiment does not contain a control, since no regulation for a dew net material exists. The hypothesis was, "If a mesh net is used to collect dew, then the water collected in milliliters will be greater". The dew nets were constructed by installing eyelets within sheets of the measured fabric and were tied to wooden dowels. Driven within the ground, where a hose bombarded mist at the nets, and the resulting amount of water was collected using a graduated cylinder. The mean of the amount of water collected by the mesh nets was 579.8, the canvas nets were 550, and the cloth nets were 502.5 milliliters. The mesh nets collected a significant amount of water from the hydrophobic qualities found within the coating and filament. The canvas and cloth nets both contained a high amount of absorbent capability, which hindered the efficiency. However, the hypothesis was supported.

The Effect of Oil Spills on Algae during Hydroponic Phytoremediation
Malek Ben Hammouda, Thomas Jefferson Middle School

The purpose of this study was to test the effect *Chlorella vulgaris* has on the pH of water containing differing amounts of oil. The independent variable was the different amounts of oil. The experimental group included: 10mL of oil and 20mL of oil. The control group had no oil. The dependent variable was the difference in pH levels (tested with a digital pH meter). The constants were the room temperature, amount of water, the amount of algae, volume of the beakers, size of algae, size of the measuring cup, time intervals until pH is tested, types of water, type of oil, amount of light, and nutrients in the water. The hypothesis was: If the beaker contains no oil in the water, then the water will show the greatest change in pH. The researcher started by letting algae grow for 2 days, taking the pH before algae, and after algae had grown. Then, the researcher added different amounts of oil to the beakers and recorded the pH, the difference in pH from before oil was added to after was calculated. The results showed that the beakers that contained 10 mL of oil resulted in the greatest change in pH. These results prove the hypothesis invalid. In conclusion this study shows that 10mL of oil resulted in the greatest change in pH. However, this study also proved that Hydroponic Phytoremediation isn't a strong enough purifying method.

The Effect of Filtration Processes on the Amount of Sodium Fluoride Detected in the Water
Abhinav Maru, George H. Moody Middle School

The purpose of this experiment was to determine the significance of the purifying method used on the amount of sodium fluoride (NaF) in the water. Since in recent years, a variety of different methods to purify water were used around the world by people who lack access to drinking water. Two and a half grams of NaF was dissolved for every 500 ml water trial and put in the containers for their IV. Then the water was purified using different methods for a total of 14 trials per independent variable (IV). The control of the experiment was not filtered sodium fluoride water. The dependent variable was the amount of sodium fluoride detected in the water measured in ppm and the levels of IV include reverse osmosis filter, charcoal and sand filter, and P&G water purifying powder. It was hypothesized by the experimenter that water treated with P&G water purifying powder would have the least amount of sodium fluoride compared to the rest of the IVs. The results revealed that the water filtered with the reverse osmosis filter had the lowest average ppm with the water purified using P&G water purifying water was 2nd. A t-test was done on the data and it revealed that the data was significant for all the comparisons between the IVs of the experiment. The results did not support the research hypothesis. It is believed that the results are due to the fact that only some or none of the sodium fluoride particles could go through the membrane inside of the filter. This research could lead to further studies that investigate the amount of sodium fluoride for optimum filtration and how other contaminants may affect the results and performance of all of the purifying methods used in this experiment.

Global Warming and Soil Moisture
Demetra-Aurora Tudorache, Swanson Middle School

Could global warming cause food shortages? Will global warming dry out the soil enough for it not to be able to sustain plant life? This project explores the effect of increasing temperatures due to global warming on the amount of moisture in loam soil. The experiment was trying to determine whether global warming can cause conditions where some crops can no longer grow and people have even more limited resources. The independent variable levels were 20 degrees Celsius, 25 degrees Celsius, and 30 degrees Celsius. The hypothesis was that as temperature increases, soil moisture decreases. It was expected that 30 degrees Celsius would have the lowest moisture level, because over the span of eight hours, most of the moisture in the soil would evaporate. To conduct this experiment, loam soil was placed in plastic tubs with drainage holes and left in an isolated room in 8-hour long trials. For each trial, the temperature was controlled and maintained using an Optimus radiator which regulates room temperatures. The soil moisture was measured for all the containers after the trial ended with a General moisture meter. The hypothesis was strongly supported by the data collected in the experiment. The average moisture levels for each independent variable level from 20 degrees to 25 degrees to 30 degrees are 48%, 36%, and 28%, respectively. The information from this experiment and other experiments like this is very important for environmental scientists, farmers, and crop distributors because it offers a prediction as to what could happen in the future, and could give people time to adapt or find solutions to counter these potential threats.

The Effect of the Angle of Solar Cells on the Electrical Current Produced by the Solar Cells
Anuj Damle, George H. Moody Middle School

The purpose of this experiment was to find the angle at which solar cells would produce the highest electrical current. Since solar panels are fixed at a certain angle and don't generally move with the sun, it is vital to identify an optimal angle to fix the panels to generate maximum electricity during the day. The independent variable in this experiment was the angle of the solar cells. The dependent variable in this experiment was the electrical current produced by the solar cells measured in amperes. The levels of the independent variable in this experiment were the solar panels at a 0-degree angle (facing straight up), at a 30-degree angle, at a 60-degree angle, and at a 90-degree angle. The hypothesis for this experiment was that if the solar cells are placed at a 0-degree angle, then they will produce the most electricity. This was based on research that shows that solar cells will always produce the highest electrical current when they are facing the sun so that the rays arrive at cells vertically. An apparatus with a flap that held the solar cells at the various angles was needed for the experiment. The apparatus containing the solar cells was then placed outside at 12:05 pm. This experiment was done twice. The first time was on a cloudy day, and the second time was on a sunny day. Of the 22 solar cells that were used in the experiment, all of them produced the highest electrical current at a 30-degree angle. The average electrical current produced at a 30-degree angle was 6.14 mA. The lowest average current produced for one angle was 4.14 mA with the solar cells at a 90-degree angle. The results of this experiment did not support the hypothesis, which stated that if the solar cells were at a 0-degree angle, then they would produce the highest electrical current. The results of this experiment can be explained with the fact that solar cells produced the highest electrical current when the sun's rays fell at a perpendicular angle. When the solar cells were at a 30-degree angle, the sun fell on them at a perpendicular angle.

ENGINEERING & TECHNOLOGY

The Effect of Color on Exterior Walls of a House on The Interior Temperature
Emma Abramson, Thomas Jefferson Middle School

The purpose of this study was to see the effect of the color of the exterior walls of a house on the interior temperature. The independent variable was the color of the house. The experimental group included: a black house, a grey house, and a white house. The control group was a house with no paint. The dependent variable was the temperature on the inside of the house. The constants were the type of house, house material, brand of paint and type of heat lamp. The hypothesis was: If the exterior walls of a house are painted white, then it will be the coolest interior temperature. In this experiment, the researcher put four different colored boxes under a heat lamp (one at a time), and determined which colored box absorbed the most heat. Using a thermometer, the researcher measured the temperature on the interior of the box before and after applying the UV heat lamp. She then recorded her findings. The results showed that the black boxes absorbed the most heat, and that every other independent variable failed to reach or exceed the black shoe boxes' temperatures. These results supported the hypothesis and showed black absorbs the most heat, while white reflects the most. In conclusion, this study suggests that a black house absorbs more thermal energy than a white house.

The Effect of Storm Drain Grate Design on the Passage of Water and Plastic Debris
Elaine Chu, Thomas Jefferson Middle School

The purpose of this study is to determine the most effective storm drain grate design by measuring each grate's ability to keep plastic out and drain water. The independent variable was the design of each grate. The experimental group included Type C grate: rounded rectangular openings, 5mm Circle grate: 5mm wide holes, and Type V Vane Style grate: sloped bars. The control group was the storm drain without a grate. The dependent variables were the number of plastic pieces kept out and the time it took 5L of water to flow through each grate. The constants were the storm drains, containers, starting amount of water poured, the total pieces of plastic, and testing setup. The hypothesis was: If the designs of storm drain grates are tested, then the Type V Vane Style grate will keep out the greatest number of plastic pieces and have the fastest water drainage time. First, the three storm drain grates were 3-D designed and printed. Identical storm drains were made for each grate and the control out of styrofoam boards. Next, the baseline water drainage time for each grate was measured by pouring 5L of water into the storm drain and recording the time it took to drain through the grate. Then, plastic debris was added to each storm drain. Finally, the water drainage time with debris was measured in the same manner and the number of pieces of plastic kept out by each grate was counted. The results showed that the control with no grate drained water at 5.6 sec per 5L, the Type V Vane Style Grate had the best hydraulic efficiency, draining water at 6.7 sec per 5L, and the 5mm Grate had the best ability to screen out plastic debris, keeping out 98 pieces out of 100. These results in part accepted the hypothesis. In conclusion, the study suggests that grates do not greatly hinder water flow in storm drains and make a significant difference in preventing plastic from entering storm drains and flowing into waterways. Furthermore, the standard storm drain grate designs in cities, like the Type C Grate, should be replaced with more effective designs such as the 5 mm Circle and Type V Vane Style Grates.

The Effect of Hull Cross Sections on the Efficiency of a Watercraft
Camellia Sharma, George H Moody Middle School

The watercrafts move through viscous water and experience a much higher drag than other means of transport, such as airplanes and automobiles. The seaborne cargo accounts for 90% of the international trade in goods. Ships contribute 2.8% of the greenhouse gases by burning fossil fuels. The maritime industry is always looking for ways to reduce fuel consumption and the carbon footprint of the watercrafts. The purpose of this experiment was to investigate the ways of reducing the energy usage and the frictional drag on the ship hulls and making them more efficient. It was hypothesized that the slender bulb will be the most efficient. The project was done in two complementary parts. In the first part, the hull was designed and computationally analyzed with the Orca3D Marine Designer software. The resulting hull was exported from Orca3D in the STL file format and fabricated on a 3D printer. The Froude numbers were matched between the full-sized hull and the model. A testing tank was designed that measured how much a boat model is pushed back due to the drag. That gave a relative measure of which hull has a lesser drag. It was found that there is a good correlation between the theoretical values and actual measurements. In both cases, the drag increases with speed. Further, the analysis showed that the widebody model is an outlier that is neither suitable for carrying cargo nor is fuel efficient. In comparison, the hull with a slender bulb is the most efficient. The hull offers a lower drag while not compromising on the cargo carrying capacity. The project could be extended to non-displacement hulls such as planning hulls and catamarans. The experimental setup could also benefit from more precise force measuring instruments. That will give the option of getting the absolute values of force exerted by the model. The t-tests were performed for the four ships speeds and the data was found to be statistically significant.

The Effect of Different Filters on the Intensity of Blue-Light Emissions from a Smartphone
Isabella Kenney, George H. Moody Middle School

With the recent rise in the use of computers and hand-held devices in people's everyday lives, exposure to blue light from device screens has increased significantly. Research has shown that overexposure to blue light, especially at night, causes the most damage to the retina of any other light colors and can cause a drop in the body's secretion of melatonin. This, in turn, can increase the chances of developing certain diseases like diabetes, obesity, and cancer. These negative health effects are what prompted the purpose of this experiment, which was to find the most effective filter to block the blue-light emissions of a smartphone. The hypothesis going into the experiment was "if yellow-tinted blue-light-blocking glasses, clear blue-light-blocking glasses, external yellow light, "night mode", and no filter are used, then the yellow-tinted blue-light-blocking glasses will cause the greatest percentage reduction in the intensity of the blue light emissions when compared to the control group." This hypothesis was tested by placing the spectrometer (measuring in $\mu\text{W}/\text{cm}^2$) five centimeters away from the phone's white screen with each of the filters (one at a time) in place. In addition, the control measurements were taken without any filter, and this (plus the other levels of the independent variable [IV]) was repeated for a total of fifteen trials each. Then, the percentage reduction of each of these measurements from the measurement taken with no filter in place was calculated. The results indicated that the yellow-tinted glasses created the greatest percentage reduction (70.78%), while the external yellow light created the least percentage reduction (0.00%). The standard deviation for the raw data of each level of the IV was below $0.92 \mu\text{W}/\text{cm}^2$, suggesting that all of the filters were quite consistent. The data supported the research hypothesis, but to conclude that yellow-tinted blue-light-blocking glasses are the best, more research with other brands would have to be conducted.

Tent Stake Designs for Soft Sand
Gideon Colliver, Blacksburg New School

A cheap, portable, lightweight, durable and effective tent stake for sand is a need for any camper who tents in the sand, such as desert or beach locations. The loose soil and wind prevent most stakes from staying in place. Three designs were tested: an auger, shovel, and a bowl to see which design would give the greatest resistance in the sand. The models were printed using a three-dimensional (3D) printer with non-carbon or carbon Polylactic Acid (PLA) filament. Each model was tested in a sand-filled-bucket and the resistance required to pull each prototype from the sand was measured. The bowl design met all criteria and gave the greatest

The Effect of Different Classification Algorithms on the Accuracy of Machine Learning Resistance with a high of 40 Newtons (N).

Devesh Kumar, George H. Moody Middle School

Machine learning is quickly gaining popularity and public interest. It can be divided into different types of algorithms, including classification, regression, and clustering. In this research, classification algorithms were studied. Classification algorithms classify and sort items in a data set. Their performance was measured by comparing the different algorithm's accuracy. The purpose of finding this information was so that the performance of self-driving cars and autonomous robots could be improved. Finding the best classification algorithm will remove the hassle of having to choose an algorithm when using tasks with classification, simplifying the process needed to use machine learning. The research hypothesis was that if a support vector machine, or SVM, was used, then the accuracy would be the highest. To test this, a computer program called WEKA was used. WEKA (Waikato Environment for Knowledge Analysis) is a GUI machine learning platform developed by the University of Waikato in New Zealand. Using the experiment function, the algorithms were tested. The results indicated that logistic regression had the highest accuracy, followed by decision trees and SVMs respectively. An ANOVA test showed that the null hypothesis was rejected and that SVMs did not perform as expected. Logistic regression did the best since it uses a more numerical approach. Decision trees also did well, since they used rules to classify and the data sets that were used were well-designed enough for the rules to be effective. With the emergence of artificial intelligence and machine learning, this research will help fuel the development of new technologies.

Examining Rates of Rowhammer-Type Errors Between Manufacturers of DRAM Chips
Curtis Case, Southwest Virginia Governor's School

Rowhammer is a phenomenon experienced in Dynamic Random-Access Memory (DRAM) chips. Rowhammer occurs when multiple nearby horizontal “wordlines” in a DRAM cell are accessed repeatedly within a short period of time. This action can cause electrical charges used to move data to leak into unwanted areas, potentially causing nearby bits to change their electrical charge, or “flip.” This phenomenon can have multiple effects, such as privilege escalation in virtual machines or rewriting of information crucial to a computer system. This study sought to identify whether there was a difference in the number of rowhammer errors that occurred in DRAM modules between 3 major manufacturers. To collect these data, two DRAM modules from each manufacturer were inserted into a test system and subjected to a program that tested the modules for any rowhammer errors. This test accessed 10 memory addresses per iteration and checked for any rowhammer errors. The test was run for 5,000 iterations per memory module to accrue a large sample size. After data collection was completed, a total of 0 rowhammer errors were found. For statistical purposes, the null hypothesis stated that there was no detectable difference between the number of rowhammer errors between manufacturers. With a total number of 0 errors found, the researcher was unable to reject the null hypothesis. This result suggested that rowhammer was less common under current memory standards than previous standards set less than a decade ago. However, further study will be required to concretely assert the cause behind the lack of rowhammer errors. While this study could not achieve statistical significance, the information gained promotes reinvestigation of the rowhammer phenomenon and serves as a jumping-off point for future research seeking to find a definitive solution to the rowhammer problem.

The Effect of Household Hygiene Products on the Generation of Microplastics in Water
Peize Wang, George H. Moody Middle School

The objective of this project is to find out the effect of the household hygiene products on the generation of microplastic particles in water. Microplastics are plastic particles smaller than 5 mm in diameter or even smaller. The hypothesis was, “some hygiene products contain indissoluble microplastic particles and will be released into water, causing environmental and health issues”. This project was chosen because it signifies which hygiene product would do the most harm to the environment. To test the hypothesis, the type of household hygiene products was used as the independent variable (IV). Five types of hygiene products, that is, soap, conditioner, face cleanser, and shampoo were bought. Three constants, such as water (20 mL), room temperature, and the amount of hygiene products (1 gram per trial), were fixed. The hygiene products were first mixed with water to make suspensions, which were then placed on microscope slides and heated until dry samples were obtained. These microscope slides were then put under an optical microscope to count the number of microplastic particles. Each sample of the hygiene products was analyzed for 10 times. To calculate the number density of the microplastic particles, the mass conservation law was used. The results show that the rounded average amount of particles per ml of solution for each different level of IV were 0 for soap, 6267 for conditioner, 360333 for face cleaner, and 18800 for shampoo. It is clear that the face cleaner contains the most microplastics and would do the most harm to the water. To make this project even better, there are many new ideas and improvements, such as researching on the water temperature and the type and size of microplastics since these are important to understand the possibility of these microplastic particles to enter the environment and even the human body.

The Effect of the Type of Soil on the Stability of a Building in an Earthquake
Charlotte Minnigh, Williamsburg Middle School

The purpose of this experiment was to determine whether different types of soil affected the stability of a building in an earthquake. How soil affects the stability of buildings is important so that buildings can be designed to withstand earthquakes in diverse locations. This information could be significant in earthquake prone places like California. In this experiment, a shake table was built, sand and topsoil was purchased, and red clay soil was collected from a backyard in Arlington, Virginia. The soil was placed on the shake table, a wood block building with four levels was placed flush with the shake table, and the bottom two levels were submerged under the soil, acting as a foundation. As the shake table was shaken, and a stopwatch was used to determine the time until the building's top two levels became unstable and fell. The building in red clay soil remained stable the longest, the top two layers stayed stable for a mean value of 13.3 seconds. The building in topsoil remained stable for a mean value of 5.6 seconds. The building placed in sand kept the building stable for the least amount of time, with a mean value of 4.9 seconds. Red clay soil had high variation, but the other soils did not, which indicates mostly reliable data. The hypothesis — that sand would be the most stable — was rejected; red clay soil held the building stable for the longest and sand kept the building stable for the least amount of time. Topsoil scored slightly better than sand, while red clay held the building up for significantly more time.

The Effect of External Inputs on Q-Learning
Spencer Anthony, Sabot at Stony Point

This experiment was conducted to test the effect of external inputs (an input given from something other than the Artificial Intelligence (AI)) on how well AI can complete tasks. The purpose is to test the effectiveness of different levels of external input: full input, partial input, and no input. The data showed that external inputs made no effect. There was a difference between the control and partial input, however, that difference was not statistically significant. The difference was not statistically significant because the ranges of the data (50 for no input, 40 for partial input and, 50 for full input) are larger than the difference. Also, there was a very high amount of overlap between the levels of the independent variable.

The Effect of Types of Fabric on its Ability to Limit UV Radiation
Sophia Voulgaris, Thomas Jefferson Middle School

The purpose of this study was to see the effect of different types of fabric on the amount of UV radiation screened. The independent variable was the type of fabric. The experimental group included: cotton, polyester, and rayon. The control group was no fabric. The dependent variable was milliwatts of radiation. The constants were the same fabric color, same amount of fabric, and same experiment location. The hypothesis was: If UV radiation is projected on fabrics, then cotton will let the most milliwatts of radiation through. The different fabrics were draped on the dome with a UV sensor in the center of the dome and a UV sensor outside of the dome. The sensors were linked to an Arduino which took measurements every two seconds. The results showed that rayon let the most milliwatts of radiation through. Thus, the hypothesis was rejected. In conclusion, the study suggests that polyester is the fabric that will protect skin the most.

The Effect of Different Genetic Algorithm Types on Processing Speed
Anooshka Pendyal, George H. Moody Middle School

Genetic algorithms are algorithms that are inspired by the biological process of natural selection and belong to a larger class of algorithms called evolutionary algorithms (Carr, 2014). The genetic algorithms used in this project rely on changing the crossover types, which means that the algorithm changes the way that the matrix randomly mutates during the process of finding the ideal solution (Umbarkar and Sheth, 2015). The purpose of this experiment was to determine which genetic algorithm would sort a dataset in numerical order the most quickly. The independent variable (IV) in this experiment was the different types of the genetic algorithm used to sort the data in numerical order. The dependent variable was the time spent on the algorithms to sort through the dataset. The four levels of the IV were single-point crossover, two-point crossover, uniform crossover, and flat crossover. It was hypothesized that the single point crossover algorithm would sort the dataset the most quickly. First, the materials used in this project were all obtained from the internet. Then, the algorithms were run with the modified code, and the data was collected and analyzed. The experiment showed that single-point crossover was the fastest, then two-point, uniform, and finally flat crossover. The hypothesis was proven correct due to the fact that single-point crossover requires the least amount of changes in-between steps, which is less work for the computer. Many papers support the results found in this experiment such as one written by Alden H. Wright. For further research, the sizes of the dataset could be changed. An improvement that could be made would be to use a more diverse dataset. This could lead to a more balanced outcome.

