The Virginia Junior Academy of Science
of the Virginia Academy of Science

Wishes to Express Its Appreciation To:

American Association for the Advancement of Science
  Arlington County Schools
  Bethel High School
Botany Section, Virginia Academy of Science
  Dominion Virginia Power
  Dr. and Mrs. Preston H. Leake
Friends of the Virginia Museum of Natural History
  Hampton University
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  Old Dominion University
  Randolph-Macon College
Randolph-Macon Woman’s College
Richmond Area Speleological Society
State Public Education Committee of the American Cancer Society
  The Allan T. Gwathmey Fund
  The Family of Ann M. Hancock
The Phil Robinson Virginia Naturally 5K Run
Tidewater Section of the American Society of Naval Engineers
  Virginia Academy of Science
  Virginia Association of Biological Education
  Virginia Association of Science Teachers
  Virginia Commonwealth University
Virginia Chapter of the National Foundation of Infectious Diseases
  Virginia Environmental Business Council
  Virginia Environmental Endowment
  Virginia Sea Grant College Program
  VPI & SU Chapter of Gamma Sigma Delta
  Virginia Wesleyan College

For the Financial and Personal Assistance

Which Make Possible These Activities
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## Winning Papers and Abstracts

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Of the 812 papers submitted, 514 papers were selected for presentation.

The number of papers selected by categories were as follows:

- Agriculture and Animal Science: 15
- Animal Behavior: 22
- Botany: 22
- Chemistry A: 17
- Chemistry B: 17
- Computer Science: 11
- Consumer Science A: 20
- Consumer Science B: 20
- Earth and Space Science: 14
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- Environmental Science A: 22
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- Physics: 19
- Psychology - General: 15
- Psychology - Learning and Perception A: 22
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- Psychology - Social: 22
- Statistics: 18
- Zoology: 20

Selected papers from each category were presented to Senior Academy Sections.
VIRGINIA JUNIOR ACADEMY OF SCIENCE COMMITTEE 2008-2009

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Lori Andersen, Gloucester County Schools, Gloucester, VA
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Joyce Corriere, Hampton High School, Hampton, VA
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Kathleen Frame, Biotechnology Institute, Arlington, VA
Pamela Gentry, Alee High School, Mechanicsville, VA
David Hagan, Science Museum of Virginia, Richmond, VA
Debra Hydorn, University of Mary Washington, Fredericksburg, VA
Leonard Klein, Waynesboro, VA
Paula Klonowski, VA Dept. of Education, Richmond, VA
John Kowalski, Roanoke Valley Governor’s School, Roanoke, VA
Richard Krieg, VCU/MCV, Richmond, VA
Charles LaRocca, James River High School, Richmond, VA
Chuck Layne, Averett University, Glen Allen, VA
Preston H. Leake, Retired, Hopewell, VA
Michael Lovrencic, Yorktown High School, Arlington, VA
Kurt Michael, Shenandoah Valley Governor’s School, Fishersville, VA
George Minson, Appomattox governor’s School, Petersburg, VA
Judith Peatross, St. Anne’s-Belfield School, Charlottesville, VA
Dallas O. Pinion, Consultant, Dinwiddie, VA
Eric M. Rhoades, Stafford County Public Schools, Stafford, VA
Kay Seliskar, Swanson Middle School, Arlington, VA
Sarah Ward-Petroske, Tidewater Community College, Norfolk, VA
Thomas Watson, New Kent High School, New Kent, VA
Barbara (Bobbie) Whittier, Retired, Arlington, VA
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SPECIAL AWARDS

Botany Section Award, given by the Botany Section of the VAS, for the best paper on a botanical subject.

MADHURA V. CHITNAVIS
Roanoke Valley Governor's School

Richmond Area Speleological Society Award for outstanding research addressing karst or topics related to speleology.

HANA-MAY EADEH
George H. Moody Middle School

Mathematics Award for the paper that evidences the most significant contribution in the field of mathematics.

SOHINI SENGUPTA
Ocean Lakes High School

Statistics Award for the paper that evidences the most significant contribution in the field of Statistics

KATHERINE C. LARSON
Mills E. Godwin High School

Smith Shadomy Infectious Disease Award in honor and memory of Dr. Smith Shadomy given by the Virginia Chapter of the National Foundation of Infectious Diseases.

GREGORY THOMPSON
Central Virginia Governor's School

KATHERINE E. BAUMANN
George H. Moody Middle School

Roscoe Hughes Award for the best paper in the field of genetics.

CHELISSE PERRY
Chesapeake Bay Governor's School

Rodney C. Berry Chemistry Award for the paper that evidences the most significant contribution in the field of chemistry.

PRASANNA G. JOSHI
Mills E. Godwin High School
The Dr. and Mrs. Preston H. Leake Award in applied chemistry is given to the author of a research paper which best exemplifies how chemicals, chemical principles, or chemistry have been used, are used, or might be used to enhance or even to save life.

First Place

AMANDA K. RODGERS
Southwest Virginia Governor's School

Second Place

EMILY SPILLER
George H. Moody Middle School

Catesby Jones - Russell J. Rowlett Award for the best research paper of the year.

JOY LEE
Thomas Jefferson High School for Science and Technology

Virginia Sea Grant College Program Award is given by the Virginia Sea Grant College Program for outstanding marine or coastal research.

SETH THEUERKAUF
Chesapeake Bay Governor’s School

American Cancer Society Award is to recognize outstanding science papers related to cancer research.

First Place

PAUAN G. GUDIMETTA
Deep Run High School

Honorable Mention

AMANDA K. RODGERS
Southwest Virginia Governor's School

CONAN ZHAO
George H. Moody Middle School

The Gamma Sigma Delta Award is presented by the VPI & SU Chapter of the Honor Society of Agriculture in recognition of excellence in research dealing with application of new technologies and/or concepts in agriculture, forestry, or veterinary medicine.

TIAN ZHOU
Blacksburg High School
Dominion - W.W. Berry Award is given by Dominion Virginia Power in honor of Mr. W.W. Berry who was a past Chairman of the Board of Virginia Power and is presented to the best engineering paper.

Joy E. Lee  
Thomas Jefferson High School for Science and Technology

Joyce K. Peterson Award is presented for the outstanding paper by a middle school student.

Conan Zhao  
George H. Moody Middle School

The Ann M. Hancock Memorial Award is given to the best paper in genetics.

Carolyn Song  
Mills E. Godwin High School

The Dorothy S. Knowlton Award is given in her honor for the best Consumer Science paper.

Brittany Cook  
Southwest Virginia Governor's School

The VABE Award is given by the Virginia Association of Biological Educators to the best paper in the Zoology section.

Alexander Kim  
Thomas Jefferson High School for Science and Technology

The Virginia Museum of Natural History Award is given by the Friends of the Virginia Museum of Natural History in recognition of significant contribution in the study and interpretation of Virginia’s Natural Heritage.

Seth Theuerkauf  
Chesapeake Bay Governor’s School
AJAS - AAAS Delegates

These students will represent the VJAS at the next Annual Meeting of the American Association for the Advancement of Science (AAAS). Their papers were selected as the most outstanding research papers by high school juniors and younger students at the Annual Meeting of the Virginia Junior Academy of Science and will be presented by them before the American Junior Academy of Science at the AAAS meeting.

BRANDEN T. KATONA  
Mills E. Godwin High School

PRASANNA G. JOSHI  
Mills E. Godwin High School

AAAS Honorary Membership

PRAKRITI VERMA  
Grafton High School

TARA ADISHESAN  
Ramana Academy

VAS Honorary Membership

ELIZABETH GENTRY  
Atlee High School

The Bethel High School Scholarship

KATHERINE AGNEW  
Central Virginia Governor’s School

Henry MacKenzie Environmental Scholarship

SETH THEUERKAUF  
Chesapeake Bay Governor’s School

The Frances and Sydney Lewis Environmental Scholarship

ALEXANDER KIM  
Thomas Jefferson High School for Science and Technology
E.C.L. Miller Science Teacher of the Year Award is given to an outstanding science teacher.

MARAVIC MITCHELL
George H. Moody Middle School

VJAS Distinguished Service Award, the most prestigious award given by the VJAS, is presented to a person for exceptionally outstanding service to the VJAS.

PAM GENTRY
ANIMAL BEHAVIOR

FIRST PLACE

EFFECT OF CAFFEINE CONCENTRATION ON GREEN HYDRA RESPONSE TIMES

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Abstract: Caffeine is known to increase alertness and may also affect response times, a measure of learning ability, because it dampens the effects of a depressant called adenosine. Adenosine is a nucleoside that regulates lack of oxygen, restriction of blood supply, and inflammation. In excess, adenosine can lead to neural damage and cell death. Blockage of adenosine receptors can, therefore, be beneficial. However, whether caffeine actually increases learning ability is not known. The purpose of this experiment was to determine the effect of caffeine concentration on the response times of green hydra would decrease. The research hypothesis for the experiment was that if the caffeine concentration increased, then the response times of green hydra. The null hypothesis was that response times for different caffeine concentrations would not be significantly different. Green hydra contract when a burst of air bubbles are blown on them, but they stop when they “learn” that the bubbles are not harmful. Learning response times were measured by recording the number of times the green hydra took to not contract three times consecutively. Green hydra were kept in one of five concentrations of caffeine solution for 24 hours before testing for learning rate. Caffeine concentration had no statistically significant effect on green hydra response times. This result infers that caffeine has no effect on learning rate for simple animals, possibly because they do not secrete adenosine. For further study, long term effects and a wider range of caffeine concentrations could be investigated, and the animals should be analyzed for adenosine functionality.

Introduction: Every morning, people drink coffee to prepare themselves for the day. Coffee affects the body and mind because it contains caffeine. Caffeine blocks adenosine receptors in the brain. Studies have shown that caffeine can increase the firing of neurons, increasing alertness (Specterman et al., 2005). Caffeine may also affect response time, a measure of learning ability. Whether caffeine actually increases a person’s learning abilities and how it affects response times is not known. The effects of caffeine on brainless organisms, in relation to learning, are also not known.

Green hydra inhabit ponds, rivers, and lakes. They are among those organisms with nerve nets. Stimuli travel from the tentacles through the hydra nerve nets (Otto et al., 1981). If green hydra secrete adenosine, caffeine may block adenosine receptors in the nerve nets, affecting nerve nets and brains in similar ways. Does caffeine have an effect on the response times of green hydra? The purpose of this experiment was to determine the effect of caffeine concentration on the response times of green hydra.

Chlorohydra viridissima, green hydra are polyps of the phylum Cnidaria, class Hydrozoa, order Hydroidea, and family Hydridae (Hoare, 2002). Hydra are between one and four centimeters in length and have two cell layers separated by the mesoglea, a jellylike material. Hydra mouths are surrounded by tentacles and stinging cells (Otto et al., 1981).

Green hydra are carnivores that feed on freshwater organisms. They capture prey using nematocysts, round cells containing hollow coiled thread that is shot out at high speeds. Hydra use four different types of nematocysts. One type injects a poison into the prey, while another has thread that snaps in the bristles of the prey. A third type is defensive and is shot at predators. The fourth type of nematocyst anchors the tentacles when the hydra moves (Hoare, 2002). Located in the mesoglea, hydra nerve nets conduct impulses in all directions. A stimulus applied at one tentacle will travel through the nerve net to the rest of the body. A hydra usually responds to a stimulus by withdrawal, or contraction (Otto et al., 1981).

Green hydra are cultured at temperatures of 20˚C, with a cycle of sixteen hours of light exposure because of
their symbiotic relationship with photosynthetic algae Chlorella and eight hours of darkness (Karntanut and Pascoe, 2005). Hydra inhabit freshwaters, where they attach to aquatic vegetation and submerged stones (Rainis and Russell, 1996).

Green hydra exhibit several unusual properties. Hydra normally reproduce asexually by budding, but reproduce sexually in the fall. During budding, a knob grows on an adult, eventually becoming a new hydra. Hydra also regenerate lost body parts (Otto et al., 1981).

Caffeine is a stimulant with the chemical formula 1,3,7-trimethylxanthine (Weast, 1966). Caffeine dampens the effects of a depressant called adenosine by blocking adenosine receptors (Specterman et al., 2005). Adenosine is a nucleoside that regulates lack of oxygen, restrictions of blood supply, and inflammation. In excess, adenosine can lead to neural damage and cell death (Chen et al., 2007). Blockage of adenosine receptors can, therefore, be beneficial.

Caffeine has many positive effects. Many studies report that caffeine makes people alert, focused, and energized (Nehlig and Boyet, 2000) and may help prevent Parkinson’s Disease. A study by Travis (2000) that investigated a condition similar to Parkinson’s Disease in rodents showed a connection between caffeine consumption and increased brain cell protection from the toxins that cause Parkinson’s Disease. A study by Specterman et al. (2005) on the effect of caffeine and glucose on neural activity found that because of the way adenosine is affected, caffeine increased brain activity, the heightened sensitivity that many caffeine consumers experience. In Homan and Mobarhan’s review (2006), increased caffeine corresponded to decreased levels of two enzymes in the liver that are considered indicative of high alcohol intake. A cohort study found that mild caffeine consumption (Paganini-Hill et al., 2007) led to a decreased risk of death.

Caffeine can be dangerous, however. The Paganini-Hill et al. study (2007) found that very high consumption of caffeine lead to higher risk of death. In a study, pregnant rats consumed small amounts of caffeine each day, but the brains of the rat young were damaged at birth (Brownlee, 2006). Similarly, pregnant women who consumed caffeine were found to be more likely to bear underweight babies. Because caffeine inhibits blood flow when it passes into the placenta, even small doses of caffeine can be dangerous to fetuses (Fenster et al., 1991). Caffeine has also been shown to induce apoptosis (Qi et al., 2002).

Despite the large amount of information available on caffeine, much is yet to be discovered. Although caffeine has been shown to have a positive effect on abnormal enzyme activity, the effect of caffeine on the alimentary tract and psychological effects has not been investigated (Homan and Mobarhan, 2006).

Learning rate can be measured by response times. Green hydra display a learning behavior of habituation. Habituation is a basic form of learning, in which an animal learns from experience not to respond to a certain situation if the consequence of a response has no positive or negative effect (Starr and Taggart, 2004).

Researchers test the learning behavior of animals through habituation. For instance, Elise Nowbahari (2007) tested the learning of colonial odor of ants, Cataglyphis niger. She collected C. niger from two different areas and then separated the two colonies and maintained them under homogeneous conditions. Ants from each colony were isolated and placed in separate cylinders. They were then released into a neutral arena and observed. The ants only responded to odors of other colonies. Other researchers have conducted similar experiments.

Methods and Materials: The research hypothesis for the experiment was that if the caffeine concentration increased, then the response times of green hydra would decrease. The null hypothesis was that the response times for different caffeine concentrations would not be significantly different. The independent variable was caffeine concentration, and the dependent variable was response time, measured by the number of times it took for the green hydra to not contract three times in a row in response to air bubbles. Each caffeine concentration was tested ten times. The caffeine concentrations were 0, 1.98, 3.92, 5.83, and 7.69 milligrams of caffeine per liter of water, with 0 mg/L as the control. The green hydra were kept at a constant temperature of 20 ± 1°C. All the green hydra were kept in the caffeinated solutions for 24 hours, and the volume of caffeine solution per green hydra was four milliliters.
Green hydra were cultured in a container filled with spring water. The container was placed on top of six stacked brick tiles in a two-gallon plastic aquarium. The aquarium was filled with water up to the lid of the container. The green hydra were not fed, but received natural sunlight.

Green hydra must be kept at a constant temperature of 20°C (Karntanut and Pascoe, 2005). Accordingly, a heating component was needed for this experiment. A small aquarium heater, referred to as the Hydra Heater, was purchased at the store Wally's Aquarium: Fish and Supplies.

The purpose of the Hydra Heater was to maintain a two-gallon aquarium within a temperature range of 20 ± 1°C (Lasker et al., 1982), regardless of the room temperature. The Hydra Heater was a submersible plastic tubular heater, which needed to be submersed in the aquarium to function properly (Hargrove and Hargrove, 2006). The heater thermostat responded to changes in water temperature by turning the heater on and off (Skomal, 2005). The thermostat was operated by a bimetallic strip that consisted of two different metals. When heated, the two metals expanded at different rates. The uneven expansion bent the bi-metallic strip in a certain direction (“Thermostat,” 2008). This bending either opened or closed a circuit, regulating electricity flow to the heater (Sandford, 1999).

The physical setup of the Hydra Heater is shown in Figures 2, 3, and 4 in the Appendix, and a diagram of the internal workings is shown in Figure 5 in the Appendix. The Hydra Heater was attached to the interior of the tank by a plastic suction cup and a power cord was attached from the top of the heater to an electrical power source through a wall socket.

Inferring from a weight chart, the average human weighs about 150 pounds (about 68 kilograms). Of this weight, 65% to 70% is water, meaning that the average human contains about 50 kg of water. A safe dosage of caffeine is 200 mg per day, while consuming 1000 mg of caffeine per day is dangerous for humans (Clayman, 1994). Four hundred milligrams of caffeine or more per day is, therefore, a safe dosage. Since one gram of water is equal to one milliliter of water, 400 mg of caffeine daily per 50 kg of water is equivalent to 8 mg of caffeine per liter of water. From this information, five caffeine concentrations were calculated for the other levels of the independent variable. A stock solution was made by dissolving a No-Doz™ pill (200 mg of caffeine) into one liter of spring water. One milliliter of the stock solution was added to 100, 50, 33.3, and 25 mL of spring water. The caffeine concentrations were 0, 1.98, 3.92, 5.83, and 7.69 mg/L.

Mixing electricity and water can be very dangerous. The experimenters were careful not to put their hands in the aquarium water while the Hydra Heater was submersed. They were also careful to keep the Hydra Heater submersed at all times while it was plugged in, to prevent it from malfunctioning.

A green hydra was placed in a solution of 1.98 mg of caffeine per liter of water using a pipette. After twenty-four hours, the hydra was then placed into a separate container with fresh spring water using a pipette. After the hydra fully extended, a pipette was squeezed to blow bubbles near the tentacles. The green hydra was allowed one minute to fully extend before being blown with bubbles a second time. This process was repeated until the hydra did not contract three times consecutively. The response time was recorded. The hydra was then removed from the container with a pipette and placed in an empty container. The procedures above were repeated nine more times for a total of ten trials. The processes above were repeated for the other caffeine concentrations of 0, 3.92, 5.83, and 7.69 mg/L.

**Results:** The effect of caffeine concentration on the response times of green hydra for all trials of each level is shown in Table 1 in the Appendix. The blank data was an outlier in the 3.92 mg/L caffeine concentration. The average response times for green hydra were 11, 22, 10, 13, and 17 for caffeine concentrations of 0, 1.98, 3.92, 5.83 and 7.69, respectively.

The effect of caffeine concentration on the response times of green hydra is summarized in Table 2 in the Appendix. Caffeine concentration (mg/L) of 1.98 exhibited the highest mean of 22, and caffeine concentration of 3.92 exhibited the lowest mean of 10. Variations within the groups were not similar, with caffeine concentrations of 0, 1.98, 3.92, 5.83 and 7.69 having standard deviations of 10, 16, 4.8, 7.1 and 16, respectively. Caffeine concentration of 7.69 exhibited the highest standard deviation of 16, and caffeine concentration of 3.92 exhibited the lowest standard deviation of 4.8. ANOVA was used to test the following null hypothesis at the 0.05 level of
significance: the response times of green hydra at different caffeine concentrations were not significantly different. The null hypothesis was not rejected (F= 1.977 < 2.59 at Factor df= 4, Error df= 44, α= 0.05; p= 0.115).

As shown in Figure 1 in the Appendix, caffeine concentration had no significant effect on the response times of green hydra.

**Discussion and Conclusions:** The major finding of this experiment was that caffeine concentration did not have a significant effect on the response times of green hydra. This finding was supported by an ANOVA test at a 0.05 level of significance. The null hypothesis was not rejected: the response times of green hydra at different caffeine concentrations were not significantly different (F= 1.977 < 2.59 at Factor df= 4, Error df= 44, α=0.05; p= 0.115), therefore, a trendline was not used in Figure 1. The data did not support the research hypothesis that if the caffeine concentration increased, then the response times of green hydra would decrease.

One outlier was found in the data: 31 for the 3.92 mg/L caffeine concentration. This outlier was calculated by multiplying the interquartile range, the difference between the upper and lower quartile, by 1.5. This value was added to the upper quartile and subtracted from the lower quartile. Any number above or below these two values were outliers (Mulekar, 2006).

Some errors occurred during the experiment. Inconsistencies in bubble blowing put more pressure on certain hydra, depending on how much each experimenter squeezed the pipette. Decisions determining whether a hydra contracted or not differed among experimenters.

Caffeine could have affected the response times of green hydra at the cellular level by acting as a stimulant. Caffeine makes one alert and focused (Specterman et al., 2005) because it dampens the effects of a depressant called adenosine, a human brain secretion (Otto et al., 1981). If adenosine were present in the nerve nets of green hydra, then caffeine exposure could have a negating effect on it. The data of this experiment indicate that caffeine does not have a significant effect on the response times of green hydra, inferring that green hydra might not secrete adenosine, or that learning rates of green hydra are not indicative of increased alertness or focus.

A recent study performed by Nowbahari (2007) showed how ants learn the odors from their own colony, but not from other colonies. Similarly, in this experiment, green hydra developed the habit of not responding to air bubbles, after they became accustomed to them. Many humans today consume caffeine thinking that it increases intelligence. Although caffeine increases alertness and focus for short periods, it does not necessarily increase intelligence (Specterman et al., 2005). In this experiment, green hydra did not show any significant “intellectual” differences when exposed to caffeine.

In conclusion, the purpose of this experiment was to determine the effect of caffeine concentration on the response times of green hydra. The major finding of this experiment was that caffeine concentration had no significant effect on the response times of green hydra. The research hypothesis that if caffeine concentration increased, then the response times of green hydra would decrease was not supported. The null hypothesis was not rejected: the response times of green hydra at different caffeine concentrations were not significantly different (F= 1.977 < 2.59 at Factor df= 4, Error df= 44, α=0.05; p= 0.115). In the experiment, green hydra learned not to respond to bubbles, similar to a recent experiment performed on ants by Nowbahari (2007). Caffeine dampens the effects of adenosine. Because green hydra treated with caffeine did not have significantly different response times, green hydra may not secrete adenosine (Specterman et al., 2005). For further study, long term effects and a wider range of caffeine concentrations could be investigated.

**LITERATURE CITED**


ACKNOWLEDGMENTS

I would like to thank Dr. Barbara Wood, Mr. Craig Lewis, and Mrs. Helen Lepkowski for their guidance and support for this experiment. I would also like to thank Thalia Aoki, Stephanie Marzen, and Hamed Eramian for conducting this experiment with me.

Appendix

Figure 1. The Effect of Caffeine Concentration on the Response Times of Green Hydra

![Figure 1. The Effect of Caffeine Concentration on the Response Times of Green Hydra](image)

Figure 2. Hydra Heater Side View

The Hydra Heater was submersed in a tank of water.

Photo taken by the student researcher.
Figure 3. Hydra Heater Top View

The Hydra Heater had a power cord that attached to a wall socket, providing electric power.

Photo taken by the student researcher.

Figure 4. Hydra Heater Back View

The Hydra Heater attached to the wall of the aquarium using a suction cup.

Photo taken by the student researcher.
This diagram shows the internal workings of the Hydra Heater.

1. power cord
2. electrical resistance heating element
3. end of electrical resistance heating element
4. first electrical connection
5. inlet of internal tube
6. hollow heat conducting internal tube
7. outer surface of 6
8. bi-metallic strip
9. hotline of powercord
10. second electrical connection
11. outlet of internal tube
12. neutral side of powercord
13. end of electrical resistance heating element

(Image and labels from http://www.freepatentsonline.com/7085482-0-large.jpg)
### Table 1. The Effect of Caffeine Concentration on the Response Times of Green Hydra

<table>
<thead>
<tr>
<th>Caffeine Concentration (mg/L)</th>
<th>Response Times (number)</th>
<th>Trials</th>
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<tbody>
<tr>
<td>0</td>
<td>11 22 10 13 17</td>
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</tr>
<tr>
<td>1.98</td>
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<td>3.92</td>
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<td></td>
</tr>
<tr>
<td>5.83</td>
<td>22 11 18 7 16 3 25 7 9 13</td>
<td>13</td>
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<tr>
<td>7.69</td>
<td>30 3 3 10 8 5 19 54 15 25</td>
<td>17</td>
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### Table 2. The Effect of Caffeine Concentration on the Response Times of Green Hydra

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>Caffeine Concentration (mg/L)</th>
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<tr>
<td>Mean of Response Times</td>
<td>11 22 10 13 17</td>
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<tr>
<td>(number)</td>
<td>1.98 3.92 5.83 7.69</td>
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<tr>
<td>Standard Deviation</td>
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<tr>
<td>of Response Times</td>
<td></td>
</tr>
<tr>
<td>(number)</td>
<td></td>
</tr>
<tr>
<td>Number of Trials</td>
<td>10 10 9 10 10</td>
</tr>
</tbody>
</table>

Results of ANOVA

- $F= 1.977$
- $p= 0.115$
- $\alpha= 0.05$
SECOND PLACE

THE MSR (MIRROR SELF-RECOGNITION) ABILITY IN Corvus brachyrhynchos

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ABSTRACT

Birds have a far different brain structure than mammals; specifically, they lack a neocortex, which is believed to be essential to self-awareness and, therefore, higher intelligence. Evidence of self-recognition in Corvus brachyrhynchos, the common crow, could prove that the essential components of mammal self-recognition have evolved independently in different vertebrate classes with diverse evolutionary backgrounds. The objective of this research was to determine whether members of the Corvus brachyrhynchos species could recognize themselves in a mirror. It was hypothesized that if the subjects could recognize themselves in a mirror, then they would remove a colored dot from their chest. Two tame subjects were obtained, observed, and recorded in four trials each. The subjects were first tested to determine if the dot was noticeable to the crow. The crow was then introduced to a mirror without a dot. The mirror was positioned so that the subject could move out of the mirror’s range if it wished. A black dot was added for the next trial and a yellow dot was placed on the crow’s chest for the fourth trial. The subject’s behavior was recorded by the researcher and by a camcorder. It was concluded that Corvus brachyrhynchos does not possess the mirror self-recognition ability. Neither of the two subjects removed the yellow dot in the fourth trial, thereby demonstrating that they did not seem to recognize themselves in the mirror. If performed again, more subjects would be acquired. Additionally, the use of subjects that are more tame and accustomed to human contact would be helpful. Further studies should be conducted on this topic. It would also be sensible to determine why some members of a species can recognize themselves in mirror while others cannot.