Optimization of Swanson Solar
Liam King, Swanson Middle School

This experiment was designed to figure out the optimal orientation of a solar panel, and then use that data to figure out whether or not Swanson Middle School could potentially go carbon neutral. To do this, a computer simulation was run to figure out the optimal orientation for both Tilt and Azimuth for the location. After that, the system calculated how much energy could be potentially generated across the entire roof by extrapolating the production figure to fit the number of solar panels able to potentially be placed in each roof section. What was discovered was that contrary to the simulation's expected orientations of 180° and 38°, the ideals actually occurred at 182° and 34°, therefore invalidating the simulation's complete data tables. When extrapolated to fit the roof's 68,528sf surface area, the solar panels selected generated 1,311,358 kWh of electricity in a year. This figure, although fairly significant, is far lower than the consumption figure of 1,846,988 kWh, the one that was supposed to be offset by the addition of solar panels. The leftover 535,630 kWh would either come from a nuclear power plant, or a coal fired one, neither one as desirable an option as on-site solar.

An Artificial Intelligence Prognostic System to Accurately Predict Lung Cancer
Sanaa Karkera, Ronald Wilson Reagan Middle School

Lung Cancer is the second most common cancer in both men and women world-wide. Currently, Lung cancer has a 96% false positivity rate as diagnosing methods are ineffective causing mass mortality. Present day diagnosis methods include Computed Tomography (CT) scans which use X-rays to make detailed cross-sectional images of the human body. CT scans take numerous pictures for a computer to combine in order to display a slice of a part of the body being studied. CT scans are more likely to show lung tumors than routine chest x-rays. It can also show the size, shape, position of lung tumors, and discover enlarged lymph nodes (small structures that filter harmful substances) that could contain cancer. In addition to CT scans, Positron Emission Tomography (PET) scans are an invasive method for diagnosing lung cancer by injecting a slightly radioactive form of sugar, known as FDG, into the blood to collect cancer cells. Often, PET and CT scans are combined using special machines that can conduct both simultaneously allowing radiologists to compare areas of higher radioactivity on the PET with a detailed photograph on the CT scan. To improve testing accuracy, my project creates an AI deep learning model that combines pathological and imaging data with deep learning methods to significantly increase the accuracy of lung cancer prognosis and assist radiologists in reducing time for a diagnosis.

The Effect of Material between Mobile Device and Receiver on the Amount of Radiation Received

Nayan Mehta, Moody Middle School

The purpose of the experiment was to determine the material that transmits the highest and lowest amount of electromagnetic radiation. Thorough research was conducted in preparation of the experiment. Most objects with mass are radioactive to a degree, including mobile cell phones. Radiation can be used for beneficial purposes, such as curing illnesses and diseases, or for destructive or negative causes. The hypothesis stated, "If the material used has a higher density, then the radiation received will decrease". The experiment was initiated by gathering 3 different phones, a radio frequency meter, a laptop computer for data recording, and a flat surface. The experimenter used two of the cell phones to call each other, and the other for timing. The RF meter was used to measure the amount of radiation received (in volts per meter). The experiment consisted of six levels of IV, which were the different materials, air (control), aluminum, cotton fabric, plywood, glass, and paper. The dependent variable was the amount of radiation received. The results were varied, but the statistical mean for each material is as follows. Air: 1.27 v/m, aluminum: 0.82 v/m, cotton fabric: 1.18 v/m, plywood: 1.01 v/m, glass: 1.22 v/m, and paper: 1.14 v/m. After experimenting, it was concluded that the hypothesis was supported by the data. Aluminum was the densest and transmitted the least radiation, while air, being the least dense, transmitted the most radiation. This data can help aid engineers in developing products that block or cover a fraction of the radiation emitted, likely with products that emit a higher amount of radiation to begin with. The more people know about the effects of radiation, the more they will care for their safety from it.

HUMAN BEHAVIOR

The Effect of Spinning on the Ability to Walk in a Straight Line

Hannah Kate Harrison, George H. Moody Middle School

The purpose of this experiment was to see the effect of spinning on the ability to walk in a straight line. The group of volunteers that were tested were seventh-grade girls only. The experimenter found from research that there is fluid in the ear that moves around when the head is spinning or is jolted around. The more movement there is in the head/body, the more the fluid moves around. That information led the experimenter to this hypothesis: If the number of times the volunteer spins increases, then they will stray from the straight line at or before one-hundred and fifty centimeters (the halfway point in the straight line). In the experiment, all volunteers (one at a time) were blindfolded, and spun zero, five, and ten times. After each number of times being spun, (zero, five, and ten) the volunteer was asked to walk in a straight line. If/when the volunteer started to stray from the straight line, they were stopped and the distance they were able to walk after spinning was recorded. After all of the volunteers had been spun and all the test results were organized, the experimenter found that

The Effect of a Human Voice Vs. a Synthesized Artificial Intelligence Voice on the Comprehension of a Story

Risshi Naavaal, George H. Moody Middle School

The purpose of this study was to see if there is a correlation between a type of voice and one's comprehension of a spoken text. The two types of voices being compared were a human voice and an artificial intelligence (AI) voice. It was hypothesized that the participants who listened to the human voice would exhibit a higher level of comprehension compared to those who listened to the AI voice. Fifty participants in total were recruited to take part in the study, twenty-five for each voice group. The human voice was that of the experimenter and the AI voice was generated using Google Wavenet's Text-to-Speech service. A comprehension test was developed to determine the participant's level of comprehension of the given story. The test had ten comprehension questions. There was no time limit to complete the questionnaire. After data collection was finished, the mean scores for each voice group were calculated. The human voice group had a mean score of 5.72 correct responses while the AI voice group had a mean score of 3.00 correct responses. A two-sample homoscedastic student's t-test was conducted to see if there was any significant difference between the two groups at a 0.05 level of significance; the null hypothesis was rejected ($t = -4.0177$, $df = 48$; $p=0.0002$). Research limitations were recorded for future reference. According to the findings of the study, it can be said that an AI voice can be improved to become more comprehensible for a human listener in the future.

The Effect of Music Played Before Solving Multiplication Problems on Accuracy
Shruthy Rajkumar, George H. Moody Middle School

In 1993, Francis Rauscher published an experiment where she tried to find a relationship between music, specifically classical music, and how well her participants did while being tested on spatial reasoning. She decided to call this relationship the Mozart Effect because the song she chose to use for her experiment was composed by Mozart. After much controversy, the Mozart Effect has now been generalized to any music. The purpose of this experiment was to see if different genres of music had an impact on the accuracy of multiplication problems when played before solving. Twenty-five people listened to specific genres of music for five minutes before being able to solve double-digit multiplication problems for one minute. Their worksheets each had 20 questions and were graded out of 100%. The results indicated that people scored the highest when they had listened to Rock Music with the mean of scores being 21.6% and they scored the lowest after listening to Classical Music. The data didn't support the research hypothesis that if different genres of music were played before taking a test, then the genre that would result in the best accuracy would be classical music.

The Effect of the Type of Music on the Ability to Multitask
Shorya Malani, Moody Middle School

Most of the population has a workflow. Many hours are spent with this workflow, making efficiency extremely important. Most workers have distractions in their workflow and also listen to music. Music has different effects on the brain based on tempo. This tempo is also usually the difference between genres. This experiment was created to see if having different genres of music makes for different results in the focus of a worker. This is important because even a little efficiency goes a long way in the long run. At the beginning of the experiment, it was thought that non-vocal music would be better for focus on math problems and everyday distractions rather than no-music, pop music, or rap. For this experiment, a website was set up to serve a quiz and save the results. The website had simple math problems with multiplication problems. The website would also serve up distractions for people to think about as if they were distractions in the real world. During this, the website plays music that the test subject will listen to. At the end of each type of song, the website asks for information about the distractions. Surprisingly, no music, pop, rap, and non-vocal had averages of 14;13;11;8 respectively. This was odd because it meant non-vocal was the worst for performance and pop was the equivalent to no music. This was much different than other studies that showed that non-vocal was the best for studying.

The Effect of Music on Math Tasks
Scott Shockley, Sabot at Stony Point

Many people enjoy listening to music while they work. Some people claim that music helps them with work and others that it is a distraction from work. Studies have been conducted in the past with music distractions. Many of these studies are inconclusive or disagree with each other. This test was conducted to show how music affects people while they do math-related tasks. Each participant was given a test with 100 three-digit addition and subtraction problems. They had one minute to complete as many as they could. They did this three times. Once, they did it in silence, once they did it with music and no lyrics, and once they listened to the same song with lyrics. The hypothesis is that music will not have any meaningful effect on work tasks, and this was supported. However, the analysis revealed that everyone tested had different outcomes. There was hardly any difference in the percentage of problems that were correct. The highest average was music with Lyrics (81.49% correct). This was only 1.48% higher than the second highest treatment which was silence, and only 0.32% higher than the treatment with only instrumental music. The difference is very small. The overall conclusion was that treatments had a different effect on math performance at the individual level. Overall, twenty two people were tested and the data differed for each person. Exactly 50% of adults performed with two music treatments, both with lyrics and no lyrics but the other half of adults did worse with both types of music. Exactly 40% of children tested did better with lyrics and only 30% performed better with instrumental music. Fifty percent of kids did worse with instrumental with 20% of children performing the same across the different treatments.

The Effect of Design or Messaging on the Buying Decision of any Product Among Elementary and Middle School Students

Anusha Rathi, George H. Moody Middle School

Purpose: Does age and understanding affect buying products and does the design and messaging of a product influence different age groups?

Hypothesis: The elementary school students will pick a product with an attractive design compared to middle school students who will pick a product based on information rather than on the attractiveness of the design.

Results: Total 150 students of which 81 were from elementary school and 69 from middle school participated in this study. 42 out of 81 (52%) elementary school students chose attractive design and not much information of the product and similarly 35 out of 69 (51%) middle school students chose the same option. Nearly 48% of the remaining elementary and middle school students chose informational message and non-attractive design of the product. Therefore, there was no difference between the elementary school and middle school age group students.

Conclusions: Our results demonstrate that there was no difference between elementary and middle school students' decisions related to design of a product vs. the information on a product. The elementary school students were as smart as middle school students in understanding the value of the information on a product.

The Effect of Stereoscopic Vision Techniques on the Ability to Detect Differences in Images.
Viktor Vaniakin, George H. Moody Middle School

Normally, when people try to find differences in almost identical images (e.g., “find 10 differences” games), they focus their vision on one image at a time and keep shifting between the two images. Some people have a unique talent to use human stereoscopic vision ability allowing them to have both images in focus simultaneously and merge them into one. Once the two images are overlaid into one, any discrepancies in the images start to glimmer, allowing to easily detect the difference within seconds. The researcher discovered he had this ability and wanted to better understand the science behind it, develop a way to measure and compare to common human ability, test if this skill could be trained, and design a tool to simulate this skill for others. Testing was done by presenting pairs of almost identical images with one difference to participants using different vision techniques (independent variable) and measuring the percentage of differences identified correctly within fifteen seconds (dependent variable). The experiment proved that people possessing advanced stereoscopic vision ability were substantially better at quick difference detection – 100% differences were found correctly within 15 seconds vs. 8% in the control group. Training increased the results from 8% to 19%; however, the change was not statistically significant and had high variability – the majority of participants did not achieve any improvement, confirming the skill cannot be easily taught. Realizing that a virtual reality headset worked in a similar way to stereoscopic vision technique was a breakthrough idea – using a VR headset to simulate the skill helped achieve 73% correct difference detection rate. This new method of image difference detection opens opportunities in different areas that rely on humans interpreting images – e.g., radiology image reading, comparing sky images to discover new objects, detecting earth and ocean changes from the satellite images.

The Effect of Screen Time on Behavioral and Social Interactions
Ananya Nanduru, George H. Moody Middle School

The purpose of this Independent Research Project was to find out how screen time affected behavioral and social interactions. This topic was chosen after it was found that screen time negatively affects the brain, and therefore affects the behavior of human beings. The levels of IV for the experiment were 0 Minutes/Hours of Screen Time (Control), 10 Minutes of Screen Time, 20 Minutes of Screen Time, 30 Minutes of Screen Time, and 40 Minutes of Screen Time. First, they were asked questions that would provoke cues and facial expressions to assess behavior. Next, they were asked to use their phones for 10 minutes, and they were asked different questions of the same style as earlier. Then they were asked to use their phones for another 10 minutes and the procedure repeated. The same was applied two more times. In all, this took 5 times to complete. Of these levels, it was believed that 0 Min. of Screen Time would result in the most positive social interactions and the best behaviors because research proves too much screen time can be a bad effect. In other words: If the subject is exposed to 0 Min. of Screen Time, then they will exhibit more positive behavior (this was the proposed hypothesis). One of the major things which was observed by the experimenter is that overall, the behaviors of the participants majorly deteriorated and began to be generally negative. One other thing observed was that the participants became increasingly tired and/or exhausted as they kept using their electronics as time progressed. 80% of people had their behavior deteriorate over time, while only 20% of people had their behavior stay the same or become more positive. This means the majority of people had their behavior decrease in positivity or deteriorate. Overall, the experimenter believes the hypothesis was supported by the results.

The Effect of Blue Light from Digital Devices on the Time Taken for a Human to Sleep
Misthi Choksi, George H. Moody Middle

Blue light is emitted from all sorts of digital devices. Blue wavelengths increase attention and awareness, making it harder for a person to fall asleep. It also affects a human's sleep pattern by suppressing the amount of melatonin in a person's body. The purpose of this project is to determine how blue light can affect how long it takes for a human to fall asleep. Group A watched a video before going to bed without any filter on the device. Group B watched the same video with a blue light filter on the intensity of 50%. Then both groups turned on an app that calculated their sleep based on their breathing and movements. The next morning, the app was turned off. The results indicated that using a blue light filter caused the subjects to fall asleep faster with a mean of 10 minutes. Without a blue light filter the mean of the data was 20 minutes. The data minimum for subjects using a filter was four minutes, whereas devices without the filter, the data minimum was five minutes. The data maximum using a filter was 19 minutes, however without the filter, the maximum was 38 minutes. The data supported the research hypothesis that if a 50% intensity level of the blue-light filter was applied, then the subject would fall asleep faster. Based on the data received from this research, there is a correlation. The correlation noticed in the data is that when the time the subject takes to fall asleep is lower, the time it takes the subject to go into a deep sleep is lower as well.

The Effect of Deep Breathing on Free Throw Shooting Performance in Basketball
Emma Sicat, George H. Moody Middle School

Taking a free throw during a basketball game can be very stressful as the shooter can encounter many distractions. Research has suggested that pre-performance routines can have a positive impact on preparing an athlete's mind and body to perform a skill, such as making a free throw shot. The purpose of this experiment was to determine if a deep breathing technique (one potential aspect of a pre-performance routine) helped improve free throw shooting accuracy. The hypothesis in this experiment was if 25 free throws without deep breathing were taken, then 25 free throws were taken with a pre-deep breathing technique applied, the accuracy of the free throws would be greater. Twenty-five female subjects aged 10-14 were enrolled in the study and were required to play on an organized basketball team for at least one season. Twenty-five trials were conducted for each subject without and with the deep breathing technique and were recorded. The mean number of baskets made without the deep breathing technique was 5.92 baskets (range 1 - 14). The mean number of baskets made with the deep breathing technique was 6.76 baskets (range 1 - 16). The mean free throw shooting accuracy without the deep breathing technique was 24% and with the deep breathing technique was 27%. Overall, of the twenty five subjects, 64% of subjects improved (n = 16), 4% stayed the same (n = 1), and 32% did not improve (n = 8) their free throw shooting accuracy with the deep breathing technique. The results of this study supported the conclusion that incorporating a deep breathing technique can improve basketball free throw shooting accuracy in young girls, although the difference was small. Further larger studies are needed examining the impact of deep breathing on performance in adolescents in a variety of different sports.

SHE Can Do It! Can the Growth Mindset Encourage Girls to Pursue STEM Careers?

Rania Lateef, Louise A Benton Middle School

Background/Main Objectives: Despite major advances in gender equality, men still far outnumber women in Science, Technology, Engineering and Math (STEM) professions. The purpose of this project was to determine whether having a certain mindset (fixed versus growth) could affect a student's future career choices and whether this effect differed based on gender. It was hypothesized that if girls had a growth mindset, then they would be more likely to consider pursuing STEM careers in the future, compared to girls with a fixed mindset.

Materials and Methods: Seventy-one elementary and middle school students were recruited for this study and informed consent was obtained from every subject and his/her parents. Each subject completed the Dweck mindset quiz and a score was assigned between 0 and 30. The subject was assigned a "fixed" mindset for scores ≤ 18 , and "growth" mindset for scores ≥ 19 . Each subject was then shown the picture of a workplace without any male or female workers in it. They were asked the following questions, "Would you consider doing a job like this in the future?"; "Is this something that you think you would be able to do?" Each subject was shown a total of 11 workplace pictures: 5 "male"/STEM, 5 "female", 1 neutral. If a subject picked $\geq 3/5$ "male"/STEM careers, he/she was considered "likely" to pursue a STEM/"male" career. Results were tabulated and graphed.

Results: Males picked more possible future careers compared to females (7 vs. 5, out of 10 options). When looking within the gender groups, 86% females who had a growth mindset were likely to consider a "male"/STEM career whereas only 16% of females with fixed mindset would likely to consider a "male"/STEM career.

Conclusions: It is fascinating to know that mindset may determine how one thinks about future career options. Especially for girls, this may be a great strategy to address the problem of fewer girls picking STEM careers. In the future, I would like to design a growth mindset video which can teach kids about the growth mindset and use it to encourage more STEM career choices. The more we believe we can, the more we can accomplish!

The Effect of Physical Activity on Human Memory in Different Age Groups
Saniya Sangle, George H. Moody Middle School

The changes in memorization ability of people who participate in physical activities and people who don't participate in physical activities were studied in four different groups of ages 30-49 and 50-69 of people who do exercise for at least 150 minutes every week and people who don't exercise every week. It was hypothesized if the participants in both age groups regularly engaged in moderate-intensive physical activity at least for 150 min per week (spread across 3-5 days per week), then the chances of decline in memory will decrease independent of age. 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. Differences in the test performance of each group were analyzed to determine the impact of physical activity on memory. The results have been discussed in terms of variation in the average number of letters recalled by different age groups. Post experiment data comparisons revealed that the average number of letters recalled gradually decreased by 1-2 letters as the age groups of people who didn't exercise increased. This supported the hypothesis that memorization ability decreases for people who are less physically active. This study also observed that the high memory load (when presented multiple letters) resulted in decrease in accuracy of the letters recalled by all participants whether they regularly exercise or not.

The Effect of Birthplace on Divergent Thinking
Navya Thoota, George H. Moody Middle School

All 195 countries on earth have unique characteristics that separates them from others. Separate cultures have varying beliefs, causing people from one culture to think differently from those in another. Divergent thinking is a method of problem-solving where a variety of solutions are presented in hope to find one. It augments imagination, an imperative trait in problem-solving. This contributes to one's divergent thinking. The purpose of this experiment is to help scientists when conducting experiments to avoid inaccurate results and receive the best data by knowing which side of the hemisphere fits the experiment. In this investigation, birthplace was the independent variable and divergent thinking was the dependent variable. There was no control because there is no "normal" birthplace that the results can be compared to. It was hypothesized that if the participant was from the eastern hemisphere, they would be more of a divergent thinker. Twenty-five people from the western hemisphere and twenty-five people from the eastern hemisphere were gathered to complete a questionnaire. The constants were the questionnaire and method of completion, environment, grading rubric, and the grader. The scores were calculated using a rubric, recorded, and placed into a raw data table. No safety precautions were needed because there was no risk; however, confidentiality was ensured for each participant. The number of divergent thinkers born in the western and eastern hemisphere were both 15. The data showed that divergent thinkers from both hemispheres were equally divergent. The average score was 12.28. The data for both independent variables were similar with few outliers. The hypothesis was not supported by the data. Some potential errors include age, time limit, and varying countries of birth.

The Effect of Color on Flavor Perception
Tanvi Palavalas, George H Moody Middle School

For humans, colors can add beauty, prompt emotions, and even convey information. Color is the human brain's perception of the wavelengths of visible light. Color is also an important sensory cue in situations such as, predetermining the taste of a food or drink. Taste is one of the five senses, the others being smell, touch, vision, and hearing. Primarily there are five flavor groups that taste buds can identify, bitter, sour, sweet, salty, and Umami, a Japanese term that translates to savory. The purpose of this experiment was to identify the effects of color on flavor perception and to learn about the effects of visual interference with taste or flavor perception. The test subjects were given frosting that is colored to see if the visual signals mislead the flavor perception. This experiment would figure out if the human mind can override the senses and communicate back if a taste can be tasted by us or can't. The data was recorded and organized into three categories. As per this experiment the major finding that I noticed is the younger people that were tested were more likely to identify the taste based on the color. On the contrary, the more mature people ignored the coloring and determined the flavor based on the taste. In most cases the hypothesis, If the relationship between color and flavor perception is strong enough then, the test subject will guess a flavor that relates to the colored frosting, was true. Especially with yellow frosting as 56% of the subjects identified the flavor based on the color. After conducting the experiment and analyzing the results, I found that color can impact the flavor of the food.

MATH PATTERNS & RELATIONSHIPS

The Effect of Population Density on SOL Performance in Virginia

Timothy Porter, Moody Middle School

The purpose of this experiment was to find if there was a correlation between population density and the performance of students on SOL tests in Virginia counties. Population density, commonly measured in population per km², is a measurement of how “packed together people are in a certain area. It is an important statistic that can affect many aspects of a society. It was also the independent variable in this experiment. SOLs, or Standards of Learning tests, are examinations given annually in Virginia to measure one’s proficiency in a course or subject. It was the dependent variable of this experiment. hypothesis was as follows: If the SOL pass rates for each county in Virginia is compared to each county’s population density, then the pass rates of counties with a population density between 100-1000 per square kilometer will be highest due to being high enough for enough access to resources, but low enough as to not severely affect socioeconomic class. The experimenter began with organizing and sorting the initial data. The matching population density for each county will then be compared to the pass rates. The results showed a slight trend upward in the DV as the IV increased, but it was statistically insignificant and thus the null hypothesis was accepted. The lack of correlation may be to a lack of significant relation between socioeconomic class and population density, as socioeconomic class has been shown to affect test and school performance (Clark and Gorski, 2002). If a correlation was found in the future, then it would likely have much different data than this experiment, due to both a rise in population density and constantly shifting average school performance (Malnezzi, 2013).

PHYSICAL SCIENCE & ASTRONOMY

The Effect of Different Textures on Radar Visibility *Spencer Frank, Kenmore Middle School*

In 2019, the researcher did an experiment on stealth aircraft's design and radar visibility, hoping to find which shape reflected the most radar, using light. This year, radar visibility was tested based off of texture- Paper, aluminum foil, 180, 120, and 80 grit sandpaper. It was hypothesized that the aluminum would reflect the most light, the paper the second most, and the 180, 120, and 80 grit sandpaper the least light, in that order. A box was covered with black paper on the inside, and holes were cut on one side. The flashlight was placed in the center, with the Lux meter below it. The textures were cut out to be 8½" by 11" along with a cardboard sheet. The cardboard was folded lengthwise, and after each set of trials, the previous texture was removed, and a new texture applied. The shape was placed in the box, and the light was turned on. After five seconds, the light reflection was recorded. Each texture had twenty trials. The average light reflections were as follows: Paper- 30.8 Lx, aluminum foil- 7.65 Lx, 80 grit sandpaper- 11.5 Lx, 120 grit sandpaper- 8.25 Lx, 180 grit sandpaper- 10.6 Lx. The results showed the paper as stealthiest, the 80 and 180 grit sandpaper, second stealthiest, the 120 grit sandpaper penultimately stealthiest, and the aluminum foil stealthiest. This led to further proof of the color white's reflectiveness.

Identification of the Gradient Drift Instability in the Subauroral Polarization Stream
Vishvesha Sridhar, Blacksburg High School

The ionosphere is a region of Earth's atmosphere composed of plasma through which radio waves propagate. Radio wave propagation is dependent on the density of electrons, which in turn is affected by instabilities that can occur within the plasma. In the ionosphere, a phenomenon known as the subauroral polarization stream (SAPS) occurs. This paper studies whether or not a specific type of instability, the gradient drift instability (GDI), can occur in the SAPS. This analysis is carried out using a simulation modeling electron and ion temperatures, electron density, and electric potential. Simulations are run at 9 different Fourier modes, and at each mode the growth rate of the instability present is calculated. This data is then compared with the expected growth rate for the GDI at each mode. The results of this analysis suggest that the gradient drift instability is not relevant in the SAPS. This information can be used to improve radio communication techniques and better understand the mechanisms of the SAPS.

The Effect of Ski Wax on The Sliding Speed of a Ski
Will Hahn, Sabot At Stony Point

Skiers use ski wax to improve their racing speeds, but does the ski wax actually improve the sliding speed of a ski? The experiment was conducted to determine if ski wax makes skis slide faster. The experiment tested 3 different types of wax; regular Hertel Racing Wax, Biodegradable Swix Wax, and Zumi rub on max with a control of no wax. The hypothesis, if ski wax is applied to a ski then the ski will slide faster than with no wax, was supported. The Hertel racing wax with a mean of 7.03 seconds, the Swix Biodegradable Wax with a mean of 6.82 seconds, the Zumi Rub on ski wax with a mean of 6.69 seconds, and the control with the mean of 8.01 seconds. Each ski wax shows a faster time and the difference appears to be statistically significant.

The Effect of Upper Shoe Material on Ankle Support
Owen Parker, Sabot at Stony Point

This experiment investigated how different upper shoe materials affect the force at which an ankle rolls. Understanding this could help people find shoes that would best protect their ankle. This experiment was conducted using a model leg and three different shoes and measured the force, in Newtons, that it took to roll the ankle with each shoe. The results of 20 trials show that the average force in Newtons required to roll the ankle for each shoe ranged from 38.4 to 39.7, suggesting that there is not a significant difference between the shoes. There was no significant variability in the data suggesting that the conclusions can be trusted.

The Effect of Types of Soundproofing Materials on Sound Absorption
Oliver Frankel, Sabot at Stony Point

Sound is present everywhere, but very abundant in crowded areas such as restaurants. That is why some restaurants have baffles or panels around the edges or roof. These are forms of soundproofing, meant to absorb sound and sound reverberation to make a quieter environment. This experiment was conducted to test different types of sound-absorbing materials and determine which type is most effective. The experiment was conducted with a wooden box and two types of sound absorbing materials. The experiment was conducted with two Vernier sound sensors, which measured decibel levels of a sound consisting of a low, medium, and high frequency. The materials were fiberglass and acoustic foam, and results were consistent and evident that fiberglass was more effective than acoustic foam as a sound absorbing material. The cellular material showed an average 14.487dB absorbed and fiberglass showed 20.955dB absorbed on average. Variability of the trials showed no overlap between levels of the independent variable. This shows an evident and clear conclusion that fiberglass is more effective.

The Effect of Wood Type on the Rigidity of Laminates
Tom Meyers, Sabot at Stonypoint

Determining the best wood for an individual longboard is a problem when designing a specialized board for optimal performance. This experiment is designed to determine which of three wood varieties, considered optimal for longboard construction, is the most flexible. In this experiment, samples of equal thickness of the three wood veneers were each tested and the relationship of force to displacement was measured. The results of the experiment showed that, for the same force applied, maple exhibits the least displacement, then bamboo and then birch exhibits the most displacement. In terms of density, maple is the densest, followed by birch and then bamboo. This experiment demonstrates that there is not as much correlation between density and displacement as was hypothesized.

The Effect of Different Sunglass Lenses on the Transmission of Ultraviolet Light
Grace Marcus, Sabot at Stonypoint

UVA and UVB light damage your eyes every day. The damage can break up the proteins in your eyes causing defective vision. UVA and UVB light is transmitted from the sun, entering the retina along with the light to be processed as colors, pictures, and words. Over time, too much exposure to UVA and UVB light can impair vision. People use sunglasses to protect their eyes, keeping them healthy for longer. The sunglasses act as a kind of shield to your eyes from UV light. There are many types of sunglasses in the industry, all with different kinds of protection abilities and shades. They can have a variety of lenses and coatings for the lens. This study was performed to find which of a collection of sunglasses had the best protection abilities to shield your eyes from harmful UVA and UVB light. Four kinds of specific sunglass categories were chosen for this experiment. Two sunglasses were purchased for each category of sunglasses, ensuring variability between all of the types. The categories of sunglasses chosen were: Anti-Reflective, Gradient, Multi-Focal, and Mirror-Coated. The control for this experiment was no protection. This experiment was performed with a UV flashlight to mirror the sun's UVA and UVB rays of light. Both UVA and UVB Vernier sensors

The Effect of Different Metals on the Strength of Radio Transmission Signal
Nolan Hoover, Sabot at Stony Point

Some thieves can use a signal amplifier to steal radio signals from a wireless car key (key fob) and open a car door. This is called a Signal Amplification Relay Attack. Finding the best way to block the key fob from transmitting a signal to the amplifier is the reason for this experiment. The signal that is emitted from the key fob is a radio wave signal. This experiment was performed to test how metal density affected radio wave transmissions (from the key fob to the car) The hypothesis was that the more density the material blocking the signal had, the shorter the radio signal would travel. The experiment was conducted using a key fob, special lead lined pouch, and three kinds of metal to cover the opening of the pouch were tested. The distances from the car when the key fob could no longer interact with the vehicle were measured. The averages were as follows, Aluminum 10.8, Steel 10.1, Copper 9.5 and Control 15.2. The data was measured in meters. The data showed the greater the density of the metal being tested, the shorter the distance the signal traveled. In conclusion, human error and testing error is possible but unlikely, and the evidence suggests that higher density metals are better for blocking radio transmissions.

The Effect of Arlington Lights on the Visibility of the Night Sky
Maya Kaminski, Kenmore Middle School

The purpose of this experiment is to determine the amount of light pollution in Arlington and its effect on the ability to see the night sky. This experiment is important because light pollution is harming animals and the ecosystem, wasting energy, and affecting the ability to research and view the night sky. The hypothesis of this experiment is the brighter the lights are in the location where the experiment is being done, then the fewer stars will be visible. The procedure for this experiment entailed going to six different locations in Arlington: an Arlington driveway, an Arlington street corner, the Ridgeview Street cul de sac, Oak Grove Park, the Koons Toyota Dealership (Lee Highway), and the David M. Brown planetarium. This experiment was done each night for sixteen nights, between eight and ten p.m.. At each location, the constellation Perseus was found in the sky and compared to star charts, ranked zero to eight (zero, meaning no stars seen in the sky to eight, meaning the whole sky filled with stars). These star charts were provided by Globe at Night, a citizen science program used for this project. Additionally, a light meter was used in each location to see how much lux (the measurement of light) was in the area. The experimental results supported the hypothesis, showing that the brightest location, 352.9 lux, was an average of zero on the star charts, with no stars seen, while the location with the least amount of light, 0.0 lux, was an average of two-point-one on the star charts, having an average amount of stars seen. This science project contributes to astronomy in Arlington, Virginia because it was found that the different types of lights in Arlington are affecting the amount of light pollution that is emitted into the community's atmosphere. If all of the lights in Arlington were changed to LED lights, then the atmosphere could have significantly less light pollution in it. Additionally, all of the star chart numbers viewed in different locations on different nights were submitted to Globe at Night, helping others see how much light pollution is in Arlington.

The Effect of the Temperature of Water on Time for UV-Sensitive Beads to Change Color in Sunlight

Qingyuan (Eric) Hu, George H. Moody Middle School

Ultraviolet Radiation (UV Radiation) is a type of electromagnetic radiation, like visible light, but with more energy. On Earth, UV radiation usually comes from the sun, but can also be generated from man-made objects like tanning beds and welding torches. A way to prevent UV radiation from reaching an object is to use sunscreen. Sunscreen can not only prevent sunburns, but also decrease the risk of skin cancer. The goal of the experiment is to find out if water can be used as a substitute for sunscreen, and if so, at what temperature. A tool that can be used to measure UV radiation are UV-sensitive beads, which changes color as they are exposed to UV radiation. The hypothesis for this experiment was that if the temperature of the water that the UV-sensitive beads were in was increased, then the UV beads will change color faster. The experimenter took UV-sensitive beads and put 15 of them in a cup filled with water. There were 5 different temperatures of water tested, 0°C, 10°C, 20°C, 30°C, and 40°C, with each one being tested 20 times. The experimenter then brought the cups outside, and timed and recorded the time it took for the UV-sensitive beads to change color in each temperature of water. The results of the experiment showed that as the temperature of the water increased, the time it took for the UV-beads to change color decreased. The average times for the UV-beads to change color in 0°C, 10°C, 20°C, 30°C, and 40°C water were 23.89 seconds, 20.37 seconds, 19.16 seconds, 17.77 seconds, and 17.41 seconds, respectively. From these results, scientific principles, and other researches, the experimenter can conclude that out of the temperatures from 0°C to 40°C, 0°C is the best temperature to use water as a substitute for sunscreen, since it shielded UV-sensitive beads from UV-radiation the best.

Beat the Heat
Leo Fall, Swanson Middle School

As fossil fuels are becoming more costly and rare, renewable resources are replacing them for the better. One of these renewable resources is solar panels, harnessed by light from the sun to produce energy. Most people do not understand that heat has a diminishing effect on the solar panel and there is a wide array of optimal solar panel cooling methods to use. This experiment investigated the effect of different cooling methods on improving the efficiency of a heated solar panel by measuring the change in surface temperature and voltage output after three minutes of heating. It was hypothesized that of the three cooling methods used, water, air and gel, the water-cooling condition would have the best effect on the efficiency of the solar panel throughout the three minutes of heating. After the data was collected it was concluded that the water-cooling condition was the most effective at cooling the solar panel with an average decrease of only 0.18v (Volts) and an increase of only 45 degrees Celsius over the 3 minutes of heating. Following the water condition, the Air-Cooling method had an average decrease of 0.22v and an increase of 57 C per minute, while Gel cooling, the least consistent cooling device, had an average decrease in 0.38v and an increase of 67 C. The control condition was largely exceeded by each cooling device, demonstrating that they were all effective, with an average decrease of 0.65v and an increase of 72 C. The data supports the hypothesis that water cooling was the most effective cooling device and can be implemented in industrial use as well as with home solar panels with the right technology.

The Effect of Light Bulbs and Fabric on Heating and Dissipation
Ananya Sinha and Zoe Salen, Swanson Middle School

Heating and cooling systems are part of everyday life for many people, and use up a significant amount of energy. This experiment was designed to discover ways to decrease energy use in everyday life, specifically for heating and cooling. The first component of the experiment was testing the effect of type of fabric on how much heat it dissipates. This project would help people determine the most suitable clothing for specific climates, and will find the most efficient insulator. The second component of this project was testing the effect of different types of lightbulbs on how much it heats a cloth. This would help builders put the most effective lightbulbs in certain parts of buildings to lessen heat production. Insulating material and specific light bulbs could be used to optimize the time heating and cooling systems are used. The set-up was similar for each component of the experiment. Twelve grams of linen, wool, cotton, and polyester were cut. The fabrics were heated under a halogen light bulb for ten minutes. The temperature was measured twice, once after ten minutes, and again after five minutes of cooling. In the second part of the experiment, the type of lightbulb was changed. Linen cloth was heated by halogen, LED, compact fluorescent, and incandescent light bulbs for ten minutes. The temperature of the fabric was measured before, immediately after ten minutes of heating and five minutes after heating. After the experiment was conducted, it was found that linen dissipated the least heat of the fabrics that were tested, with an average of 2.31° Celsius lost. In the second part, it was found that halogen bulbs of the bulbs tested heated the linen cloth the most, with an average of 6.09° Celsius increase in temperature. The results of this project can be used to help reduce energy use in the future and shows that small steps can make a large difference.

The Science of a Medieval Siege Engine
Lucy Turner Watts and Solomon Galpern, Swanson Middle School

Although medieval siege may not seem very relevant in today's world, counterweights, which are essential to trebuchets, are also helpful in modern engineering, such as in elevators. The technology used in trebuchets can also be used to launch planes off of aircraft carriers. The experiment tested the effect of the mass of the counterweights on the distance the projectile travels. The experiment also tested the effect of the type of projectile on the distance the projectile travels. To test these things, a trebuchet was built to launch for the experiment. After the building was completed, the trebuchet was taken to an empty field where it was set up with a tarp staked under it to make sure launches were smooth. Next, counterweights with masses of 24, 50, and 74 kilograms were loaded onto the throwing arm and locked it in place. Then the sling was loaded and launching began. The data supported the hypotheses. It was hypothesized that the projectile would travel furthest when launched with 75 kg, the highest counterweight mass. The average distance with those counterweights was 18.02 meters, the greatest average distance of any independent variable level. This fact supported the hypothesis. It was also hypothesized that of the different shapes that were launched, the basketball would launch the furthest. This was supported when the average distance the basketball traveled was 17.21 meters, the farthest of the three levels. This knowledge could help to estimate the counterweight mass needed to move items in a system. It could also help to predict how far certain objects would fly, given their shape and weight.

The Effect of the HB Scale on the Electrical Resistance of Mechanical Pencil Lead
Akira Lux, Swanson Middle School

The purpose of this experiment addresses the electrical resistivity of mechanical pencil lead: the effect of the HB scale on the pencil lead's electrical resistance in a circuit. The experiment was intended to investigate the properties of a certain material and how those properties can be applied to an electrical circuit. It was hypothesized that if five different degrees of mechanical pencil lead are tested as resistors (4B, 2B, HB, 2H, and 4H) in a circuit, then the 4B pencil lead would produce the least electrical resistance because it was the IV level inferred to consist of the most graphite and the least polymer compounds. To test this hypothesis, individual sticks of mechanical pencil lead were attached to a multimeter that measures electrical resistance. After ten trials per level, the 4B lead had the highest average resistance (2.82 ohms), while the 4H lead had the lowest average resistance (0.64 ohms). The results refuted the hypothesis of the experiment, but further background research showed that the electrical resistance of a conductor also depends on how tightly bound a material's particles are; this justifies why 4H lead's tightly bound particles allowed it to have minimal electrical resistance. This experiment contributes to the field of physical science and astronomy because its results indicate that particle density is an important property to consider before fully applying a certain material as an electrical conductor or resistor.

The Effect of Different Electromagnetic Bands on Chlorophyll Levels in Plants
Apoorva Saurav, George H. Moody Middle School

The purpose of this experiment was to determine the effect of different electromagnetic spectrum of chlorophyll levels in plants. The sun radiates these different spectra through sunlight, and plants absorb them with the chloroplasts used for photosynthesis (California Institute of Technology, 2019). While most of these wavelengths are filtered by the atmosphere, three that remain are ultraviolet, the visible spectrum, and infrared (Windows to the Universe, 2010). The health of a plant could be affected by the type of electromagnetic energy because chloroplasts absorb the red-orange and blue-violet sections of the spectrum. Infrared and ultraviolet are the extensions of those sections (Robertson, 2007). First, six trays with equal amounts of upland cress seeds were exposed to sunlight for two weeks. They were then placed in their respective cubicle for a month, and data was collected periodically. Different electromagnetic spectra common on earth such as infrared, ultraviolet, and red, blue, and green visible light were used as the levels of the independent variable. In addition to these, a full spectrum light bulb was used as a control. The spectra shown to maximize chlorophyll content was full-spectrum light, the control, possibly because it provided the plant with a variety of electromagnetic wavelengths. Other experiments have echoed this finding, but others have found blue to have higher chlorophyll levels.

PLANT SCIENCE & MICROBIOLOGY

Effect of Salinity on *Elodea canadensis* Growth
Samantha Lionberger, George H. Moody Middle School

Elodea canadensis is a freshwater plant that in the wild is a source of food and protection for animals. It also helps control water temperature and oxygen levels. Salinity is the amount of salt in the water and many plants and animals have a select range in which they can live. *Elodea canadensis* generally lives in waters with 0.0 % salinity. According to previous studies, when submerging *Elodea canadensis* in saltwater for a long period of time can harm or eventually kill it (Blackburn, 2000). Knowing *Elodea canadensis*' tolerance to salinity levels is important because if there was a saltwater leak, the saltwater could kill the plant. If the plant was killed, the ecosystem could suffer because of the loss of the species. It was hypothesized that if 500g of salt was added to the water, then the *Elodea canadensis* stalks would have the highest average height. First, four containers were purchased. Next, the containers were filled with sand that was the same thickness over the whole bottom. Then the bottles of water had the right amount of salt added to them. Next, the water was poured into the containers, close to the bottom of the container. After the water was poured in, fifteen *Elodea canadensis* stalks were placed into the sand at the bottom of the container. Next, the containers were labeled with a sharpie. The results showed that *Elodea canadensis* grew best in freshwater, with a mean of 11.5 cm and a standard deviation of 4.37. The container with 500g of salt had an average of 10.4 cm and a standard deviation of 0.72, while 1,000g had 9.9 cm and a standard deviation of 0.46. The container with 1,500g had the lowest average with 9.3 cm and a standard deviation of 0.35. Based on the data the experiment shows, the hypothesis was not supported. Instead, the water with no salt helps *Elodea canadensis* grow.