THIRD PLACE

THE EFFECT OF ALUMINUM CHLORIDE ON Daphnia magna REPRODUCTION

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ABSTRACT

The purpose of this experiment was to determine the effect of aluminum chloride (AlCl3) on Daphnia magna reproduction. Aluminum chloride has been linked to apoptosis, highly regulated programmed cell death; D. magna are freshwater invertebrates that reproduce asexually. The levels of the aluminum chloride dosage were prepared, tested for conductivity levels, and these levels were checked to ensure proper correlation of the other levels of dosage. Each dosage was later administered to the D. magna, and the number of eggs produced was recorded. The major finding of this experiment was that as the dosage of aluminum chloride increased, the reproduction of D. magna decreased. The data supported the research hypothesis that increasing the concentration of aluminum chloride would decrease Daphnia reproduction. The data also rejected the null hypothesis that D. magna reproduction would not change significantly with changes in aluminum chloride dosage. Other researchers have examined the effects of aluminum on cells and have come to the conclusion that aluminum may cause apoptosis. The decrease in the reproduction of D. magna was most likely caused by increased apoptosis. Recommendation for further study would include smaller dosages of aluminum chloride to determine the effects of small dosages. Another recommendation would be to make sure that the aluminum, not the chloride was affecting the D. magna reproduction by conducting another experiment with other aluminum-based substances such as aluminum potassium sulfate.
THE EFFECT OF GUARANA EXTRACT ON THE APPEARANCE OF A SPIDER’S WEB

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ABSTRACT

The purpose of this project was to find out whether or not spiders’ webs will be affected if they are given energy drinks. A similar project was conducted by NASA in 1995 that investigated whether different drugs had an effect on the spider’s web. The results of this study showed that chemicals can affect the spider’s ability to build its web. It was thought that if energy drinks were given to the spider than that would also affect the appearance of its web. The substance tested on the spiders for this project is pure guarana extract. The spiders tested are commonly known as orb weaver spiders. The orb weaver spider is approximately 2 centimeters in length. The hypothesis for this project was that if the guarana extract is fed to the spiders than it will affect the appearance of the spider’s web. This was thought partly because of NASA’s findings that the stimulant caffeine greatly affected the appearance of the spider’s web. The independent variable for this project was the guarana extract and the dependent variable was the effect it had on the spider’s web. As it turned out the spider’s web was affected. In fact, the spider eating guarana laced crickets built no web at all. When the spider had fed on regular crickets it build a new web approximately every 12 hours. But when fed the guarana-laced crickets the spider made one thread and then receded into a corner. Each spider originally built webs that were about 1.03 centimeters apart each time. Spider one’s average web strand span without guarana was about 1.4 centimeters. Spider two’s average web strand span without guarana was about 1.11. Spider three’s average web strand span without guarana was about .89 centimeters. Spider four’s (control) average web strand span with no guarana for all four trials was about 1.03 cm. However, none of the spiders built measurable webs when fed the guarana extract.

ROLE OF NICOTINIC ACETYLCHOLINE RECEPTORS (nAChRs) ON COCAINE SENSITIZATION AND MORPHINE WITHDRAWAL IN MICE

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ABSTRACT

The research examined the role of nicotinic acetylcholine receptors in cocaine sensitization and morphine withdrawal in mice. Morphine is a potent drug derived from opium. While it benefits some, it is also highly addictive and frequently abused. Cocaine is also habit-forming and harmful. Dependence results in physiological damage and psychosis. In experiment I, six groups if mice were pretreated with saline, and placed into locomotor chambers for a 30-minute habituation period. For one week, four groups subsequently received cocaine treatments while two continued to receive saline. On the challenge day half of the cocaine and control groups received an nAChR antagonist and activity of all mice was measured after receiving prescribed treatment. In experiment II, two groups of mice, one wild type and one α7 knockout were treated with increasing doses of morphine for one week. On the challenge day, all mice received a nAChR antagonist. Somatic signs of withdrawal were observed. The same protocol was performed for a group of six-α5 knockouts. In the sensitization protocol, data revealed a significant difference in locomotor activity between cocaine groups with intact nAChRs and those with deactivated receptors. In the morphine withdrawal protocol, the data revealed that while the average number of withdrawal incidents was
higher in the wildtype, the differences were not significant due to the variation in the data. These findings indicate that while the nAChR may have some interaction in the transduction pathways of cocaine and morphine, more tests must be done to determine its overall impact on addiction.

**HONORABLE MENTION**

**THE EFFECT OF *Lavandula officinalis* ON *Drosophila melanogaster* BEHAVIOR**

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**ABSTRACT**

The purpose of this experiment was to determine if *Lavandula officinalis* extract had an effect on *Drosophila melanogaster* behavior. This study was conducted at Central Virginia Governor’s School for five weeks. Precisely four drops of *Lavandula officinalis* was placed into four vials of twenty *Drosophila melanogaster* environments. The *Drosophila* was observed for twenty minutes before the lavender, during the lavender, and after the lavender. Their behavior was recorded according to the Hirsh Behavioral scale. After performing a one way ANOVA test, it was determined with a p-Value of 1.44E-08, and an alpha level of 0.05, that the *Lavandula officinalis* did have a significant effect on the *Drosophila melanogaster* behavior. When a tukey test was performed, with a minimum difference of 0.97, it was shown that the group during the lavender exposure and the group after the lavender exposure were significant when compared to all other groups. The original hypothesis for this experiment, if *Lavandula officinalis* is placed into the vial with the *Drosophila melanogaster*, then the behaviors of the *Drosophila melanogaster* will be evaluated at a grade of at least a 5 on the Hirsh behavioral scale which range between 0 and 7, was supported by the data. In conclusion, the results show that the *Lavandula officinalis* did have an effect on the behaviors of *Drosophila melanogaster*.

**OTHER PAPERS SELECTED FOR PRESENTATION:**


The Effect of Horse Age on the Ability to Learn and Remember a Task.  Jessica L.P. Benson, Yorktown High School,Arlington County Schools.

Optimal Foraging in Mummichogs (*Fundulus heteroclitus*): A Test of the Ideal Free Distribution Theory.  Bradley W. Carter, Chesapeake Bay Governor’s School, Caroline County Schools.

K-911 The Effect of the Type of Dog on Paw Preference.  Grey P. Davenport, Gildersleeve Middle School, Newport News City Schools.

The Effect of Caffeine on *Daphnia magna* Heart Rate.  Mary Claire Geyer, Hanover High School, Hanover County Schools.

The Effect of Different Substances on Repelling Ants.  Sonia A. Holar and Jasmine J. Mann, Gunston Middle School, Arlington County Schools.

The Effect of Different Colors on the Attraction of Crickets.  Heather A. Hudson, Hermitage High School, Henrico County Schools.

The Effect of the Type of Birdseed on the Amount Consumed.  Sarah E. Johns, Hermitage High School, Henrico County Schools.

The Effect of the Time of Day on the Number of Insects Attracted.  Saadhana Kukkala, George H. Moody Middle School, Henrico County Schools.
The Effect of Foreign Stridulation on Indigenous Adult *Odontotaenius disjunctus*. Marlene T. Logan and Jessica C. Lewis, Chesapeake Bay Governor’s School, Lancaster and Richmond County Schools.


The Effect of Music Genre on the Speed of a Mouse through a Maze. Jessica C. Shen, Williamsburg Middle School, Arlington County Schools.

The Effect of Brain Size on the Ability of Various Animals to Learn How to Navigate a Maze. Sarah K. Vaughan, Deep Run High School, Henrico County Schools.

The Effect of Different Types of Food on the Behavior of Ants. Alexandra C. Wood, Deep Run High School, Henrico County Schools.
AGRICULTURE AND ANIMAL SCIENCE

FIRST PLACE

IDENTIFICATION OF PHYSICAL INTERACTIONS BETWEEN MAIZE Rxo1 AND Xoc AvrRxo1

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Blacksburg High School, Blacksburg, Virginia 24060

Abstract: Plant resistance protein (R proteins) either indirectly or directly interact with the cognate pathogen avirulence (Avr) proteins resulting in plant disease resistance. Maize R gene (Rxo1) encodes a NBS-LRR type R protein, recognizes and triggers a hypersensitive response (HR) to a rice pathogen Xanthomonas oryzae pv. oryzicola (Xoc) harboring an avirulence gene Xoc-avrRxo1. The Yeast Two Hybrid System was employed to detect whether Rxo1 directly interacts with Xoc AvrRxo1 and rice B116, a putative transcriptional factor that is conserved in a wide range of plant species. Xoc causes rice bacterial streak disease and delivers an effector Xoc AvrRxo1 through the type III secretion system. In the genome of Xoc, a gene ORF2 that is adjacent to Xoc-avrRxo1 has been previously identified as a putative chaperone-like gene. ORF2 is co-regulated with avrRxo1 by the same operon. The result showed that ORF2 directly interacts with the carboxyl terminal of XocAvrRxo1 and also confirmed that AvrRxo1 can directly interact with a plant chaperone-like protein Ain-1NbAin-1.

Introduction: Plant pathogens use diverse strategies to obtain nutrients by destroying host cells. Plants, in order to survive, resist pathogens through a variety of preformed and induced mechanisms. Among these, one important mechanism in plants is plant-pathogen interaction (Dodds, 2006). Plant disease resistance (R) proteins have encoded receptor components that recognize the presence of specific avirulence genes (Avr) carried by the pathogens. The specific recognition between the R and Avr genes, following the gene-for-gene resistance system, triggers a series of defense responses in plants known as hypersensitive reaction (HR) or a localized cell death to quarantine the spread of the pathogens from the infection site (van der Biezen and Jones, 1998). A number of plant R genes have been identified from a wide range of plant species. Majority of them have nucleotide binding site (NBS) and leucine-rich repeat (LRR) domains (Mackey et al., 2003). The R protein either directly or indirectly recognize the effectors secreted by the pathogens, resulting in effector-triggered immunity (Jones and Dangl, 2006).

Xanthomonas oryzae pv. oryzicola (Xoc) is a pathogen which causes bacterial streak disease in rice. Xoc uses the Type-III secretion system to deliver effector AvrRxo1 inside of plant cells (Zhao et al., 2004). No genetic sources of effective resistance have been identified in rice. However, Xoc cannot cause disease in maize due to the presence of the R proteins Rxo1 (Zhao et al., 2005). The R gene Rxo1 has been cloned and identified, and confers resistance to the rice pathogen Xoc (Zhao et al., 2005). The ability of maize Rxo1 to recognize AvrRxo1 in rice presents a possible way to achieve durable disease resistance. However, it is still unclear how the two proteins interact with each other to activate the plant defense system. Previous studies indicate that most bacterium-triggered defense responses in plants are thought to be caused by the indirect interaction between the resistance proteins and the avirulence effectors. Therefore, in this paper, we want to test whether Rxo1 and AvrRxo1 directly binds to each other and trigger plant innate immunity.

Yeast Two-Hybrid system (Y2H) is a powerful tool for detecting protein-protein interactions (Fields and Song, 1989). It was based on the fact that many eukaryotic transcription factors have discrete and separable DNA-binding and transcriptional activation domains. In the Y2H system, protein-protein interactions were tested by fusing one target protein to the DNA binding domain of the yeast GAL4 transcription factor, and the other protein is fused to the activation domain of GAL4. The fusion proteins were expressed in a suitable yeast strain and the interaction is detected by assaying the expression of several GAL4 responsive reporter genes (Fields and Song, 1989; Causier and Davies, 2002). This system has been also applied in plant-pathogen interaction, especially in R protein and Avr protein interaction (Deslands et al., 2003; Dodds, 2006). In this study, the Y2H system is employed to detect the interactions between Rxo1 and Xoc AvrRxo1, Rxo1 and B116, Xoc AvrRxo1 and its chaperone ORF2, Xoc-AvrRxo1 and Nb-Ain-1.
Materials and Methods: Strains and plasmids - The bacterial strains used in this study were Escherichia coli DH5α and DE3.1. The yeast strain was Saccharomyces cerevisiae AH109.

Construction of hybrid plasmids for use in yeast two-hybrid studies - The targeted genes were cloned in the TOPO Entry vectors (Invitrogen) which is used for further cloning to the Gateway® compatible Y2H vectors described below. The Gateway compatible Y2H destination vectors were previously constructed by inserting the ccd (B) cassette into the at NdeI site of pGADT7 and pGBKT7 vectors (Clontech) (Figure 1). The gene fragment in the pENTR/D-TOPO vectors were cloned into the Y2H vectors through LR® cloning according to the manufacturer’s instruction (Invitrogen). In brief, the LR reaction were performed by mixing 1 µL Y2H destination vector, 1 µL entry clone, 1 µL 5xLR buffer, 0.5 µL clonase (Invitrogen Gateway® LR Clonase™ Enzyme Mix), and 1.5 µL ddH2O in a 1.5 mL centrifuge tube and incubating the reaction mix at room temperature for 1 hour.

Transformation of prey and bait vectors into E. coli. - The LR mixtures were transformed into E. coli DH5α. 3 µL of LR mixture were mixed with 50-100 µL of DH5α competent cells, placed the competent cells on ice for 2 minutes, and transferred them into an ice-cold cuvette (2.5mm or 1.0 mm, depending on competent cell volume). For electroporation, we set gene pulser at 2.5 KV for 2.5mm cuvette or 1.7KV for 1.0 mm cuvette (BIO-RAD Pulse Controller Gene Pulser™). After electroporation, 1 mL of LB medium was added into the cuvette and gently transferred into a fresh 1.5 mL microcentrifuge tube, incubated at 37°C for 1 hour with shaking. After incubation, the transformants were plated onto LB plates containing 100mg/L ampicillin for pGADT7 or 50mg/L kanamycin for pGBKT7. The plates were incubated at 37°C overnight or until single colonies emerge.

Confirmation by colony PCR and digestion - Eight single colonies of each transformants were chosen for colony PCR. Of them, four colonies were transferred for liquid culture. The reaction mix of colony PCR contained 2µL 10× PCR buffer, 2 µL dNTPs, 2 µL 10× DMSO, 1.2 µL MgCl2, 0.3 µL Taq polymerase, 0.1µL Pfu polymerase, 10 µL ddH2O and 1 µL of T7 forward and reverse gene-specific primers. After an initial denaturation step at 96°C for 6 min, the template was amplified using 30 cycles with the following conditions: 1 min at 94°C, 50 sec at 55°C, and 2 min at 72°C. The final extension step was conducted at 72°C for 7 min. The PCR product were resolved on 1% agarose gel, stained with ethidium bromide and visualized under UV light.

Based on colony PCR results, plasmid DNAs of one positive clone of each transformants were isolated using Plasmid DNA Purification Kit (BioNeer). To further confirm the orientation of inserted DNA fragments, the plasmid DNAs were digested with restriction enzymes (New England Biolab Inc.) (Table 1). The reaction mixtures were the following: 5 µL plasmid DNA, 1 µL restriction enzyme (add 1 µL BSA if necessary), 2 µL buffer and 10-11µL ddH2O. The reaction mixtures were incubated at 37°C overnight and separated on 1% agarose gel, stained with ethidium bromide and visualized under UV light.

Transformation into yeast AH109 - To prepare yeast competent cells for chemical transformation, a single colony of AH109 was chosen from YPD plate, incubated in 10mL of YPD medium overnight at 28°C with shaking, diluted the culture to 100mL YPD medium and incubated to reach OD 600=0.5. The culture was incubated on ice for 15 minutes and centrifuged at 1600 × g for 5 minutes at 4°C. The resulting pellets were washed with 20mL of ice cold EZ1 (Zymo Research) followed by centrifugation to pellet the cells and resuspended in 2mL of ice-cold EZ2. An aliquot of 50µL cell suspension were transferred in 1.5mL centrifuge tube.

Zymo Research Frozen EZ Yeast Transformation II Kit™ was used for chemical transformation. 50µL of AH109 competent cells were mixed with 3µl plasmid DNA, followed by adding 500 µL of EZ-3 solution and incubating at 30°C for 45 minutes. 300µL of transformants were plated onto SD/-Leu/-Trp [the yeast growth medium that that is lacking amino acids Leucine (Leu) and Tryptophan (Trp) plates]. The plates were incubated at 28°C until single colony emerging.

Growth of co-transformants - Four to five single colonies of each transformants were pooled and incubated in 5mL of SD/-Leu/-Trp media at 28°C for three days with shaking. 50uL of cell suspension of each co-transformants were striped onto SD/-Leu/-Trp/-His plates containing 5mM of 3-AT to prevent leaky expression and incubated at 28°C for three days.

β-Galactosidase Assays - The #1 Whatman filter paper with a 9cm of diameter were labeled orientation and number, put on the plates for seconds until the paper was completely wet by colonies, lifted the paper with forceps
and put it in liquid nitrogen for 1 minute, then thawed it at room temperature for 5 minutes or longer to break the yeast cells. Another filter paper was soaked in X-gal staining buffer: 100 mL Z buffer (Na_2HPO_4·7H_2O 16.1g/L, NaH_2PO_4·H_2O 5.5g/L, KCl 0.75g/L and MgSO_4·7H_2O 0.246g/L), 1.67mL of X-gal stock solution( Dissolve 5-bromo-4-chloro-3-indolyl-β-D-galactopyranoside in N,N-dimethylformamide at 20mg/mL, stored in the dark at -20°C) and 0.27mL β-mercaptoethanol, at 37°C for several hours to overnight or until blue color emerging.

Results: Construction of hybrid plasmids for using in yeast two-hybrid studies - Rxo1 can recognize Xoc AvrRxo1 and trigger defense response in rice (Zhao et al, 2005), indicating that they may directly or indirectly interact in vivo. This interaction is critical to understand their function and molecular mechanism. To test how Rxo1 and Xoc AvrRxo1 interact and which domain of Rxo1 is crucial for their interaction, wild type Rxo1 with the deletion of signal sequence (1-40bp) Δ40Rxo1, NBS domain and LRR domain, wild type Xoc avrRxo1 with the deletion of type -III secretion signal (1-195bp) Xoc avrRxo1<sup>196-1263</sup>, and ATP binding site mutation Xoc avrRxo1<sup>1167N</sup> were cloned into prey vector pGADT7 and bait vector pGBKTK7. Our previous Y2H cDNA library screening identified rice B116 may interact with Rxo1 (unpublished data). To further confirm this result, rice B116 gene was cloned into pGADT7 and pGBKTK7 vectors, respectively. According to gene sequence analysis, Xoc avrRxo1 (ORF1) has an effector domain (196-639 bp), a regulator domain (640-1263 bp). It also has a chaperone sequence (ORF2) with the length of 313 bp, which shares same promoter with Xoc avrRxo1 and has a ribosome-binding site. To address the interaction between Xoc avrRxo1 ORF1 and ORF2 as well as the function of ORF1, Xoc avrRxo1<sup>196-639</sup>, Xoc avrRxo1<sup>640-1263</sup>, and Xoc avrRxo1<sup>ORF2</sup> were cloned into pGADT7 and pGBKTK7 vectors. A total of twenty prey and bait constructs were transformed into <i>E. coli</i> DH5a (Table 2 and Figure 3).

Confirmation of transformants - The resulting transformants were firstly confirmed by colony PCR with T7 forward primer and gene-specific primers. With exception of pGADT7-B116, all the prey constructs have been obtained PCR-positive single colonies (Figure 4A) and all bait constructs have been obtained PCR-positive single colonies (Figure 4B). To further determine whether the resulting constructs are in correct orientation, plasmid DNA from one of PCR-positive colonies was isolated and digested with restriction enzyme(s) according to the vectors and gene sequences (Table 1). As shown by Figure 4C, all prey and bait constructs were dropped off right DNA fragments from plasmid DNAs, indicating that all constructs are in correct orientation and can be used for yeast transformation.

Co-transformation of prey and bait constructs into yeast cells - The resulting hybrid plasmids carrying either BD or AD in-frame fusion with the tested genes (Table 3) were co-transformed into yeast reporter strain AH109, which virtually eliminates false positives by using three reporters-<i>ADE2</i>, <i>HIS3</i>, and <i>lacZ</i>-under the control of distinct GAL4 upstream activating sequences (UASs) and TATA boxes, by chemical method.

The resulting co-transformants were selected on SD/-Leu/-Trp plates, which only allow co-transformants survive but not single transformants. As indicated in Figure 5, all co-transformants could grow on SD/-Leu/-Trp plates. Some co-transformants, such as Δ40Rxo1/ Xoc avrRxo1<sup>196-1263</sup> and Rxo1<sup>NBS</sup>/ Xoc avrRxo1<sup>196-1263</sup> grow slowly. Interestingly, all these co-transformants have Xoc avrRxo1<sup>196-1263</sup>, indicating that Xoc avrRxo1<sup>196-1263</sup> may be toxic to yeast cells. In addition to the tested constructs, the positive control plasmids pGADT7-T/pGBKTK7-53 and negative control plasmids pGADT7-T/pGBKTK7-lamin C were also co-transformed into AH109 cells.

Identification of multiple protein interactions by yeast two-hybrid system - In addition of positive and negative controls, eighteen pairs of interesting proteins were identified by Y2H. Of them, fourteen pairs showed positive Y2H phenotype based on X-gal assay. The interacting pairs can be divided into the following four categories.

(i) Rxo1 and Xoc AvrRxo1 physical interaction at NBS domain - Rxo1 and Xoc AvrRxo1 were postulated to directly bind each other. In this study, both wildtype and mutated Xoc AvrRxo1 were used to test their interaction with Rxo1. The results illustrated that both wildtype (Xoc AvrRxo1<sup>196-1263</sup>) and mutated Xoc AvrRxo1 (Xoc AvrRxo1<sup>T167N</sup>) can physically interact with Rxo1 and showed X-gal activity (Figure 6A). This is in agreement with our previous observation. To determine which domain of Rxo1 is crucial for their interactions, NBS domain and LRR domain of Rxo1 were used as preys and AvrRxo1<sup>196-1263</sup> were used as bait for Y2H. As shown in Figure 6B, only Rxo1 NBS domain but not LRR domain can physically interact with Xoc AvrRxo1.
AvrRxo1, but not its homologs, co-inoculated with Xcv carrying hybrid system. Furthermore, both N-terminal and C-terminal of Xoc AvrRxo1 are critical for their physical interaction. Here, we illustrate that Xoc AvrRxo1 directly interacts with its chaperone ORF2 in yeast two-hybrid system. Type III secretion system is critical to deliver effector proteins into host cytoplasm. In addition to T3S secretion of T3S substrates also depends on cytoplasmic T3S chaperones, which are small, acidic and leucine-rich proteins. T3S chaperones bind to effectors and promote stability and secretion of their partner (Lorenz and Buttner, 2008). Xoc avrRxo1ORF2 shares same promoter with Xoc avrRxo1, encodes a 10kDa and acidic protein and may play an important role in Xoc AvrRxo1 secretion. To test whether Xoc AvrRxo1ORF2 physically binds Xoc AvrRXo1 and which domain is critical for their binding, Xoc avrRxo1196-639, avrRxo1196-639T167N, and avrRxo1196-639 were cloned into prey and bait vectors, respectively, for yeast two-hybrid assay. The results, as shown in Figure 5E and F, illustrated that Xoc AvrRxo1 chaperone ORF2 directly interacted with Xoc AvrRxo1. Nevertheless, very weak signals were detected from the mating between ORF2 and N-terminal ORF1 and C-terminal ORF1, suggesting that ORF1 and ORF2 interaction may require both domains.

(ii) Rxo1 physical interaction with rice B116 - The defense response triggered by Rxo1/Xoc AvrRxo1 must happen in nuclear. Nevertheless, Rxo1 localizes in cytoplasm but not nuclear. Therefore, at least one interactor in plant cells is necessary to interact with Rxo1 and transduct the defense signals into nuclear to regulate the defense-related gene expression. Previous cDNA library screening using the Y2H system, we identified that Rxo1 possibly interacts with B116, which is a putative rice transcriptional factor. Interestingly, rice B116 has homologs in diverse plant species, including N. benthamiana, and Arabidopsis thaliana (Zhao, unpublished data). To further confirm this finding, rice B116 genes was cloned into prey and bait vectors by LR reaction, and transformed into yeast AH109 cells. No matter what is B116 used as prey or bait, it showed yeast two-hybrid positive phenotype with Rxo1 (Figure 6C), indicating that B116 directly binds to Rxo1.

(iii) Xoc AvrRXo1 physical interaction with its chaperone - In addition to the type III signal, efficient secretion of T3S substrates also depends on cytoplasmic T3S chaperones, which are small, acidic and leucine-rich proteins. T3S chaperones bind to effectors and promote stability and secretion of their partner (Lorenz and Buttner, 2008). Xoc avrRxo1ORF2 shares same promoter with Xoc avrRxo1, encodes a 10kDa and acidic protein and may play an important role in Xoc AvrRxo1 secretion. To test whether Xoc AvrRxo1ORF2 physically binds Xoc AvrRXo1 and which domain is critical for their binding, Xoc avrRxo1196-639, avrRxo1196-639T167N, avrRxo1196-639T167N, and avrRxo1196-639 were cloned into prey and bait vectors, respectively, for yeast two-hybrid assay. The results, as shown in Figure 5E and F, illustrated that Xoc AvrRxo1 chaperone ORF2 directly interacted with Xoc AvrRxo1. Nevertheless, very weak signals were detected from the mating between ORF2 and N-terminal ORF1 and C-terminal ORF1, suggesting that ORF1 and ORF2 interaction may require both domains.

(iv) Xoc AvrRXo1 direct binding to Nb-Ain-1 - Type III protein secretion systems mediate the transfer of bacterial virulence protein, such as Xoc AvrRxo1, directly into the host cell cytoplasm. The secreted proteins are thought to travel this pathway in a largely unfolded manner. The chaperone, which specifically binds cognate secreted protein, is essential for this process (Akeda and Galan, 2005). The remaining question is how the secreted protein refolds and functions in plant cells. Our previous Y2H screening also identified a small protein Nb-Ain-1 from a tobacco (Nicotiana benthamiana) Y2H cDNA library. Nb-Ain-1 shares no sequence similarity with Xoc AvrRxo1ORF2. The predicted 2nd structure of Nb-Ain-1 is homology to protein chaperone proteins, which is also structurally similar to Xoc AvrRxo1ORF2. To confirm whether Nb-Ain-1 binds to Xoc AvrRXo1, the full length of Nb-Ain-1 and Xoc avrRxo1T167N were cloned into prey and bait vectors, respectively. As shown in Figure 6D, Nb-Ain-1 directly interacted with AvrRxo1T167N. This result also suggested that ATP binding is not necessary for their interaction.