The Effect of Chemical Type on Seed Germination Rates
Caroline Fern, Kenmore Middle School

The purpose of this experiment was to see the effects that different chemicals have on the germination rates of pre-soaked radish seeds. "Food production will need to increase by at least 70 percent to meet the demands of this growing population by 2050..."(Kennedy, 2014) It is apparent that our society needs to find ways to meet the demands of the Earth's growing population, and this experiment highlighted one possible solution. This experiment suggested new ways to accelerate the growth of botanical life, which would ultimately result in a greater production of food in a shorter amount of time. The hypothesis of this project was, if radish seeds are pre-soaked in various chemicals, the seeds exposed to 3% hydrogen peroxide would demonstrate the highest germination rate. For the procedure, the researcher conducted three trials, each lasting 20 days, consisting of six seeds pre-soaked for four hours in a variety of chemicals and then were left to germinate. The four chemicals used in this experiment were 3% hydrogen peroxide, dilute isopropyl alcohol solution, dilute hydrochloric acid solution, and lemon juice. The results were not consistent with the hypothesis and showed the control (non-pre-soaked seeds) yielded a germination rate of 94.4%, while the 3% hydrogen peroxide yielded a rate of 88.8%. The results of this project can contribute to the future planning of local farmers and scientists who previously speculated that 3% hydrogen peroxide increased normal germination rates. The National Center for Biotechnology Information ("NCBI") states that hydrogen peroxide does accelerate growth rates, which was not consistent with this experiment.

The Effect of Eco-Friendly Multi-Purpose Cleaners on the Height of a White Dutch Clover
Moya Zouhon, Thomas Jefferson Middle School

The purpose of this study was to test the effect of eco-friendly multi-purpose cleaners on the height of a white Dutch clover. The independent variable was the brand of eco-friendly multi-purpose cleaner. The experimental group included: Seventh Generation Disinfecting Multi-Surface Cleaner, Method All Purpose Cleaner (Lavender), and Mrs. Meyers Lavender Multi-Surface Everyday Cleaner. The control group was no cleaner at all. The dependent variable was the height of the white Dutch clover plants. The constants were the amount of cleaner given to the plants, the number of seeds planted, the amount of water given to the plants, and the rate of watering. The hypothesis was: If White Dutch clover plants were watered with Mrs. Meyers Lavender Multi-Surface Everyday Cleaner, then they would have the highest overall plant height. 20 cups were labeled, filled with soil and one seed and separated into four groups. Each group was watered with a different eco-friendly solution every day for three weeks. The height of each plant was recorded every day. The results showed that Seventh Generation produced the tallest plants, while the Mrs. Meyers plants had not grown at all by the end of the experiment. These results rejected the hypothesis. In conclusion, the study suggests that not all eco-friendly products are eco-friendly.

The Effect of Illumination on Disturbed Subterranean Seedlings
Brinda Iyer, George H. Moody Middle School

The purpose of this experiment was to see the effect of different illumination levels on disturbed subterranean seedlings. A major problem farmers face is unwanted weeds growing after plowing the fields. To solve this issue, an experiment was created to test different amounts of light on weed growth of Fescue grass. The hypothesis for the experiment was if seedlings are disturbed and exposed to twilight-like illumination, then the seeds will not germinate. The levels in the experiment were direct sunlight, overcast day illumination, near window light, and twilight-like illumination. To test the hypothesis, 10 cups containing seedlings were placed under the illumination of each level of IV. They were then disturbed each day for 14 days continuously until they had germinated. After testing, it was found that underneath the twilight-like light, the seedlings did not germinate. The seedlings for all three other levels germinated within the 14 week time frame. A trend was drawn showing under the illumination circumstances of over 100 lux, grass seedlings have the ability to germinate. These results supported the hypothesis. A chi-square test was conducted to see how accurate the results were. The chi-square value for the data was 10.0. Assuming an alpha of 0.05, this means that the difference in illumination was significant. It was concluded that the best time of day for farmers to plow their farms was at twilight or any time after, before dawn. This made sense through statistical research, which demonstrated that the amount of light at which plants do not germinate is the range of 10-1 to 10^3 W/m^2 .

The Effect of Amount of Time Exposed to Elevated CO₂ on Bush Beans
Scarlett Yareli Carrasco, Thomas Jefferson Middle School

The purpose of this study was to determine if different amounts of time exposed to carbon dioxide affected the height, number of leaves and the color of the bush bean stem. The independent variable was the amount of time plants were exposed to a given carbon dioxide level. The experimental group included: four hours exposed, eight hours exposed and 16 hours exposed to elevated carbon dioxide. The control group had no exposure to elevated carbon dioxide. The dependent variables were the height, number of leaves and the color of the bush bean stem. The constants were the given level of carbon dioxide, type of soil, the variety of bush beans, pH of the soil, amount of light, and the amount of water. The hypothesis was: If bush beans were grown under different times exposed to elevated carbon dioxide, then the bush bean plants exposed longest to elevated carbon dioxide will be the shortest, have fewer leaves, and will have an unhealthy color of the stem. Every day, over the course of 16 days, seeds of the Container French Mascotte Bush Bean plant (*Phaseolus vulgaris*) were exposed to elevated carbon dioxide. The amount of time exposed to elevated carbon dioxide was measured depending on the group (four hours, eight hours, 16 hours, zero hours). This is with the exception of the control group which was never exposed to elevated carbon dioxide. The results showed that four hours and 16 hours exposed to elevated CO₂ grew the highest, 16 hours exposed to elevated CO₂ had the second most leaves, and had a healthy stem color. Therefore, the results did not support the hypothesis. In conclusion, the study suggests that the exposure to elevated carbon dioxide helped quicken the process of photosynthesis in the bush bean plants.

The Effect of Organic vs. Synthetic Fertilizer on the Growth of a Mustard Plant
Swati Gupta, Thomas Jefferson Middle School

The purpose of this study was to find out which type of fertilizer (organic or synthetic) best increases the growth of a mustard plant. The independent variable was the type of fertilizer. The experimental group included: one organic fertilizer (Jobe's Organics) and one synthetic fertilizer (Urea). The control group was plants with no fertilizer. The dependent variable was the height and number of leaves of the plant for 15 days. The constants were the amount of fertilizer spread around each plant, how often the fertilizer was applied, the amount of water given to each plant, how often the plant was watered, the amount of sunlight received, type of soil, and the number of days grown. The hypothesis was: If the plant receives synthetic fertilizer, then the plant will increase the most in height and number of leaves. Fifteen pots were set on top of the tablecloth while distributing soil and seeds. While the seeds germinated, each pot received 45 mL of water every other day. When the seeds germinated, the pot labeled "Organic Fertilizer" received 1 gram of organic fertilizer, the pots labeled "Synthetic Fertilizer" received 1 gram of synthetic fertilizer, and pots labeled "No Fertilizer" received no fertilizer for 14 days. The results showed that organic fertilizer produces the most growth of a mustard plant. The hypothesis was not supported. In conclusion, the study suggests that organic fertilizer works best in terms of stopping soil erosion and nurturing plants.

The Effect of Species of Household Aquacultural Fish on Hydroponic Plants in an Aquaponic System

Natalie Wooden, George H. Moody Middle School

Aquaponics is the combination of Aquaculture, the process of fish farming, and Hydroponics, the process of farming plants without soil. Aquaponics uses a mutualistic symbiotic relationship between Aquacultural fish and Hydroponic plants to obtain the optimum growth of both species. The experiment was created to help Aquaponic farmers obtain optimal growth in their small scale Aquaponic systems. It was hypothesized that if the Household Aquaculture species of *Otocinclus* is used then the basil's height will increase the most. To test this hypothesis, three species of household Aquaponic fish were used; Neon Tetra, Fancy Guppy, and *Otocinclus*, and control of no fish within four separate Aquaponic systems, and the growth of the twelve basil plants in each system, forty-eight in total, was measured. For a span of forty-five days, the fish were fed every twelve hours, and the height of the basil plants was recorded every twenty-four hours. After forty-five days, all the basil plants were still growing, however, the basil plants exposed to the excretions of the *Otocinclus* species increased the most in height. The experiment supported the hypothesis of the experimenter as the basil plants in the Aquaponic system with the Aquacultural species of *Otocinclus* had the highest growth rate.

The Effect of Increased Heat on the Growth of Coffee Plants
Nominjin Nancy Shinekhuu, Thomas Jefferson Middle School

The purpose of this study was to find the effect of increased heat on the growth of coffee plants. The independent variable was colder temperatures than what the coffee plant is used to (outside) and warmer than usual (next to a heater). The experimental group included: the coffee plants inside at room temperature and next to a heater. The control group was the coffee plant placed outside (room temperature). The dependent variable was the height of the coffee plant. The constant was the type of plant. The hypothesis was: If a coffee plant was placed near a heater to simulate a hotter environment, then the plant's height growth would decline by a significant amount. The experiment was done by watering each coffee plant placed in different conditions 78.8 ml of distilled water each week using a liquid measuring cup and placing them in different locations appropriate for the light the plants needed. Each location had different temperatures to test how the plants would respond (one location was outside, another was inside, the last place was near an air heater). After a week was over, the researcher recorded the data to see if its height had changed in any way. The results showed that coffee plants are negatively affected by heat. These results support the hypothesis. In conclusion, the study suggests that increased heat will affect coffee plants health and growth negatively.

The Effect of Natural Antibiotics on the Development of *E. coli* k12 Colonies
Aryan Mhaskar, George H. Moody Middle School

Common household remedies that are used globally to treat infections and illnesses include honey, ginger, and turmeric mixed with milk. However, the effectiveness of these remedies remains questionable. The purpose of the experiment was to test the effect of these natural antibiotics on the development of *E. coli* k12 colonies. By doing so, the value of taking these remedies could be found, and the remedy that works the best could be found. *E. coli* k12 was used since it is a safe strain of *E. coli* used for experimentation in schools and home experiments. It was hypothesized that if honey was used, then the fewest number of *E. coli* colonies would develop. The hypothesis was tested by swabbing 40 agar plates with the *E. coli* k12 strain, and then administering ginger juice to ten agar plates, honey to ten agar plates, and then turmeric mixed with milk to ten plates. After 12 hours, the number of *E. coli* colonies that developed were counted, honey had the fewest average *E. coli* colonies develop (0.5 *E. coli* colonies), ginger juice had the second fewest average (5.3 *E. coli* colonies), and turmeric had the highest average (42.3 *E. coli* colonies). Honey's antibacterial effectiveness is due to three main reasons, honey absorbs any spare moisture, which bacteria, like *E. coli*, need to survive, honey is acidic enough to prevent bacteria from multiplying, (pH between 3-4), and enzymes in honey produce hydrogen peroxide, an antimicrobial substance. The increase in *E. coli* colony development caused by turmeric mixed with milk is likely due to the milk component of the mixture. Milk contains important nutritional components for bacterial development, which is why *E. coli* colony development was greater when turmeric mixed with milk was administered in comparison with the control.

The Effect of Type of Soil on Helianthus Growth
Nicole Talledo, Thomas Jefferson Middle School

The purpose of this study was to test different types of soil on helianthus growth. The independent variable was the type of soil. The experimental group included: Silty soil, Sandy soil, and Saline soil. The control group was Loam soil. The dependent variable was the Helianthus (Sunflower) growth measured in centimeters. The constants were the amount of water that was applied, the room temperature, time of growth, and the type of plant. The hypothesis was: If Helianthus growth is tested based on different types of soil, then the Helianthus flower will grow taller with Saline soil. I labeled all of my four pots with the correct soil name and the correct soil. I watered my plants with about 1 L of water in each pot and measured the growth of Helianthus Plant in centimeters over a period of five days. The results showed that the Helianthus Plant grew tallest with Sandy soil. Those results rejected the hypothesis. In conclusion, the study suggested that Sandy soil was the best when wanting to grow different types of plants, especially sunflowers.

The Effect of how many Electrons are Extracted from Different Natural Resources Using a
Microbial Fuel Cell

Aarushi Rao, George H. Moody Middle School

In the past 10–15 years, microbial fuel cell (MFC) technology has captured the attention of the scientific community for the possibility of transforming organic waste directly into electricity through microbial catalyzed anodic, and cathodic electrochemical reactions. Reliable energy access empowers considerable socio-economic benefits. Such as enabling shops/businesses to stay open longer, giving communities access to better healthcare, and providing children with domestic lighting for after-school study time. This being said, soil is a natural resource found anywhere in the world which contains exoelectrogenic bacteria. This type of bacteria contains enough electrons to produce electricity. If electrons are extracted from 4 different natural resources using a microbial fuel cell, then the most electrons would be extracted from clay because it has the most electrical conductivity and pH levels. Four microbial fuel cells will be built with one salt bridge connecting every two chambers (8 chambers total). One chamber will have water inside at all times and the other will have the natural resource designated to that MFC. Sixteen ounces of Benthic mud, Loam, Sand, and Clay will be extracted from their appropriate places using a hand spade and will be placed in the MFCs. The maximum generated current in the stack of cells was 201 mV which peaked at 250 mV. The average electricity measured from all the 4 natural resources was 144.65 mV. The Benthic Mud produced the most electricity at an average of 196.7 mV which occasionally peaked at 217mV. By extracting bioenergy from environments, the MFC technology exhibits a promising potential of powering sensors in remote locations where it is difficult to replace batteries.

The Effect of Type (NSAIDs and Acetaminophen) and Concentration (mg) of Prescription Medication on the Germination Rate and Height of *Raphanus sativus*
Arjun Majety, George H. Moody Middle School

The mass production of pharmaceuticals and its improper disposal has led to several environmental problems, such as traces prescription medication found in agricultural soil, waterways, etc. Not only does this disrupt the ecosystem, but it poses several problems to the plant and animal life. The purpose of this experiment was to see the effects of two commonly used pain medication: Acetaminophen and Ibuprofen on the germination rate and height of *Raphanus sativus*. It was hypothesized that as the concentrations of the drug increased, the germination rate and height of the plants decreased. In order to perform the experiment, the corresponding amounts of Acetaminophen (Tylenol) and Ibuprofen were crushed to a fine powder and incorporated into the soil with growing radish seeds. Overall, the results indicated that Acetaminophen (800 mg) and Ibuprofen (800 mg) induced a 0% germination rate and 0 cm mean growth. It was concluded that the toxic chemicals in the prescription medications were absorbed into the soil and altered its chemical properties, making the soil no longer conducive for plant growth. The results from this experiment accompanied by scientific studies, on medication, reinforce its negative, yet relevant, and rapidly growing impact on the environment.

Measuring Bacterial Growth in Water Bottles Over Time
Layla Moussavi, Louise A. Benton Middle School

Reusable water bottles are utilized all around the world to help people stay hydrated as well as to protect the environment from pollution. An unknown fact to many is that if a reusable water bottle is left to sit out, it can accumulate potentially hazardous bacterial growth. This experiment was conducted to determine which type of water bottle is best at resisting bacterial growth over a period of 48 hours. The hypothesis was that if a stainless steel bottle was exposed to a k-12 strain of *Escherichia coli* (*E. coli*), then it would grow the least number of bacterial colonies at the end of 48 hours. The stainless steel bottles were compared to both disposable Polyethylene Terephthalate (PET) plastic bottles and reusable Polyethylene Terephthalate (PET) plastic bottles. To begin the experiment, all three (3) types of water bottles were collected. *E. coli* was then added to all bottles (excluding the control group), along with tap water. The water from the bottles was swabbed onto agar plates at 24-hour increments, and the bacterial colonies were measured at 0, 24, and 48 hours. The results showed that at the end of the 48 hours, the disposable PET plastic bottles grew the most bacterial colonies, averaging seven (7) colonies. The control group grew the least, as expected, with 0 colonies. Both the stainless steel and reusable PET plastic bottles grew an average of 3.33 colonies, so the hypothesis was partially supported. Trial #3 (48 hours) for stainless steel bottles held an outlier, which might have made the data for that trial slightly inaccurate. In the future, it would be helpful to conduct more trials, to achieve maximum accuracy for each type of bottle. This experiment could be very helpful, due to the fact that many people leave their reusable bottles sitting for long periods of time, and then consume the potentially contaminated water. This study teaches that it is best to throw out a disposable plastic bottle after one use, and to wash stainless steel and reusable PET bottles after each use to stay healthy and safe.

Effect of Time on the pH of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* in Yogurt Preparation

Arjun Modi, George H. Moody Middle School

Yogurt is a fermented food item which can be made from the milk of cows, sheep, goat, and water buffalo depending on where in the world the consumer is from. Once being called the sacred food of the gods in India, yogurt has proven to be a highly beneficial product helping to cure insomnia, liver disease, and the common cold as a medicine. Many factors such as temperature, the amount of time it is left to sit while forming, and even the source and type of milk can determine how it turns out. The purpose of this experiment was to examine the effect of time on the pH of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* in yogurt preparation. When left at room temperature (21° C), there are certain periods one should leave the yogurt resting for the healthiest results. It was hypothesized that "If the yogurt has been put out for a longer duration of time, then it has a higher, acidic ph." After boiling 600 mL of milk, the whole milk is put into ten small containers with 30mL of yogurt culture in it. Each of the samples was at the same temperature and were tested with a pH meter at each of the eight-time periods (0, 2, 4, 6, 8, 10, 12, and 14 hours.) The results from this experiment indicated that the hypothesis was supported by showing the longer the yogurt was kept the higher of an acidity it would have as shown through the data. At two hours, the mean value was 5.29, at 8 hours, the mean value of the was 5.01, and at 14 hours it had a mean value of 4.52. Based on the pH values determined in this research, there appears to be a direct correlation between the acidity of the yogurt and the duration it is kept out. With the appropriate pH of yogurt being between 4.0 – 4.6, the best results of the yogurt were found at 12 – 14 hours. If the yogurt was kept for a much longer duration, consumption of the product would be detrimental to health because of its highly acidic properties. However, for the most accurate results in this experiment, this experiment should be conducted again.

The Effect of the Number of Earthworms on Plant Growth
Judy Ma, Moody Middle School

Some research has indicated that earthworms have significant benefits to plant growth, which may improve agriculture. Due to the burrowing and tunneling of earthworms, they create pore-like air sockets in the soil, aerating it. They also provide nutrients for the soil by their castings and bodies which decompose in the soil. However, other research, while sparse, has shown the possibility of earthworms as invasive predator species. The purpose of this experiment was to determine the effect of the number of earthworms on plant growth with no earthworms (Group A), one earthworm (Group B), and two earthworms (Group C). The hypothesis for this project was if plants received one worm, then they had the most plant growth. In each independent variable group, plants were first measured for their original height. Worms were then placed into each plant, according to each group in which the plant belonged to. After one week, the plant height was measured again. The original plant height was subtracted from the final plant height, which was the plant growth. Each plant should have received the same amount of light, water, and pot. The results indicated that an increase in worms showed an increase in plant growth. The mean of Group A (.59 cm) showed the least amount of plant growth, while Group C (1.82 cm) showed the most amount of plant growth. The data did not support the hypothesis. However, there were potential errors in seed placement, water, light, and soil.

Deice: Not So Nice.

Ella Cohen, Dorothy Hamm Middle School

The purpose of the experiment was to find out the effects of different types of roadside deicers on vegetation that may be found close to roads. This is in order to find the least harmful deicer for likely affected common plants. Chosen deicing chemicals put on roads were tested, including one natural alternative and one claiming to be eco-friendly. The main environmental concern comes from the NaCl, commonly known as table salt, which is adapted for use on roads. In osmosis, water moves to the solution with the highest concentration of dissolved chemicals. Therefore, NaCl outside the plant attracts water to it creating an effect known as physiological drought. Accordingly, it was hypothesized that plants coming in contact with beet juice deicer containing a minimal percentage of NaCl and an environmental claim would be affected the least, growing the highest mean. To find out the answer, radishes were watered with a mixture of the deicer and water, differentiating by experimental group type of deicer. In the end, the hypothesis was disproved, though the null hypothesis was proven. Even the small amount of salt in the beet juice 'eco-friendly' deicer killed the plants as did all experimental groups containing any degree of NaCl. In the end, the sand alternative lacking the NaCl component, showed the healthiest growth among independent variable levels. The anti-icing agents in this experiment were not tested for ice melting efficiency, however, and sources suggest the alternative should be combined with NaCl for maximum effectiveness.

The Effect of Different Cost-Effective Water Decontamination Methods on the Number of Bacterial Colonies Cultivated from the Water
Aashka Shah, George H. Moody Middle School

Clean drinking water is important to prevent water-borne diseases. In many third world countries the citizens do not have access to clean drinking water, so they must use cost-effective water decontamination methods. The purpose of this experiment was to determine the most effective cost-effective water decontamination method. The methods tested were boiling, using a UV lamp, and using a homemade water filter, and they were compared to the control, no method. The research hypothesis was if the cost-effective water decontamination method used was boiling, then the least number of bacterial colonies would have been cultivated in the agar plates. In order to test this, 40 cups of water were collected. There were ten repeated trials for each independent variable, so one cup of water was used for each trial. For no method, ten water samples were collected and tested. For boiling, the water was boiled for five minutes, and for using a UV light, the water was placed under a UV lamp for 12 hours. Water went through a homemade filter made with sand, rocks, and a cotton cloth for the final independent variable. After decontaminating the water, 25 microliters of each sample were spread onto an agar plate, and the number of bacterial colonies cultivated from each sample after 48 hours was counted. The means were 140.6 colonies for no method, 0.2 for boiling, 1 for the sunlight method, and 165.9 for using a homemade water filter. The ANOVA and post-hoc Tukey test found a significant difference between both the sunlight and boiling method when they were compared to the control and a significant difference when they were both compared to using a homemade water filter. No significant difference was found when boiling and the sunlight method were compared to each other and when using a homemade water filter and no method were compared. In conclusion, the hypothesis was partially supported because the mean for boiling was the least, but the difference between boiling and the sunlight method was not significant. Boiling and the sunlight method were very effective at decontaminating the water, while the control and homemade water filter were very ineffective.

The Effect of Disinfectant Processes on the Number of Bacterial Colony Forming Units in a Kitchen Sponge

Liah Chung, George H. Moody Middle School

Although the purpose of sponges is to clean dirty items, most sponges are not properly disinfected and grow an abundance of bacteria as time progresses. Sponges are made to have a high liquid absorption level and retain moisture well which makes an excellent feeding ground for bacteria. Bacteria is spread from sponges to other surfaces as it 'cleans' them. Disinfectants are meant to rid contaminated surfaces of bacteria, viruses, and mildew. The purpose of this experiment is to find the best disinfectant for a kitchen sponge. If a sponge is put through different processes of disinfection, heating in a microwave, soaking in bleach, and soaking in vinegar, then the microwave treated sponge will have the least bacterial growth. Used Scotch Brite sponges were cut into equal fourths and then disinfected by submerging in either a vinegar or bleach solution for 5 minutes or microwaving for one minute. Samples were collected from each sponge as well as the control sponge with a sterile swab and then rolled in a five streak zigzag pattern across agar plates. The control sponge grew a mean 1327.3 CFU, the vinegar treated sponge grew a mean 341 CFU, the bleach treated sponge grew a mean 6.5 CFU and the microwave treated sponge grew a mean of 3.7 CFU. The p-value comparing microwave treated sponge vs bleach treated sponge was 0.4417. Bleach, vinegar and microwave were all effective at disinfecting a household sponge, but bleach and microwave were more effective than vinegar.

The Effect of the Acidic or Basic Substance Added to the Soil on the Height of Pea Plants
Emma Hemsch, Dorothy Hamm Middle School

The purpose of this experiment was to determine the effects of an acidic or basic substance added to the soil on the growth of pea plants. In theory, pea plants must have a soil pH in a range from 5.8 to 7.0 in order to grow. In this experiment, it was hypothesized that the farther away from neutral the soil pH was, the less the plant would grow. This was because of the symbiotic bacteria Rhizobia. Pea plants need these bacteria to grow on their roots to provide ammonia for the plant. Rhizobia cannot thrive in highly acidic or basic soils, so to test the hypothesis, nine pea seeds were planted in separate peat pots. Vinegar was added to the soil of three pots, and baking soda was added to the soil of three other pots. Three pots remained as the control without an acid or base added. All of the pea plants were then watered regularly. The pH of the soil was taken ten minutes after the substances had been added. The pots with vinegar had a soil pH of approximately 5.5, while the pots with baking soda had a soil pH of approximately 9.0. The pots with only water added to them had a soil pH of approximately 6.0. The height of the plants was measured every seven days. After three weeks, the seeds with an acid or base added to them did not show any evidence of germination, while the seeds with only water added to them grew an average of 50.8 centimeters. This could indicate that pea plants must always have a soil pH in the optimal range for them to germinate.

The Effect of Chlorinated Water on Cut *Dianthus caryophyllus*
Cy Overstreet, Sabot at Stony Point

Many people enjoy the beauty of flowers, which is why there are many shops that sell them. In 2017 the floral industry produced 35.2 billion dollars worth of flowers. This makes the preservation of flowers very important. The purpose of this study was to test the effectiveness of “water additives on the longevity of cut *Dianthus Caryophyllus*. With the results of this experiment being useful towards the preservation and keeping of cut flowers. The experimental approach was to take cut *Dianthus Caryophyllus* and place them in 250 milliliter mason jars with different types of added possible longevity products, to see which flower group lasted the longest. The major results showed the flower group that lasted the longest were 0.05 ml of chlorine, followed up by 0.15 ml of chlorine, 0.10 ml of chlorine, water and flower packet water tied for the least. The conclusions from this data were that cut flowers with chlorine in their water lasted longer than any of the other flower groups. This was shown by all three flowers groups with chlorine having flowers that lasted the longest amount of days.

The Effect of Salinity on the Growth of Chlorophyta
Joseph Cohen, Sabot at Stony Point

This experiment was performed to determine if the growth of Chlorophyta will increase as climate change causes freshwater to become saltier. To determine what will happen, this experiment compared the growth of Chlorophyta in different salinities of water. Green algae mixture was put into each of thirty plastic water bottles at different levels of salinity. There were 10 trials. Change in turbidity was used to measure the growth of the algae and turbidity was measured after thirty days. The data showed that on average, algae in water with 0 parts per thousand (ppt) salinity changed by 4.15 Nephelometric Turbidity Units (NTU) and showed the most significant growth, followed by 15 ppt with 0.89 NTU and then 5 ppt with 0.66 NTU.

The Effect of Detergents on Mint Plant Growth
Abigail Hogan, Kenmore Middle School

For years people have been using chemical based detergents to wash things outside, and now the environment has begun to see the effects. Because these detergents have built up over time, it has become important to be more environmentally cautious and contain the runoff created from using them outside. In most cases, people use more detergent than necessary, so it interferes with plant growth. This experiment investigates whether different detergents have a positive or negative effect on local plants. To measure this, sixteen mint plants were planted in exactly the same way. For fourteen days, their growth was charted, and they were watered with a mixture of a specific detergent and water. Four plants were watered with Dawn dish soap, four with Tide laundry detergent, four with Adam's car shampoo, and four with just water, as the control. The hypothesis was the dish soap would have the most negative effect on the plants because it is made to be harsh and scrape dirt and oils off of dishes, which means it also has a high pH level. The results did not support the hypothesis. The dish soap plants had the highest average growth of 11.125 cm, which was even higher than the control (water) with an average growth of 10.25 cm. The plants watered with the car shampoo mixture had an average growth of 5.875 cm and laundry detergent plants had the lowest average growth with 2.75 cm. This was because dish soap has a high phosphorus concentration, which helps to fertilize and grow plants. This experiment showed that dish soap helps grow plants, with a higher growth rate than water. In contrast, due to harmful ingredients that deteriorate the structure of the soil, laundry detergent and car shampoo are harmful to plants.

The Effect of Various Types of Water on a Plant
Ramitha Dasari, George H. Moody Middle School

The purpose of this experiment was to determine if the different types of water would help plants grow without dying. If they did, it would help the organizations that work to keep the rivers clean know what plants they should plant more to help the environment. The experimenter came up with a hypothesis after identifying the purpose. The hypothesis is if the plants were watered with tap water, it would be the tallest and the healthiest. For the procedure, to conduct the experiment the experimenter gathered all of her material to begin. She followed the steps in order, she first set up the workspace and germinated her mung bean seeds. She then watered the seeds every day for 2 weeks and observed the growth. She recorded her results and created the appropriate graphs to express the results. The results of the experiment were graphed on graphs and were verbally reported. Most of the results were observations made by the experimenter. The conclusions were written after the experimenter completed her experiment. She reported her major findings and statistics. She supported her findings and explained the results. Lastly, she explained what he would do to change the project for future research purposes.

The Effect of the Environment on the Effectiveness of a Natural Antibiotic
Lautaro Lo Prete, Sabot at Stony Point

Bacteria is one thing that can be a cause of fear and misunderstanding to a lot of people. Ginger is a natural antibiotic, but the environment plays a big role in how bacteria grows, it is a known fact that *E-coli* K12 grows best in temperatures of 31 degrees celsius. Ginger is a repellent to *E-coli* K12, as a natural antibiotic, but less effective. This experiment was performed by testing ginger in Petri dishes filled with *E-coli* K12, and to let it grow a number of days. To see the effect of adding the ginger on to the bacteria that has had some time to grow. "If two of the same *E-coli* K12 bacteria are placed in two different environments, then the warmest environment will be the hardest to let the ginger kill the bacteria." When testing the bacteria the hypothesis was supported when looking at the results, the environment does have an effect on how the ginger affects the bacteria.

The Effect of Different Wavelengths of Light on the Metabolism of *Saccharomyces cerevisiae*.
Aditya Badhrayan, George H. Moody Middle School

Yeast, also known as *S. Cerevisiae*, was and is a key component in baking and brewing. People across the world use it daily, and much of this world's delicacies and alcoholic beverages would not have been made without this special fungus. Yeast is not only used in cooking, but now it is being used to create biofuels. Yeast is known to play a major role in biofuel production due to its ability to create ethanol. The purpose of this experiment was to determine if variations of the light spectrum (colors of light) would affect Yeast metabolism and if it did which variant would increase the metabolic rate, and which one would decrease it. If the Yeast metabolic rate was quickest in a certain color of light, then humans could modify various machines to create products quickly to feed the growing population of the planet. The Levels of the Independent variable of this experiment were White light (control), Blue Light, Green Light and Red Light. The metabolic rate was measured by the Carbon-dioxide (ppm) produced within a certain amount of time. The experiment was hypothesized as following: if yeast is placed in the presence of Blue Light it would produce more carbon-dioxide than placed in the presence of Red Light. The hypothesis was proven after concluding the experiment. According to the data collected, when yeast was placed in the presence of Blue Light it produced the most CO₂, but when yeast was placed in the presence of Red Light it produced the least amount of CO₂. When yeast was placed in Green light it was second-fastest in CO₂ production and when yeast was placed in White light it was the second slowest in CO₂ production. The researcher realized that the shorter the wavelength of light the better it was for Yeast metabolism and the longer the worse. The concluding thesis was that to increase Yeast's metabolic rate it should be placed in the presence of the shortest wavelength of light.

The Effect of Different Growing Methods on the Brix Level of Romaine Lettuce
Elise Rickard, Thomas Jefferson Middle School

The purpose of the study was to determine the effect of different growing methods on the Brix levels, a measure of nutrient content, of romaine lettuce. The independent variable was the type of growing method. The experimental group was the hydroponics group, and the control group was the soil group. The dependent variable was the Brix levels of the plants. The constants were the plant type, the seeds, light and sun exposure, temperature, and the refractometer. The hypothesis was: If different methods of growing romaine lettuce are tested for their Brix levels, then the plants grown hydroponically will have higher Brix levels. First, a plastic bin was used to grow eleven seeds in soil and eleven seeds hydroponically. Eleven days later, another setup was constructed using seed plugs. After that, the four tallest seedlings from the soil group were transplanted to larger containers and then placed under a T5 grow light. Then, the four hydroponics group seedlings were transferred to a larger bucket, surrounded by growing pebbles, and placed under the same grow light. A refractometer was used to measure the Brix levels. The results showed that the hydroponics group had higher Brix levels. These results support the hypothesis. One reason the hypothesis was accepted may be because the nutrient solutions used in hydroponics helped give hydroponically grown plants more nutrients than traditionally grown plants. Another reason may be because the hydroponics group always had access to water, resulting in healthier plants, as opposed to the soil group which received water once a day, possibly causing water-and-nutrient-deficient plants. In conclusion, the study suggests that hydroponically grown plants are more beneficial because they have more nutrients, and that therefore that they should be used more often.

The Effect of Environmental Condition on Bacterial Growth
Jaya Shah, Williamsburg Middle School

The purpose of this experiment was to inform others on how environmental conditions can affect a household sponge. The environment can significantly influence the bacterial growth on a sponge. This data could provide people with information on the importance of taking care of their sponges and could result in an improvement of people's health. This experiment was done by placing four Petri dishes into four different environmental conditions: 27° Celsius with 50% humidity (warm and humid environment) in an incubator; 27° Celsius with 25% humidity (warm and dry environment) in an incubator; 17° Celsius with 50% humidity (cold and humid environment) in the classroom and 17° Celsius with 25% humidity (cold and dry environment) in the classroom. A wet bulb was used to create 50% humidity. The bacterial growth was measured after 72 hours (three days). The key results of this experiment were as follows: the warm and humid environment produced the most amount of bacteria with approximately 10.7% of bacteria covering a section of a Petri dish. The warm and dry environment as well as the cold and humid environment produced very similar amounts of bacteria, the former created 7.4% of bacteria while the latter created 6.9%. The cold and dry environment produced the least amount of bacteria at approximately 4.2% of the given surface area. The data in this experiment demonstrated that warm and humid environments created more bacteria on sponges than the other conditions. Therefore, it is recommended to keep sponges in cold and dry environments, where the least amount of bacteria grew. This will keep people safer and less prone to illness.

The Effect of Different Levels of Radiofrequency Radiation on *Phaseolus vulgaris* Seed Germination

Cameron Joyce, George H. Moody Middle School

The amount of mobile device usage worldwide has grown exponentially in the past few years, requiring more cell towers to meet the growing demand for WiFi and cell service. Cell towers emit radiofrequency radiation (RFR), which has a potentially adverse effect on living things, including seed germination and plant growth. The purpose of this experiment was to test whether or not RFR had an effect on seed germination. The hypothesis for this experiment was that if *Phaseolus vulgaris* (bean) seeds are exposed to high, low, and very low RFR levels, then the lowest percentage of seeds will germinate when exposed to high RFR levels. Three hundred bean seeds each were exposed to RFR from an Amazon Echo Dot and a WiFi Extender. One hundred seeds each were exposed to $<3 \text{ mW/m}^2$ (very low RFR), $3\text{-}10 \text{ mW/m}^2$ (low RFR), and $>35 \text{ mW/m}^2$ (high RFR) RFR per RFR source for 6 days after setup. The results showed that there was a statistically significant difference between the germination percentages of high RFR versus low and very low RFR on days 2 and 3, indicating delayed germination in the high RFR group. By day 4, germination percentages were the same across groups. In conclusion, overall germination was not affected; however, delayed germination resulting from high RFR exposure may reflect cellular changes in the seed that could adversely impact plant growth later. Negative effects on plant growth may ultimately affect food production. Therefore, RFR exposure may be an important consideration when farmers are deciding where to plant their crops.

The Effect of Sodium Chloride on the Germination of Radish Seeds
Mihir Pokhriyal, George H. Moody Middle School

Every day, all around the world, many plants sprout, and many new plants germinate. Germination is crucial as this is the beginning of the plant's life. However, germination can be affected by other factors such as sodium chloride, therefore, possibly altering the success of the germination. Sodium chloride, also known as salt, is an essential compound that keeps humans alive and running. Sodium chloride, however, includes a variety of negative effects. Therefore, it is important to measure the best amount of salt for radish seeds to germinate as it is a naturally occurring compound. The purpose of this experiment was to determine the effects of sodium chloride on radish seeds and determine what the best ratio of salt to water is for radish seeds to germinate successfully. To begin, the experimenter made solutions of different ratios of salt to water in terms of grams. These ratios included 0:20 1:20, 3:20, 5:20 and 7:20. The control was the 0:20 grams of salt to w

The Effect of Temperature on Bacteria Growth
Alice Zhang, Moody Middle School

The purpose of this experiment was to investigate which temperature bacteria grows the most at the range from $-20\text{ }^{\circ}\text{C}$ to $37\text{ }^{\circ}\text{C}$. There were reports that leaving food at room temperature causes bacteria to double every 20 minutes. Because of this, people store food in freezers and refrigerators. Each year, about 5,000 people in the United States die from food borne illness. There are 31 known pathogens that cause food borne illnesses. The hypothesis for this experiment was, if bacteria is left at room temperature, then it will grow the most. This experiment was conducted by placing *E. coli* into four different temperatures, $-20\text{ }^{\circ}\text{C}$, $4\text{ }^{\circ}\text{C}$, $22\text{ }^{\circ}\text{C}$, and $37\text{ }^{\circ}\text{C}$. The average for $-20\text{ }^{\circ}\text{C}$ was 1.47×10^7 . The average for $4\text{ }^{\circ}\text{C}$ was 1.68×10^8 . The average amount of bacteria grown for $22\text{ }^{\circ}\text{C}$ was 7.07×10^8 . The average amount of bacteria grown for $37\text{ }^{\circ}\text{C}$ was 8.49×10^8 . Out of the bacteria grown, $37\text{ }^{\circ}\text{C}$ had the highest average of bacteria grown. These findings are consistent with life experience, when in the summer, food is more easily spoiled than any other season because the temperature in the summer is closer to $37\text{ }^{\circ}\text{C}$.

The Effect of Varying Levels of Salinity on Plant Growth
Rhea Prakash, George H. Moody Middle School

The main purpose of this experiment was to observe the effects that saline solutions had on the growth of a common garden plant, specifically Lobelias. Research for this topic usually came from professionals/students looking into how this topic affects the agricultural industry. Salinity can affect crops in negative ways, such as causing osmotic stress, which is the decrease of hydration and water content given and taken by the plant. The hypothesis of this experiment was if varying levels of salinity are added to water being given to plants, then the plants with no salinity added would grow the tallest. In other words, if there is a higher percentage of salinity in the saline solution given, then the height will decrease according to how much salinity there was in the solution. First, forty seedling plants were purchased from a Lowes store that was local to the area of testing. The forty seedlings were first measured for initial height, then separated into groups of ten and organized into four rows, labeled with the four main independent variables, including the control, which had no salinity added. Over the course of nineteen days, the ten trials per independent variable were performed by adding the certain saline solution to each plant. The four independent variables included 0% salinity, 10% salinity, 20% salinity, and 30% salinity. In the results, the main observation taken was that the difference between the initial and final height increased as the salinity percentage increased. In fact, the only plants that increased in height were the control group with 0% salinity. Another important observation was that all the plants that weren't in the control seemed dead and wilted by the end of the experiment. By the end of the process, it was concluded that as the percentage of salinity increases, the height of the plant decreases, depending on the salinity level.

What is Actually in My Instrument
Dalia Singer, Swanson Middle School

This experiment investigated how much bacteria grows in the mouthpiece and spit valve of students' wind instruments. The different instruments that were used were 4 trombones, and 4 trumpets. The places swabbed on each instrument were the mouthpiece and the spit valve, and then the samples were grown on agar. For the control the mouthpieces and the spit valves of one trumpet and one trombone were sterilized and then swabbed. The hypothesis that was tested is that one of the trumpet mouthpieces had the most bacterial growth, because the trumpets were played more often, and not cleaned as much. What was observed was when the bacteria was swabbed from different instruments the instrument that was cleaned the most recently was the cleanest, with the least amount of bacteria, which was one of the trumpet mouthpieces. This experiment didn't support the hypothesis because the result supported by the data was that one of the trombone mouthpieces had the most bacterial growth with 52cm².

BEST OF SYMPOSIUM

Benjamin Bankston; Central Virginia Governor's School

Comparing Microplastic Presence in both Indoor and Outdoor Environments

Abstract

The purpose of this study was to determine whether or not there were significantly more microplastics, microscopic pieces of plastic, inside than outside a local high school. The data for this study was collected in November of 2019. Samples of dust were collected in eight different locations both indoors and outdoors over three days for a total of 24 samples. The dust was then density separated for two weeks and 0.5 mL was pipetted out and observed through a dissecting microscope. The resulting mean number of microplastics per sample outdoors was .917 and indoors was 7.583. A two sample t-test assuming equal variances comparing the indoor and outdoor numbers of microplastics yielded a p-value of .02 against an alpha value of .05. This statistical significance supported the research hypothesis that if dust is collected from both indoor and outdoor areas, then there will be a larger number of microplastics collected per sample inside than outside. Select samples were also viewed in a FEI Quanta 600 FEG Scanning Electron Microscope (SEM) at a university research institution where pieces of unsaturated aliphatic hydrocarbons and other mixtures were identified. In conclusion, location where dust is collected does have an effect on the number of microplastics per sample. Microplastics are potentially dangerous particles that, based on this study, are very frequent in places that humans spend time in.

Introduction

It is commonly known that many of the items we use every day are made of plastic; what is lesser known is that from every kind of plastic, microscopic particles known as microplastics decompose and enter the air around us. Currently, the harmfulness of breathing in microplastics is a serious topic of discussion (Vianello, Jensen, Liu, & Vollertsen, 2019). Further research on the presence of microplastics in the atmosphere may help us to better protect future generations from their probable threat and aid us in better understanding the relative frequency of these particles. To work towards each of these goals, I established the research question: what numbers of microplastics (in microplastics per sample) will be discoverable in areas of 19.06 square meters as collected by settled dust both inside and outside a local high school? I hypothesized that, if dust is collected from both indoor and outdoor areas, then there will be a larger number of microplastics collected per sample inside than outside. This hypothesis was tested in a causal-comparative experiment in which collected dust was analyzed for its composition of microplastics. My independent variable was the area where the dust was collected, and the dependent variable was the amount of microplastics collected per sample from those areas. The controls included the method of collection, area of space being collected, and time of dust settling before collection. This project requires knowledge of the concepts of microplastics and their tendency of being airborne, how they settle in dust, and techniques for their collection, specifically, vacuuming. The final major concept necessary to understand is the method to identification of microplastics in both indoor and outdoor environments.