Discussion and Conclusions: NBS-LRR type R proteins directly or indirectly recognize the cognate Avr protein and the recognition results in disease resistance (Jones and Dangl, 2006). Most of reported R-Avr proteins are indirectly binding each other; very few cases are direct interaction (Jia et al, 2000; Deslandes et al, 2003; Dodds, 2006). In this study, we demonstrate that Xoc AvrRXo1 is an avirulence protein that interacts in the yeast two-hybrid system with Rxo1, a typical NBS-LRR R protein conferring resistance to several strains of Xanthomonas carrying avrRxo1 homologs. This is consistent with our observation of transient assay in N. benthamiana which was co-inoculated with Agrobacterium carrying Rxo1 and Xoc avrRxo1. To detect whether Rxo1 specifically bind Xoc AvrRXo1, but not its homologs, Xcv avrRxo1, an avirulence gene of X. campestris pv. vesicatoria which causes tomato bacterial spot disease, was cloned into both prey and bait vectors. The yeast two-hybrid analysis indicated that Rxo1 can directly interact with Xcv AvrRXo1 (data not shown). In addition to directly binding to Xoc AvrRXo1, Rxo1 also directly interacts in yeast two-hybrid system with B116, a putative transcriptional factor in rice. Interestingly, B116 gene has a number of homologs in diverse plant species, including N. benthamiana, and Arabidopsis thaliana (Zhao, unpublished data). To further confirm this finding, rice B116 genes was cloned into prey and bait vectors by LR reaction, and transformed into yeast AH109 cells. No matter what is B116 used as prey or bait, it showed yeast two-hybrid positive phenotype with Rxo1 (Figure 6C), indicating that B116 directly binds to Rxo1.

Type III secretion system is critical to deliver effector proteins into host cytoplasm. In addition to T3S signal, efficient secretion of effector proteins also depend on cytoplasmic T3S chaperones, which are small proteins and bind to effectors. Here, we illustrate that Xoc AvrRXo1 directly interacts with its chaperone ORF2 in yeast two-hybrid system. Furthermore, both N-terminal and C-terminal of Xoc AvrRXo1 are critical for their physical interaction. Up to date, how the secreted effectors refold in plant cells is still unknown. In this study, we also confirmed that an ORF2 structure-similar protein Nb-Ain-1 directly interacts with Xoc AvrRXo1 in yeast two-hybrid system. This protein may play an important role in AvrRXo1 refolding in plant cytoplasm and restoring its function.
Further experiments aimed at confirming the interactions of Rxo1 and Xoc AvrRxo1, Rxo1 and B116, AvrRxo1 and ORF2, and AvrRxo1 and AvrRxo1 and Nb-Ain-1 using other powerful tools such as co-immunoprecipitation (Co-IP) and pull down assay. Understanding the biological function of Rxo1/AvrRxo1 system in different plant species and molecular mechanisms of this system is another goal. The observation that Rxo1 interacts with B116, which is a putative transcriptional factor, suggests that B116 may be released from Rxo1/AvrRxo1/B116 complex, enter into plant nucleus after Rxo1/AvrRxo1 interaction and lead to transcription readouts resulting in plant resistance. As an effector, AvrRxo1 enters into plant nuclear after being secreted into plant cytoplasm and refolded by plant protein (s), such as Nb-Ain-1, and targets at plant transcriptional factors to suppress plant basal defense system. This may help understand R genes-regulated plant resistance and effector-based pathogenesis and design new strategies to enhance plant resistance and decrease pathogen virulence.

ACKNOWLEDGMENTS

I would like to thank everyone that contributed to my project. I am especially thankful for my mentor, Dr. Bingyu Zhao, for giving me this opportunity, guidance and facility to work on the project.

LITERATURE CITED


Appendices

Table 1. Restriction enzymes used for digesting plasmid DNAs

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Table 2. Obtained constructs for Y2H

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Table 3. Co-transformants for Y2H

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Figure 1. The pGADT7 and pGBK7 vectors of yeast two-hybrid system and their modification.
Figure 2. Structure of maize Rxo1 and Xoc avrRxo1

Rxo1 has signal peptide (NX), nucleotide binding site (NBS) and leucine rich repeat domain (LRR). Xoc AvrRxo1 has type III secretion signal (TT3S), effector domain including a putative ATP binding site (T167), regulator and a chaperone. T167N is an ATP binding mutation.

Figure 3. Single colonies of transformants in *E. coli* selected on LB/kanamycin or ampicilin plates

Entry plasmid DNAs harboring each gene fragments were subcloned into Yeast two-hybrid vectors pGADT7 (prey) and pGBKKT7 (bait) by LR reactions. The resulting constructs were transformed into *E. coli* DH5α cells by electroporation followed by selecting on LB/Kan50 (pGBKKT7) or LB/Carb100 (pGADT7) plates.
Figure 4. Agarose gel profiles of colony PCR and digestion of plasmid DNAs with restriction enzymes

Eight colonies of each transformants were chosen for liquid culture and colony PCR using T7 forward and gene-specific primers. Subsequently, the PCR products were analyzed by running 1% agarose gel followed by staining with EtBr and photographing with gel imager (Figure 4A and B). With the exception of No. 4 construct, PCR-positive colonies were obtained from each transformants. To further confirm the transformants, the plasmid DNAs were isolated and purified from one PCR-positive colony of each transformants and digested with restriction enzymes according to their sequences. The reaction mixes were analyzed by running 1% agarose gel followed by staining with EtBr and photographing with gel imager (Figure 4C).
Figure 5. Single colonies of each yeast transformants

The prey and bait constructs are co-transformed into yeast AH109 cells by chemical method. The transformants are grown on SD/-Leu/-Trp plates that only allow co-transformants grow but not single transformants.

Figure 6. X-gal assay of each yeast transformants

The co-transformants are grown on SD/-Leu/-Trp/-His plates plus 5mM 3-AT for four days. The colony-lift filter assay is used to measure the activity of β-galactosidase.
SECOND PLACE

THE EFFECT OF DIFFERENT SOIL AMENDMENTS ON THE MEAN LEAF GROWTH OF TOMATO PLANTS OVER TIME

Matthew T. King
1601 Melissie Court, Henrico, Virginia 23238
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The experiment, performed in constant conditions and under cautious direction, had clear results, which corresponded to known facts of agronomy and organic agriculture. The purpose of this experiment was to find which of five soil amendments (Coffee Grounds, Dehydrated Cow Manure and Humus, Homemade Compost, Aged Sheep Manure, and Worm Castings) produced the greatest increases in mean leaf growth of tomato plants over five of the eight weeks of the experiment. On the final day of the experiment, buds were counted and the height of each of the plants was measured, in addition to the number of leaves. The experimenter’s hypothesis was that the homemade compost group would show the greatest increases in all areas of growth when compared to the control. The procedure consisted of several steps. Firstly, the materials were gathered. Secondly, the soil-less mix was prepared from a mixture of perlite, vermiculite, and sphagnum peat moss. Thirdly, the seeds of “Siberian,” a variety of tomato, were planted at a depth of 1 cm, watered, and the experiment officially began. Fourthly, the seedlings were watered, rotated and generally maintained. Fifthly, the plants were thinned down to the healthiest, “leafiest,” tallest plants. Sixthly, measurements of the leaves were taken every Saturday since the thinning, concluding on the last day of the experiment. Seventhly, the number of buds and height were measured at the final day. Finally, the experiment was continued for two weeks to take additional measurements. The results were obvious; the coffee grounds stunted growth, whereas worm castings accelerated growth. Other soil amendments showed significant improvements over the control. The macronutrients, moisture retention capabilities, organic matter, texture, and pH all affected the overall health and growth of the plants. The plants were successfully tested for eight weeks under artificial, but constant, conditions.

THIRD PLACE

IS Stevia rebaudiana A VIABLE AGRICULTURAL CROP IN SOUTHEASTERN VIRGINIA?

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Chesapeake Bay Governor's School, Tappahannock, Virginia 22560

ABSTRACT

Stevia rebaudiana (Stevia) is an herb that is ten times sweeter than sugar, without causing tooth decay, obesity, nor does it affect blood sugar. With its many potential health benefits, Stevia should be grown in the United States and distributed as a natural sweetener. In this study, Stevia was grown from seeds, cuttings, and plants, with varying levels of success at 0%, 4%, and 86%, respectively. Attempts to cultivate Stevia from seed and cuttings yielded poor results, while transplants were very successful with an 86% survival rate. Plant growth success rates showed the potential of Stevia as a viable crop in Mathews County, Virginia. Blind taste tests also showed Stevia’s potential as a non-sugar sweetener for beverages. This study demonstrates that Stevia can be grown from transplants successfully in Southeastern Virginia and could be a new valuable crop for Virginia farmers.
HONORABLE MENTION
THE EFFECT OF VARIOUS NATURAL AND SYNTHETIC SUBSTANCES ON THE REPELLENCY OF DISEASE-BEARING INSECTS

Katherine Chen
5616 Summer Creek Way, Glen Allen, Virginia 23059
Mills Godwin High School, Richmond, Virginia 23233

ABSTRACT

The purpose of this experiment was to find the effect of various synthetic and natural substances on the repellency of mosquitoes and other disease-bearing insects. One out of 17 people die every year because of a mosquito transmitted disease. In this experiment, citronella oil, eucalyptus oil, DEET, and tea tree oil impregnated fly-trap papers were placed outside to repel insects. A piece of fly trap paper that was not sprayed with any substance served as the control and was also placed outside. It was hypothesized that, “If DEET was used, then more insects would be repelled.” The results revealed that DEET had repelled the most insects. The control group attracted the most insects, which showed that all of the repellents were effective. The conducted t-test values were all statistically significant. The results supported the research hypothesis. It was believed that the results were due to the fact the each of the substances had a special trait that made it unpleasant to insects. This research could lead to future studies that test the effect of the repellents on a broader variety of insects.

HONORABLE MENTION
THE EFFECT OF EARTHWORMS ON PLANT GROWTH

Victoria S. Fubara
12700 Beryl Court, Richmond, Virginia 23233
Deep Run High School, Glen Allen, Virginia 23059

ABSTRACT

Most scientists believe that earthworms are the most vital organisms in the creation of fertile soil. Research has shown that earthworms stimulate root growth and create vermicompost which is seven times richer in plant nutrients than fungi or bacteria compost. It also has been recorded that earthworms create a loose soil structure that is very beneficial for healthy plant growth. The purpose of this experiment was to determine if different amounts of earthworms, zero, five, ten, and fifteen affected the growth rate of plants. It was hypothesized that if one plant received fifteen earthworms, then that plant would grow the tallest. Four flower pots were labeled A, B, C, and D and assembled together with four cups of soil and twenty cat grass seeds. Pot A acted as the control and received zero earthworms, pot B five, pot C ten, and pot D fifteen. Each pot was watered every other day for ten days, and at the conclusion was measured in inches with a standard size ruler. These steps were repeated four more times for a total of five trials. The results indicated that the plants with the largest amount of earthworms produced the tallest plants with a mean of 4.62 inches and the plants with the smallest amount of earthworms produced the shortest plants with a mean of 3.58 inches. A t-test was used to test the following null hypothesis at a 0.05 level of significance: Earthworms have no effect on the growth of plants. The null hypothesis was accepted (t=2.08 < 2.306; t= 1.72 < 2.306 at df= 8; p>0.05), and rejected (t=3.20 > 2.306; t= 5.52 > 2.306; t=5.65 > 2.306; t=3.03 > 2.306 at df= 8; p<0.05). Most of the data supported the research hypothesis that plants with more earthworms produce taller plants. The findings were as found because it has been recorded that earthworms give off growth enhancing acids and nutrients, stimulate root growth, and a loose soil structure needed by plants to grow best. To better this experiment more levels of the independent variable could have been tested and the temperature of each plant could have been closely monitored.
HONORABLE MENTION

THE EFFECT OF CALORIC INTAKE ON THE POPULATION DENSITY OF Caenorhabditis elegans

Vaishnavi Kosuri  
2511 Isham Randolph Drive, Herndon, Virginia 20171

Divya Madhusudhan  
5217 Tulip Leaf Court, Centreville, Virginia 20120  
Thomas Jefferson High School for Science and Technology, Alexandria, Virginia 22312

ABSTRACT

From the smallest amoeba to the largest whale, every process an organism goes through requires energy to function. Caloric intake, the consumption of energy, affects many important processes such as cellular respiration. Caenorhabditis elegans are ideal for experimenting with caloric intake because of their simple digestive system. Thus, if caloric intake was measured in C. elegans, would caloric intake have an effect on the population density of C. elegans? The purpose of this experiment was to determine the effect of caloric intake on the population density of C. elegans. The experimental hypothesis was if caloric intake increased, then population density would also increase. Our treatment groups for caloric intake (microliter levels of Escherichia coli) were determined by calorie application at 200, 300, 400, 500 (control), 600, 700, and 800 levels with ten trials each. Population density was measured by the number of C. elegans in a two by two millimeter area. This experiment was conducted by placing agar cubes of C. elegans in E. coli. The populations of C. elegans were then measured. The major finding of this experiment was as caloric intake increased, population density increased. The ANOVA test was used to find that the null hypothesis (α = 0.05) was rejected (f = 3.28 > 2.25; p = 0.007) while the experimental hypothesis was supported. The increase in population density was enhanced by an optimal environment from increased caloric intake. Caloric intake drove cellular respiration, creating ATP and allowing body systems to function efficiently, and thus allowing for successful reproduction. Further implications show that a limiting control on caloric intake will allow for efficient metabolic functioning and reproductive increase. By maintaining the metabolism at a constrained amount of food, the organism's likelihood of survival and reproduction would increase.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Hydrogen Peroxide on Seed Germination. Mallory Banton, Hanover High School, Hanover County Schools.

The Effects of Kennel Cough Vaccinations and a Dog's Immunity to the Disease. Rachel A. Barlow, Shenandoah Valley Governor's School, Augusta County Schools.

The Effect of Different Types of Manure on Corn Plant Height. Mikey Cantor and Kathryn G. Daylor, Deep Run High School, Henrico County Schools.

The Effect of the Type of Fertilizer on Plant Growth. Katharine E. Hines, George H. Moody Middle School, Henrico County Schools.

The Effect of Medicated and Non-Medicated Feeds on the Growth of Gallus gallus. Epifanio Perez V, Chesapeake Bay Governor's School, King and Queen County Schools.

The Effect of Type of Apple on the Apple's Sugar Content. Kayla E. Pfäb and Margaret E. Stuckey, Deep Run High School, Henrico County Schools.

The Effects of Chemical vs. Organic Fertilizer on Tomato Plants. Catherine C. Robertson, Chesapeake Bay Governor's School, Mathews County Schools.
The Effect of Dosage on a Thoroughbred's Race Time on Different Track Surfaces. Sarah G. Stratton, George H. Moody Middle School, Henrico County Schools.

The Effect of Edible Substances on Aging Apples. Abigail B. Ward, George H. Moody Middle School, Henrico County Schools.
Abstract: Allelopathy is the process in which plants release chemicals that inhibit, or in some cases help other plants to grow. The purpose of this project was to determine if radish and cabbage extracts affected the growth of broccoli in terms of height, mass, root length, and number of plants sprouted. The hypothesis was if broccoli plants were grown with radish or cabbage extracts, then the plants grown with distilled water alone (control) would be the healthiest. Radish plants and green cabbage were used to make the extract. After reaching a height of 10 cm the radish plants were uprooted and washed, and the roots were removed. The plants were crushed to make a paste; distilled water was added and mixed well. The cabbage extract was made in a similar manner by using a cabbage head. The broccoli seeds were then planted by placing twenty seeds in each pot. Fifty broccoli pots were prepared in this manner, ten for each experimental group: dilute radish extract, dilute cabbage extract, radish extract, cabbage extract, and the control (distilled water). The plants were watered accordingly. An analysis of variance (ANOVA) was done for all the data and the confidence intervals (CIs) did not overlap for height of the plants after experimentation and the mass of the plants, both data sets were significantly different. The results suggest that cabbage and radish do have an allelopathic effect on the growth of broccoli in terms of height and mass. The hypothesis was supported by the results.

Introduction: Allelopathy is the process in which plants release chemicals that inhibit, or in some cases help other plants to grow (Allelopathy, 2008). Plants use allelopathy to make sure they get enough nutrients, water, space to grow, and sunlight. It works by releasing chemicals that are not harmful to the plant itself, but potentially harmful to other plants. This process is known to affect the occurrence, growth, structure, and productivity of plant ecologies. Some effects of allelopathy include reduced seed germination and reduced seedling growth. The chemicals released in allelopathy are complex and can include the interaction of different chemical classes. These chemicals stay in the soil, affecting the neighboring plants and the plants planted in the same area afterward (Ferguson, 2000).

Allelopathy is an important field of study because by using allelopathic chemicals, scientists can engineer more environmentally friendly pesticides and herbicides. Since allelochemicals have been shown to be more biodegradable than traditional herbicides, the research of allelopathy would prove to be quite productive. However, there is no doubt that the field of allelopathy should be looked into before widespread use; if not further looked into, non-target species may be harmed in the process. Allelopathy could provide a safe alternative to traditional pesticides and herbicides. Through research, allelochemical pesticides and herbicides may be created to specifically target certain plants or insects, such as weeds or plant-eating pests (Ferguson, 2000).

Allelopathy has a variety of applications in the modern world. Due to the fact that allelopathic chemicals in certain plants can harm the growth of other plants, it is important to know which plants can and cannot be grown together. Thiocyanate for example, is an allelopathic chemical known to discourage insect feeding. This chemical can be found in vegetables in the Brassicaceae family such as broccoli, *Brassica oleracea var. botrytis*, radish, *Raphanus sativus*, and cabbage, *Brassica oleracea var. capitata*, and is known to affect the germination and growth of other plants, especially small-seeded ones. Thiocyanate is released when the foliage and stems of these plants decompose into the soil and thus, prohibit the future growth of other plants (Silva, 1997). Some of these chemicals are so powerful that they are known to inhibit the growth of plants that are within the same family. A specific example would be that broccoli, *Brassica oleracea var. botrytis*, is known to affect the growth of other plants in the Brassicaceae family (Ferguson, 2000).

Broccoli, or *Brassica oleracea var. botrytis* is a garden vegetable in the Brassicaceae family that is closely related to cauliflower (Liptay, 2008). Broccoli’s cultivation originated in Italy, where its Italian name, Broccolo
means, “cabbage sprout” (Mateljian, 2008). It contains a thick cluster of flower buds that eventually form green, branched open heads. Broccoli is rich in fiber, protein, minerals, folate, and the vitamins C, K and A (Liptay, 2008). It is also a great source of phosphorus, potassium, magnesium and the vitamins B6 and E. Due to its many different components, broccoli provides a range of tastes and textures, from soft and flowery (the floret) to fibrous and crunchy (the stem and stalk) (Mateljian, 2008). Broccoli can be eaten both raw and cooked. Broccoli grows best in cool weather and moist, fertile soil. If started from seeds, broccoli can take anywhere from 100 to 120 days to grow. The prime temperature range to grow broccoli lies between 10 and 20 degrees Celsius (Liptay, 2008).

Broccoli, and other Brassicaceae plants have a variety of health benefits. They contain the phytonutrients sulforaphane and the indoles, which are known to have significant anti-cancer effects. In fact, animal studies and human population studies have shown that diets rich in Brassicaceae vegetables such as kale, broccoli, cabbage, and cauliflower are associated with low cancer incidences. In addition to lowering cancer risks, broccoli may also support stomach health. *Antimicrobial Agents and Chemotherapy* published a study with evidence that supports broccoli’s ability to eradicate the bacteria *Helicobacter pylori* (*H. pylori*), a bacteria known to be the primary cause of ulcers (Mateljian, 2008).

This experiment was conducted to test the ability of cabbage and radish to inhibit the growth and development of broccoli. The hypothesis was: If broccoli was grown with varying amounts of radish extracts or cabbage extracts, then the plants that were grown with only distilled water would be the healthiest. The independent variable in this experiment was the amount and types of extracts watered to the plants. The dependent variable in this experiment was the growth of the plants in terms of height, mass, root length, and number of plants sprouted.

The concept of allelopathy is very interesting. The mere thought that plants have their own sort of defense mechanism to ensure they have the proper resources to grow is extraordinary and fascinating to think about. Therefore, the effects that allelopathic chemicals have on other plants are essential information for someone who is interested in botany and the growing of plants.

This experiment was conducted because plants in the Brassicaceae Family, broccoli especially, are known to have allelopathic characteristics (Silva, 1997). Broccoli residue, if left behind in the soil, prevents other Brassicaceae plants from growing (Fergusson, 2000). Radish and cabbage are also known to have allelopathic characteristics, but whether their chemicals can affect the growth and development of other Brassicaceae plants is unknown. This project was done to determine if radish and cabbage extracts would, like broccoli, have allelopathic tendencies towards other Brassicaceae plants, specifically against broccoli.

**Methods and Materials:** Seventy pots filled with 30 grams of Sta-Green potting soil with fertilizer were prepared. In 20 of these pots, 10 radish seeds were placed per pot. In the other 50 pots, 20 broccoli seeds were placed in each pot. All of the pots were placed in plant labs. Each pot was watered with 20 milliliters of distilled water as needed. The radish plants were grown until the plants were 10 cm tall. The broccoli plants continued to be grown and watered with distilled water. The radish plants were removed from the soil and washed well. The roots of the radish plants were removed. Fifty grams of sand were placed in the mortar and pestle for every 85 grams of radish plants. The ingredients were crushed into a fine paste. This same procedure was followed for making the cabbage paste, by using a green cabbage from the grocery store. One thousand milliliters of distilled water was poured into each paste container. The solutions were stirred well. Using filter paper, the solutions were filtered. The solutions were kept in separate bottles and refrigerated for preservation. The broccoli plants were divided into five groups of ten. The tray containing each pot was labeled according to the group it contained. Group one was watered with 15 milliliters of distilled water and 5 milliliters of radish extract. Group two was watered with 15 milliliters of distilled water and 5 milliliters of radish extract. Group three was watered with 20 milliliters of radish extract. Group four was watered with 20 milliliters of cabbage extract. Group five was watered with 20 milliliters of distilled water. Each pot was watered daily with extracts according to its group. The plants were grown for a period of two weeks. One plant was randomly selected from each pot and the height, a dependent variable (DV), of the plant was recorded prior to experimentation, in the middle of the experimentation, and after the experimentation was completed. The number of plants (DV) sprouted in each pot was counted.

At the end of the growth period, the plants were removed from the soil, washed well, and massed (mass was another DV). The length of the roots (DV) was also measured and recorded. The statistical analyses were performed. Conclusions were drawn.
**Results:** An analysis of variance (ANOVA) was done on each set of data: height of the plants before, during, and after experimentation, root length, number of plants in each pot, and the mass of plants. The confidence intervals (CIs) overlapped for the height of the plants before and during experimentation, root length, and the number of plants in each pot. The confidence intervals that did not overlap were the height of the plants after experimentation and the masses of the plants (Appendix, figures 2 and 4). Two-sample t-tests were performed for all sets of data with overlapping confidence intervals (Appendix, figures 1 through 5). The p-values for the height of the plants prior to experimentation were greater than 0.05 (Appendix, table 1). The p-values of the root lengths were also greater than 0.05. The plant height upon completing the experiment and the mass of the plants had p-values less than 0.05 when comparing the control group to the other experimental groups. The control group had the greatest average mass, 14 g, final plant height, 15.7 cm, and root length, 11.25 cm (Appendix, table 2 and graphs 1 through 4).

**Discussion and Conclusions:** Since the p-values for the final height of the control versus the final height of the other groups and the final mass of the control versus the final mass of the other groups were less than 0.05, it was concluded that there was a significant difference between the final heights and masses of the plants. There was a significant difference in the height of the dilute radish versus the control (p-value of 0.02), the dilute cabbage versus the radish (p-value of 0.025), the dilute cabbage versus the control (p-value of 0), the radish versus the control (p-value of 0.008). There was a significant difference between the mass of the dilute radish versus the control (p-value of 0.044), the dilute cabbage versus the radish (p-value of 0), the dilute cabbage versus the control (p-value of 0), the radish versus the control (p-value of 0), and the cabbage versus the control (p-value of 0). In addition, the control group had the greatest average mass, final plant height, and root length, (Appendix, table 2 and graphs 1 through 4).

The results of this experiment suggest that radish and cabbage extracts do have an allelopathic effect on the growth of broccoli. The hypothesis was: If broccoli plants were grown with varying amounts of radish extract or cabbage extract then the plant grown with only distilled water, the control, would be the healthiest. The results obtained support this hypothesis. However, since p-values for the root lengths, and number of the plants were greater than 0.05 and there was no significant difference, further experimentation needs to be conducted.

This experiment could be improved by having more trials, growing the plants over a longer period, and concocting a stronger extract solution. Repeated trials provide for more data, therefore more accurate averages and results. The extension of the growth period would also provide for more accurate results. A broccoli plant typically takes 100 to 120 days to grow, therefore in order to see significant differences in the root lengths of the plants a longer growth period is needed. Finally, this experiment could be improved by making the extract solution stronger. Making a stronger extract solution may provide for more noticeable results, even over a short period of time.

This project may be conducted in the future by growing the plants with the extracts from the very beginning instead of starting the plants with distilled water and then watering the plants with extracts. If the broccoli seeds were planted and initially watered with the extracts one might find a significant difference in the number of plants sprouted. This project was intended to be conducted in this manner, however there was not sufficient time to grow the radish plants, make the extract, and then grow the broccoli.

**ACKNOWLEDGMENTS**

I would like to thank my parents and family for their constant support and belief in me, no matter what I pursue. I would also like to thank my teachers for all the help they have given me in the experimental design of my project.
LITERATURE CITED


Appendix

Table 1: The P-Value Results of the Two-Sample T-Tests sets tested

<table>
<thead>
<tr>
<th>Data</th>
<th>Beginning Plant Height(cm)</th>
<th>Mass of Plants (g)</th>
<th>Final Plant Height(cm)</th>
<th>Root Length(cm)</th>
<th>Number of Plants per Pot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilute Radish vs. Dilute Cabbage</td>
<td>0.823</td>
<td>0.296</td>
<td>0.492</td>
<td>0.894</td>
<td>0.704</td>
</tr>
<tr>
<td>Dilute Radish vs. Radish</td>
<td>0.746</td>
<td>0.15</td>
<td>0.197</td>
<td>0.158</td>
<td>0.846</td>
</tr>
<tr>
<td>Dilute Radish vs. Cabbage</td>
<td>0.835</td>
<td>0</td>
<td>0.805</td>
<td>0.813</td>
<td>0.123</td>
</tr>
<tr>
<td>Dilute Radish vs. Control</td>
<td>0.831</td>
<td>0.044</td>
<td>0.02</td>
<td>0.062</td>
<td>0.838</td>
</tr>
<tr>
<td>Dilute Cabbage vs. Radish</td>
<td>0.425</td>
<td>0</td>
<td>0.025</td>
<td>0.592</td>
<td>0.804</td>
</tr>
<tr>
<td>Dilute Cabbage vs. Cabbage</td>
<td>0.552</td>
<td>0</td>
<td>0.312</td>
<td>0.057</td>
<td>0.279</td>
</tr>
<tr>
<td>Dilute Cabbage vs. Control</td>
<td>0.53</td>
<td>0</td>
<td>0</td>
<td>0.259</td>
<td>0.617</td>
</tr>
<tr>
<td>Cabbage vs. Radish</td>
<td>0.889</td>
<td>0</td>
<td>0.274</td>
<td>0.071</td>
<td>0.131</td>
</tr>
<tr>
<td>Radish vs. Control</td>
<td>0.883</td>
<td>0</td>
<td>0</td>
<td>0.175</td>
<td>0.717</td>
</tr>
<tr>
<td>Cabbage vs. Control</td>
<td>1</td>
<td>0</td>
<td>0.008</td>
<td>0.0605</td>
<td>0.145</td>
</tr>
</tbody>
</table>

If p-values were less than 0.05, data sets were significantly different. The data sets mass of plants and final plant height were significantly different.

Table 2: Data Averages

<table>
<thead>
<tr>
<th>Groups</th>
<th>Beginning Plant Height (cm)</th>
<th>Final Plant Height (cm)</th>
<th>Root Lengths (cm)</th>
<th>Number of Plants Sprouted</th>
<th>Mass of Plants (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilute Radish</td>
<td>12.1</td>
<td>13.9</td>
<td>8.5</td>
<td>18</td>
<td>9.25</td>
</tr>
<tr>
<td>Dilute Cabbage</td>
<td>12.3</td>
<td>14.4</td>
<td>8.75</td>
<td>18</td>
<td>7.25</td>
</tr>
<tr>
<td>Radish</td>
<td>11.8</td>
<td>12.9</td>
<td>9.5</td>
<td>18</td>
<td>6.5</td>
</tr>
<tr>
<td>Cabbage</td>
<td>11.9</td>
<td>13.7</td>
<td>8.25</td>
<td>16</td>
<td>4.13</td>
</tr>
<tr>
<td>Control</td>
<td>11.9</td>
<td>15.7</td>
<td>11.25</td>
<td>18</td>
<td>14</td>
</tr>
</tbody>
</table>

The control group had the greatest average final height, root length, and mass.
**Figure 1- ANOVA for Beginning Plant Heights:**

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>D- Radish Ht A</td>
<td>10</td>
<td>12.100</td>
<td>2.470</td>
</tr>
<tr>
<td>D-Cabbage Ht A</td>
<td>10</td>
<td>12.300</td>
<td>1.252</td>
</tr>
<tr>
<td>Radish Ht A</td>
<td>10</td>
<td>11.800</td>
<td>1.476</td>
</tr>
<tr>
<td>Cabbage Ht A</td>
<td>10</td>
<td>11.900</td>
<td>1.663</td>
</tr>
<tr>
<td>Control Ht A</td>
<td>10</td>
<td>11.900</td>
<td>1.524</td>
</tr>
</tbody>
</table>

All confidence intervals were overlapping, two-sample t-tests were needed.

**Figure 2-ANOVA for Final Plant Heights:**

<table>
<thead>
<tr>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>D- Radish Ht C</td>
</tr>
<tr>
<td>D-Cabbage Ht C</td>
</tr>
<tr>
<td>Radish Ht C</td>
</tr>
<tr>
<td>Cabbage Ht C</td>
</tr>
<tr>
<td>Control Ht C</td>
</tr>
</tbody>
</table>

Radish vs. control intervals and cabbage vs. control intervals were significantly different because the confidence intervals were not overlapping.

**Figure 3-ANOVA for Root Lengths:**

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>D- Radish RL</td>
<td>4</td>
<td>8.500</td>
<td>1.000</td>
</tr>
<tr>
<td>D- Cabbage RL</td>
<td>4</td>
<td>8.750</td>
<td>3.304</td>
</tr>
<tr>
<td>Radish RL</td>
<td>4</td>
<td>9.500</td>
<td>0.577</td>
</tr>
<tr>
<td>Cabbage RL</td>
<td>4</td>
<td>8.250</td>
<td>1.708</td>
</tr>
<tr>
<td>Control RL</td>
<td>4</td>
<td>11.250</td>
<td>1.893</td>
</tr>
</tbody>
</table>

All confidence intervals were overlapping, two-sample t-tests were needed.

**Figure 4-ANOVA for Mass of Plants:**

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-Radish M</td>
<td>4</td>
<td>9.250</td>
<td>2.689</td>
</tr>
<tr>
<td>D-Cabbage M</td>
<td>4</td>
<td>7.250</td>
<td>2.127</td>
</tr>
<tr>
<td>Radish M</td>
<td>4</td>
<td>6.500</td>
<td>1.538</td>
</tr>
<tr>
<td>Cabbage M</td>
<td>4</td>
<td>4.125</td>
<td>1.391</td>
</tr>
<tr>
<td>Control M</td>
<td>4</td>
<td>13.975</td>
<td>2.300</td>
</tr>
</tbody>
</table>

Dilute radish vs. control, dilute cabbage vs. control, radish vs. control, cabbage vs. control were significantly different because the confidence intervals were not overlapping.
Figure 5- ANOVA for Number of Plants in Each Pot:

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>Pooled StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-Radish P</td>
<td>10</td>
<td>18.500</td>
<td>2.550</td>
<td></td>
</tr>
<tr>
<td>D-Cabbage P</td>
<td>10</td>
<td>18.000</td>
<td>3.197</td>
<td></td>
</tr>
<tr>
<td>Radish P</td>
<td>10</td>
<td>18.300</td>
<td>1.947</td>
<td></td>
</tr>
<tr>
<td>Cabbage P</td>
<td>10</td>
<td>16.400</td>
<td>3.204</td>
<td></td>
</tr>
<tr>
<td>Control P</td>
<td>10</td>
<td>18.800</td>
<td>3.795</td>
<td></td>
</tr>
</tbody>
</table>

All confidence intervals were overlapping, two-sample t-tests were needed.

Graph 1

Box plot showing the height range for each experimental group. The control group was most concentrated at the greater heights.
Graph 2

Box plot showing the mass range for each experimental group. The control group was most concentrated at the greater masses.

Graph 3

This graph shows a comparison of the masses of the plants. The control group had the highest overall mass.
This graph shows a comparison of the average final plant heights. The control group had the highest overall height.
SECOND PLACE

THE EFFECT OF ADDING A DETERGENT SOLUTION AT DIFFERENT INTERVALS ON PLANT GROWTH

Suchana H. Costa
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Washington-Lee High School, Arlington, Virginia 22201

ABSTRACT

Mannmade pollutants are an unavoidable part of the environment. The focus on completely ridding nature of inorganic pollutants has shifted to finding ways to minimize damage from pollutants. Washwater, which is composed of detergents and soaps, is a major part of human accredited pollution. In a previous study, the addition of a biodegradable detergent solution, after the solution was exposed to different amounts of ultraviolet light, resulted in improved plant growth in the group which received the most exposure to the ultraviolet light, but eventually, all plants that received the detergent solution died. Increasing the intervals between additions of the solution may prevent death by allowing a more diluted concentration to reach the plants. This study determined the effect of adding a detergent solution at different intervals on plant growth by adding a detergent solution to Brassica rapa plants at 3, 6, and 9 day intervals. A detergent solution was created by diluting Tide Laundry Detergent to distilled water, and placing the solution under ultraviolet light for 36 hours. The Brassica rapa plants were watered with the solution at appropriate intervals for 24 days. The study was conducted to determine the environmental fate of detergents and to develop a method to curve harmful effects of the detergent solution. The 6 day intervals had a significantly greater amount of growth, which suggests that detergent solutions can act as fertilizers after photodegradation and if added at longer intervals. Although detergents are inherently pollutants, through manipulation, detergent solutions can become almost beneficial.

THIRD PLACE

THE EFFECT OF DIMINISHING WHITE LIGHT ON Brassica rapa GROWTH

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200 North Galveston Street, Arlington, Virginia 22203
Washington-Lee High School, Arlington, Virginia 22201

ABSTRACT

The experiment conducted was chosen to answer the question, if a plant will grow towards yellow light which has a lower absorption rate rather than white light if the amount of white light is little enough. After background research was conducted it is very clear that white light is far more favorable to a plant because it contains all visible colors and so it has the benefits of yellow light plus all the other light waves available to a plant with white light. The experiment was designed then, to let plants have a yellow and white light source which were equally available so the plant can grow towards the better light source. The idea was to decrease the amount of white light to the point where there were so few rays of white light, yellow light was more useful to a plant's chloroform. This was done by using cutouts with yellow and white film in otherwise opaque boxes where the white cutouts decreased in size making different experimental groups. It was hypothesized that if a plant is placed directly between a source of white light and a source of yellow light, the plant will always grow towards the source of white light, no matter how little white light is given. The hypothesis predicted no change in orientation of plant between the control plants and those with less white light. To test the hypothesis, trials were grown of four different amounts of white light with a constant amount of yellow light. The results showed that for a plant with a 3.1 cm² cutout for yellow light and a 0.79 cm² cutout for white light and any cutouts for white light that were smaller, the Brassica rapa grew towards the yellow film. The hypothesis that quality of light and not amount was important to a plant's absorption rate was not supported by the data.
HONORABLE MENTION

THE EFFECT OF DIFFERENT SOLUTIONS ON THE NUMBER OF DAYS A FRESH CUT DAISY WILL SURVIVE

Sarah N. Boegner
10805 Leabrook Drive, Glen Allen, Virginia 23059
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The purpose of this research project was to determine the effect that different solutions had on the number of days a fresh cut daisy would survive. The hypothesis of this experiment was if fresh cut daisies were placed in 250 mL of different solutions, then the fresh cut daisies placed in the commercial flower food solution survived the longest number of days. First, five fresh daisy flowers (*Chrysanthemum maximum*) were gathered. Five clean glass canning jars (473 mL) were gathered. The first jar was filled with 250 mL of water (control). The second jar was filled with 250 mL of commercial flower food solution. The third jar was filled with 250 mL of bleach solution. The fourth jar was filled with 250 mL of aspirin solution. The last jar was filled with 250 mL of sugar solution. Each of the 5 flowers’ stems was cut so that it was 20 cm in length. Each flower was placed in a separate jar. After 24 hours, each flower was checked to see if it was still living. If the flower was no longer living, it was recorded as dead. The flowers were checked every 24 hours until all 5 flowers were no longer living. This entire procedure was repeated an additional 24 times, using an additional 120 daisies. The flowers placed in the flower food lived the longest number of days and the flowers in the bleach solution lived the shortest number of days. The sugar solution performed second best, water (control) performed third best, and the aspirin solution performed fourth best. The findings of this experiment supported the hypothesis. The flowers placed in the flower food solution performed the best. The research conducted supported the findings. There were some improvements that could be made for future studies. First of all, the concentrations of some of the solutions could have varied. Also, the flower type could also vary.

HONORABLE MENTION

THE EFFECTS OF WHITE, RED AND GREEN LIGHT ON THE GROWTH OF MUTANT AND WILD TYPE *Arabidopsis thaliana*

Jake H. Hill
1131 North Fork Road, Bedford, Virginia 24523
Central Virginia Governor's School, Lynchburg, Virginia 24502

ABSTRACT

The purpose of this study was to determine if the 5PTase2-1 gene and the gcr2-2 gene in *Arabidopsis thaliana*, both part of the inositol triphosphate signaling pathway, play a role in responding to light signals from the plant’s environment. The study took place between November 2008 and December 2008 at a local high school. Four types of *Arabidopsis* plants were grown under three types of light: mutant 5PTase2-1, wild type C5908, mutant gcr2-2, and wild type Columbia. All four types of plants were grown under white, red, and green light for a period of four weeks. Four two-way ANOVA tests were conducted: one to compare the height (mm) of all the plants under all of the lights after four weeks, and three separate tests to compare the height (mm) of the plants grown under white, red, and green light respectively. The ANOVA test used to compare all of the height data after four weeks showed significance, giving a p-value of 2.14E-08. The ANOVA conducted on the plants grown under the white light also showed significance, producing a p-value of 0.0032. Additionally, the ANOVA test for the plants grown under red light showed significance, producing a p-value of 5.18E-06. After tukey tests were performed on all of the ANOVA
test results, it was found that the significance lay between the mutant 5PTase2-1 and wild type Columbia plants, regardless of the type of light. The 5PTase2-1 plants grew taller on average than did the wild type Columbia plants. This implies that *Arabidopsis thaliana* without the 5PTase2-1 gene undergo more growth under white, red, and green light, than those that possess the gene. Taking these results into consideration, the alternate hypothesis stating that all group mean heights are different was accepted. In conclusion, the results indicate that the 5PTase2-1 gene in *Arabidopsis thaliana* causes plants to experience less growth than plants without the gene, no matter what type of light the plant is grown under.

**HONORABLE MENTION**

**THE EFFECT OF SUPERABSORBENT POLYMERS ON THE OVERALL HEALTH OF GRASS WITH LIMITED WATER**

Christopher M. Nowak  
12436 Grace Hill Lane, Glen Allen, Virginia 23059  
George H. Moody Middle School, Henrico, Virginia 23228

**ABSTRACT**

The purpose of this experiment was to help solve an issue that the world is struggling with: fresh water supply. Conserving water means fewer expenses, less usage of the world’s fresh water supply, and less runoff. Being able to use water for other means than keeping grass healthy would be ideal. It was hypothesized that if superabsorbent polymers were tested to see if they were an efficient way to conserve water for grass, and therefore maintained its overall health well, then the test group with three grams of dry superabsorbent polymer would have the overall highest health. One hundred grass plants, with increasing levels of superabsorbent polymer, (one, two, and three grams) were planted under the same conditions for six weeks. The first three weeks were the period in which the plants received water; each plant received 150 milliliters of water every three days. The next three weeks were a simulated drought period. After the drought period, the plants were measured for height. Superabsorbent polymers made grass plants more resistant to droughts. However, this was not always consistent. Certain amounts of superabsorbent polymer were more effective than others. For example, one gram of superabsorbent polymer was more effective than two grams of superabsorbent polymer. However, two grams of superabsorbent polymer was still better than nothing, or the control. In conclusion, manually testing each amount of superabsorbent polymer and tweaking it to the specifications required for the real-life application is the easiest way to achieve maximum efficiency.

**OTHER PAPERS SELECTED FOR PRESENTATION:**

The Effect of Sodium Sulfate on the Growth of *Miscanthus sinensis* “Yaku Jima”. Matthew C. Aadland, Central Virginia Governor’s School, Lynchburg City Schools.

The Effects of 8 mM of Zinc Sulfate on Mutant (pathogenic Gene HP-261 inserted) and Wild Type *Arabidopsis thaliana*. Jamie K. Bagwell, Central Virginia Governor’s School, Lynchburg City Schools.


The Effect of Music on Plant Life. Brittany N. Edwards, Appomattox Governor’s School, Prince George County Schools.

The Effect of *Eisenia fetida* on the Growth of a Pea Plant. Hannah M. Good, George H. Moody Middle School, Henrico County Schools.


The Effect of Time of Harvest on Dry Mass of *Brassica rapa*. Lauren B. Kesler, Hanover High School, Hanover County Schools.

The Effect of Different Source of Light on the Transpiration Rate of a Plant. Seung-Hwan Kim, George H. Moody Middle School, Henrico County Schools.

The Effect of the Amount of 10% Hydrogen Peroxide on Radish Seed Germination Time. Mavra Masood, George H. Moody Middle School, Henrico County Schools.


The Effect of Developmental Stage on Radiosensitivity of *Brassica rapa*. Eric A. Morris, Douglas S. Freeman High School, Henrico County Schools.


Caffeine in Plants: Stimulating or Depressing? Catherine S. Southall, Appomattox Governor’s School, Amelia County Schools.

The Effect of Different Pollution Levels in Water on Plant Propagation from Stem Cuttings. Lavinia V. Unverdorben, George H. Moody Middle School, Henrico County Schools.

The Effects of Increased Ethylene Exposure on the Growth and Development of *Brassica rapa*. Austin R. Walker, Central Virginia Governor’s School, Lynchburg City Schools.
CHEMISTRY A

FIRST PLACE

THE EFFECT OF CHIRAL HYDROPHOBIC AMINO ACIDS ON STORAGE FOODS TO INHIBIT ICE RECRYSTALLIZATION

Prasanna G. Joshi
3005 Ridgegate Drive, Glen Allen, Virginia 23059
Mills E. Godwin High School, Richmond, Virginia 23238

Abstract: The purpose of this project was to find which chiral hydrophobic amino acids, when treated with storage foods, would inhibit ice recrystallization. Recently, some companies have used AFP’s in their food products to increase storage life and inhibit ice recrystallization. However, AFPs are extremely expensive ice recrystallization inhibitors and therefore another purpose of this experiment was to find an alternative to expensive AFP’s. The carrots were treated with various chiral hydrophobic amino acids at a 5mg/ml concentration. The control food group used in this experiment did not receive any amino acid treatment. It was hypothesized that if the food products were treated with D- amino acids and frozen, then the D- amino acids would inhibit ice recrystallization to a greater extent than the corresponding L- amino acids. The results revealed that the food product treated with D- cysteine, D- phenylalanine, and L- cysteine all were significantly better in inhibiting ice recrystallization. A t-test was done on the data and it revealed that all of the data was significant except for D- histidine and D- tryptophan. Therefore, the results were partially supported by the data collected. It is believed that the results are due to the fact that AFPs are made up of polypeptides containing cysteine amino acid residues, while phenylalanine has a higher hydrophobic character, which may have contributed to ice recrystallization inhibition. This research could lead to further explore whether the effect is concentration dependent and can be exploited for commercial application as a substitute of AFPs.

Introduction: Some foods when frozen seem to lose quality and smooth creamy texture because of the membrane damage with reduced water holding capacity. Subsequently, the loss of nutrients is caused by cellular destruction due to the growth of large ice crystals, known as ice recrystallization. It has been found that antifreeze proteins (AFPs) are a class of polypeptides chains that are rich in amino acids such as alanine and cysteine. These AFP’s are produced by certain vertebrates, plants, fungi and bacteria permit their survival in subzero environments but also inhibit crystal growth and ice recrystallization. So far biologists have found antifreeze proteins in several species of Arctic and Antarctic fish (Tomczak et al., 2003). Although there are several structurally different variants of AFPs, all of them show similar ability to interact with incipient ice crystals and inhibit crystal growth (Tachibana et al., 2004). The commercial applications of AFPs include (a) protection of fish and plants against cold and freezing temperatures, (b) cold protection of mammalian cells, tissues, and organs (Amir et al., 2004, Pham et al., 1999), (c) enhanced tumor cell destruction during cryosurgery, and (d) longer shelf life for and better quality of frozen foods (Fletcher et al., 1999; Grandum and Nakagomi, 1997). Although AFPs are effective in inhibiting ice recrystallization, they are very expensive; therefore amino acids are being explored as alternatives.

A protein is the result of condensation of amino acids to form a chain of amino acid “residues” linked by a peptide bond. Amino acids are present in every living organism. Depending on the molecular structure of an amino acid, the use of an amino acid can vary from a food sweetener to a treatment for common diseases.

Although all AFPs contain polypeptide chains consisting of alanine and cysteine residues in their structure, no reports were found in the literature for the use of amino acids to prevent ice recrystallization. Therefore, the primary goal of this continued research investigation was to find which chiral hydrophobic amino acids, when treated with household storage foods, would produce less ice crystals, inhibit ice recrystallization to a greater extent, and could become a cheaper alternative (as amino acids are cheaper as compared to AFPs) to AFPs, thus saving the lives of many rare Arctic and Antarctic fishes. The hydrophobicity of any amino acid depends on the type of aliphatic or aromatic group attached to the amino acid part of the molecule and it increases with the size of the group.
It is well known that some foods (e.g., strawberries, raspberries, and tomatoes) cannot be frozen without loss of quality that can be attributed to cellular destruction, membrane damage, and water holding capacity due to shrinkage of material; even food products that freeze well deteriorate to varying degrees over time due to these factors. One of the implications of deterioration during frozen storage is the growth of large ice crystals within the product when refrigeration temperatures are not optimal. This process, known as ice recrystallization, occurs when the products are stored at subzero temperatures or are subject to fluctuating subzero temperatures such as those which occur during freezer defrost cycles (Fenney, 2000). Food quality and texture would be improved if a means could be found to reduce or eliminate this phenomenon using inexpensive amino acids that have greater ice recrystallization inhibition property than AFPs.

It was hypothesized that if the food products are treated with D- amino acids and frozen, then the D- amino acids would inhibit ice recrystallization to a greater extent than the corresponding L- amino acids, as water (forming ice) could bind differently to the surface of D and L amino acids.

Methods and Materials: There were five levels of the independent variables used in this project. To investigate whether chirality plays any role on ice recrystallization, the D- and L- amino acids of phenylalanine, tryptophan, cysteine, and histidine were used from mentor’s laboratory. The experiments were set up in mentor’s laboratory using his lab space and instruments. The carrot samples not treated with amino acids acted as the control group in the experiment.

The dependent variable in this experiment is the formation or inhibition of ice crystals in the absence or presence of various chiral hydrophobic amino acids. Safety played a big role in this experiment, even though all of the amino acids used are safe to handle, it was important to review corresponding compound Material Safety Data Sheet (MSDS) and proper precautions were taken. When conducting the experiment, it was essential to wear a proper lab coat, goggles, and gloves. All of the materials produced by the experiment were non-toxic and would not harm or damage the environment and were disposed of properly.

To conduct this experiment, 5 mg of each D and L amino acid (tryptophan, phenylalanine, cysteine, and histidine) were dissolved in 1 mL of deionized water to make an amino acid solution. Next, the fresh organic carrots were cut into small individual pieces and weighed using an electronic balance (g). The carrot pieces were immersed in the amino acids solution for ten minutes and placed in properly labeled Petri dishes. Each Petri dish was properly sealed airtight therefore no moisture could enter and were kept in a -20˚C freezer. On days 0, 7, and 14 of the experiment, the Petri dishes were weighed to measure any increase in the weight due to any ice crystal formation. The entire experimental procedure was repeated for each amino acid a total of twenty-five times.

Results: The effects of various chiral hydrophobic amino acids on ice recrystallization were studied and corresponding data is presented in tables 1-7 and plotted in graphs 1-5. For proper statistical analysis, the mean/average weights were determined for each level of the independent variables as shown in tables one, two, and three. The data collected on all three time points were compared to see which chiral hydrophobic amino acids showed the greatest tendency of ice inhibition. The comparison of the data collected on days 0, 7, and 14 showed that the various chiral hydrophobic amino acids except for the control group, which consisted of no amino acid treatment, had a wide range of effects on ice recrystallization on a storage food. Upon further analysis, it was shown that the D- phenylalanine was the best inhibitor initially since there was only a 0.0390 gram change in the weights between day 0 and day 7 and less ice formation. But after day 7, it was noticed that D- cysteine started to show a more positive trend in ice recrystallization inhibition since there was only a 0.0120 gram difference in weight between the original weight on day 0 and the final weight on day 14 due to less ice crystal formation, as shown in data table 4. It was observed that D- cysteine was the best inhibitor of ice recrystallization followed by D- phenylalanine, and L- cysteine. Due to these results, the research hypothesis is partially supported by the data, but did show that chiral hydrophobic amino acids have an impact on ice crystal formation on storage foods. The reason why the research hypothesis is partially supported is because although chiral D- cysteine was the best inhibitor of ice recrystallization, while L- cysteine and D- phenylalanine were also good inhibitors. The variance and standard deviation were calculated for each of the levels of the independent variables to test the precision of the data. After calculating the standard deviation, it was concluded that the standard deviation for all of the levels of the independent variables were relatively low. Therefore, this implies that the data sets were tight and precise.
A t-test was performed on the data at a level of significance of 0.001 with the degree of freedom of 48. The level of significance was chosen to such a degree due to the fact that if the results were to be exploited for commercial application and it would be used to extend the shelf life of storage foods. Therefore for the safety of the humans, it was tested at a level of significance of 0.001. The null hypothesis for the experiment was that there would be no difference in ice recrystallization between the various chiral hydrophobic amino acids and the control. The calculated t values on day 0 showed that all of the levels of the independent variables had a higher t value than the table t value of 3.506, except for D- phenylalanine, which had a t value of 0.532. This implies that the null hypothesis should and shouldn’t be rejected since the majority of the amino acids had a t value above the table t value, but since D- phenylalanine had a t value lower than that of the table t value, the null hypothesis should not be rejected as well. The probability of the results being due to chance for D- phenylalanine, L- histidine, and D- tryptophan are greater than 0.001, and implies that the results of D- phenylalanine, L- histidine, and D- tryptophan has a greater probability of 1 in a 1000 of being due to chance.

On day 14, the calculated t values showed that D- phenylalanine, D- tryptophan, D- cysteine, L- cysteine, and D- histidine had a calculated t value lower than that of the table t, which was 3.506. On the other hand, L- phenylalanine, L- tryptophan, and L- histidine had a calculated t value greater that the table value therefore being significant. This implies that the null hypothesis can and cannot be rejected since there are both categories to prove and disprove the null hypothesis. This states that D- phenylalanine, D- tryptophan, D- cysteine, L- cysteine, and D- histidine are insignificant in inhibiting ice recrystallization and the results have a 1 in a 1000 chance of being due to chance.

The data collected on the effect of chiral hydrophobic amino acids on the inhibition of ice recrystallization is both statistically and not statistically significant. The data collected on day 0 vs. the control implies that most amino acids except D- phenylalanine are statistically significant. The results obtained on day 7 and 14 both state that the most of the D- chiral hydrophobic amino acids are statistically insignificant when compared to the control group.

**Discussion and Conclusions:** The purpose of this project was to find which chiral hydrophobic amino acids, when treated with storage foods, would inhibit ice recrystallization to the greatest extent. Over a period of two weeks, carrots were treated with 5 levels of the independent variables: no amino acids, D- & L- phenylalanine, D- & L- tryptophan, D- & L- cysteine, and D- & L- histidine. It was found that D- Cysteine, D- Phenylalanine, and L- Cysteine had a greater impact on ice recrystallization growth than the other corresponding chiral hydrophobic amino acids. Due to these results, the research hypothesis was partially supported by the data, but did show that chiral hydrophobic amino acids have potential in extending the quality of food product by inhibiting ice recrystallization of storage foods.