Microplastic concentration and its interaction with humans has recently become a more

serious scientific topic of discussion. According to a study done by Vianello, Jensen, Liu and Vollertsen (2019), 4% of all inhaled organic compounds are microplastics, minute pieces of plastic breakdown from consumer and industrial waste. Their frequency is becoming increasingly alarming as world plastic production is estimated to be 352 million metric tons per year and is increasing annually at a rate of 3% (Gasperi et al., 2018). As far as indoor environments, apartments vs. outdoor environments were found to have significantly more microplastics (Dris et al. 2016). In addition to potentially causing human harm, microplastics have recently been discovered as a major detriment to water purity (leading to the assumption that they may also greatly affect the quality of air) (Hobson, 2019).

Microfibers and phthalate plasticizers, substances added to plastics to increase flexibility, durability, and shine, are two of the most common types of airborne, plastic organic compounds that could potentially be collected and analyzed in this study. Both microfibers and phthalate plasticizers are substances that deteriorate from plastic materials over time. Airborne microplastics such as these are emitted from everyday sources and are very common in indoor air; microfibers specifically, because of their larger size, can be detrimental to human health (Williams, 2018). Microfibers are found in common material like polyester and polyamides. Because these fabrics are widely used today, there are increasing amounts of microplastics in the atmosphere. Phthalate particles are easily absorbed into the air and therefore are easily deposited (Benning, Liu, Tiwari, Little, & Marr, 2013). Collection of these particles as dust is easiest by use of vacuum due to the precision of sampling area and ease of removing the sample from its collection location (Dris et al., 2016). Research studies have also found that semivolatile organic compounds (SVOCs) are best transferred directly, rather than through the air (Sukiene et al., 2017). While sticky paper is a convenient method of collecting samples, often only particles larger than ten micrometers can be collected, limiting the size of sample particles (Silverman, 2012). For these reasons, vacuuming is the preferred method of collection.

The analysis of collected particles involves the determination of particle type, optical analysis, and microscopic analysis. Shape, color, and size are three visual cues that help to separate microplastics from otherwise indistinguishable microscopic particles (Hidalgo-Ruz, Gutow, Thompson & Thiel, 2012). Optical analysis of particles is useful in determining one specific type from another. A specific set of criteria laid out by Dris et al. (2015) suggested looking acutely for exact consistency throughout the particle and to be wary of clear and green fibers to avoid confusing microplastics with natural molecules. After this has been completed, electron microscopy is a more useful technique for detecting differences between distinct microplastics (Dehghani, Moore, & Akhbarzadeh, 2017). Spectroscopy, the observation of spectra emitted by particles, can be used to identify individual compound makeup (Pietrodangelo, Salzano, Bassani, Pareti, & Perrino, 2015). It is still yet to be demonstrated that microplastics pose a significant threat to human health and further work and research is still to be done to prove either way (Vianello et al., 2019). Also, this collection method and analysis technique does not guarantee there were no airborne particles collected smaller than those observed that could potentially be harmful to people (Dris et al., 2016). The purpose of this study was to determine if microplastic concentration was greater inside or outside and what type of microplastics were abundant in each. This research could lead to better understanding of potential impacts of microplastics and solid evidence of microplastic appearance in specific environments. This project is directly related to STEM principles by microscopes and like

technology for the investigation of the environmental effects of human activity and progress towards a greener Earth.

Materials and Methods

My materials and methods began by gathering dust samples from high dust concentration areas from various common spaces inside and outside a local high school. Indoor data had accumulated only from throughout the day, while outdoor dust likely had been sitting for slightly longer because of the infrequency of cleaning as compared to the floors inside. Four indoor and outdoor locations were analyzed over the course of three days for a total of twelve samples each (indoor and outdoor) from a 19.06 square meter area per sample. These samples were to be collected using a Black + Decker handheld, canister vacuum cleaner, but instead, were first swept into a concentrated pile using a broom. The samples were then placed into 8.5 centimeter petri dishes after being caught in the filter paper in between the vacuum nozzle and the canister of the vacuum. Each petri dish was labeled with location and collection date. The vacuum canister and broom were each wiped after every sample with a clean, 100% cotton cloth, as not to leave microplastic fibers or other residue that could potentially affect data.

I weighed each of these collected samples to the nearest 0.0001 g using an Ohaus Pioneer balance to find the mass of dust collected from each area by day (calculated by subtracting the weight of the petri dish before dust was collected from the weight of each petri dish after it was collected). The solids from each sample were relocated to glass vials, the size of each was determined by the mass of that sample containing a proportionate amount of 5 M NaCl solution for two weeks. To prepare the solution, 292 grams of sodium chloride stirred overnight with a liter of water on a stir plate, then added to samples in amounts proportional to mass. To allow them to properly settle having only the suspected microplastics (particles smaller than 2.5 mm with densities near equal to water) float in the solution, samples were stirred with a glass stirrer and left to run. Unfortunately, I had not planned for the rapid evaporation of the water. This evaporation allowed the salt to crystallize, the molarity of my solution to decrease, and more particles than expected to sink in the solution, potentially jeopardizing the collection of my microplastics. To prevent this, a new salt solution was prepared and small amounts were added to each solution, covered in aluminum foil held on by a rubber band, in order to compensate for the solution lost to evaporation. Restored to spur density separation, the samples were given two weeks to settle.

After settling was complete, I used a 1 mL pipette to collect 0.5 mL of the floating top layer of the solution and put each sample into a depression slide for optical analysis. I allowed them to dry via evaporation for 24 hours, then closely analyzed the particles using a Zeiss PrimoStar dissecting microscope at 40x magnification in the analytical lab at my school. This was done to identify microplastics by their unique shape and size.

For further analysis, with a trained technician, I analyzed my samples with Raman spectroscopy using an FEI Quanta 600 FEG Scanning Electron Microscope (SEM) at an offsite university research facility. Through the use of the SEM, I identified the distinct particles located in the microplastics to help determine a specific original source.

Data was analyzed using a two-sample t-test to distinguish significance of particles coming from indoors and outdoors. As neither my samples nor solutions posed any serious health risk, neither gloves nor goggles were worn during data collection, but a dust mask was worn while transferring samples, and I made certain to follow all lab safety procedures.

Results

The data showed that there were significantly more microplastics in indoor environments than outdoor environments. The independent variable was the environment that dust was collected in and the dependent variable was the amount of microplastics collected per sample. Twelve samples of about 19 square meters of dust were collected over three days at a rate of four indoor samples and four outdoor samples per day. After recording each value of observed number of microplastics per sample in the table, I took the average of both indoor and outdoor values and ran a two-sample t-test assuming equal variances on the data. Then, I graphed the averages on a bar graph and added the confidence intervals to each bar. This yielded a two-tailed p-value of .020 which was less than the alpha value of .05. Each indoor and outdoor average respectively was 7.58 and .917 and the standard deviations of each were 9.16 and 1.00. As seen in Figure 1 below, the error bars for indoor samples were much larger than that of the outdoor samples because of the differences in the number of microplastics found in various areas around the high school in which I collected data.

Area collected

Figure 1. Average microplastics per sample in indoor and outdoor environments.

In addition to the observations through my high school's dissecting microscope, two of my 24 samples were also analyzed using a FEI Quanta 600 FEG Scanning Electron Microscope (SEM) at an offsite university research facility. One of the two samples that was analyzed gave a clear picture as to what specific microplastics were present in the area collected. In my sample, "13Caf" (collected in the local high school's cafeteria on November 13), there were peaks at ~840, 1060, 1300, 1445, and 1655 cm^{-1} , characteristic bands of unsaturated aliphatic hydrocarbons, compounds commonly used in production of rubber and plastic (Aliphatic Hydrocarbons, 2020) (see Figure 2), but it is likely these peaks result most often result from cooking oil, based on the area they were collected ("personal communication," January 2020). The research hypothesis of my experiment, if dust is collected from both indoor and outdoor areas, then there will be a higher concentration of microplastics collected per sample inside than outside, was supported by collected data. The alternative hypothesis that there would be a significant difference between the number of microplastics found indoors and outdoors was also supported. The null hypothesis, that there would be no difference between concentration of microplastics indoors rather than outdoors was rejected by the data.

Figure 2. 13Caf Raman test results. CCD is short for the charged coupled device. Frequency of the waves are denoted by relative $1/\text{cm}$. Figure provided by Raman microscope technician.

Discussions and Conclusions

The purpose of my research was to determine whether there are higher numbers of microplastics per sample indoors than outdoors. My results suggested that there is a significant relationship between the concentration of microplastics and the areas in which they are collected.

I concluded this by completing a two sample t-test on the number of microplastics per square meter versus the environment tested. This test yielded a p-value of .02, less than the accepted alpha value of .05. It was seen that almost every indoor sample had more microplastics than those from outdoors. All of this supported my hypothesis that said that if dust is collected from both indoor and outdoor areas, then there will be a larger number of microplastics collected per sample inside than outside.

My results were comparable to those found in other, similar experiments. Dris et al.

(2015) found a significantly larger number of microplastics indoors rather than outdoors using a procedure similar to my own. They investigated microplastics within apartments and office buildings and studied the differences in what they found. In the 2017 experiment by Dehghani, Moore, and Akhbarzadeh, collection of plastics yielded an average of 33.5% microfibers, 65.9% granules, and 0.6% spheres. This contrasts my results in that all but two of the microplastics that I observed were microfibers. In an average of my samples, 98.0% were microfibers of the total 102 plastics that I observed (see Figure 3).

Figure 3. Picture taken from above samples on a dissecting microscope. Crystals seen in picture are crystallized salt surrounded by dark, thin microfibers.

Many of the measurements in my experiment were as expected. Numbers of outdoor microplastics ranging between zero and three were along the lines of my hypothesis. On the contrary, indoor counts ranged between zero and thirty-five microplastics per sample. While I did expect larger numbers to be counted indoors than outdoors, the variance in indoor samples can likely be contributed to the inconsistency of activity and the higher traffic of one of the areas where I collected. These extreme values (35, 11, 8) played a part in raising my indoor microplastic average but also made my standard deviation so extreme that my t-critical value nearly exceeded the t-statistic.

In research design, I had trouble at first with the collection of my samples. It was my original plan to vacuum, with my handheld vacuum, all 19.06 square meters for each sample. I quickly realized I would have to use a broom because of the time it took to collect from just a small area with the vacuum. I cleaned the head of the broom in between each sample collection.

After each was prepared and settling, I ran into an issue of water evaporating from my salt solutions. Each uncovered salt solution was rapidly losing water and the salt was beginning to crystallize out of the remaining water and around the beaker. This decreased the densities of my salt solutions and jeopardized my ability to find results. To make up for this, I prepared another full liter of 5 M NaCl solution and replaced in each beaker what I had estimated had already evaporated out. This addition of new solution meant that I had to restart the two week settling time for each sample. This change was necessary to ensure that the microplastics could properly rise to the surface of the solution and data could be collected. Along these lines, when collecting data, it is possible that I may have missed a spot in my sweeping or not collected every microplastic from the coffee filters my dust was concentrated on. In the lab, the extraction of microplastics likely would have been more accurate if more pipette samples had been taken from the larger beakers or erlenmeyer flasks had been used for a consistent opening size to extract from. This inconsistency may be partially responsible for extreme counted values from a few of my samples.

Along with these changes, a larger sample size and more variance in area of data collection could have resulted in a lower p-value because of the trends shown in existing data. As the samples were diluted, in the future, with a more even grade of solution per gram of dust, multiple pipette samples from each beaker likely would have provided a more accurate representation of microplastic numbers per sample. Instead of only taking one sample per beaker, I also could have taken one sample per open centimeter of the beaker to better represent the number of microplastics inside. I think this would have helped to give me larger indoor numbers, possibly even normalizing the extreme values I have already.

In the future, it is likely that repetition of this experiment will yield a result with higher

concentrations of microplastics indoors than outdoors based on my p-value of 0.02. There were few areas in my study that had particles other than microfibers. I think it would be fascinating to look into these places specifically for the types of microplastics that collect within them. Beyond this, the method in which the microplastics are collected, whether by vacuuming or another method may also be interesting to research. There is still much research to be done on the harmful effects of microplastics on the human body. Until then, we can only continue to execute more studies on the prevalence of microplastics around us so that we understand how best to handle the problem of microplastics.

These results can be paralleled to real life implications. The smaller numbers of outdoor microplastics likely can be attributed to wind, rain, and other outdoor phenomena. Because microplastics have been hypothesized to be harmful to human lungs, this study shows that they are very common in our daily lives and measures should be taken to decrease their ubiquity in the world around us. To decrease the number of microplastics in the air, more cotton clothes and fewer utilities made from plastics like unsaturated aliphatic hydrocarbons should be utilized; without these changes, there are still dangerous effects to the human body and environment possible.

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Chirayu Nimonkar; Todd Allen Phillips Center for Medical Sciences at Godwin High School ***The Effect of Magnetic Shielding Geometry on Focality for Transcranial Magnetic Stimulation***

Abstract. Transcranial magnetic stimulation is a growing field that holds the potential to revolutionize neuroscience research and medicine. To fully realize the capabilities of this technology, every aspect of the treatment must be optimized. This investigation aimed to determine the effects of magnetic shielding geometry on the focality of the stimulation area. A hybrid geometry was developed and hypothesized to yield the highest focality of the tested geometries. Using Sim4Life finite element simulation software, a spherical model was stimulated with a figure-8 coil with a V-shape, parabola, and hybrid flat-U shield above the head. Stimulation with no shielding was also measured as the control to compare the results with the shielding. The raw Sim4Life files were post-processed in MATLAB to retrieve the percentage of the sphere that was stimulated above a threshold, which was a representation of the focality. The hybrid geometry had the highest focality (0.793% stimulated) followed by the V-shape, parabola, and control. The observed results supported the hypothesis because the hybrid geometry yielded the highest focality. Multiple t-tests showed that each comparison was significant, and therefore shielding geometry influences focality. The findings from this experiment are similar to other studies that found shielding has a significant impact on focality. The hybrid geometry, which was designed to incorporate the best characteristics of the parabola and V-shape, had the highest focality as it redirected more magnetic fields into the desired region. To optimize performance, further research into magnetic field interactions and other shielding characteristics would be needed.

Introduction. Mental disorders like depression, schizophrenia, and Parkinson's disease are some of the leading causes of illness worldwide, affecting about 450 million patients globally (Rastogi,

2019). For such a prevalent ailment, there is a huge demand for better treatments that eliminate unwanted symptoms and prevent worsening of the disease. Many of the available treatments, however, involve invasive techniques that can yield an array of side-effects including seizures, worsened symptoms, and other complications (Hernandez-Garcia et al., 2010). Transcranial magnetic stimulation (TMS) is a non-intrusive method that holds the potential to revolutionize research and treatment of the brain. Currently, the FDA has only approved TMS for the treatment of depression, reduction of migraines, and pre-surgery brain mapping. The full capabilities of the applications for TMS, however, cannot be realized without full control of the depth and focality of the stimulation (Wang et al., 2018). With this specialized shielding material, it is possible to redirect or block magnetic fields to increase focality (Grilli, 2017). By increasing the focality of the stimulation, only the targeted region can be manipulated without affecting unwanted areas. Currently, the various methods to optimize focality with magnetic shielding have not been fully explored. TMS involves stimulating the brain with short pulses of magnetic fields to generate an electric field (E-field) in the targeted area. The E-field is what determines the location of the stimulated region and the intensity of the stimulation in the brain (Eldaief et al., 2013). Without the need for anesthesia, TMS makes it possible to change certain synaptic connections to normalize brain activity and even manipulate neuroplasticity (Pohar & Farrah, 2019).

Research is also being conducted for using TMS as an effective treatment for respiratory disease caused by a lack of control over nerve cells in the body (Vinit et al., 2014). MuMetal is a popular patented brand of the generic TMS shielding material perm-alloy. The alloy is made from 80% nickel, 15% iron, and 5% molybdenum; however, perm-alloy is more loosely defined as any nickel-iron alloy. Perm-alloy and its variants are designed to have a high magnetic permeability, which causes the magnetic field around the surface of the shield instead of over the brain (Grilli, 2017). This property makes perm-alloy very desirable for TMS applications because all areas other than the targeted region need to remain shielded. Furthermore, in a study of TMS on rats, magnetic shielding did not have a statistically significant difference in physical parameters such as body weight, internal temperature, blood pressure, and other vitals, meaning there were few side-effects (Vinit et al., 2014). The geometry of the shield influences to what extent magnetic fields are dispersed over the surface, but no extensive research has been conducted yet in identifying the geometric characteristics of permalloy. The brain can broadly be broken down into the brain stem, which controls unconscious actions necessary for survival; the cerebellum, associated with motor coordination; the limbic system, involved in emotional

responses and memory; and the cerebral cortex, which is used to create complex thoughts (Ackerman, 1993). Due to how magnetic fields interact with the brain, the outer regions of the cerebral cortex, such as the dorsolateral prefrontal cortex, frontal pole, hand knob, and orbitofrontal cortex receive stronger stimulation than the deeper areas (Wang et al., 2018). These regions of the brain that are usually stimulated include parts of the limbic system, such as the hippocampus, thalamus, and hypothalamus. The stimulation in a brain from TMS is possible due to Faraday's law, which shows that the voltage in an electrical circuit, such as the brain, is proportional to the rate of change of the magnetic flux (Φ) going through the circuit. This law is often paired with Lenz's law, which states that the generated voltage travels in the opposite direction to the flux change (Jiles, 1991).

When a TMS procedure induces a magnetic field on the brain, a voltage is produced which corresponds to activated or deactivated brain activity. This brain stimulation can be measured as the magnetic flux over a given area measured in Webers (Wb). Another common way of measuring the stimulated region is halving the maximum voltage output in the region to get a threshold of what is considered stimulation ($V_{Max}/2$). The ratio between volume above this threshold and the total volume of the brain can be converted to a percentage (Hernandez-Garcia et al., 2010).

The purpose of the investigation is to determine how the geometry of the shielding affects the focality of the stimulated area in the brain. After conducting preliminary research into magnetic shielding and TMS, it is hypothesized that if the hybrid flat-U shape is utilized, then the stimulated region will have the highest focality of all the tested shields. This geometry was chosen because research has shown that shielding works by focusing and blocking magnetic fields coming from various angles (Rastogi, 2019). Although the specific hybrid shape was not used in past studies, it is expected that this shield will be able to reflect more fields coming from various angles due to its unique shape.

In this investigation, the independent variable is the geometry of the magnetic shield. The levels of the independent variable are the V-shape, parabola shape, hybrid flat-U, and no shielding (which served as a control). The V-shape was chosen because it performed the best in a magnetic shield investigation, and the parabola shape is a modified version of the semi-circle shield shape from the same study (Rastogi, 2019). The flat-U shape is used because it has aspects of both the parabola and V-shape shields. No shielding is used as a control to compare with other research in magnetic shielding (Deng et al., 2013). The dependent variable, focality, will be measured in the percentage of grey matter stimulated (%).

Methods and Materials. To begin, all the hardware and all the software was checked for any damage or other issues. To ensure safety, a qualified scientist was present during the experimentation. Following the inspection, a spherical head model with a radius of 19 cm was created in the computer- assisted design software SolidWorks and then loaded into the simulation program Sim4Life. This head model served as the simulated patient for the TMS treatment electric properties which mimicked those of real grey matter. A TMS coil was then loaded into the program above the simulated brain. Following the setup in Sim4Life, the parabolic, V-shape, and hybrid flat-U shape shields were created using the program SolidWorks. Then, 25 simulations of the TMS treatment were conducted with a parabola shape shield placed five millimeters from the scalp. Parameters such as the shielding material (permalloy), thickness (one mm), and permeability (70,000 units) were kept constant throughout the trials. The induced electric fields were calculated using Sim4Life and recorded into a separate computer. The mean volume of the brain stimulated was exported to MATLAB for post-processing and to create a visual for the area stimulated. Using the program, the percentage of the brain volume stimulated above $V_{max}/2$ was calculated from the file. This process was separately repeated for the V-shape shield, hybrid flat U-shape shield, and no shield above the scalp, which served as a control. After all the data was collected, the equipment was properly turned off. To statistically analyze the data, the mean volume of the brain stimulated in each shielding shape was determined, the standard deviation for the twenty-five trials was calculated for each independent variable, and multiple t-tests were conducted between each independent variable to determine significance. The most focused geometry was then modified with trial and error to receive the most optimal shielding. This was then used on a real brain model to see how it functioned on an uneven surface.