A t- test was performed on the data to determine if the data was significant. The data collected for the various chiral hydrophobic amino acids having an effect on ice crystal inhibition is both statistically and not statistically significant. All of the data collected except for D- Histidine and D- Tryptophan was proven to be significant. This implies that the data was due to the independent variable.

Other researchers have investigated the behavior of hydrophobic amino acids and ice recrystallization in sub zero environments. DeOliveira and Payne found that by extracting a certain peptide bond from the AFP’s, and when treating it with common foods, it drastically increased the storage life of the product. It also decreased in cellular membrane damage as well as loss in vital nutrients (DeOliveira et al., 1997; Payne et al., 1994). The findings from this study were very similar to the findings from the study conducted by Payne, since he used peptides.

The possible explanation as to why D-cysteine was such a leading inhibitor of ice recrystallization may lie in the molecular structure of AFPS. AFPS were found to be rich in polypeptide chains composed of high amounts of cysteine residues (Feeney, 2000). Therefore, D-cysteine may be highly effective in repulsing water molecules and inhibiting ice recrystallization as compared to other D or L amino acids. Also, future experiments can be performed by using different concentrations of D and L –cysteine to determine whether the ice recrystallization inhibition is concentration dependent.
LITERATURE CITED


ACKNOWLEDGMENT

I would like to thank my parents and mentor for their support and help in my research project. I would also like to thank VCU for allowing me to use their laboratory.
APPENDIX

EXPERIMENTAL DESIGN DIAGRAM

**Title:** The Effect of Chirality of Various Hydrophobic Amino Acids on Storage Foods to Inhibit Ice Recrystallization

**Hypothesis:** If various food products are treated with D- amino acids and frozen, then the D- amino acids would inhibit ice recrystallization to a greater extent than the corresponding L- amino acids.

<table>
<thead>
<tr>
<th>Independent Variables (IV): D- amino acids, L- amino acids each at 5 mg/mL concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (Control)</td>
</tr>
<tr>
<td>25 samples</td>
</tr>
</tbody>
</table>

**Dependent Variables:** The amount of ice crystals formed (g) obtained by the subtracting original weight from new weight

**Constants:** Amount of amino acid solution prepared, freezer temperature (-20°C), storage time (2 weeks), freezer, concentration of amino acids solution (5 mg/mL), balance used to weigh, and laboratory.
Table 2: Statistical Table for The Effect of Chiral Hydrophobic Amino Acids on Storage Foods to Inhibit Ice Recrystallization Day 0

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>Chiral Hydrophobic Amino Acids</th>
<th>None</th>
<th>Phenylalanine</th>
<th>Tryptophan</th>
<th>Cystine</th>
<th>Histidine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>L</td>
<td>D</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>17.3999g</td>
<td>17.2186g</td>
<td>16.1795g</td>
<td>15.5221g</td>
<td>15.4688g</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>4.2312g</td>
<td>5.3423g</td>
<td>2.9212g</td>
<td>1.2441g</td>
<td>1.2310g</td>
</tr>
<tr>
<td>Max</td>
<td></td>
<td>18.8204g</td>
<td>19.3407g</td>
<td>17.8204g</td>
<td>16.3502g</td>
<td>16.2134g</td>
</tr>
<tr>
<td>Min</td>
<td></td>
<td>14.5892g</td>
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<td>14.8992g</td>
<td>15.1061g</td>
<td>14.9824g</td>
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<tr>
<td>Variance</td>
<td></td>
<td>1.0508</td>
<td>1.8580</td>
<td>1.0004</td>
<td>0.1046</td>
<td>0.1247</td>
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<tr>
<td>Standard Deviation</td>
<td></td>
<td>1.0251</td>
<td>1.3631</td>
<td>1.0002</td>
<td>0.3234</td>
<td>0.3531</td>
</tr>
</tbody>
</table>

Results of the T-Test

None vs. D-Phenylalanine  \( t = 0.532 \)  \( p > 0.001 \)
None vs. L-Phenylalanine  \( t = 4.261 \)  \( p < 0.001 \)
None vs. D-Tryptophan  \( t = 8.735 \)  \( p < 0.001 \)
None vs. L-Tryptophan  \( t = 8.906 \)  \( p < 0.001 \)
None vs. D-Cystine  \( t = 8.562 \)  \( p < 0.001 \)
None vs. L-Cystine  \( t = 7.551 \)  \( p < 0.001 \)
None vs. D-Histidine  \( t = 4.438 \)  \( p < 0.001 \)
None vs. L-Histidine  \( t = 4.499 \)  \( p < 0.001 \)
At \( df = 48 \)  \( t = 3.506 \)  \( \alpha = 0.001 \)
Table 3: Statistical Table for The Effect of Chiral Hydrophobic Amino Acids on Storage Foods to Inhibit Ice Recrystallization Day 7

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>Chiral Hydrophobic Amino Acids</th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>Phenylalanine</td>
<td>Tryptophan</td>
<td>Cystine</td>
<td>Histidine</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>L</td>
<td>D</td>
<td>L</td>
<td>D</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Mean</td>
<td>17.3421g</td>
<td>17.2579g</td>
<td>16.1248g</td>
<td>15.4690g</td>
<td>15.3173g</td>
<td>15.3389g</td>
<td>15.5753g</td>
</tr>
<tr>
<td>Range</td>
<td>4.1373g</td>
<td>5.2910g</td>
<td>3.0112g</td>
<td>1.9395g</td>
<td>1.2181g</td>
<td>2.0353g</td>
<td>2.3913g</td>
</tr>
<tr>
<td>Max</td>
<td>18.8203g</td>
<td>18.9363g</td>
<td>17.8593g</td>
<td>16.2403g</td>
<td>15.9983g</td>
<td>16.3480g</td>
<td>16.7130g</td>
</tr>
<tr>
<td>Min</td>
<td>14.6830g</td>
<td>13.6453g</td>
<td>14.8381g</td>
<td>14.3008g</td>
<td>14.7802g</td>
<td>14.3127g</td>
<td>14.3217g</td>
</tr>
<tr>
<td>Variance</td>
<td>0.9324</td>
<td>1.3115</td>
<td>1.1162</td>
<td>0.1635</td>
<td>0.0986</td>
<td>0.2621</td>
<td>0.3845</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.9656</td>
<td>1.1452</td>
<td>1.0565</td>
<td>0.4043</td>
<td>0.3141</td>
<td>0.5119</td>
<td>0.6201</td>
</tr>
<tr>
<td>1 SD</td>
<td>0.0065-18.3077</td>
<td>0.0065-18.4031</td>
<td>0.0068-17.1811</td>
<td>0.0064-15.8733</td>
<td>0.0032-15.6314</td>
<td>0.0027-15.8508</td>
<td>0.0022-15.6956</td>
</tr>
</tbody>
</table>

Results of the T-Test

None vs. D-Phenylalanine  \( t = 0.281 \)  \( p > 0.001 \)
None vs. L-Phenylalanine  \( t = 4.252 \)  \( p < 0.001 \)
None vs. D-Tryptophan  \( t = 8.946 \)  \( p < 0.001 \)
None vs. L-Tryptophan  \( t = 9.971 \)  \( p < 0.001 \)
None vs. D-Cystine  \( t = 9.164 \)  \( p < 0.001 \)
None vs. L-Cystine  \( t = 7.693 \)  \( p < 0.001 \)
None vs. D-Histidine  \( t = 5.286 \)  \( p < 0.001 \)
None vs. L-Histidine  \( t = 1.662 \)  \( p > 0.001 \)

At df= 48  \( t = 3.506 \)  \( \alpha = 0.001 \)
Table 4: Statistical Table for The Effect of Chiral Hydrophobic Amino Acids on Storage Foods to Inhibit Ice Recrystallization Day 14

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>None</th>
<th>Phenylalanine</th>
<th>Tryptophan</th>
<th>Cystine</th>
<th>Histidine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D</td>
<td>L</td>
<td>D</td>
<td>L</td>
<td>D</td>
</tr>
<tr>
<td>Mean</td>
<td>17.1839g</td>
<td>17.1419g</td>
<td>15.9718g</td>
<td>15.3878g</td>
<td>15.3342g</td>
</tr>
<tr>
<td>Range</td>
<td>3.6352g</td>
<td>5.4923g</td>
<td>3.3592g</td>
<td>1.2702g</td>
<td>1.5843g</td>
</tr>
<tr>
<td>Max</td>
<td>18.4689g</td>
<td>18.7263g</td>
<td>17.7994g</td>
<td>16.1042g</td>
<td>16.4139g</td>
</tr>
<tr>
<td>Min</td>
<td>14.8337g</td>
<td>13.2340g</td>
<td>14.4402g</td>
<td>14.8340g</td>
<td>14.8296g</td>
</tr>
<tr>
<td>Variance</td>
<td>0.7837</td>
<td>1.4546</td>
<td>1.2378</td>
<td>0.1080</td>
<td>0.1693</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.8853</td>
<td>1.2061</td>
<td>1.1126</td>
<td>0.3286</td>
<td>0.4115</td>
</tr>
</tbody>
</table>

Results of the T-Test

None vs. D-Phenylalanine  t= 0.140  p>0.001
None vs. L-Phenylalanine  t= 4.263  p<0.001
None vs. D-Tryptophan    t= 0.951  p>0.001
None vs. L-Tryptophan    t= 9.474  p<0.001
None vs. D-Cystine       t= 1.135  p>0.001
None vs. L-Cystine       t= 2.373  p>0.001
None vs. D-Histidine     t= 3.094  p>0.001
None vs. L-Histidine     t= 4.642  p<0.001
At df= 48  t=3.506  α= 0.001
Figure 1: Some of the Pictures taken on Day 14 of samples treated with D- Cysteine (1), D- Phenylalanine (2), L- Histidine (3), L- Cystiene (4), D- Tryptophan (5), and Control (6)
SECOND PLACE

A NANOPARTICLE-BASED SOLUTION TO MITIGATE CORROSION OF AN ALKALINE FUEL CELL BIPOLAR PLATE

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ABSTRACT

The search for viable alternative energy sources has become a critical area of research, especially due to the adverse effects of existing energy sources (e.g. fossil fuels) on global warming. Fuel cells are one promising technology as they are energy efficient and clean, producing water and heat as byproducts. This study investigated the potential for increasing the corrosion resistance of the bipolar plates in alkaline fuel cells (AFCs) using nanotechnology. By decreasing the corrosion rate of the bipolar plate, a vital component in the fuel cell, the life and efficiency can be enhanced. One approach is to increase the surface area of the coating using nanoparticles. Uncoated (control), gold sputter coated, and NiFe nanoparticle coated steel (provided by QuantumSphere) were tested under open circuit conditions in a 33%wt KOH solution. The mass change was recorded periodically. Additionally, these different coatings were tested in a potentiostatic experiment where the samples were cathodes (-) immersed in KOH. The current produced was recorded and served as a measure of corrosion. The results indicated that the NiFe coating decreased corrosion the most, followed by the gold coating, and the control. T-tests showed significant differences between the NiFe coating and the control. Therefore, the research hypothesis that the NiFe coating improves corrosion resistance was validated. Additional trials are required to improve the accuracy of the findings. Future research should incorporate a potentiostat and corrosion cell setup, as well as scanning electron microscopy for characterization of the corrosion products.

THIRD PLACE

THE EFFECT OF CHEMICAL TREATMENT AND NANOSTRUCTURING ON METAL CORROSION

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ABSTRACT

Certain chemical treatments and resulting surface nanostructures can significantly inhibit corrosion of metals. The effects of three different treatments on the corrosion of aluminum were compared to find the best corrosion inhibitor: electropolishing, which reduces surface roughness to nanometer scale; anodizing, which produces a protective oxide film on the metal surface; and annealing, which removes crystallographic imperfections from the surface. Highly pure (99.999% pure) aluminum foils were either electropolished, anodized, or annealed, and then immersed in 35% hydrochloric acid to induce corrosion. Inspection of the corroded surfaces under an optical microscope revealed that electropolishing yields the most effective resistance to corrosion, followed by anodizing. Annealed samples showed no discernable resistance and no difference with untreated samples. Results of this nature suggest that reducing surface roughness to a few nanometers through electropolishing is far more effective than forming a protective oxide film with anodization, since anodized films contain pores, or defects, which still remain vulnerable to corrosion. Further research will involve studying annealing in further detail, challenging anodizing and electropolishing further to see if similar results persist, testing if longer or shorter lengths of electropolishing inhibits corrosion better, and researching whether combining electropolishing, anodizing, and annealing would provide an optimal solution.
HONORABLE MENTION
CATALASE ACTIVITY IN CELL TISSUES

Sofonias Getachew
1723 North Veitch Street Apt. #9, Arlington, Virginia 22201
Williamsburg Middle School, Arlington, Virginia 22207

ABSTRACT

This experiment tested catalase activity in the cell tissue of liver of veal, beef, carrot, russet potato, and tilapia. Catalase breaks down hydrogen peroxide into water and oxygen. The level of oxygen produced was measured by the displacement of hydrogen peroxide in a graduated cylinder. It was found that liver had the largest abundance of catalase while tilapia had the smallest. In general it appears that tissues that use more oxygen and detoxify poisons in turn have larger amounts of catalase.

HONORABLE MENTION
THE EFFECT OF TEMPERATURE ON CHEMILUMINESCEENCE

Andrea E. Green
4827 North 33rd Road, Arlington, Virginia 22207
H.B. Woodlawn, Arlington, Virginia 22207

ABSTRACT

This project was designed to test what the effect was of temperature on chemiluminescence (also known as the way a glow stick produces light). The hypothesis was that heat would cause a brighter light, while colder temperatures would cause a dimmer light. To determine the outcome of this experiment, a glow stick was submerged in a bowl of water for three minutes. There were three different temperatures of water, -10 degrees Celsius, 20 degrees Celsius, and 70 degrees Celsius. After three minutes, the glow stick was cracked and shaken for ten seconds, then held up to a light meter to determine the amount of light it gave off in lumens. This measurement was done in a room with absolutely no light to ensure accurate results. Five trials were done for each bowl of water, including a control group that was not placed in any water. The average amount of light given from a -10 degrees Celsius glow stick was only one lumen, whereas a 70 degrees Celsius glow stick averaged 38.98 lumens. The 20 degrees Celsius glow sticks averaged 7.32 lumens, and the control averaged 8.84 lumens. The conclusions for this experiment were that the hypothesis was supported and that a hotter glow stick would produce a brighter light than a colder glow stick.

HONORABLE MENTION
THE EFFECT OF ULTRAVIOLET LIGHT ON THE STRUCTURES OF PROTEINS

Jimin He
3046 North Harrison Street, Arlington, Virginia 22207
Yorktown High School, Arlington, Virginia 22207

ABSTRACT

The purpose of this experiment was to determine if exposure to ultraviolet light would affect the structures of protein found in egg white. Fifty mL of egg white were placed into each of six beakers and exposed to UV light for twenty-four hours. The exposed proteins were analyzed using gel electrophoresis. The same steps were repeated for 48-hour and 72-hour exposure. Unexposed egg white was also analyzed using gel electrophoresis to serve as the control of the experiment. The unexposed protein blots had a mean size of 0.850 cm by 0.300 cm; the 24-hour
exposure protein blots had a mean size of 1.017 cm by 0.383 cm; the 48-hour exposure protein blots had a mean size of 1.533 cm by 0.417 cm; the 72-hour exposure protein blots had a mean size of 1.583 cm by 0.400 cm. A Tukey's HSD test was performed; the results indicated that only exposure time greater than or equal to 48 hours would affect the structures of protein. The test returned a p-value of 0.2361 between unexposed protein and 24-hour exposure, 0.0075 between unexposed protein and 48-hour exposure and 0.0069 between unexposed protein and 72-hour exposure. The gel electrophoresis did not produce the characteristic protein fragments, which would indicate whether the structures of exposed proteins were affected. However, it should be noted that when egg white denatures, it forms a firm solid. Thus the increased size of the protein blots after prolonged exposure to UV light could indicate that the egg white proteins had denatured, but not to the degree severe enough that the protein actually broke apart.

**OTHER PAPERS SELECTED FOR PRESENTATION:**

The Effect of the Yeast and Sugar on Bread Height. Abigail K. Bessler, Williamsburg Middle School, Arlington County Schools.

The Effect of the Addition of a Chlorophyll Extract to Sunscreen on the Amount of Ultraviolet Radiation Prevented from Reaching a Surface. Claire A. Bobst, Yorktown High School, Arlington County Schools.

The Effect of Generic Versus Non-Generic Drug Brands on Drug Solubility Time. Kaitlyn M. Booker, Hanover High School, Hanover County Schools.

The Effect of Temperature on the Weight and Growth of Rock Crystals. Cassidy E. Bresee, Hanover High School, Hanover County Schools.

The Effect of Air on the Heat of Combustion. Matthias J. Brooks, George H. Moody Middle School, Henrico County Schools.

The Effect of Different Temperatures of Various Liquids on Viscosity. Joshua J. Donohue, Hanover High School, Hanover County Schools.

The Effect of Linear Alkyl Benzene Sulfonate on Extraction of Various Oils from Cotton Cloth. Mary A. England, Central Virginia Governor’s School, Lynchburg City Schools.


The Relationship of Calcium Carbonate Content in Egg Shells between Non-Organic and Organically Produced Eggs. Dennis S. Liu, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Temperature on Battery Life. Jason M. Parker, Deep Run High School, Henrico County Schools.
CHEMISTRY B
FIRST PLACE
THE SELECTIVE CRYSTALLIZATION AND ANALYSIS OF CALCIUM CARBONATE POLYMORPHS USING FOURIER TRANSFORM INFRARED SPECTROSCOPY

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Abstract: Calcium carbonate has three crystal phases, or polymorphs (calcite, aragonite, and vaterite), which naturally occur in many manmade structures and materials, in the industrial, material, and pharmaceutical sectors. It is essential to be able to distinguish these polymorphs, because different polymorphs may have different physical and chemical properties, such as strength, durability, solubility, reactivity, etc. Also, the ability to synthesize these crystals for laboratory study is of the utmost importance. In this study, methods were developed for the artificial synthesis of the three polymorphs. Due to the relative instability of aragonite and vaterite, additional measures had to be put into place to ensure that they would not decompose to yield calcite. After the synthesis was complete, the samples were analyzed with a Perkin-Elmer FTIR System 2000 spectrometer to look for differences in the IR spectra. Spectra were recorded from 400 to 4000 cm⁻¹ range with 4 cm⁻¹ resolution using the Perkin-Elmer Spectrum 3.0.1 software. The spectral range from 650 cm⁻¹ to 1150 cm⁻¹ showed unique spectral features for different polymorphic forms, suggesting that there is a plausible way to distinguish between the polymorphs in the field. Hopefully now, spectroscopy will become a procedure used in industry to determine the exact composition of a compound, because this can become critical, especially in fields such as pharmaceuticals, where having the correct polymorph of a substance is essential.

Introduction: Calcium carbonate (CaCO₃) is a very common mineral, constituting about 4% of the Earth’s crust. There are three crystal phases of calcium carbonate that are found in nature: calcite, aragonite, and vaterite (in the order of their thermodynamic stability). These different phases exist in “numerous materials including, but not limited to, industrial scale formation, limestones and several pathological cases (urinary stones, pancreatic calcification, etc.)” (Kontoyannis and Vagenas, 2000). Polymorphs, or different crystal structures of the same molecule, can be very significant in the pharmaceutical and industrial areas because different polymorphs may have different physical and chemical properties, such as strength, durability, solubility, reactivity, etc. Because of this, the different polymorphs can act differently (in the human body, in a structure, etc. Therefore, being able to distinguish them from each other is of the utmost importance.

Infrared (IR) spectroscopy analyzes IR light before and after interaction with the vibrations of the sample’s molecules. This gives information about the sort of bonds that are in a substance. Bond vibrations simply refer to the movements that a molecule’s bonds make. IR spectroscopy takes advantage of the fact that molecules have specific frequencies at which they vibrate, corresponding to discrete energy levels. Therefore, when a beam of IR light interacts with the bonds in a substance, the substance may absorb some of the light and have a net dipole movement, resulting in a molecular vibration. This type of molecule is said to be IR active (Banwell and McCash, 1994).

The frequency at which the light is absorbed is important, because this tells us what type of molecule it is. Infrared spectroscopy is a highly useful technique in inorganic and physical chemistry because it allows the chemist to find out the chemical identity of a substance, since different functional groups’ bonds have different frequencies at which they have net dipole movement (Hsu, 1997).

Fourier Transform infrared spectroscopy involves sending IR light at the sample at different time intervals, and analyzing the light after it has interacted with the sample. The difference in time is achieved by using a device called an interferometer. Then, the collected measurement is known as an interferogram, which is then converted from the time domain into the frequency domain using the mathematical Fourier Transformation. This is a
complicated set of equations and calculations performed by the computer to yield an IR spectra with the domain of frequency (or wavenumber) and a range of %T.

The use of vibrational spectroscopic tools such as Raman and IR to distinguish polymorphic forms is a usual practice now. The goal of this study was to selectively crystallize CaCO₃ into different polymorphic forms and identify those crystal forms using IR spectroscopy.

**Methods and Materials:** Calcite was the first polymorph to be synthesized. 50 mL of 0.025M NaHCO₃, 50 mL of 0.025M CaCl₂, and 10mL of 0.1M NaOH were obtained. The NaHCO₃ and CaCl₂ were both brought to pH 10 by drop-adding NaOH. Then, 20 mL of NaHCO₃ and CaCl₂ each were mixed and left to crystallize overnight. The mixture with calcite crystals were centrifuged and the calcite extracted from the bottom of the centrifuge container. The presence of magnesium as a co-solute was found to inhibit the crystallization of calcite.

Aragonite was the next polymorph. It was reported in Falini, *et al.* (1996) that the magnesium ion, due to a large hydration sphere, is able to inhibit the crystal growth of calcite: “The gelatin film allows a high degree of magnesium of calcium in calcite […] The presence of magnesium in solution induces a substantial change in the crystal morphology […]” (Falini, *et al.*, 1996). A similar phenomenon was reported in urchins (Xingfa, *et al.*, 2005). Consequently, more aragonite forms following the loss of calcite (Kitano, *et al.* 1969). In order to synthesize aragonite, the following procedure was used: 50 ml of 0.025M CaCl₂ and 50 ml of 0.0625M MgCl₂ were mixed with 50 ml of NaHCO₃. The pH was kept below 9. The aragonite was separated from the wall of the crystallizing vessel.

Finally, vaterite, the most difficult to produce in a stable form was synthesized. Shivakumara, *et al.* (2006) described that glycine could be used as a directing agent for the creation of vaterite. It is presumed that the presence of carboxylic acid functionality (aminoacids) are reported to interact with the crystal causing a change in the crystal habit. However, it is certain that the interaction of glycine with calcium carbonate ends with the creation of vaterite. Vaterite was prepared using the following method:

Five mL of a 0.09 M L-glycine solution was mixed with 10 mL of a 0.05 M CaCl₂ solution, under constant stirring. The glycine would act as a directing agent so that only vaterite would form (Shivakumara, *et al.*, 2006) (Dupont, 1997). Two drops of 0.05 M HCl solution were added to this and stirred for 5 minutes. 10 mL of 0.05 M NaHCO₃ were mixed with this solution to yield a white precipitate. The precipitate was subsequently centrifuged, washed, and dried.

FTIR spectra of samples were recorded using PerkinElmer FTIR System 2000 spectrometer. Sample pellet were made using KBr, which is transparent to IR light. The crystals that formed were dried overnight before analyzing. Spectra were recorded from 400 to 4000 cm⁻¹ range with 4 cm⁻¹ resolution using the PerkinElmer Spectrum 3.0.1 software.

**Results:** After the calcium carbonate samples were run in the IR spectrometer, spectra were obtained that interestingly enough, matched the results described in the literature. Figure 1 shows the spectra of the three polymorphs (range of 400 to 2300 cm⁻¹), Figure 2 shows the expanded region of the spectra (from 600 to 1150 cm⁻¹), and Table 1 shows the corresponding peak values.
Figure 1. IR spectra for calcite, aragonite, and vaterite.

Figure 2. Expanded region of the spectra (from 600-1150 cm$^{-1}$).
Calcite Peak Values (cm<sup>-1</sup>) | Aragonite Peak Values (cm<sup>-1</sup>) | Vaterite Peak Values (cm<sup>-1</sup>)
---|---|---
668 | 671 | 672
712 | 699, 712 | 713, 743
874, 848 | 854 | 875
1082 | 1082 | 1077, 1088
1423 | 1485 | 1406, 1485

Table 1. Peak values for the spectra.

Spectral range from 650 cm<sup>-1</sup> to 1150 cm<sup>-1</sup> shows unique spectral features for different polymorphic forms. The comparison of the spectral features for calcite, aragonite and vaterite is tabulated in Table 1. Hence, a method for distinguishing these compounds is shown.

**Discussion and Conclusions:** This study provided interesting results in many areas, but the most intriguing part was the synthesis of the samples. The methods described in this paper were developed from procedures already described in the literature. The possible applications of this discovery offer interesting ideas. For example, the relative structural strength of the different polymorphs in materials such as concrete and cement could be researched. This could offer increased strength for more rigorous building projects.

Additionally, this could have repercussions in settings such as pharmaceutical plants, where spectroscopy will hopefully become a procedure used to determine the exact mineral composition of a compound. This can become critical, especially when matters of human life are taken into account. However, it is undeniable that spectroscopy is a science that has far-reaching applications. In the coming years, its use in our daily lives will undoubtedly increase.