Results

Table 1. Statistical Analysis for the Effect of Magnetic Shielding Geometry on Focality of Transcranial

Magnetic Stimulation

Descriptive Information

Shielding Geometry Control (no shielding)

V-Shape Parabola Hybrid (flat-U) Mean

Range

Max

Min

Variance

Standard Deviation

1 SD 2 SD 3 SD

Number

1.310 %
 0.0400 %
 1.33 %
 1.29 %
 0.000112
 0.0106 1.299 - 1.321 1.289 - 1.331 1.278 - 1.342
 25
 0.839 %
 0.00400 %
 0.841 %
 0.837 %
 7.07×10^{-7}
 0.000841 0.838 - 0.840 0.837- 0.841 0.836 - 0.842
 25
 0.909 %
 0.00500 %
 0.912 %
 0.907 %
 9.93×10^{-7}
 0.000997 0.908 - 0.910 0.907 - 0.911 0.906 - 0.912
 25
 0.793 %
 0.00400 %
 0.795 %
 0.791 %
 1.08×10^{-6}
 0.00104 0.792 - 0.794 0.791 - 0.795 0.790 - 0.796
 25
 Results of t-test
 Control vs. V-Shape $t = 221.828$ $p < 0.001$
 Control vs. Parabola $t = 188.620$ $p < 0.001$
 Control vs. Hybrid $t = 243.090$ $p < 0.001$
 V-Shape vs. Parabola $t = 268.438$ $p < 0.001$
 V-Shape vs. Hybrid $t = 172.054$ $p < 0.001$
 Parabola vs. Hybrid $t = 402.836$ $p < 0.001$
 At $df = 48$; $\alpha = 0.001$; 3.505 for significance

Graph 1. The Effect of Magnetic Shielding Geometry on Focality of Transcranial Magnetic Stimulation
 (unable to copy and paste)

The effects of magnetic shielding geometry on the focality of transcranial magnetic stimulation were investigated and the results of the statistical analysis are shown in Table 1 and Graph 1. The research hypothesis formulated was that the hybrid geometry

would yield the highest focality. A comparison of the mean of the control (1.310 %), V-shape (0.839 %), parabola (0.909 %), and the hybrid (0.793 %) suggested shielding geometry does influence focality. From the graph, there also seemed to be a distinct advantage in the focality with any magnetic shielding compared to no shielding. The observed results supported the hypothesis as the hybrid flat-U shape performed the best of the geometries tested. The standard deviation was very low for each variable, implying the distribution of the data was not too spread out. All the data points, with the exception for one data point in the parabola trials, fell within two standard deviations of the mean, meaning there was only one major outlier in the dataset.

Multiple t-tests were performed between each level of the independent variable with 48 degrees of freedom with a level of significance of 0.001. The null hypothesis was that there would be no statistically significant difference in focality with different shielding geometries. The calculated t-value of control versus V-shape (221.828), control versus parabola (188.620), control versus hybrid (243.090), V-shape versus parabola (268.438), V-shape versus hybrid (172.054), and parabola versus hybrid (402.836) were all above the critical t-value of 3.505. The results of the t-test imply that the null hypothesis should be rejected and there was a very significant difference between the tested shielding geometries. The probability the results were due to chance is lower than the significance level of 0.001, which means that the focality in the experiment was most likely caused by the manipulation of the independent variable. The data for the effect of shielding geometry on focality is statistically significant, and the hybrid shield performed statistically significantly better than the other geometries.

Conclusion. The purpose of this experiment was to investigate the effects of magnetic shielding geometries on focality from transcranial magnetic stimulation (TMS). Geometries including V-shape, parabola, hybrid flat-U, and the control of no shielding were all used with a figure-8 coil above a spherical head model. Focality was measured as the percentage (%) of grey matter stimulated above a threshold ($V_{Max}/2$). The research hypothesis was that if the hybrid shielding was used, then the stimulation would have the lowest stimulated region and thus the highest focality of the tested geometries. The findings showed that the control had the lowest focality, followed by the parabola, V-shape, and hybrid. The research hypothesis was supported by the data collected in experimentation because the hybrid had the highest focality. Multiple t-tests were performed to determine the

statistical significance of the data. According to the tests, the data for all the independent variable comparisons were very significant. This meant that the results were most likely caused by the manipulation of the independent variable as opposed to other factors. Therefore, not only did magnetic shielding significantly increase the focality of the stimulation compared to no shielding, but changing the geometry also affected the focality. Since the shielding was isolated on a spherical head model, variation between trials was lowered, allowing the standard deviation to be very low in this experiment. Although variation in head anatomy in different patients affects the focality of each shield, it does not extremely alter the relative performance of each treatment (Wang et al., 2018). Other studies have investigated the effects of magnetic shielding on the focality and for the depth of the stimulation. For example, one investigation found magnetic shielding had a significant positive impact on the focality (Deng et al., 2013). In another paper, it was found that the V-shape shielding had higher focality than the parabola shielding, which was also seen in the results from this experiment (Rastogi, 2019). Furthermore, like one study found, the outer regions of the cerebral cortex like the dorsolateral prefrontal cortex did receive stronger stimulation than the deeper areas in this investigation (Wang et al., 2018). Although the findings of this experiment are similar to all the previous research, the results were closest to Rastogi's study because of the shielding geometries' relative performance (Rastogi, 2019). The results of this experiment can be explained by looking at the stimulated region from the E-field. Magnetic shielding works by redirecting magnetic fields away from what is below it, much like lightning rods redirect lightning. The hybrid flat-U likely performed the best due to the middle section, which was perpendicular to the magnetic field and was able to "capture" and redirect the most magnetic fields (Vinit et al., 2014). The curved edges allowed the field to concentrate into one region on the brain. Since the permeability and head shape was kept constant and this kind of shielding relies heavily on the ability to redirect fields, shielding shape played a crucial role in determining focality (Rastogi, 2019). Thus, there was a very significant difference between each of the tested geometries.

Some sources of error and improvements were identified for this investigation that can be addressed in the future. Although it is very unlikely, there could have been errors in the simulation software when computing the stimulation or when recording results. In future experiments, automating the data collection through the computer could allow many more trials with various shielding geometries. A machine learning program could be

utilized to find not only the best shape, but also optimized permeability, thickness, and other factors for magnetic shielding. Furthermore, using various head models and comparing relative performance between shield designs can also give more insight into how to adapt magnetic shielding for real patients. After research and experimentation, there are many possible areas for further research. For example, one study by Deng et al. points out the need to explore the effect of the complex structure of the brain and head on the electric field from TMS (Deng et al., 2013). With a better understanding of electric fields on the body, progress could be made for all types of magnetic stimulation, not just for brain stimulation. Furthermore, research into even more geometries and other parameters such as thickness and materials of the magnetic shielding can provide even more optimized shielding for TMS. Since a simulation was used in this experiment, shielded TMS in the laboratory setting would provide knowledge into how to implement the design in the real world. A large clinical study with actual patients would be needed before TMS shielding can become commonplace in regular therapy and revolutionize the face of modern nanomedicine.

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Appendix

Figure 1. Experimental Design Diagram

Title: The Effect of Magnetic Shielding Geometry on Focality for Transcranial Magnetic Stimulation

Hypothesis: If the hybrid shape is placed over the head model, then the stimulated region will be the most focused compared to the other shielding geometries.

IV: Geometry of Magnetic Shield (No shield, Parabola Shape, V-Shape, Hybrid, Flat-U Shape). 25 measurements 25 measurements 25 measurements 25 measurements

DV: Volume of Brain Stimulated (%)

Constants: simulation software (Sim4Life), coil shape (figure 8), shielding material (permalloy), the thickness of shield (1 mm), the distance of shield from the scalp (5 mm), relative permeability (70,000), head model (spherical), computer hardware

Figure 2. SolidWorks Designing Hybrid geometry as designed in SolidWorks CAD program

Figure 3. Sim4Life Simulation V-Shape geometry being used over the spherical head model in the simulation program

Figure 4. MATLAB Post-processing Code used to find the percent stimulated from the raw file from Sim4Life

Figure 5. Optimizing Shielding Optimized hybrid shielding as used on a real brain model

BEST OF SYMPOSIUM ALTERNATES

Shrinidhi Kittur; Todd Allen Phillips Center for Medical Sciences at Godwin High School
The Activation of Somatostatin Interneurons Adjacent to a Cortical Malformation

Abstract

Malformations during cortical development (MCDs) account for a third of childhood epilepsy patients. The increased c-Fos expression during the resulting seizures can allow for immunohistochemical identification of the protein and thus, neuronal activity in different types of cortical neurons can be studied; Somatostatin, an inhibitory interneuron, was hypothesized to show the most activity. To mimic MCDs in experimental groups, freeze lesions were given to mice expressing fluorescent proteins in cells with active c-Fos while “sham” lesions were given to control groups. The brain slices were immunohistochemically stained for different proteins, and the colocalization, or overlap, of the cFos protein was studied. It was found that cFos had high colocalization percentages of 94.45% and 98.20% with NeuN, marking neurons, and 97.62% and 94.28% with GAD, marking inhibitory interneurons; a t-test confirmed there was no statistical difference between cFos and GAD/NeuN positive cells, implying that the initiator was neuronal and inhibitory. When Somatostatin and another inhibitory neuron, Parvalbumin, were stained for, it was revealed that Somatostatin did indeed have a higher colocalization percentage with cFos: 88.32% of cFos in the microgyral region and 84.64% of cFos in the paramicrogyral region. A T-test confirmed the statistical significance of the data. Therefore, Somatostatin interneurons are activated at higher levels during a seizure, and can be regarded as the initiators of malformation-associated seizures, supporting the hypothesis. The implications of this study can be profound; Somatostatin-expressing cells can now be targeted by anti-epileptic medications in future studies to lessen the burden of epilepsy in patients.

Introduction

Epilepsy is a disease of the brain that predisposes a patient to recurrent unprovoked seizures and is diagnosed where an acute brain disturbance cannot be identified as the cause of seizure. One-third of epilepsy patients, especially children, are diagnosed with refractory epilepsy, where seizures are not well controlled under available medications (Lava, 2019). It is estimated that up to 40% of these cases of intractable childhood epilepsies are due to malformations during cortical development (MCDs), which result from errors and lesions during the development of the brain's cortex (Barkovich et al., 2012; Guerrini & Dobyns, 2014). MCDs and the severe seizures that characterize these developmental abnormalities consequently present a severe burden for patients, families, and society. The economic impact of epilepsy can be significant: out-of-pocket costs and productivity losses can create substantial burdens on households. Therefore, simply studying and researching MCDs for possible cures will create a significant positive change in patients' lives. To model these cortical malformations in the experimental group, a neonatal freeze-lesion (FL) was made, where the cells of the deeper cortical layers were killed, causing the developing upper layers to form a concave groove called a sulcus, mimicking a MCD. Freeze lesions have been shown to cause in vitro cortical hyperexcitability, much like the resulting seizures from a real developmental abnormality (Patrick et al., 2006). This hyperexcitability leads to an increased expression of the proto-oncogene C-fos, a gene that is expressed within neurons after depolarization; the resulting transcribed protein serves as a marker for neuronal activity following epileptic activity (Bullitt, 1990). The C-fos protein is also easily identifiable by immunohistochemical means.

Immunohistochemistry is a lab procedure involving the use of antibodies that bind to specific proteins, and are usually tagged with fluorescent markers that fluoresce under certain wavelengths of light. This allows for the visualization and colocalization of the tagged proteins under a microscope. One such immunohistochemical antibody is for the protein NeuN, a cortical neuron marker that binds to proteins present in all cortical neurons (Guselnikova and Korzhevskiy, 2015). GAD67 is a similar biomarker that identifies GABAergic inhibitory interneurons, a specific subtype of cortical neurons that releases the inhibitory neurotransmitter, GABA (Fong et al., 2005). Parvalbumin (PV) and Somatostatin (SS) are other common protein-antibody pairs that are expressed in specific types of inhibitory interneurons. The main objective of this project is to study which type of cortical cells act as the initiators of these malformation-associated seizures; these cells can be targeted by anti-epileptic medications in future studies. By observing the colocalization of the neuronal activity marker, c-Fos, in the different types of cortical cells, the neuronal subtype or subtypes that the seizures are initiated and can be also directly studied. The colocalization of cFos with other markers was studied in two areas of the brain to compare their activity: the microgyral region (MG), the area directly adjacent to the sulcus, and the paramicrogyral region (PMR), the area surrounding the sulcus. Based on previous studies conducted, the above-mentioned Somatostatin-expressing neurons appear to be activated at higher levels in the epileptiform malformed cortex as opposed to the controls (George and Jacobs, 2010). Therefore, it is hypothesized that SS acts as the initiator of seizures within the microgyral brain.

Methods and Materials

To test this hypothesis, transgenic mice that expressed green fluorescent proteins in cells with active c-Fos were utilized. In the experimental group, pups on Postnatal Day 1 (P1) were anesthetized via hypothermia. A coronal incision was made across the skin on the skull; a frozen copper probe cooled to -60°C with dry ice was placed on the surface of the skull over the somatosensory cortex for 5 seconds on each hemisphere. The pups were then sutured, warmed to normal body temperature, and returned to their home cage; they were weighed 5 days following surgery to ensure proper growth and recovery. For the control group, a “sham” lesion was made in an identical way, except that the probe was maintained at room temperature. Since evoked epileptiform activity occurs at high levels on P12 and after, their brains were examined between P12 and P18. Mice were anesthetized with isoflurane and underwent a cardiac perfusion with 4% paraformaldehyde (PFA) fixative. After decapitation, the brain was quickly excised and placed in 4% PFA in the refrigerator for 24 hours and then transferred to Phosphate Buffered Saline (PBS) of pH 7.4. The surgeries were performed solely by trained technicians and not the student, eliminating any safety concerns. The brains were sectioned at $80\ \mu\text{m}$ using a Leica VT1000S vibratome. Sections over the somatosensory cortex were collected.

First, the experimental brain slices were examined under a microscope for an increased number of cortical neurons that show c-Fos activation. If c-Fos expression was present, then immunohistochemical procedures were applied to determine the type of cells expressing c-Fos. Twenty-four brain slices were transferred into a 24 well plate, washed with PBS and Tris Buffered Saline (TBS), and blocked for 2 hours with Normal Horse Serum, to prevent non-specific binding. Primary antibodies—rabbit anti-SS14, Peninsula Laboratories T-4103 [1:1000], mouse anti-parv Sigma P3088 [1:2000]—were then applied to 12 slices and left overnight in the refrigerator on a shaker. In the remaining 12 brain slices, the primary antibody

Gad67 (mouse anti-GAD67, [1:1000]) was used. They were rinsed and incubated in the secondary antibodies—Alexa Fluor 568 goat anti-rabbit [1:200], Alexa Fluor 405 goat anti-mouse [1:150] and mouse anti-NeuN-555 (millipore MAB377A5 [1:500])—for 3 hours at room temperature on a shaker. The slices were then rinsed with TBS to remove the extra non-bound secondary antibodies, mounted on microscope slides, and analyzed under a microscope. A Zeiss Scope.A1 standard fluorescent microscope was used to obtain the qualitative results. Fiji image J software, an image processing software specifically geared towards neuroscience, was used to obtain quantitative counts of the colocalization of cells that stained for c-Fos and the other immunohistochemical markers between the experimental and control groups. A standard T-Test was used to determine the statistical significance of the data. Safety precautions were also taken during the project to prevent any dangers. Isoflurane, paraformaldehyde fixative, alcohol, and the scalpel were only used by trained staff who were aware of the risks posed and took the necessary steps to increase their safety. However, the student did use the immunohistochemical stains, the vibratome, and PBS solutions. To minimize risks, the student wore a lab coat and gloves at all times while handling these substances. The student had also been formally trained by staff to operate the vibratome, was aware of the risks posed, and operated the device with caution, adhering to all the rules. The lab personnel involved, including the student, also refrained from ingesting or inhaling any chemical agents. Any excess isoflurane vapors were filtered by a fume hood to prevent accidental human exposure, and the isoflurane container was scavenged in a charcoal canister to absorb excess vapors. The used PFA and 70% alcohol were disposed of according to guidelines by trained personnel. The PBS solutions were poured down the drain, since they can be classified as BSL-1 and were not of environmental concern. The animal carcasses were taken to the biohazard freezer and disposed of by trained personnel. 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.

Results

Graph 1: Bar Graph of the average % colocalization between cFos and either SS or PV in both the MG and PMR regions of the sham and freeze lesion slices

Graph 2: Bar Graph of the average % colocalization between cFos and either GAD or NeuN in both the MG and PMR regions of the sham and freeze lesion slices

Table 1. Statistical Data for the Significance of the Colocalization of cFos with GAD/NeuN

Descriptive statistics Cell counts (PMR) of cFos and GAD/NeuN

cFos cFos + NeuN cFos + GAD Mean

Range _{Maximum} Minimum

Variance Standard deviation

1 SD 2 SD 3 SD

Number

109.3

16 ₁₁₈ 102

43.55

6.60 102.7 - 115.9 96.1 - 122.5 89.5 - 129.1

3

108

14₁₁₆ 102

34.67

5.89 102.11 - 113.89 96.22 - 119.78 90.33 - 125.67

3

103.3

21₁₁₅ 94_{76.22}

8.73 94.57 - 112.03 85.84 - 120.76 77.11 - 129.49

3

Results of t-test cFos vs cFos + NeuN $t = 0.21$ $p > 0.01$ cFos vs cFos + GAD

$t = 0.78$ $p > 0.01$ At $df = 7$; $\alpha = 0.01$; $t = 3.4991$ for significance

Table 2. Statistical Data for the Significance of the Colocalization of cFos with SS/PV

Descriptive statistics % Colocalization (MG + PMR) between cFos and SS/PV in the

experimental (freeze lesion) group SS PV Mean

Range_{Maximum} Minimum

Variance

Standard deviation

1 SD 2 SD 3 SD

Number

86.48

5.34 83.89 89.23

4.87

2.21 84.27 - 88.69 82.06 - 90.90 79.85 - 93.11

6

11.34

4.33 13.56 9.23

3.18

1.78 9.56 - 13.12 7.78 - 14.90 6.00 - 16.68

6

Results of t-test SS vs PV $t = 64.95$ $p < 0.01$ At $df = 10$; $\alpha = 0.01$; $t = 3.17$ for significance

The percent colocalization between cFos and the other immunohistochemical markers stained for and the results of the statistical analysis are shown in Graphs 1 through 2 and Tables 1

through 2. A research hypothesis was formulated that Somatostatin, an inhibitory interneuron, was the main initiator of seizures, and contained the highest percentage of colocalized cFos.

This

average percentage was determined by dividing the number of cells positive for both cFos and another marker by the cells only positive for cFos. According to Graph 1, the % colocalization for cFos and SS in the freeze lesion slices in the MG was 88.32%, and 84.64% in the PMR.

Similarly, the average % colocalization for cFos and PV in the freeze lesion slices in the MG was 9.92%, and 12.76% in the PMR. In the control sham slices, the % colocalization was 0 for both SS and PV in both regions due to the lack of an MCD; relatively little neuronal activity was

occurring, and thus, little cFos was being produced. These data values support the hypothesis that Somatostatin, an inhibitory interneuron, does indeed contain the highest colocalization of cFos compared to its counterpart, PV. Additionally, the hypothesis is further supported by the data in Graph 2, with the average colocalization between cFos and the inhibitory neuron marker, GAD, in freeze and sham lesion slices being 95.84% and 95.95% respectively; the average colocalization between cFos and the neuronal biomarker, NeuN, respectively in freeze and sham slices is 94.45% and 98.20%. Since GAD stains for inhibitory proteins and NeuN for all neurons, Somatostatin would be included in this stain. A high colocalization percentage of cFos with GAD and NeuN also indicates a high colocalization percentage with SS. It is also important that the MG had considerably fewer numbers of active c-Fos and thus, fewer neuronal activity: the GAD/NeuN freeze lesion slices had an average of 54.67 cFos positive cells in the MG compared to 109.33 cFos positive cells in the PMR.

The variance and standard deviation were also calculated; according to Tables 1 and 2, the standard deviation was relatively low for each of the markers stained for in both the MG and

PMR regions. This implies that the data sets were tight and precise. None of the data points were

outside the SD 2 range, implying that there were no outliers. Two T-tests were performed to determine the statistical significance of the acquired data. One was conducted at a level of significance of 0.01 with 7 degrees of freedom to test the significance of the cFos with GAD and cFos with NeuN colocalization percentages. The null hypothesis was that there would be no statistically significant difference in the number of cells positive for cFos and either GAD or NeuN. According to Table 1, for cFos versus cFos + GAD, the calculated t value, 0.78, was significantly lower than the table t value, 3.499; this means that the null hypothesis is not rejected and there truly is no statistically significant difference between cFos positive and GAD positive cells. Similarly, for cFos versus cFos + NeuN, the calculated t value, 0.21, was significantly lower than the table t value of 3.499; again, this implies that the null hypothesis is not rejected, and there is no difference between cFos positive and NeuN positive cells. The probability of the results being due to chance is lower than 0.01 and implies that the results of this part of the experiment are most likely due to the immunohistochemical marker being stained for. This t-test serves to support the theory that the neuronal subtype responsible for initiating malformation-associated seizures is neuronal and inhibitory in nature.

Another was performed to test the significance of the SS colocalization percentages compared to PV at a level of significance of 0.01 with the degrees of freedom of 10, as presented in Table 2. The null hypothesis was that there would be no significant difference in the average % colocalization of cFos with SS and cFos with PV in the freeze lesioned slices. The calculated t value, 64.95, was significantly higher than the table t-value of 3.17. This implies that the null hypothesis should be rejected, and there is an extremely significant difference between the previously stated comparisons. The probability of the results being due to chance is lower than 0.01 and implies that the results of this part of the experiment are most likely due to the immunohistochemical marker being stained for. This implies that there is a considerable amount of cFos produced within Somatostatin interneurons and that Somatostatin indeed are the “initiators of seizures” within the cortical brain.