**LITERATURE CITED**


ACKNOWLEDGMENTS

Many thanks to Dr. Umapathy and the staff at IISc Bangalore, Inorganic and Physical Chemistry Lab, who helped so much with the project and the paper. However, none of this would have been possible without Ashok Samuel, who helped incredibly with advice and direction all the time. Thanks so much, because none of this would have been possible without you!
SECOND PLACE

PROTECTIVE PROPERTIES OF LEAF PIGMENTS AGAINST UV-INDUCED SKIN CANCER

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ABSTRACT

In autumn, altered proportions of pigments present in deciduous leaves result in changes in the colors of those leaves. This phenomenon serves several functions for the tree, one of which is to act as protection against damaging ultraviolet radiation. Previous research indicated that pigments extracted from yellow and orange leaves offered protection of leaf tissue and DNA against short-term UV exposure, and pigments extracted from red leaves offered longer term protection of the same kind. It was speculated that these pigments would be protective of other types of cells, as well. In this study, human epithelial cells and bacterial cells were exposed to UV radiation of increasing duration and shielded with a broad range of concentrations of purified plant pigments found in fall foliage. DNA from these cells was then analyzed for the presence of thymine dimers induced by UV radiation by dot blot using an antibody specific for thymine dimers. Thymine dimers are an indication of UV damage and are associated with the development of skin cancer. Results indicated that anthocyanins and xanthophylls are protective of human epithelial cells and bacterial cells against UV induced DNA damage. This indicates that the fall foliage pigments that are beneficial to plants are also capable of UV protection in human cells and bacterial cells. This may have implications in skin cancer prevention and treatment. Further research should include a determination of what concentrations of these pigments are typically found in human tissues, how those concentrations are impacted by diet, and whether the pigments in question maintain their structural integrity and protective properties after being metabolized by the human body.

THIRD PLACE

THE EFFECT OF TIME ON VITAMIN C IN ORANGE JUICE

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ABSTRACT

Consuming enough Vitamin C is important to good health. A major source of Vitamin C is orange juice, which is often advertised as having 100 percent of an adult’s recommended daily needs in a standard serving. Prior research has shown that many factors, including time, can cause the Vitamin C level in orange juice to decline. In this research, it is hypothesized that if a standard serving sample of orange juice (240 milliliters) is removed daily from a 1.89-liter carton for eight days, then the sample on the eighth day will not provide enough Vitamin C to meet the Recommended Daily Allowance (RDA) requirement for an adult male. The Vitamin C content of the orange juice was determined using a titration procedure. The Vitamin C was measured by comparing the volume of diluted Lugol’s solution needed to oxidize the Vitamin C in orange juice samples with the volume needed to oxidize a control solution made from 250-milligram Vitamin C tablets and distilled water. The results of this experiment tend to confirm previous research and the hypothesis. As with earlier research, there was a measurable decrease in the Vitamin C level over time for each orange juice sample tested. The results also showed that in four of five samples, an adult male would not get 100 percent of his RDA of Vitamin C from a standard size serving of orange juice on the eighth day. Additional research is needed to test more samples and determine if a problem with a starch solution used in the research caused some unexpected results.
HONORABLE MENTION

THE EFFECT OF ACIDIC WATER ON THE MASS OF LIMESTONE MARBLE CHIPS

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Washington and Lee High School, Arlington, Virginia 22201

ABSTRACT

Acidic rain is a type of rain formed when nitrogen oxide and sulfur dioxide roam in the air due to factories. This biohazardous liquid falling from condensated clouds is harmful to plants, animals, and buildings. This problem occurs in places of high industry such as the U.S and Japan. This experiment tested whether or not lower pH levels of sulfuric acid would affect the mass of limestone marble chips. This experiment contained a control, where the pH of 6 was used (the pH of regular rainwater); and also the pH of 2 and the pH of 4 groups. Marble chips were weighed and placed in ice cube trays, where they remained until the end of the experiment. The Marbles were sprayed daily (excluding weekends) with each group getting the same dose of their pH level for two weeks. After the two week period the chips were soaked for another week in their own pH level. The hypothesis was that if lower pH levels are sprayed on the marble chips, then the chips will lose mass. The marble chips were weighed after the three weeks came to an end. The pH of 2 and 6 were calculated to have a significant amount of change. The marble chips that were the most effected by the sulfuric acid were the ones sprayed and soaked with the pH of 2 with an average change of 0.07 grams. The other comparisons of groups calculated out to be not significant.

HONORABLE MENTION

THE EFFECT OF DIFFERENT DOSAGE FORMS ON THE DISSOLUTION RATE OF ASPIRIN

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ABSTRACT

Aspirin is used by a lot of people as a preventive measure against heart attacks. There are many different types of dosage forms of aspirin available commercially; however it is not commonly known how quickly aspirin dissolves from these dosage forms. Therefore the objective of this research was to determine the dissolution rate of aspirin from Regular Strength Aspirin, Regular Strength Aspirin Coated, Bufferin Regular Strength Aspirin and Enteric Coated Aspirin Tablets. The hypothesis was that if the Regular Strength Aspirin dosage form is used, then the dissolution rate will be the fastest. The experiment was carried using the USP 4 Flow-through Cell Apparatus using a dissolution media (pH 3.0, maintained the temperature at 37°C) that mimicked the stomach fluid conditions. The amount of aspirin dissolved was determined at 12, 17, 22, 27, 32, 37, 42, 47, 52, 57 and 62 minutes and up to 114 minutes for the Enteric coated tablets. Aspirin levels were measured using a UV spectrophotometer. The cumulative amount of aspirin (mean ± sd) dissolved after 62 minutes was 301.89 ± 20 mg for Regular Strength Aspirin, 288.28 ± 19.39 mg for Coated Aspirin, 281.48 ± 31.62 mg for Buffered Aspirin and Enteric Coated Aspirin tablets and 112.27 ± 60.63 mg for Enteric Coated Aspirin tablets (203 ± 44.02 mg at the end of 114 minutes). The time taken to dissolve 50% of the tablet was ~15 min for the Buffered Aspirin, ~25 min for the Coated Aspirin, ~20 min for the Regular uncoated and ~50-75 min for the Enteric coated tablets. The results did not support the hypothesis because Buffered Aspirin tablets, but not the Regular Aspirin tablets, dissolved a little faster. Despite small changes in the mean values, there were no statistical differences in the dissolution rate between the Aspirin Regular, Aspirin Coated and Bufferin tablets except for the Enteric coated tablets with significantly (p<0.05) lower dissolution rate. From this experiment it can be concluded that although the Buffered aspirin tablets dissolved relatively faster, the overall amount of aspirin delivered by the different dosage forms was similar for all the dosage forms except for the Enteric coated tablets which took the longest to dissolve and did not even deliver the amount of aspirin as was stated on the label.
HONORABLE MENTION

THE EFFECT OF SODIUM CYANIDE ON OXYGEN REDUCTION

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

Cyanide is a rapidly acting, potentially deadly chemical that acts on the mitochondrial cytochrome c oxidase, which results in the blockage of the electron transport chain. If the electron transport chain is disrupted, then the cell cannot aerobically produce ATP because cyanide inhibits the reduction of molecular oxygen to water. Thus, cytochrome c oxidase loses its native function and tissues that depend on aerobic respiration are affected. The purpose of this project was to investigate the effects of sodium cyanide on oxygen reduction. The flow injection analysis results shown that as the amount of sodium cyanide increases, reductive current of oxygen on the cytochrome c oxidase-modified electrode decreases, which supports the hypothesis stating as the amount of sodium cyanide increases, then oxygen reduction will decrease. The cytochrome c oxidases form a complex with cyanide in a 1:1 stoichiometry having the apparent inhibition constants of 0.778 and 1.33 mM at 25 and 38 °C, respectively. After the modified electrode was stored at 4 °C in air for 60 days, there was no apparent decrease on the reductive current of oxygen. The oxidase modified electrode may be used as a biosensor to detect any traces of cyanide to protect our environment from pollution and chemical terror because of the extreme toxicity and variety of cyanide usage.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Hardness of Water on the Rate of Electrolysis of Water. Rachel C. Quinn and Hannah E. Mayhew, Deep Run High School, Henrico County Schools.

The Effect of Temperature on the Reaction Rates of Iron Oxidation. Raymond J. Santucci, Hanover High School, Hanover County Schools.

The Effect of Different Concentrations of Solutions and pH Levels on Freezing Temperature. Pooja Sharma, Williamsburg Middle School, Arlington County Schools.

The Effect of Temperature on Different Compositions of Automotive Motor Oil. Michael S. Simeoni, Mills E. Godwin High School, Henrico County Schools.

Effect of a Natural Enzyme on Carbon Dioxide Sequestration. Kyle W. Smith, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of the Type of Vegetable on the Amount of Biofuel Produced When Distilled. Emily R. Spiller, George H. Moody Middle School, Henrico County School.

The Difference in the Heat Output of Ethanol with the Addition of Sugar. J. Luke Thomason, Shenandoah Valley Governor’s School, Augusta County Schools.


The Effect of Different Soaking Solutions on the Color of Tie Dyed Cotton. Brandy M. Walton, Hanover High School, Hanover County Schools.

Microwave Assisted Synthesis of Biodiesel. Rebekah I. Webster, Southwest Virginia Governor’s School, Pulaski County Schools.
The Relationship between Tombstones’ Ages and the Amount of Calcium Carbonate in Their Surrounding Soil.
Tyler C. Wood, Shenandoah Valley Governor’s School, Augusta County Schools.
CONSUMER SCIENCE A

FIRST PLACE

AN INVESTIGATION OF THE DURABILITY AND SHELF LIFE OF SPOT-ON FLEA AND TICK TREATMENT

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Chesapeake Bay Governor’s School, Tappahannock, Virginia 22560

Abstract: This research project tested the durability and shelf life of a spot-on flea and tick treatment known as Frontline. The testing was conducted on multiple Canis lupus familiaris at the local animal shelter where the researcher is employed. One hundred dogs were given Frontline, 50 fresh and 50 old. After checking the flea frequency before and after the researcher concluded that the old work just as well as the new. The experiment provided an economic and scientific advantage for consumers and their pets.

Introduction: Frontline is sold at veterinary clinics across the country as a safe and easy way to eliminate ticks and fleas. Dosage is given based on body weight and is sold in special tubes. Customers are instructed to apply one tube once a month to their animal. Prices differ among different clinics, but in all cases the larger the dose the more it costs. Many people have more than one pet and so they are in need of large amounts of Frontline every month, which can be costly.

The liquid treatment is available in four different packages, each costing a different price: treatment for dogs up to 22 lbs. costs $13 a tube, 23-44 lbs. $14, 45-88 lbs. $15, and 89-132 lbs. $16. Each box holds six tubes; all boxes distribute the same formula but contain different amounts. A dog up to 22 lbs would be given 0.6 cc of Frontline, dogs 23-44 lbs are given 1.3 cc, dogs 45-88 lbs receive 2.6 cc, and dogs 89-132 lbs are treated with 4.0 cc. It may be cheaper for pet owners to buy the largest size and, using a 3.0 cc syringe, split the formula between their pets. The veterinary clinic provides customers with 3.0 cc syringes and small green pill bottles with caps to split the Frontline. The customers are instructed to open the tubes of Frontline and place all the formula into the pill bottle, then use the syringe to distribute each pet with the needed dose. For example, suppose a customer has three dogs: one weighs 30 lbs, one weighs 35 lbs, and the other weighs 50 lbs. If the owner bought a tube for each dog based on their weight it would cost $43 once a month for a total of 5.2 cc Frontline. The customer would save money if he purchased two 4.0cc tubes for $32 and distributed the recommended dosage himself with the syringe. The owner now has 2.8 cc of Frontline left over in the pill bottle which will not be needed again for another four weeks.

At the veterinary clinic/animal shelter where the researcher works, one veterinarian advised that the Frontline will last in the pill bottle for a month and still be usable for another treatment, while another veterinarian believed that it did not last outside of the original packaging over time and that after long shelf life it would not perform effectively. This project answered the question whether or not Frontline is still efficient after being opened and if it economically saves consumers money by purchasing larger dosages with formula left over.

Over the last few years different studies have been conducted to produce the most effective form of flea and tick prevention. Dipping was introduced as one possible way to rid pets of parasites; owners were instructed to stir the formula into a tub of water and then simply dip their animal into the mixture. This form of prevention would be done every couple weeks. That type of impediment was not practical in that it was quite time consuming, messy, and labor intensive. Another form of parasite prevention for canines was spray, which was simply spraying the animal with a small bottle of prevention whenever in need. Sprays, however, had more effect on a particular area rather than on the whole animal itself. Flea collars were also produced as a way to control parasites, but they lacked effectiveness on ticks and therefore were not adequate. Shampoos and powders have also been tried, but like dipping...
they were time consuming and untidy. Spot-on treatments, like Frontline, have proved to be the easiest and most effective methods for controlling ticks and fleas. With these products the pet owners simply place the specific dose of liquid on the shoulder region of the animal. Once the formula is distributed it will travel throughout the body through oil glands. As illustrated in Figure A on the left (Frontline®) the ingredients dissolve into the follicles and then move back out and spread to other follicles nearby. Frontline not only kills fleas and ticks but also prevents future infestations by “breaking the flea and tick life cycles”. In other words Frontline contains ingredients that eliminate flea egg and larvae as well as tick egg and larvae (Frontline®).

Parasites like ticks and fleas can lead to serious health issues for pets and leave pet owners at risk of contracting deadly diseases. Flea and tick prevention is imperative to protect people and their animals. The cat flea, *Ctenocephalides felis*, and Brown dog tick, *Rhipicephalus sanguineas* are the most common parasites of canines. (Koehler and Castner, 1991). These unwanted parasites can transmit deadly diseases to their host such as tapeworms, Lyme disease, and Rocky Mountain spotted fever (Burgdorfer and Barbour, 1982). Some illnesses can then be contracted by the pet owner from the parasites as well (Bren, 2001). The researcher wanted to inform pet owners of a less expensive way to protect their animals from those deadly parasites. This experiment may educate people on the durability and shelf life of spot-on flea and tick treatment.

The hypothesis for the experiment was that the Frontline used right away and the Frontline used after weeks out of the original packaging had the same effect on the number of fleas and ticks on the dogs.

$$H_0 : F_f = F_o$$

F represents mean number of fleas and ticks, f stands for fresh Frontline, and o symbolizes the old Frontline.

The alternative hypothesis of the experiment was that the old Frontline eliminated less fleas and ticks than the fresh Frontline used right away.

$$H_A : F_f \neq F_o$$

**Methods and Materials:** By working at the veterinary clinic/animal shelter the researcher was given access to multiple dogs every day. The county Animal Control brought in dogs randomly throughout the week and each dog was in the pound for a specific time. The researcher was able to conduct the experiment on a large sample size of canines. When a county dog was brought in it was examined by the veterinarian. The veterinarian noted whether or not flea treatment was needed; if so the researcher then tested either the fresh Frontline or old Frontline on the animal.

To make the selection equal she treated the first 50 dogs with fresh Frontline and then she treated the last 50 with Frontline that had been in one of the pill bottles for four weeks. She acquired a large supply of Frontline which she placed in pill bottles and kept for four weeks. Each week she set aside more as she used what she had previously set out. The researcher used 3 cc syringes to distribute the old Frontline.

Following the procedure performed by Schenker and Humbert-Droz (2001) before treating the animal with Frontline she used a fine comb and combed through the fur off the lower back for a period of three minutes while she counted the number of ticks and fleas seen. After the data had been properly recorded the researcher waited 48 hours before recounting the particular area she had searched before. She then made a comparison of the before and after flea and tick count based on per unit area (Shanks and Jones, 2000). This procedure was conducted numerous times until the researcher had a large sample size. The independent variable was the type of Frontline used. The response variable was the number of fleas counted. The frequency of fleas were recorded as either zero, low (0-5), or high (5+). The constants were the species of dog (*Canis familiaris*), the area of body being combed, and the
sampling method. The fresh Frontline was the control. Once the researcher finished gathering all the data she required, she employed the Chi-Square test to compare her results and test her null hypothesis.

**Results:** The experiment accepted the null hypothesis. As shown in Table A and Figure C, the old Frontline had the same effect on the flea frequency as the fresh Frontline. Out of a 100 dogs half were treated with the old Frontline and the other 50 were treated with the fresh. The chi-square analysis of the after data yielded a chi-square value of 0.00, which is statistically very significant. The frequency of flea density after had a ratio of 46: 4: 0 from zero, low, and high for the fresh as well as the old.

**Discussion and Conclusions:** By using the chi-square test the researcher was able to calculate the percent of confidence within the results. As shown in Table B since the calculated chi-square was lesser than the critical value the researcher accepted the null hypothesis. The null was accepted with very high confidence since the actual ratio was the same as the expected ratio. Based on Figure D consumers are able to save money when purchasing Frontline. Further testing on Frontline could provide an even cheaper application for pet owners. Testing a longer shelf period could improve this experiment as well. This experiment provided pet owners with a statistically significant and economic advantage.

**LITERATURE CITED**


ACKNOWLEDGMENT

I would like to thank the veterinarians at the King William Veterinary Clinic, Dr. John Haile and Dr. Lindsey Haile for providing me with a place to conduct my studies and the tools I used for this experiment. I would also like to thank my MES teacher Mr. Goff for his guidance throughout all the months on this project.

APPENDIX

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Fresh Frontline</th>
<th>Old Frontline</th>
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<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Zero</td>
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</tr>
<tr>
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<td>36</td>
<td>4</td>
</tr>
<tr>
<td>High</td>
<td>14</td>
<td>0</td>
</tr>
</tbody>
</table>

Table A- Frequency of flea density.
The Effectiveness of Fresh Vs. Old Frontline: Flea Density Before Treatment Vs. After Treatment

Sample Size 50

Frequency (Percent of the Total)
Null Hypothesis: Dogs receiving fresh flea treatment will have fleas with equal frequencies as dogs receiving old flea treatment.

Table B- Chi-Square Results.

<table>
<thead>
<tr>
<th>Contingency Table</th>
<th>Zero Fleas</th>
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<th>High Density</th>
<th>Totals</th>
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<td>Fresh Actual</td>
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<tr>
<td>Expected</td>
<td>46</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Old Actual</td>
<td>46</td>
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<td>0</td>
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<td>Expected</td>
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<td>92</td>
<td>8</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Chi-Square Calculated: 0.00  
Chi-Square Critical (95% confidence): 3.841
Figure D- Pie Charts of Flea Density

Fresh Frontline
- Zero: 0%
- Low: 28%
- High: 72%

Old Frontline
- Zero: 0%
- Low: 28%
- High: 72%

Fresh
- Zero: 0%
- Low: 8%
- High: 92%

Old
- Zero: 0%
- Low: 8%
- High: 92%
SECOND PLACE

YOU LIVE, YOU LEARN, THEN YOU GET ...?

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ABSTRACT

Parents spend a substantial amount of money on disposable diapers throughout their child’s first several years of life. In this experiment the absorbency of a more expensive brand of diaper will be compared to a less expensive brand of diaper. Parents will find this useful because this could possibly save a great deal of money. To test the absorbency 118.3 milliliters of water was poured into the diaper at a constant rate. This amount was used because this is approximately how much waste a baby produces when it relieves itself. Ten seconds elapsed and a paper towel was then placed on top of the wet diaper. Weight was placed on top of the diaper and paper towel. Ten seconds elapsed and the paper towel was removed and immediately weighed. The study revealed that the most expensive brand had the worst absorbency. The middle price brand had the best absorbency, and the least expensive had the middle absorbency amount. Parents would be able to save a great deal of money by opting to buy the middle priced diaper instead of the most expensive brand. The results were very significant with a p-value less than 0.0001, showing the most expensive brand is not the most absorbent diaper and the least expensive is not the least absorbent.

THIRD PLACE

THE EFFECT OF MOMENTUM INVESTING STRATEGIES ON SHORT TERM STOCK PORTFOLIO PERFORMANCE

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Mountain Vista Governor’s School, Middletown, Virginia 22645

ABSTRACT

This study investigates the abnormal returns of momentum investing and compares them to gains from buy-and-hold methods. This paper documents the effects momentum during both bear and bull markets to see if momentum investing is helpful in making a profit, and also in saving an investor from a loss. The hypothesis is that momentum investing, selling losers and buying winners, will result in higher returns than traditional buy-and-hold strategies. Three diversified portfolios of stocks were used to simulate an institutional, moderate, and novice investor. The study has shown that momentum investing has a more significant role for selections of stocks that are increasingly random. As well, the study has shown that regardless of portfolio composition or timing of the market, momentum investing outperforms buy-and-hold strategies. From the study, the conclusion has been that there is a direct correlation between an increasing effectiveness of momentum strategies with increasingly arbitrary portfolio selections.
HONORABLE MENTION
THE EFFECT OF DIFFERENT BRANDS OF MOUTHWASH ON THE NUMBER OF BACTERIA COLONIES

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Hanover High School, Mechanicsville, Virginia 23116

ABSTRACT

This experiment tested the effect of different brands of mouthwash on the number of bacteria colonies grown. The purpose of this experiment was to determine which brand of mouthwash would grow the least number of bacteria colonies after rinsing with the different mouthwashes for thirty seconds. The information collected in this experiment could help consumers know which brand of mouthwash to buy to kill the most bacteria in the mouth. In this experiment, it was hypothesized that if individuals rinse with Listerine and the store brand mouthwash, then Listerine mouthwash will kill the most bacteria. The materials used for this experiment were Knox gelatin, one bottle of Listerine, and one bottle of Lander mouthwash, water, and petri dishes. One permanent marker, a cup, and cotton swabs were also needed. Knox gelatin was poured into the petri dishes after it was mixed with water and still in its liquid form. The petri dishes were then placed in the refrigerator so the Knox gelatin could cool and form a jelly-like substance. After the gelatin was done cooling, individual’s mouths were swabbed with cotton swabs before and after they rinsed with water, Listerine, or Lander. The cotton swabs were rubbed on the gelatin and then the petri dishes were set aside to allow for the bacteria to grow. At the end of the experiment, it was found that Listerine grew the least amount of bacterial colonies. The active ingredients in Listerine are eucalyptol, menthol, methyl salicylate, thymol, and alcohol (21.6%). Lander had the menthol and the methyl salicylate like Listerine, but did not have the eucalyptol or thymol, and it only had 5% alcohol. This may have been the reason why Listerine prevented the most bacterial growth.

HONORABLE MENTION
THE EFFECT OF ADDITIVES IN COOKIE DOUGH ON COOKIE SPREADING

Kimberly D. Castleman
3209 Old Brookewood Court, Richmond, Virginia 23233

Mackenzie G. Newman
13009 Trinity Court, Richmond, Virginia 23233
Deep Run High School, Glen Allen, Virginia 23059

ABSTRACT

Most kids reach for the biggest cookie in the cookie jar. The purpose of this experiment was to determine the effect of adding ingredients to cookie dough on how much a cookie spreads when baked. In this experiment the different additives were the independent variables and the amount a cookie spreads was the dependent variable. The control group was the cookie that was given no extra additive. The hypothesis stated that if chocolate chips were added to cookie dough, then the cookie would spread farther. The oven was preheated to 176 degrees Celsius (350 degrees Fahrenheit) and the basic cookie dough was created. On six pieces of parchment paper, ten circles that had a diameter of two centimeters were drawn using a compass and a marker. Group A received chocolate chips, group B received M&Ms, group C received raisins, group D received macadamia nuts, group E received peanut butter chips, and group F was the control. The cookies were baked for twelve minutes. The distance from the starting perimeter to the ending perimeter was measured with a ruler. Each mean was recorded. The chocolate chip cookies spread the farthest and had the largest mean, which was 0.55 cm. The order from largest to smallest mean was peanut butter chips, M&Ms, macadamia nut, and plain. The null hypothesis was rejected in most comparisons (t - 3 > 2.101; t = 3.2 > 2.101; t = 4.7 > 2.101; t = 0.7 < 2.101; t = 4.9 > 2.101 at df= 18; p<0.05). The data supported the research hypothesis. There were several reasons why the results occurred in this manner. Chocolate chips held the highest amount of sugar and were also the only additive that melted completely. Raisins and macadamia nuts did not have enough water to make the starch particles expand.
HONORABLE MENTION

THE EFFECT OF TEMPERATURE OF HEAT TREATMENT ON THE ENZYMATIC BROWNING OF APPLES

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

Enzymatic browning is a process that negatively affects the color and quality of minimally processed fruits and vegetables. As a result of the discoloration, consumer acceptability decreases. Heat blanching is a treatment that inactivates the enzyme responsible for catalyzing this browning, polyphenol oxidase, and is efficient in inhibiting enzymatic browning in frozen and canned goods. This experiment was conducted to find the optimum temperature for a heat blanching treatment for inhibiting the discoloration and increasing consumer acceptability. In this experiment, Fuji apple slices were treated at different temperatures including eighty degrees Celsius, ninety degrees Celsius, 100 degrees Celsius, and no treatment to inhibit the enzymatic browning. Each of these temperatures reduced browning at different efficiencies. The apple slices treated at 100 degrees Celsius experienced the optimum inhibition of enzymatic browning, while the ninety degrees Celsius heat treatment was very effective as well. The eighty degrees Celsius treatment caused the apples to become brown, so the treatment was not optimal. Some improvements for the experiment were to use different minimally processed fruits and vegetables, to use different methods of preserving the porous products, and to use further technology to analyze the browning over time.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Coffee Grinds Have on the Acidity of Coffee. Rachel Alexander, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Pepto-Bismol, Rolaids, and Maalox on the pH Balance of Stomach Acid. Kristin L. Butler, Shenandoah Valley Governor’s School, Augusta County Schools.


The Effect of the Amount of Recycled Hardwood Ash Added to High Fire Glaze on the Color of High Fire Glaze. Sarah D. Carter, Shenandoah Valley Governor’s School, Augusta County Schools.

Whether Weather Wears on Paint. Brittany L. Cook, Southwest Virginia Governor’s School, Pulaski County Schools.

The Effect of Different Brands of Baking Powder on Muffin Height. Elizabeth R. Easter, Hanover High School, Hanover County Schools.

The Amount of Damage Track Spikes Do to Rubberized Tracks. Jessica H. Halasz, Shenandoah Valley Governor’s School, Augusta County Schools.

Luminosity of Fiber Reactive Dyes on Cotton with 250, 300, and 600 Thread Counts. Emily B. Holroyd, Shenandoah Valley Governor’s School, Augusta County Schools.

The Difference between the Means of RBG in Paint Cards and Paint. Mary C. Hull, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of the Number of Washings on the Flammability of 100% Cotton Cloth. Kaelee A. Humphrey, Deep Run High School, Henrico County Schools.

The Difference in Heat Output of Two Fuel Additives in 10% Gasoline. Sawyer M. Janes, Shenandoah Valley Governor’s School, Augusta County Schools.
The Effect of Container Type on the Amount of Dissolved Aluminum in Soda. Seth D. Jergenson, Shenandoah Valley Governor's School, Augusta County Schools.

The Effect of Different Swimsuits on the Time It Takes a Person to Swim 50 Yards Freestyle. Peter M. Kinton, George H. Moody Middle School, Henrico County Schools.