Conclusion

The main objective of this project was to study which type of cortical cells act as the initiators of these malformation-associated seizures. By observing the colocalization of the neuronal activity marker, c-Fos, in the different types of cortical cells, the neuronal subtype or subtypes that the seizures are initiated in were directly studied. A research hypothesis was formulated that somatostatin inhibitory interneurons act as the initiators of seizures within the microgyral brain and contain the highest percentage of colocalized cFos.

It was found that cFos had high colocalization percentages, in the MG and PMR respectively, of 94.45% and 98.20% with NeuN, marking neurons, and colocalization percentages of 97.62% and 94.28% with GAD, marking inhibitory interneurons; a t-test confirmed there was no statistical difference between the number of cells positive for cFos and the number of cells positive for GAD/NeuN. This implies that the neuronal subtype responsible for initiating the malformation-associated seizures is neuronal and inhibitory in nature. When Somatostatin and another inhibitory neuron, Parvalbumin, were stained for, it was revealed that Somatostatin did indeed have a higher colocalization percentage with cFos: 88.32% of cFos in the microgyral region and 84.64% of cFos in the paramicrogyral region, compared to the colocalization percentages of cFos with PV of 9.42% and 12.76%. A T-test confirmed the statistical significance of the data. Therefore, the formulated hypothesis was supported; somatostatin interneurons are activated at higher levels during a seizure and are regarded as the initiators of malformation-associated seizures. The implications of this study are far reaching; Somatostatin-expressing neurons can now be directly targeted by anti-epileptic medications to lessen the burden of epilepsy in patients.

However, there were sources of errors that occurred while conducting the experiment that affected the results. First, the slices were not analyzed until a month after staining, and some of the transgenic cFos fluorescence faded away. The slices were also cut relatively thick, exposing background cells from other layers. The experiment could have been improved by cutting thinner slices so fewer cells appeared out of focus in the frame, and capturing images via a confocal microscope to limit the z-direction field and obtain a more even illumination. The slices could have also been imaged within 2 weeks of sectioning of the tissue to reduce fading. Nevertheless, the findings support previous studies done on Somatostatin interneurons that also reported increased activity during seizures (George and Jacobs, 2010). Similarly, researchers have published about the increased expression of cFos by GABAergic interneurons after repeated stimulation (Maloney et al., 2000). Previous studies have also reported similar findings to this study on the expression of cFos by neurons containing the NeuN antibody during epileptic episodes (Su et al., 2009). For future studies, the exact biomolecular pathway to how Somatostatin plays a role in initiating seizures in the cortex and potential ways to subdue its activation should be investigated. Other neuronal subtypes, if any, that also play a role in seizure initiation should also be studied. It is also important that the MG had considerably fewer numbers of active c-Fos and thus, fewer neuronal activity; it is beneficial to future studies aiming to develop anti-epileptic medications to target the paramicrogyral region, where higher numbers of cells express cFos and are active.

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Appendix

Experimental Design Diagram

The Activation of Somatostatin Inhibitory Interneurons adjacent to a Cortical Malformation

Somatostatin inhibitory interneurons act as the initiators of seizures within the microgyral brain and

contain the highest percentage of colocalized cFos.

Independent variable: Cortical biomarker proteins stained for SS and PV GAD and NeuN

Sham lesion Freeze lesion Sham lesion Freeze lesion

MG PMR MG PMR MG PMR MG PMR

Number of slices used

3 3 3 3 3 3 3

Dependent Variable: % colocalization of cFos with other proteins in different neuronal subtypes

Constants: software and equipment used to measure colocalization, immunohistochemical stains and procedures used, animal conditions and diet, perfusion/surgical procedures

Caroline Klotz; Clover Hill High School

The Effect of Quicklime Concentration on the Swelling Potential of Expansive Soils

Abstract

The purpose of this experiment was to determine which concentration of quicklime would yield the greatest reduction in swelling potential of soil types: MH, an elastic silt of high plasticity, CL, a silty clay of medium plasticity, and CH, a sandy clay of medium plasticity.

In-situ expansive soils are extremely hazardous to buildings and other structures, and frequently cause cracks or collapses, due to excess movement in the foundation. Through soil modification by lime treatment, the swelling potential of expansive soils can be reduced; thus, it ensures a safe and stable soil foundation for construction sites. The hypothesis was: If MH, CL, and CH clays were treated with 0%, 2%, and 4% concentrations of quicklime, the clays mixed with the 4% lime would yield the greatest reduction in swelling potential of the expansive clays. The lime concentrations: 0%, 2%, and 4%, were added to soil types: MH, CL, and CH. After the lime treatment was given 24 hours to set, the Swelling Potential Test was conducted. The Swelling

Potential Test consisted of: placing a controlled amount of soil into 10 graduated cylinders, adding water, and leaving the soil to absorb the water overnight. The swelling potential was measured by calculating the percent increase from the original soil volume to the volume after the water addition. The mean swelling potential for the MH 0% lime was 18.8 (percent change in volume), 12.6 for 2%, and 11.2 for the 4%. The mean for the CL 0% lime was 17.1 (percent change in volume), 12.6 for 2%, and 6.6 for 4%. The mean for the CH 0% lime was 14.3 (percent change in volume), 13.7 for 2%, and 11.2 for 4%. As the lime concentration increased, the swelling potential for the MH and CL soil types decreased significantly. Although the CH 2% and 4% lime groups yielded an insignificant reduction in swelling potential. The soils with 4% lime concentration yielded the greatest reduction in swelling potential.

Introduction

Weak supporting soils are the leading cause of structural failure, due to excessive movement of the walls and foundation (United States Department of Agriculture, 2019). A sturdy, compact soil can safely support a building, but a weak soil can endanger the safety and integrity of various structures, in some cases causing the structure to crack or collapse (Emarah & Seleen, 2018). Furthermore, clays have a higher risk of instability due to their high swelling potential, the percentage of swelling of the soil under a given moisture content. Soil types with a high swelling potential are characterized as expansive soils, due to their frequent tendency to expand with different moisture contents (Baldovino, Izzo & Moreira, 2019). In-situ soils with a high swelling potential can cause severe damage to civil engineering constructions, and should be treated before commencing construction, in order to achieve the desired properties of the soils (Ikeagwuani & Nwonu, 2019). Geotechnical professionals often seek out soil modification as a method of reforming these hazardous soil properties, instead of using costly measures such as removal and replacement of the soil (Muhmed & Watatowski, 2013). Lime treatment, a subset of soil modification, allows for increased workability, reduced swelling, and increased strength of the soil (Jiru & Zing, 2002). In addition, as the most drastic and effective form of soil modification, lime treatment has become a reliable, cost-efficient, and environmentally conscious alternative to removing and replacing in-situ soils (Production Division Office of Geotechnical Engineering, 2008). During lime treatment, the soil undergoes two reactions. The first reaction, known as the flocculation and agglomeration process, is an exothermic reaction, which involves the process of ion exchange, enhancing the flocculation of the clay minerals. This reaction directly influences the physical composition of the clay by heating the soil, allowing for a reduction in plasticity, swelling potential, and moisture content, but an increase in overall cohesivity (Reinhardt, 2019). The second reaction is a pozzolanic reaction, the reaction between the aluminates and silicates in the clays and the calcium silicate hydrates in the quicklime. This reaction affects the soil chemically, forming stronger bonds between the minerals and making the soil less susceptible to future moisture changes (Wang, Kong & Zhao, 2012). The following soil types were chosen for the experiment: MH, an elastic silt of high plasticity, CH, a sandy clay of medium plasticity, and CL, a silty clay of medium plasticity. The chosen soil types represented expansive soils on a spectrum of low to high plasticity clays. Plasticity is the tendency to act or have qualities of a plastic and degrades the strength and stability of a soil. Through using a variety of expansive soil types, the experiment was designed to determine which expansive soil types are responsive to the lime treatment and to what extent the lime treatment would be effective. A scientific study was conducted to observe the effect of lime on the swelling pressure of compacted expansive soils. Specifically, the experiment was designed to determine which

concentration of lime would yield the soil with the lowest swelling pressure. Swelling pressure, the pressure which the soil exerts when it is not allowed to swell, is connected to the soil's swelling potential, in that high measurements of both contribute to the instability of the soil settlement. The experiment concluded that the lime treatment reduced the soil's sensitivity to changes in moisture content and the overall plasticity. However, there was not a significant difference between the different concentrations of lime (Kechouane and Nechnech, 2015). In another study, the effect of lime treatment on the microstructure and hydraulic conductivity of Hericourt clay was studied. Hydraulic conductivity is the ease by which a soil moves with a fluid through pores. Hydraulic conductivity counteracts the swelling of soils because it focuses on the clay binding and transitioning into a liquid instead of absorbing a liquid. The results determined that the lime modification gave an increase of hydraulic conductivity of the lime-treated soils, therefore, decreasing the swelling potential (Tran, Tang, and Cui, 2014). Current studies lack research on the different lime concentrations in lime treatment and their effect on the swelling potential of expansive clays. The experiment was designed to study how lime treatment can be made more effective, as a method to proactively reform weak soil types and, subsequently, prevent structural failures. Knowing the exact concentration of lime needed for lime modification will benefit geotechnical and construction companies by providing a quantitative value to modify in-situ soils; therefore enhancing the strength and reducing the swelling potential of various soils. The purpose of this experiment was to determine which concentration of quicklime would yield the greatest reduction in swelling potential of soil types: MH, CL, and CH. The hypothesis was: If MH, CL, and CH soil types were treated with 0%, 2%, and 4% concentrations of quicklime, the clays mixed with the 4% lime would yield the greatest reduction in swelling potential. The null hypothesis said that the percentage of quicklime would not affect the swelling potential of expansive clays.

Methods and Materials

The independent variable was the percentage of quicklime concentration and the secondary independent variable was the soil type. The levels of the quicklime included: 0%, 2%, and 4%, and the levels of the soil type were: CL, a silty clay of medium plasticity, CH, a sandy clay of medium plasticity, and MH, an elastic silt of high plasticity. The 0% lime was used as the control in lime concentration. However, there was no control for the soil type. There were 10 repeated trials for the experiment. The dependent variable was the swelling potential of the expansive clays, which was measured by calculating the percentage of increase in the clay's volume after the addition of water, using a graduated cylinder. The constants included: the volume of soil placed in the graduated cylinder (35mL), the type of graduated cylinder (100 mL), the product of Quicklime, the method for testing for swelling potential, the volume of water, the time for modification of the soil, and the particle distribution (which was achieved by putting the soils through a sieve). The materials that were used include: quicklime, a metal trowel, a spray bottle, a metal bowl, large soil sieve, 9 clear containers, 10 graduated cylinders, a beaker, a food scale, a hammer, a tarp, a sharpie, and the soil types (CL, CH, MH). Before the experiment, the soils were sufficiently dried, in preparation for the swelling potential test. First, a tarp was laid out, and each soil type was shoveled onto a tarp to dry overnight. The next day, the soils were placed back into their original containers, and three plastic containers were labeled as follows: MH (0%), CL(0%), and CH (0%). A small sample from each soil type was placed into the containers with the corresponding label. Then, each individual sample was transferred to a metal bowl to break apart the large clumps of soil, using a hammer. The samples were then

placed through a soil sieve to maintain a constant physical composition. After each of the samples reached a similar composition, preparation for the Swelling Potential Test of the 0% lime soils was commenced. First, the 10 graduated cylinders were labeled MH (0%), with a sharpie and masking tape. Next, the graduated cylinders were filled with the MH soil type to the 35 mL mark, and the excess soil was transferred back into the original container. Then, 40 mL of water was added to the graduated cylinders. The soil was left for 24 hours to absorb the water. The following day, the volume of the soil was determined and recorded in a notebook. This process was repeated for the CH and CL soil samples, and the graduated cylinders were cleaned between the testing of each soil type. After the controlled soils were tested, the lime addition process began. Two plastic containers were labeled as follows: MH (2%) and MH (4%). The weight of the container was recorded, which was later subtracted from the overall weight. Then, a sample of the MH soil was placed into each of the containers, and the mass of the soil was weighed and recorded using a food scale. The recorded mass was then multiplied by the percentage corresponding on the container to determine the amount of lime. Using a food scale, the quicklime powder was scooped into a beaker until it reached the calculated mass, and was poured into the corresponding containers. Immediately after the lime was added, the soil was sprayed with water, using a spray bottle, and mixed with a metal trowel until incorporated. The mixture was then left overnight to set. The lime addition process was then repeated for the 4% ML sample, and then repeated for the 2% and 4% groups of the remaining soil types. After the lime addition process was repeated for all soil types, the Swelling Potential Test of the un-controlled soil types were commenced. The Swelling Potential Test of the un-controlled soil types followed the same procedure as the Swelling Potential Test of the controlled soil types. Then, the percent increase was calculated by subtracting the original volume (35 mL) from the current volume of the soil and dividing that by the original volume. The quotient was then multiplied by 100 to achieve the swelling potential of each soil. Goggles and gloves were worn as a safety precaution during the handling of the quicklime, to prevent contact with the chemical and possible corrosion. The mean, range, standard deviation, and variances were recorded in a table, and the mean was presented in a bar graph. An ANOVA test was performed to determine the significance of the data.

Results

The independent variables in this experiment included soil type and concentration of quicklime. The dependent variable was the swelling potential, measured by the percent change in volume (mL) after water addition. The mean was taken as a measure of central tendency. The mean for the MH 0% lime soil was 18.8 (percent change in volume), 12.6 for 2%, and 11.2 for the 4%. The mean for the CL 0% lime was 17.1 (percent change in volume), 12.6 for 2%, and 6.6 for 4%. The mean for the CH 0% lime was 14.3 (percent change in volume), 13.7 for 2%, and 11.2 for 4%. As displayed in Table 1 and Graph A, the swelling potential experienced a downward trend as the lime concentration increased among the various soil types. The Standard Deviations for the CH soil types were: 2.40 for 0% lime, 1.41 for 2%, and 0.84 for 4%. The Standard Deviations for the CL soil types were: 1.50 for 0% lime, 1.18 for 2%, and 1.52 for 4%. The Standard Deviations for the CH soil types were: 0.70 for 0% lime, 1.30 for 2%, and 1.60 for 4%. The variances for the MH soil types were: 5.9 for 0% lime, 1.3 for 2%, and 0.7 for 4%. The variances for CL soil types were: 2.4 for 0% lime, 1.4 for 2%, and 2.3 for 4%. The variances for CH soil types were: 0.5 for 0%lime, 1.7 for 2%, and 2.7 for 4%. Table 1 shows that the variances and standard deviations were

generally very low. The null hypothesis of no significant difference was tested using an ANOVA: Two Factor Test, with 0.05 level of significance. As displayed in Table 2, the F-critical value was greater than the F-value.

Table 1: The Effect of Lime Concentration on the Swelling Potential of Expansive Soils

Soil Type	MH			CL			CH			
Percent Change in Volume	lime concentration	0%	2%	4%	0%	2%	4%	0%	2%	4%
Mean	18.8	12.6	11.2	17.1	12.6	6.6	14.3	13.7	11.2	
Range	6.5	3.5	2.6	5.1	3.1	3.7	1.7	3.1	3.8	
Variance	5.9	1.3	0.7	2.4	1.4	2.3	0.5	1.7	2.7	
Standard Deviation	2.4	1.14	0.84	1.5	1.18	1.52	0.7	1.3	1.6	
Soil Type Description of Soil Properties										
MH	Elastic Silt of high plasticity, with 76% fines									
CL	Silty Clay of a medium plasticity, with 76.2% fines									
CH	Sandy Clay of a medium plasticity, with 67% fines									

Graph A: The Effect of Lime Concentration on the Swelling Potential of Expansive Soils

Table 2: Inferential Statistics

ANOVA	Source of Variation	SS	df	MS	F	P-value	F crit
Sample	65.77089	2	32.88544	15.61567	1.84E-06	3.109311	
Columns	754.9176	2	377.4588	179.2365	1.8E-30	3.109311	
Interaction	183.4844	4	45.87111	21.78192	3.14E-12	2.484441	
Within	170.58	81	2.105926				
Total	1174.753	89					

Discussions and Conclusions

The purpose of this experiment was to determine which concentration of quicklime would yield the greatest reduction in swelling potential of soil types: MH, CL, and CH. The swelling potential was tested by measuring the percent increase in volume, after 40 mL of water was added to the soils and left overnight to be absorbed. As the quicklime concentration increased, the swelling potential decreased. The soils with 4% lime concentration resulted in the lowest swelling potential, compared to the 0% and 2% lime soil groups. The MH and CL soil types experienced a significant decline in swelling potential when treated with the 2% and 4% lime, while the CH soil types had only a slight reduction in swelling potential. For example, the MH 0% lime (control group) had a swelling potential of 18.8%, which decreased by 6.2% with the 2% lime treatment, and by 7.6% with the 4% lime treatment. Similarly, the CL soil types reduced by 4.5% with the 2% lime treatment, and by 10.5% with the 4% lime treatment. However, the CH soil type only reduced by 0.6% with the 2% lime treatment, and by 3.1% with the 4% lime treatment. Although the CH soil type had the lowest overall swelling potential, it was not significantly affected by the lime additions. The variances and standard deviations were low, indicating that the data was reliable (Table 1). The calculated F value was 32.9, and the critical value was 3.1; therefore, the null hypothesis was rejected (Table 2). The hypothesis was: If CL, CH, and MH clays were treated with 0%, 2%, and 4% concentrations of quicklime, the soils mixed with the

4% lime would yield the greatest reduction in swelling potential of the expansive clays. The hypothesis was supported because the 4% lime treatment allowed for a greater volume of the soil sample to be modified and dried, therefore producing a more significant reduction in swelling potential than the 0% and 2% lime treatments. A similar experiment was conducted to observe the effect of lime on the swelling pressure of compacted expansive soils. Similar to swelling potential, swelling pressure is an indicator of poor soils with a high shrink/swell tendency and an unstable settlement. The experiment concluded that lime modification reduced the swelling pressure and the soil's sensitivity to moisture changes. However, the results also concluded that there was not a significant difference between concentrations (Kechouane and Nechnech, 2015). To achieve improved soil composition and workability under lime treatment, expansive soils undergo either drying or modification. While drying only requires 1-2% lime, modification requires a range of 3-6% lime, although many geotechnical professionals discourage lime concentrations of 5% and above for modification (4-10% lime is recommended for soil stabilization, which does not affect swelling properties). This experiment determined that soil modification (4% lime) yields the most desirable soil composition from expansive soils, due to the unique chemical reactions that take place. During soil drying, the quicklime hydrates after chemically combining with water, and it releases heat, subsequently, drying the soil through evaporation. Although soil drying reduces the soil's moisture content, it does not improve the chemical properties of the soil. Soil modification involves a reaction where the calcium ions from the quicklime migrate to the surface of the clay particles and displace the water and ions, creating a more granular and cohesive structure. Through this process, called Flocculation and Agglomeration, the plasticity index is decreased, as well as the tendency for the soil to shrink and swell. In addition, soil modification specifically benefits soil types with a higher percentage of clay particles and a high plasticity. For example, the MH and the CL soil types had 76% and 76.2% clay fines, which resulted in the MH and CL achieving a greater reduction in swelling potential than the CH soil types. The calcium ions in the quicklime only reacted with clay minerals, so the Flocculation and Agglomeration process has a greater effect with an increased amount of clay fines (National Lime Association, 2004). Error in this experiment may have resulted from the thickness of the soil and the starting moisture content of the soils, for each soil started at its optimum moisture content but might have dried out over the time span of the experiment. An improvement for this experiment would be to include testing for 6% and 8% lime concentrations, to see if the lime concentrations above 4% might have an inverse effect on swelling potential. In addition, a greater variation of expansive soils should be tested, including SC, a clayey sand, and SM, a sandy clay.

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VAS Mentorship Program

Last year the Virginia Academy of Science launched a new outreach effort in which mentors recruited from the Commonwealth's colleges, universities, and research centers worked long-term with students in high school classrooms on a research project of local interest. We paired 6 mentors with middle and high school classrooms in our inaugural effort which was cut short by the COVID-19 pandemic.

For 2020-21, there will be a strong need for supporting K-12 classrooms across the Commonwealth that will be suffering from uncertainty about the ability to meet in person and to work on science projects. To that end, we are looking to recruit both mentors (grad students, postdocs, instructors, scientists, etc.) and high school teachers who would like their students to participate in a virtually-driven long-term research project. To do this, we would like to offer high school instructors the opportunity to either do a project of local interest or to participate in a "Citizen Science" type initiative in which their class will work with others across the Commonwealth and (sometimes) the nation in the collection and analysis of data. I am excited for this model since it should allow a greater level of participation with geography and distance not being limiting factors.

If you might be interested in serving as a mentor in this project, please fill out the form found at:

<https://secure4.hsc.edu/forms/view.php?id=117158>

If you are a high school teacher with an interest in having a mentor work with your class, please fill out the form found at:

<https://secure4.hsc.edu/forms/view.php?id=116443>