The Effect of Temperature on the Strength of Polymer Adhesive. Davis A. Klabo, George H. Moody Middle School, Henrico County Schools.
CONSUMER SCIENCE B

FIRST PLACE

THE EFFECT OF SWIMSUIT DESIGN ON THE AMOUNT OF DRAG CREATED IN WATER

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Hanover High School, Mechanicsville, Virginia 23116

Abstract: It was hypothesized that if the swimmer was wearing a swimsuit with an Axcelback cut then that swimmer would experience the least amount of drag. The Axcelback had the least amount of texture change creating the smoothest surface on the swimmer. The purpose of this experiment was to determine which cut of swimsuit created the least amount of drag through water. First, the experimenter attached the elastic band to a starting block at one end of the pool. Then the swimmer put on the Recordbreaker swimsuit and silicone cap, tied the band around their waist, entered the pool where the band was tied and walked to the opposite end of the lane. When the timer started the stopwatch the swimmer formed their body into a streamline position, and let the band pull them back to their starting point; the time was then recorded in a data table. This step was repeated for each swimsuit ten times. The results showed that the Flyback suit had the least amount of drag with a mean time to complete a twenty-five meter swim of 17.534 seconds, next the Recordbreaker suit with a time of 17.824, then the Axcelback suit with a time of 17.828 seconds, and the Two-Piece suit with a time of 18.648 seconds. An explanation for these results could be that the Flyback suit covers the most skin creating a smoother glide through the water, whereas the two piece suit shows the most skin, creating more drag.

Introduction: This experiment is testing the effect of different cuts of swimsuits on their resistance to flow in water. Research shows that the cut of swimsuit is very important when determining how much drag that swimsuit will have in water (Howard, 2004). It was hypothesized that if the swimmer was wearing a nylon swimsuit with an Axcelback cut then that swimmer will complete a 25-meter swim in the fastest time. Nylon, scientifically known as Polyamide, is a manufactured fiber in which the fiber forming substance is a long chain synthetic polyamide in which less than eighty five percent of the amide-linkages are attached directly to two aliphatic groups; it is the material of all of the swimsuits being tested. The two aliphatic groups are hydrophobic (AU, 2003). Some important characteristics of nylon are that it is exceptionally strong, elastic, and abrasion resistant, low in moisture absorbency, lightweight, and provides warmth (AFMA, 2008).

The cuts of swimsuits being tested are Recordbreaker, Axcelback, Flyback, Cut Out Tank, and two piece (Swim Outlet, 2008). The Recordbreaker suit is cut high on the hips in order to give more room for leg movement; however, it has thick shoulder straps, which limit shoulder movement. The Axcelback suit has thin shoulder straps and the least amount of seams. The Flyback suit also has thin shoulder straps however it has a thick band across the back which limits movement. The Cut Out Tank Suit has thin shoulder straps and is virtually open in the back; however it is low cut in the hips (Swim Outlet, 2008). Last but not least, the two piece suit has thin straps but the most amount of seams (which create drag) due to the break in material, however it is cut high on the hips and provides the most amount of torso movement (Speedo, 2008).

The purpose of this experiment was to determine which cut of swimsuit will have the least amount of drag through twenty-five meters of water. The amount of drag created by a swimsuit is directly proportional to the amount of time it takes a swimmer to complete a swim (Raag, 2008). The results of this experiment would be very beneficial to swimmers and swimsuit companies all around the world, especially at elite levels, because in a technical sport like swimming every second counts.

Methods and Materials: The materials used in this project were one swimmer, one pool, one silicone swim cap, one stopwatch, one elastic band, 5 swimsuits of various cuts, and one timer. First the experimenter attached an elastic band to a starting block at the end of one of the pool lanes. Then the swimmer put on the
Recordbreaker cut swimsuit and the silicone cap. Next, the experimenter tied the elastic band around the swimmers waist. The swimmer then entered the pool from the same end where the elastic band was tied, and walked to the opposite end of the lane and held on to the wall. When the timer started the stopwatch the swimmer let go of the wall and formed their body into a streamline (straight) position, then allowed the elastic band pull them to the opposite end of the pool. When the swimmer reached the opposite end of the pool, the timer stopped the stopwatch and recorded the time in a data table. The timer also recorded any unusual water patterns that may have signified another variable affecting the experiment. This step of the experiment was repeated ten times for each swimsuit cut. At the conclusion of the experiment, statistical tests were performed on the data collected. If the stopwatch malfunctioned, the trial was run again. One safety precaution taken when carrying out this experiment was making sure that the swimmer was careful when entering and exiting the pool. A certified lifeguard was on duty at all times.

**Results:**

**Chart A: The Effect of Different Cuts of Swimsuits on Their Resistance to Flow in Water**

<table>
<thead>
<tr>
<th></th>
<th>Axcelback and Recordbreaker</th>
<th>Recordbreaker and Two-Piece</th>
<th>Axcelback and Flyback</th>
<th>Recordbreaker and Two-Piece</th>
<th>Recordbreaker and Flyback</th>
<th>Two-piece and Flyback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>17.828</td>
<td>17.824</td>
<td>18.648</td>
<td>17.534</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>17.690</td>
<td>17.730</td>
<td>18.740</td>
<td>17.610</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>2.76</td>
<td>1.28</td>
<td>2.0</td>
<td>1.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>19.78</td>
<td>18.60</td>
<td>19.40</td>
<td>18.36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>17.02</td>
<td>17.32</td>
<td>17.40</td>
<td>17.58</td>
<td></td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>0.837</td>
<td>0.371</td>
<td>0.731</td>
<td>0.555</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Variance</strong></td>
<td>±0.701</td>
<td>±0.138</td>
<td>±0.535</td>
<td>±0.308</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

**Chart B: The Effect of Different Cuts of Swimsuits on Their Resistance to Flow in Water**

<table>
<thead>
<tr>
<th></th>
<th>Axcelback and Recordbreaker</th>
<th>Axcelback and Two-Piece</th>
<th>Axcelback and Flyback</th>
<th>Recordbreaker and Two-Piece</th>
<th>Recordbreaker and Flyback</th>
<th>Two-piece and Flyback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T-Test Calculation</strong></td>
<td>0.014</td>
<td>2.33</td>
<td>0.925</td>
<td>3.18</td>
<td>1.37</td>
<td>3.84</td>
</tr>
<tr>
<td><strong>Significant Difference?</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Discussion and Conclusions: The purpose of this experiment was to determine which cut of swimsuit would have the least amount of drag through twenty-five meters of water, because the amount of drag created by a swimsuit is directly proportional to the amount of time it takes a swimmer to complete a swim. This purpose was achieved because the data collected shows distinct differences between the amounts of drag the swimmer experienced in each swimsuit. It was hypothesized that if the swimmer was wearing the suit with the Axcelback cut then they would experience the least amount of resistance in the water. The results did not support the hypothesis because they showed that the Flyback suit had the least amount of drag with a mean time to complete a 25 meter swim of 17.534 seconds, followed by the Recordbreaker suit with a mean time of 17.824, then the Axcelback suit with a mean time of 17.828 seconds, and finally the Two-Piece suit with a mean time of 18.648 seconds. The T-test did show a significant difference between most of the mean times.

An explanation for these results could be that the Flyback suit covers the most amount of skin, which could create a smoother glide through the water, whereas the two-piece suit shows the most skin, creating more drag. Research showed that the less seams and texture changes a swimsuit had, the less resistance it exhibited in the water; the results did support the research because the suits with more seams and texture changes had slower times. The research and results of this experiment could be useful to any swimmer or swimsuit company who is looking to purchase or design a swimsuit that will give the most aid in achieving a faster time. One problem that was encountered during the experiment was that the elastic bands did not always carry the swimmer all the way across the lane; so if another scientist were to carry out this experiment one way that they could improve upon it would be to test the suits over a longer distance, with a stronger band.

Literature Cited


Appendix

**Experimental Design**
Title: The Effect of Different Cuts of Swimsuit on the Amount of Drag the Swimsuit has in Water

Hypothesis: If the swimmer is wearing a suit with an Axcelback cut, then they will complete the 25 meters with the least amount of drag.

Null Hypothesis: If the swimmer is wearing a suit with an Axcelback cut, then they will complete the 25 meters with the same amount of drag as the swimsuits with the other cuts.

**IV: Cut of Swimsuit**

<table>
<thead>
<tr>
<th>Level of IV</th>
<th>Recordbreaker Back</th>
<th>Flyback</th>
<th>Axcelback</th>
<th>CutOut Tank</th>
<th>Two Piece</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Repeated Trials</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

DV: Amount of drag (measured by time in seconds it takes to complete 25m. swim)

Constants: Swim Cap used, material of swimsuits, stopwatch used, elastic band used, pool, swimmer used, timer, water temperature, distance of test, weight of swimmer, body position of swimmer.
SECOND PLACE

THE EFFECTIVENESS OF COMMERCIAL AND “GREEN” GENERAL PURPOSE CLEANERS

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ABSTRACT

Multipurpose cleaners are designed primarily to remove particulate matter from inanimate objects. “Green” cleaners claim to be as effective as normal commercial cleaners with fewer harmful ingredients, and have less environmental impact than commercial cleaners. The purpose of this study was to determine if green household multipurpose cleaners are as effective in removing grease as their commercial counterparts. By testing the ability of each cleaner to remove grease from a flat surface, the effectiveness of the cleaner was determined. Significant difference in the effectiveness of the cleaners was found.

THIRD PLACE

THE AMOUNT OF FRACTURES ON BONE WHEN USING POINTE SHOE TOE PADS

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ABSTRACT

Different types of pointe shoe toe pads are believed to absorb different amounts of shock when dancing ballet. The purpose of the study was to determine whether gel or lamb’s wool toe pads help to reduce bone fractures when dancing en pointe. Toe pads were obtained from a local dance supply store and deer bones were collected from a deer processing plant. The toe pads were placed on the deer bones and pounded into a piece of hard wood floor. An ANOVA was used to determine if there was a statistical difference between the toe pads. No statistical difference was found. The researcher concluded that gel and lamb’s wool toe pads prevent the same amount of fracture when weight is placed on them.

HONORABLE MENTION

EFFECTS OF FLAME: NATURAL VS. SYNTHETIC

Katherine B. Modly
330 Cannon Way, Warrenton, Virginia 20186
Mountain Vista Governor’s School, Warrenton, Virginia 20187

ABSTRACT

Fire safety in organic and synthetic options is an issue in consumer sciences. Because organic fabrics are inherently imbued with some flame resistant qualities, they will demonstrate more effective flame resistance than synthetically produced polymers when both are exposed to flame. To test which fabrics were the best at preventing ignition and flame spread, two samples each of organic (cotton, jute[burlap]) and synthetic (nylon, polyester) fibers
were exposed to flame to measure ignition and burn time and compare the efficacy of both types. The ignition times for the synthetic fabrics had an average of 2.09 seconds and the flame burned, on average, for 9.8 seconds. The organic fabrics had an average ignition time of 1.6 seconds and a burn time of 13.18 seconds. In contrast with the organic fabrics, synthetic fabrics took longer to ignite and the flame went out faster in those trials. The organic fabrics, however, ignited quickly and burned for a longer time. This shows that the synthetic fabrics are more beneficial to preventing clothing fire from starting or extinguishing existing flame than organic fabrics are.

HONORABLE MENTION

THE EFFECTS OF ETHANOL ON THE EFFICIENCY OF GASOLINE

Erin R. Veasey
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Southwest Virginia Governor’s School, Pulaski, Virginia 24301

ABSTRACT

Interest in the area of the efficiency of gasoline has arisen due to the recent dramatic rise in gasoline prices. This study was to determine if it is more efficient to use gasoline that contains ethanol, or gasoline that contains no ethanol. The test consisted of running two types of regular-grade gasoline through a generator, letting the generator idle, timing the trials until the generator stops running, and then recording the end temperature. The mean run time of the gasoline with no ethanol was 11.71 minutes with a standard deviation of 0.70. The mean run time of the gasoline with up to 10% ethanol was 9.84 minutes with a standard deviation of 0.29. The p-value of the data was less than 0.001. These results indicated that gasoline with no ethanol had a significantly longer run time than gasoline with up to 10% ethanol. The mean end temperature of the gasoline with no ethanol was 243.9°F with a standard deviation of 3.44. The mean end temperature of the gasoline with ethanol was 238.5°F with a standard deviation of 3.66. The p-value for this data was less than 0.001. These end temperatures indicated that gasoline with no ethanol ran at a significantly hotter temperature than gasoline with ethanol. Further studies on this project could consist of testing premium-grade gasoline and regular-grade to observe if it is more efficient to use premium gasoline or regular gasoline.

HONORABLE MENTION

THE DIFFERENCE IN HEAT OUTPUT BETWEEN BIODIESLES AND PETROL DIESEL

Joshua J. White
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Shenandoah Valley Governor’s School, Fishersville, Virginia 22939

ABSTRACT

This experiment was conducted to test the difference between the heat output of soybean biodiesel compared to that of petrol diesel and peanut derived biodiesel. An apparatus was made to simulate a bomb calorimeter and used to analyze the burning temperatures of the diesels. The research concluded that there is no statistical difference between the heat outputs of soybean biodiesel compared to that of peanut biodiesel or petrol diesel.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Different Types of Insulation on Heat Retention. Justin W. Lau, George H. Moody Middle School, Henrico County Schools.

The Effect of Shampoo on the Tensile Strength of Hair. Richard R. Li, George H. Moody Middle School, Henrico County Schools.

Can Different Age Groups Identify a Difference in the Clarity of Music Played through Different Media? James P. Mulvihill, James River High School, Chesterfield County Schools.

The Effect of Different Levels of SPF in Sunscreen on the Amount of Sun Received. Meghan Nasta and Maura Folliard, Deep Run High School, Henrico County Schools.

The Effect of the Type of Apple on the Amount of Juice Produced. Sara A. Neel, Washington-Lee High School, Arlington County Schools.


Iron Content in Organic Versus Regular Brand Breakfast Cereals. Jordan L. Parker, Appomattox Governor’s School, Chesterfield County Schools.


The Effect of Brand of Wood Stain on It’s Ability to Protect Wood from Outdoor Weathering. Stephen T. Scipione, Deep Run High School, Henrico County Schools.

Effect of Beverage Types on Aleve’s Dissolve Rate. Sara S. Spiers, Hermitage High School, Henrico County Schools.

The Effect of Commercially Prepared Orange Juice on Its Vitamin C Concentration. Sydney L. Thomas, Deep Run High School, Henrico County Schools.

COMPUTER SCIENCE

FIRST PLACE

USE OF A PARABOLA REFLECTOR TO INCREASE WIRELESS SIGNAL STRENGTH

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Abstract: An access point is a transmission tower or wireless router connected to a network that broadcasts a signal intended for reception by a computer’s wireless modem. While this provides convenience, the strength of the signal rapidly decreases with an increase in the distance between a computer and the access point. The purpose of this experiment was to determine the effect of parabola reflector positioning on the signal strength of a cellular device. It was believed that if a parabola reflector was used to concentrate a cellular signal, then when the parabola is facing the transmission tower the wireless signal will be the strongest. The closest Verizon Wireless tower and a laptop computer attached to a Blackberry 8830 handheld were measured using GPS coordinates to be 0.90 miles apart at a heading of 167° South. The aluminum parabola reflector was placed over the antenna and fastened to the handheld. The signal strength (decibels) was measured as the parabola was turned in 22.5 degree increments from 0° to 180°. The results indicated the presence of a parabola reflector facing the laptop computer increased the mean signal strength to 17.6 dB and the signal strength when the parabola was facing away from the laptop computer was the weakest with a mean signal strength of 7.5 dB. A t-test performed on the data indicated a significant difference between the means of the groups (t= 11.43 > 2.101; t= 8.59 > 2.101; t= 5.62 > 2.101; t= 4.67 > 2.101; t= 3.15 > 2.101; t= 4.02 > 2.101; t= 7.00 > 2.101; at df= 18; p < 0.05). The data supported the research hypothesis that the signal will be the strongest when a parabola reflection dish is used and faced towards the access point. Based on the signal values determined in this research, there appears to be a direct correlation between the signal strength and the direction of a signal concentrating parabola.

Introduction: Wireless “hotspots” are appearing in stores, restaurants, and hotels. Restaurants like Starbucks and McDonald’s are using them to bring in more customers and more revenue. Businesses and schools are also setting up wireless internet access so that authenticated users may connect with laptops to the internet from anywhere in the building without using a network cable plugged into a network jack. This eliminates the worrying of someone tripping over the network cable or network access not being provided by a wired network jack (Derfler and Freed, 2005). Due to the low cost of implementing wireless networks, even small businesses are creating wireless networks for the employees. As the cost for cellular device connectivity decreases, more people are using cellular networks with broadband connections (Patra et. al., 2007). Presently, cellular networks have low bandwidths, high round trip times, and frequent outages (Chakravorty et. al., 2004).

Workplaces and restaurants are not the only places that implement wireless networks. People have private wireless networks for access anywhere in the home and even outdoors. Due to the low cost of a personal wireless router, most consumers get a personal router which does not accommodate connections from great distances. Efficient networks are designed to minimize wireless signal overlap created when multiple signals are received from different routers (Kotz and Essien, 2002).

An access point is a transmission tower or wireless router connected to a network that broadcasts a signal intended for reception by a computer’s wireless modem. While this provides convenience, the strength of the signal rapidly decreases with an increase in the distance between a computer and the access point. The access point even allows connected network users to move around and change location within the limits of the signals strength. Access points can require the data transmission be encrypted with a password to keep unwanted people from accessing the provided wireless network (Mahajan et. al., 2007).

Encryption is the process of converting information into data that can not be directly read by unauthorized users. For wireless networks, the encryption keeps an unwanted user from getting an internet connection that
someone else is paying for. Encryption keeps these people from accessing personal networks and possibly personal data (Pfleging and Zetlin, 2006).

A wireless router creates a network which allows computers to communicate by transmitting information through radio waves according to a standardized set of rules. The wireless modem receives and sends data by translating the data based on the 802.11 protocol into a form the computer can understand. For commercial routers, the provided signal may be strong enough to provide access from ten floors away. Most private routers are designed for use in two or three story houses and are not intended to generate a signal that is strong enough to be reliable outside the house (Evennou and Marx, 2006).

Cellular devices use cellular transmitters to create a network which allows telephones and computers to communicate by transmitting information through radio waves according to the Personal Communications Services (PCS) protocol. The cellular device receives and sends data by translating the data into packets according to the Code Division Multiple Access (CDMA) compression technology which allows several devices to share the same channel. The data is only exchanged using the assigned channel. When a stronger signal is detected from a different cellular transmitter, the cellular device is assigned a new channel on the new cellular transmitter and the corresponding signal routing assignment is sent to the cellular device (Gralla, 2006).

Radio signals are everywhere. Signals are bouncing off walls and going into outer-space. A parabola can be used in the collection and projection of radio waves. A parabola is a curved line in which the line’s steepness increases as the distance from the center point increases, but the steepness increases at a much quicker rate. For example, if the variable x is the distance horizontally and y is the distance vertically, then making the value of y the square of x \(y = x^2\) will produce a two dimensional parabola. To produce a three dimensional parabola, the two dimensional parabola is spun around the z axis at the parabola’s origin \((0,0)\). A satellite dish is an example of a three dimensional parabola.

Reflection is when a wave is not absorbed, but is forced to travel in another direction. Examples of common reflectors are mirrors, water, glass, and shiny, metal surfaces. If a reflector is shaped into a parabola, it will reflect waves into many directions or cause the signal to become focused based upon whether the parabola is convex or concave. If a convex parabola reflects the signal, then the signal becomes scattered and is weakened. Signals are strengthened when focused by a concave reflector because the signal converges at the focal point (Aguayo et. al., 2004).

The purpose of using a satellite dish in radio signal transmission is to focus the signal from the satellite to a certain point in front of the dish where a stronger signal is collected. Larger dishes produce a stronger signal, but are more expensive. The amplification of sound waves is seen when studying the structure of a human ear, which picks up sound better when the external cartilage is intact. If the external cartilage is damaged or completely removed, then the person or animal will lose most of the normal hearing strength. The strength of the signal captured by a satellite dish is similar to how loud a sound is when it comes to an ear (Hutchenson and Noneaker, 2005).

There are computer programs available that display the signal strength being received from a wireless network. VZAccess Manager is a good example of such a program. VZAccess Manager determines the strength of a wireless signal and displays the strength in decibels. A decibel is a unit used to measure the power or velocity of a wave. Decibel is derived from one-tenth of a bel and is mainly used in the field of acoustics. A decibel is more common than the bel, because the bel is used to measure wavelengths up to a mile in length. The program can be used in “war driving” to determine available wireless networks and whether the network is using encryption (Pfleging and Zetlin, 2006). The program is helpful in monitoring the available signal strength when implementing a home wireless network or cellular network. A wireless router is easily moved and the wireless access is checked by means of a notebook computer during the installation of the wireless network (Evennou and Marx, 2006).

Common obstacles encountered during the implementation of a wireless network include the signal having to travel through furniture and walls. Most furniture is made of cloth, which absorbs the signal. Walls can present problems because of the reflecting or slowing of signals. Every time a wave goes through an obstacle or traverses a great distance, the signal strength weakens and communication with the access point is tougher (Yarvis et. al., 2005).
A parabola shaped dish is a good wave reflector as it focuses a signal during broadcast. An access point broadcasts signals in all directions from its antenna. By placing a parabola shaped dish behind the antenna of the wireless device, the signal strength in front of the dish is increased due to the presence of the reflected waves. The measured signal strength is a combination of all the radio waves that reach the wireless device.

A parabola reflector dish is better than a half-spherical shaped dish because the point where the reflected signals converge is outside of the dish. Also, a half-spherical shaped dish has more reflective surface that is close to being parallel to the signal. Surfaces that are parallel to the signal do not beneficially reflect the signal. Placing the parabola reflector dish on the antenna so that the signal is concentrated from the closest transmission tower will increase the quantity of signals received and decrease the interference from other electronic devices.

Attempting to connect to a cellular network having a strong signal is sometimes difficult due to the location of a transmission tower (Gralla, 2006). Interestingly, sometimes it is difficult to get a wireless connection even when the transmission tower and computer are only a short distance away (Letchner et. al., 2005). By controlling the reflection of a portion of the signal that is normally not used, the signal strength can be increased to allow the radio waves to travel farther. Inexpensive parabola reflector dishes can be made to improve the signal strength, preventing the need to invest in expensive commercial signal repeaters. Also, the parabola reflector dish can be used with wireless routers to deter “war driving” players (Pfleging and Zetlin, 2006).

In this investigation, the degree of rotation of a parabola reflector relative to the location of the transmission tower was the independent variable and the measured signal strength (decibels) was the dependent variable. The control group was the measured signal strength when the cellular device had no parabola reflector attached. Based on experiments that stated signal strength decreases with increased distance from the signal source, it is believed that if a parabola reflector is used to concentrate a cellular signal, then when the parabola is facing the transmission tower the wireless signal will be the strongest.

**Methods and Materials:** The top and bottom of an aluminum can was carefully removed with tin snips and a cut was made down the side of the cylinder so that the piece of aluminum could be laid flat. To create a parabola with a diameter of 6 inches and a 1.5 inch depth, a grid composed of one inch blocks was drawn on a thin piece of wood using a ruler and pen. The parabola was created by graphing the equation $y = 0.1666 x^2$ onto the wood, cut out with a scroll saw, and glued to the aluminum sheet. A 5/8 inch hole was drilled at the focal point that was determined to be 1.5 inch from the bottom of the parabola by using the freeware Parabola Calculator V1.0 program. A cardboard disc with a diameter of eleven inches was marked with a pen in 22.5 degree increments using a ruler and protractor and labeled (group B) 0°, (group C) 22.5°, (group D) 45°, (group E) 67.5°, (group F) 90°, (group G) 112.5°, (group H) 135°, (group I) 157.5°, and (group J) 180°. The absence of the parabola was (group A) the control group. The closest Verizon Wireless tower and a Dell Latitude D810 laptop computer attached to a Blackberry 8830 handheld were measured using GPS coordinates to be 0.90 miles apart at a heading of 167° South. The cardboard disc had a hole cut in the center, was placed over the antenna, and fastened to the Blackberry handheld oriented using a compass so that the base line ran perpendicular to the line created between the tower and computer. The signal strength (decibels) was measured using the VZAccess Manager version 6.7.3 program without the parabola and then with the parabola placed around the antenna at the different increments. The values were recorded on data tables. The set of trials was repeated 9 more times. The mean signal strength was calculated for the ten groups and the results were interpreted on line graphs. T-tests were performed on each set of data to determine significant differences between the means of each group.

**Results:** The use of the parabola reflector increased the mean signal strength (17.6 dB) from the mean control signal strength (11.6 dB) and linearly decreased the signal as the parabola reflector focus moved away from the cellular tower to the weakest mean signal strength (7.5 dB) when the parabola is facing away from the tower. Variations within the groups were similar, with standard deviations varying between 0.53 and 1.44. Sixty percent of the groups had a standard deviation of 0.95 or less. The t-test was used to test the following null hypothesis at a 0.05 level of significance: The mean signal strength received from the cellular tower with the parabola reflector attached is not significantly different from the mean signal strength received without the use of a parabola reflector. The null hypothesis was rejected when the control was compared to the use of the parabola reflector at 0 degrees, 22.5 degrees, 45 degrees, 67.5 degrees, 90 degrees, 157.5 degrees, and 180 degrees ($t= 11.43 > 2.101; t= 8.59 > 2.101; t= 5.62 > 2.101; t= 4.67 > 2.101; t= 3.15 > 2.101; t= 4.02 > 2.101; t= 7.00 > 2.101$ at df= 18; $p < 0.05$).
Table 1: The Effect of Parabola Placement (degrees) on the Received Signal Strength (dB)

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>Parabola Placement Direction (degree)</th>
<th>A: None (control)</th>
<th>B: 0</th>
<th>C: 22.5</th>
<th>D: 45</th>
<th>E: 67.5</th>
<th>F: 90</th>
<th>G: 112.5</th>
<th>H: 135</th>
<th>I: 157.5</th>
<th>J: 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>11.6</td>
<td>17.6</td>
<td>15.7</td>
<td>14.0</td>
<td>13.5</td>
<td>12.9</td>
<td>12.0</td>
<td>11.0</td>
<td>9.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Range</td>
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<td>2</td>
<td>2</td>
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<td>2</td>
<td>4</td>
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<tr>
<td>Minimum</td>
<td></td>
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<td>16</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td>13</td>
<td>19</td>
<td>17</td>
<td>15</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td>1.38</td>
<td>1.38</td>
<td>0.90</td>
<td>0.44</td>
<td>0.28</td>
<td>0.32</td>
<td>0.67</td>
<td>1.56</td>
<td>0.62</td>
<td>2.06</td>
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<tr>
<td>Standard Deviation</td>
<td></td>
<td>1.17</td>
<td>1.17</td>
<td>0.95</td>
<td>0.66</td>
<td>0.53</td>
<td>0.57</td>
<td>0.82</td>
<td>1.25</td>
<td>0.79</td>
<td>1.44</td>
</tr>
<tr>
<td>Number of Trials</td>
<td></td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Inferential Statistics (t-tests)

- A vs B: t = 11.43
- A vs C: t = 8.59
- A vs D: t = 5.62
- A vs E: t = 4.67
- A vs F: t = 3.15
- A vs G: t = 0.88
- A vs H: t = 1.11
- A vs I: t = 4.02
- A vs J: t = 7.00
- B vs C: t = 3.98
- B vs D: t = 8.43
- B vs E: t = 10.08
- B vs F: t = 11.40
- B vs G: t = 12.39
- B vs H: t = 12.19
- B vs I: t = 17.44
- B vs J: t = 17.24
- C vs D: t = 4.64

F vs H: t = 4.38
F vs I: t = 10.09
F vs J: t = 11.07
G vs H: t = 2.12
G vs I: t = 6.13
G vs J: t = 8.62
H vs I: t = 2.57
H vs J: t = 5.82
I vs J: t = 4.44

Df = 18
α = 0.05

Figure 1: The Effect of Parabola Placement on Received Signal Strength

- *Group Means*
- **Line of Best Fit**
null hypothesis was accepted when the control was compared to the use of the parabola reflector at 112.5 degrees and 135 degrees ($t= 0.88 < 2.101; t= 1.11 < 2.101; t= 1.11 < 2.101$ at df= 18; $p < 0.05$). The data supports the research hypothesis that the signal will be the strongest when a parabola reflection dish is used and faced towards the cellular tower.

**Discussion and Conclusions:** The purpose of this experiment was to determine the effect of parabola reflector positioning on the signal strength of a cellular device. The presence of a parabola reflector facing the cellular tower increased the mean signal strength to 17.6 dB with a variance of 1.38 dB. The signal strength decreased as the parabola reflector was turned away from the cellular tower. The null hypothesis was rejected when the parabola reflector was at 0 degrees, 22.5 degrees, 45 degrees, 67.5 degrees, 90 degrees, 157.5 degrees, and 180 degrees ($t= 11.43 > 2.101; t= 8.59 > 2.101; t= 5.62 > 2.101; t= 4.67 > 2.101; t= 3.15 > 2.101; t= 4.02 > 2.101; t= 7.00 > 2.101$ at df = 18; $p < 0.05$), therefore the data supported the research hypothesis that the signal will be the strongest when a parabola reflection dish is used and faced towards the cellular tower.

The findings were consistent with similar research, in that small changes in antenna orientation had a predictable and notable impact on the received signal strength (Yarvis et. al., 2005). The closest cellular tower was a distance of 0.90 miles away from the cellular device and allowed for the receiving of a consistent signal at all parabola positions. This agreed with related research, in that the strongest signal strength received by the device will be used for determining the channel (Gralla, 2006). The use of a parabola reflector produced repeatable signal strength at all intervals. The findings agree with similar research, in that the parabola reflector pattern is found to produce a consistent, strong signal (Hutchenson and Noneaker, 2005).

Because more signals were collected and concentrated by the parabola reflector, the signal strength increased as the focused signal was collected toward the cellular tower. The parabola reflector decreased the signal when directed away from the tower, reducing the distance required for a user of the provided network. The increase of the signal can benefit players who are “war driving” (Pfleging and Zetlin, 2006).

The experiments could be improved by completing the trials all in one day to ensure the weather does not interfere with the signal. The addition of cloud cover or high humidity causes the signal to be reflected due to the water molecules in the air. Additionally, the aluminum could be polished to produce a shiny, smooth surface which would increase the strength of the reflected signal.

Future experiments may look at studying the signal strength with the change of wireless protocol (802.11a, 802.11b, or 802.11g), the use of different metals in the construction of the parabola reflector, and the reduction of additional signal reflection by conducting the experiment outdoors in the middle of an open field.

**LITERATURE CITED**


Appendix A

Raw data: The Effect of Degree of Rotation on the Signal Strength Received by Device.

<table>
<thead>
<tr>
<th>Degree of Rotation (degrees)</th>
<th>Trials: Signal Strength (dB)</th>
<th>Average Signal Strength (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>10  11  13  11  12  10  13  13  11  12</td>
<td>11.6</td>
</tr>
<tr>
<td>0</td>
<td>16  16  17  17  19  18  18  19  19  17</td>
<td>17.6</td>
</tr>
<tr>
<td>22.5</td>
<td>15  15  14  16  17  16  17  16  16  15</td>
<td>15.7</td>
</tr>
<tr>
<td>45</td>
<td>14  13  15  14  14  15  14  14  14  14</td>
<td>14.0</td>
</tr>
<tr>
<td>67.5</td>
<td>14  14  13  14  13  14  13  14  13  13</td>
<td>13.5</td>
</tr>
<tr>
<td>90</td>
<td>13  13  13  14  13  13  12  12  13  13</td>
<td>12.9</td>
</tr>
<tr>
<td>112.5</td>
<td>12  12  13  13  13  12  11  12  12  11</td>
<td>12.0</td>
</tr>
<tr>
<td>135</td>
<td>10  11  13  13  12  10  11  11  10  10</td>
<td>11.0</td>
</tr>
<tr>
<td>157.5</td>
<td>10  11  11  10  10  9  9  10  9  9  9</td>
<td>9.8</td>
</tr>
<tr>
<td>180</td>
<td>9   6   7   10  9   6   7   8   6   7</td>
<td>7.5</td>
</tr>
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</table>

Appendix B

Signal Reflection: The Effect of Surface Curvature on the Signal Focal Point.
SECOND PLACE
THE EFFECT OF INCREASING THE PROCESSOR MULTIPLIER ON SYSTEM STABILITY

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ABSTRACT

Processors have always been the core component of computers since the creation of computers. Processors have been the most expensive component, and often cost an enormous amount of money for a good speed. What has controlled the speed is the multiplier setting embedded in the processor. Average users have desired a system with great performance, at minimal cost. The multiplier has been increased quite easily with proper knowledge in the past, but balancing speed with stability was another matter that still remains a challenge today. The purpose of this project was to determine if a user could increase the multiplier high enough to achieve optimum speed for price, without losing system stability from 12x to 16x settings, with 12x being the default setting. The multiplier setting was increased by intervals of one, and tested under stress to record the duration of system stability. The results indicated that increasing the multiplier compromised system stability. The level of instability discovered was unacceptable for an average user. Therefore, increasing the multiplier setting was deemed unreasonable for average computing. A t-test performed on the data indicated a significant difference between the means of the groups (t=2.61>2.101, t=2.41>2.101, t=11.51>2.101, t=7.48>2.101, t=11.81>2.101, t=29.39>2.101, t=25.91>2.101, t=24.47>2.101, t=17.83>2.101, t=97.7>2.101 at df=18; p<0.05), and the null hypothesis was rejected (if the multiplier setting of the processor was increased, then it did not affect system stability). The data supported the research hypothesis that if the multiplier setting was increased, then the duration of system stability would decrease. Based on the duration of system stability (in minutes), there appears to be a direct relationship between the multiplier setting value and the duration of system stability. Before it can be concluded that increasing the multiplier was the sole cause of system instability however, more tests will need to be conducted on various processors and motherboard combinations to determine if increasing the multiplier was the sole cause of system instability.

THIRD PLACE
COMPARING GENETIC ALGORITHMS AND PARTICLE SWARM OPTIMIZATION

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ABSTRACT

Population-based heuristic search algorithms, such as Genetic Algorithms and Particle Swarm Optimization, are computer algorithms that use a population of individuals in order to solve complex optimization problems. This research focused on comparing the efficiency between a Genetic Algorithm and a Particle Swarm Optimization Algorithm. Upon literature review, the researcher predicted that Genetic Algorithm would prove to be more efficient. The researcher wrote a Genetic Algorithm and a Particle Swarm Optimization Algorithm in C++. He then modified both algorithms to run the ulysses22 Traveling Salesman Problem, in which a “salesman” must find the shortest route to travel between 22 different cities. The researcher discovered that the Genetic Algorithm was about twice as efficient as Particle Swarm Optimization in finding the shortest paths to an ulysses22 Traveling Salesman Problem. A parametric unpaired t-test confirmed that there existed a significant difference between the results from the two algorithms. Therefore, the researcher concluded that the Genetic Algorithm is more efficient than Particle Swarm Optimization in solving the Traveling Salesman Problem. The researcher suggested that a combination of the Genetic Algorithm and Particle Swarm Optimization would prove a more efficient approach to the Traveling Salesman Problem.
HONORABLE MENTION

THE EFFECT OF ADVANCED CLOCK CALIBRATION ON THE OVERCLOCKING
ABILITY OF THE PHENOM 9850 BE PROCESSOR

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ABSTRACT

The purpose of this experiment was to study the effects of Advanced Micro Devices' (AMD) Advanced Clock Calibration (ACC) on the overclocking ability of the Phenom 9850 BE processor, and the effect varying levels of ACC had on performance. The testing occurred at the researcher’s home and Central Virginia Governor's School between November 21, 2008 and December 18, 2008. A custom built personal computer (PC) was used as the test platform with an AMD Phenom 9850 BE processor. The HTT reference clock and Clock multiplier were run at 9 different overclocked settings with 0, 2, 4, and 6 percent of ACC enabled. The successful runs were then tested with 3 different performance benchmarks to measure the performance of the overclocked settings, and the effect ACC had on these settings. The results of the experiment yielded support for the ability of ACC to increase overclocking ability. The Chi-squared test returned significant p-value of 2.0137 \times 10^{-2}. The original hypothesis that ACC would increase overclocking ability was supported. However, graphical analysis of the performance data revealed no change in performance due to ACC once an overclocked setting was achieved. All of the results show that while ACC benefits user overclocking, once a higher operating frequency is achieved, ACC provides no further aid.

HONORABLE MENTION

THE EFFECT OF THE SORTING ALGORITHM USED ON THE NUMBER OF STEPS
REQUIRED TO SORT A COLLECTION

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Deep Run High School, Glen Allen, Virginia 23059

ABSTRACT

Computer science is the focus of solving problems as efficiently as possible through automation. Common tasks include searching and sorting collections of data. Computer programmers have strived to make their programs as efficient as possible in order to reduce execution time. This attitude has embedded into computer science the study of efficiency and growth patterns, represented using Big-O notation. The purpose of this project was to analyze the efficiency and growth patterns of six sorting algorithms: Radix Sort, Bubblesort, Quicksort, Mergesort, Selection Sort and Insertion Sort. The results were measured in the number of steps required to sort the collections, which varied in sizes ranging from 25-12,800 elements. The number of items in the collections doubled for each trial after the first. These algorithms were implemented in the Java language, using variables to record only the number of steps required by the algorithm. This allowed for allowed for the efficient completion of this experiment without blurring the divide between theory and practice. The results indicated that Radix Sort was not only the most efficient sorting algorithm and also had the lowest growth rate with a mean of 59,515.1 steps and an O(n). A t-test performed on the groups (largest t = 1.054 < 2.101, smallest t = 0.292 < 2.101, at \alpha=0.05 and df=18) indicated that there was not a significant difference between the means of the groups. The data rejected the research the hypothesis that Insertion Sort could sort a collection more efficiently than the other sorting algorithms. Based on the data, it can be concluded that Radix Sort is the most efficient sorting algorithm tested because it only uses comparisons to ascertain the value of the value at the given index of the value. Bubblesort is the least efficient algorithm because it compares each value in the collection to every other value in the collection, and making at least that many swaps.
HONORABLE MENTION

THE EFFECT OF THE NUMBER OF PROCESSORS ON THE LENGTH OF TIME REQUIRED TO FIND EVERY PRIME NUMBER UP TO ONE MILLION

Andrew E. Vitkus
3013 Crossfield Road, Richmond, Virginia 23233
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

This experiment was conducted to find how the number of processors affected the performance of computers. The hypothesis was if the number of processors increased, than the time taken would decrease with diminishing returns. To test this a prime number sieve algorithm was used. This was because if there are more processors computing the algorithm, than computation times should decrease along with changes in time, as stated in Amdahl’s law. The number of threads was the independent variable. The levels of the independent variable were 1, 2, 4, 8, 16, 32, and 64 threads. Each trial was run on a Sun V890 with eight dual core CPUs and constant settings. When run on one thread, the algorithm took 32357 milliseconds to complete. It averaged 12418 milliseconds to complete on two threads. On four threads, it averaged 4844.7 milliseconds. With eight threads, it took an average of 1842 milliseconds. When run on 16 threads it took an average of 962 milliseconds. The algorithm took an average 898 milliseconds to complete when run on 32 threads. The average time when run on 64 threads was 986 milliseconds. The hypothesis was supported by the results. As more threads were added, the performance increased because more processors computing concurrently. At 64 threads, however, performance degraded because all of the processors were over utilized.

OTHER PAPERS SELECTED FOR PRESENTATION:


The Effect of How Much Space Is Taken Up in a Hard Drive on the Performance of an Application. Sujith S. Narayanan, George H. Moody Middle School, Henrico County Schools.

The Effect of Signal Strength on Download/Upload Speed. Megan E. Stewart, George H. Moody Middle School, Henrico County Schools.

The Effects of Gamma Radiation on Flash Memory Data Retention. J. Reed Taylor, Central Virginia Governor’s School, Lynchburg City Schools.
Abstract: A new, user-friendly biosensor capable of detecting target biomolecules was successfully developed and tested. To create the biosensor, quinone molecules were first immobilized onto a gold wire electrode and were reacted with thiolated ssDNA molecules to form a second layer. This biosensor was tested through exposure to target treatment molecules and non-target control molecules. By analyzing the resulting shifts in the peaks of the cyclic voltammograms, the changes in the electrochemical characteristics of the biosensors during the testing process were observed. Statistical analysis of the results indicates that the differences between the treatment and the control data are significant. One major advantage of this biosensor is the brevity of time required for detection. Possible applications include detection of potential bioterrorism agents. Future research with different molecules is suggested to increase the range of target molecules.

Introduction: Many of the biosensors currently in use for detecting certain biological agents require extensive preparation and expert knowledge for proper identification (Kneen et al., 2004). In this project, a new biosensor capable of detecting target biomolecules within the span of a few hours was developed and tested. This user-friendly biosensor can be easily operated with little previous training. It was created by adding two different layers of organic molecules in series to a gold wire electrode, the second of which can be changed, allowing for detection of a wide variety of molecules. To the best of the author’s knowledge, this detection method of observing changes in the electrochemical properties through direct immobilization of the biomolecules onto the biosensor has never been demonstrated. This new method has the potential to save many lives by quickly detecting hazardous bioagents in the environment.

In a biosensor, a transducer, “translates a biological recognition event into a useful quantifiable signal,” by binding molecules through a process known as immobilization, which often involves covalent bonds (Shankaran and Miura, 2007). When quinone molecules are immobilized onto a gold electrode transducer, they are bound through gold-thiol bonds.

In order to prevent false positives, biosensors must sense only the target molecule (Eggins, 1996). Biosensors are more reliable if we can control the interface of biomolecule attachment to lessen the number of false positives (Shankaran and Miura, 2007). In this project, short, complementary segments of single-stranded DNA (ssDNA) functioned as the target biomolecules. Since DNA segments will hybridize with the thiolated ssDNA incorporated in the biosensor only if the bases pair perfectly, the interface can be controlled.

Two layers of molecules were used to create the biosensor. The base monolayer was a self-assembling monolayer (SAM) composed of quinone molecules. SAMs are generally composed of molecules that have thiol (sulfur) groups that can quickly form bonds with a metal electrode to form monolayers (Wink et al., 1997). These molecules are adsorbed (built up on the surface of a solid) onto the electrode from a homogenous solution (Bard and Rubinstein, 1996). In order to have a monolayer surface that facilitates further reactions, all the molecules must be organized so that they are all arranged in the same direction (Bard and Rubinstein, 1996).

The base monolayer of this biosensor was created using 2-{{4- (methylthio)phenyl}ethynyl}benzene-1,4-diol (quinone) molecules that had a reactive headgroup (Figure 1 to the left ) and a thiol group. This quinone monolayer was created to react with, and bind to, other molecules. The reactive heads of these quinone molecules when in their oxidized state were able to bind a layer of thiolated DNA molecules.
To obtain measurements from the biosensor, a three-electrode setup was used. In a three-electrode setup, the amount of current passing from the working electrode to the counter electrode is measured while the reference electrode acts as a reference potential (Brett and Brett, 1993). Cyclic voltammetry is a specific type of voltammetry through which the potential of the electrochemical cell is cycled at a specific sweep rate \( v \) from the initial potential \( E_i \) to the final potential \( E_f \) (Brett and Brett, 1993).

**Methods and Materials:** Developing the Biosensor - Setting up the Electrochemical Instrumentation - A three-electrode electrochemical cell setup was used. The working electrode was a coiled gold wire, the counter electrode was a platinum electrode, and the reference electrode was an Ag/AgCl electrode. A BAS Cell Stand C3 and an Epsilon potentiostat were used for electrochemical measurements. The data were recorded using a program called BASiEpsilon. Electrochemical experiments were as follows. Chronoamperometry was used for electrochemical cleaning in 0.1 M H\(_2\)SO\(_4\). The potentiostat was used to first apply the potential in the electrochemical cell at three volts, and at negative three volts after 500 milliseconds. During this cycle, the current that was passed through the cell changed from ten mA to negative ten mA. As the electrode was repeatedly oxidized and reduced, the impurities were removed from the surface. Cyclic voltammetry was used for recording the electrochemical properties of the working electrode. Data were collected at a rate of one data point per mV. The scan rate and the specific composition of the electrolytic solution varied according to the particular measurement and are referenced individually below.

Creating the Quinone Monolayer - Gold wire measuring 14 cm in length was cleaned by immersion in piranha (18 M H\(_2\)SO\(_4\) and 30% H\(_2\)O\(_2\), 4:1) solution for 60 seconds. Around a 2 mm diameter cylinder, 7 cm of this wire were coiled (see Figure 2) to increase the surface area of exposure in a given volume of solution. The coil was then cleaned electrochemically by chronoamperometry. Fifty cycles were required to clean the gold electrode. After electrochemical cleaning, each coil was characterized by cyclic voltammetry at a scan rate of 200 mV/s in 0.1 M H\(_2\)SO\(_4\) for at least ten cycles. The potential was scanned from 0 mV to 1500 mV. The coil was soaked (Figure 2) in 400 \( \mu \)L of 2 mM 2-\{4-(methylthio)phenyl\}ethynyl]benzene-1,4-diol (quinone) dissolved in ethanol and 20 \( \mu \)L of 0.1 M H\(_2\)SO\(_4\), which was designed to acidify the solution so that the thiol groups would not form disulfide bonds (Hermanson, 2008). In order to prevent the evaporation of this quinone solution, the tube was sealed with parafilm. When the coil was removed from solution, it was rinsed with 200 proof ethanol and Milli-Q water. Then, a cyclic voltammogram (CV) at 100 mV/s was recorded in pH 7.13 potassium phosphate buffer. When the electrode was removed from solution during the soaking period for monitoring purposes, it was rinsed with Milli-Q water first, then with 200 proof ethanol before being replaced in solution. All monolayer and electrode preparation procedures were repeated five additional times for a total of six times.

Preparation of the Thiolated ssDNA - Ten nmol Fluor 25MeR ssDNA aliquot was removed from the freezer and was added to 20 \( \mu \)L Milli-Q ultrapure water, then mixed using a micropipettor. This solution was incubated at room temperature for five minutes. An additional 5 \( \mu \)L of Milli-Q water was then added to obtain a final volume of 25 \( \mu \)L. Four mg of dithiothreitol (DTT) were added to 25 \( \mu \)L of Milli-Q water; 5 \( \mu \)L of the resulting solution was then added to the ssDNA solution, which was mixed with a micropipettor and incubated at room temperature for one hour.
Since DTT was determined by the author to react with the quinone monolayer, the DTT was removed from the ssDNA solution through purification using a size exclusion column. The size exclusion column was rinsed three times with 2M NaCl in a pH 7.13 potassium phosphate buffer to ensure that the original buffer solution was completely purged from the system. Then, the ssDNA solution was micropipetted onto the center of the top filter and allowed to migrate through the barrier. After all the ssDNA had passed through the top filter, an additional 0.5 mL of 2M NaCl solution in pH 7.13 potassium phosphate buffer was added to the column to facilitate the migration of the ssDNA through the column. When the ssDNA solution reached the bottom of the column, 0.5 mL of the potassium phosphate buffer containing the ssDNA was collected. The molarity of this ssDNA solution was 20 μM. Procedures for reducing thiolated DNA were adapted from general procedures outlined by Hermanson (2008).

Creating the Layer of Thiolated ssDNA - The gold coil electrode with a quinone monolayer was exposed to 1.5 mL of 2M NaCl made from pH 7.13 potassium phosphate buffer and 0.5 mL of the original reduced thiolated ssDNA solution (procedure described under “Reducing the Thiolated ssDNA”) and an initial CV was recorded to monitor the reaction. At least ten cycles of data, which corresponds to 11,859 data points, were collected (represented below as “Before DNA Reaction” in Figure 8, pg. 14). The gold coil electrode was then immersed in the thiolated ssDNA solution overnight while the electrode was in its oxidized state. Before the electrode was removed from solution, a final CV was recorded to determine if there was a change in the electrochemical data as a result of this exposure. At least ten cycles of data were collected once more (represented as “After DNA Reaction” in Figure 8, pg. 14). All thiolated ssDNA reaction procedures were repeated five additional times for a total of six times. Each of these electrodes was the finished biosensor that was tested in either the treatment or control groups.

Testing the Biosensor - The biosensor was tested for detection of the DNA hybridization by comparing the electrochemical data from the treatment group (exposure to complementary segments of DNA) to that of the control group (exposure to non-complementary segments of DNA). The biosensor was also tested for nonspecific binding, which would result in false positives. To test for non-specific binding, the biosensor was exposed to non-complementary DNA segments, which functioned as non-target molecules that would not hybridize with the DNA incorporated in the biosensor. The shift in the formal potential, \( E_{\text{formal}} = \frac{E_{\text{ox}} + E_{\text{red}}}{2} \), was measured using cyclic voltammetry before and after a reaction. Three trials each were run for the treatment and the control groups. The volume of electrolyte in the electrochemical cell for each measurement was held constant at 2 mL, and the pH of the potassium phosphate buffer was also held constant for all trials at pH 7.13. The ion concentration of the potassium phosphate buffer was artificially increased to 2M NaCl to mask the negative charges of the DNA molecules. This masking would prevent repulsion between the DNA molecules. The volume of quinone solution, to which the gold coil was exposed, was held constant at 420 μL for the treatment and control for all trials. The surface area of gold electrode exposure and of the monolayer, was also constant for all trials.

The treatment consisted of biosensor exposure to a solution of 4.8 μL of 1.9 mM CompFAM, which was the complementary sequence of DNA, and 2 mL of 2 M NaCl in pH 7.13 potassium phosphate. Once the gold electrode was placed in this solution, an initial CV of at least ten cycles at 100 mV/s was run to record the electrochemical characteristics of the biosensor. Then, the biosensor was left in the oxidized state and exposed to the solution for at least forty-eight hours. At the end of the exposure period, a final CV of at least ten cycles at 100 mV/s was run to record the electrochemical characteristics of the biosensor after exposure to the complementary segments of DNA. All manipulations of the gold electrode outlined in this paragraph were repeated twice using the other biosensor for a total of three treatment trials.

For the control, all manipulations of the gold electrode outlined in the above paragraph were repeated using non-target, non-complementary segments of DNA, SeqFAM, instead of target, complementary segments of DNA. The exposure time was approximately four hours. Previous experimentation by the author suggested that after approximately five to seven hours, additional exposure of the electrode to the complementary DNA solution did not seriously affect the electrochemical characteristics of the sensor. Thus, while the exposure time between the treatment and control groups varied, the difference was determined to have no effect on the data.

Results and Discussion: Creating a Quinone Monolayer on a Gold Electrode - The CV of the clean gold electrode displayed well-defined peaks with a large surface area, shown in Figure 3 (See Appendix). Although the graph was composed of two cycles of data collected for the same potentials, the data overlapped precisely and
demonstrated the stability of the material. This stability indicated that the electrochemical properties of the gold surface were not changing during the data collection period.

The graphs in Figure 4 (See Appendix) were recorded after the gold electrode was immersed in quinone solution for approximately five hours. When a monolayer generates a good signal, the peaks of the graph are well-defined, protrude clearly from the base, and have a small base (Bard and Rubinstein, 1996). Additionally, the stability of the material can be determined by observing whether or not the data overlap precisely when multiple cycles are run (Bard and Rubinstein, 1996). The stability of the monolayer was important to the biosensor. Had the electrochemical properties of the monolayer changed spontaneously, it would not have been possible to determine whether the observed changes in the subsequent reactions were caused by the reactions or by the spontaneous change in the monolayer. The graph in Figure 4 represents upwards of twenty-four cycles of overlapping data. Since the graphs overlap for multiple cycles of data collection, the values of the data must remain generally constant over time as exemplified in Figure 4. The constancy in the data indicates that the overall electrochemical properties of the monolayer are not changing over time and the monolayer is stable.

Previous studies have found that as the molecular surface coverage increases, the peak area also increases (Bard and Rubinstein, 1996). A large peak area indicates that many molecules comprise the monolayer (Smith et al., 2004). By integrating the area under the peaks in Figure 4 (See Appendix) using the BASiEpsilon software, the total charge, \( Q \), was determined to be \( 45 \times 10^{-6} \text{ C} \). The coverage is \( \Gamma = \frac{Q}{nF} = \frac{45 \times 10^{-6} \text{ C}}{2 \times 96485 \text{ C/mol}} = 2.3 \times 10^{-10} \text{ moles} \), where \( n \) is the number of moles of electrons transferred in the redox reaction and \( F \) is Faraday’s constant.

The surface area of exposed gold electrode was equal to \( 3.14 \times (2 \times 0.251 \text{ mm}) \times 8 \text{ cm} = 1.26 \text{ cm}^2 \), and the coverage was \( 1.9 \times 10^{-10} \text{ mol/cm}^2 \). Typical coverage of hydroquinone molecules attached to gold using alkane thiols is \( \sim 5 \times 10^{-10} \text{ moles/cm}^2 \) (Hong and Park, 2001). When the molecules of a monolayer are in a horizontal configuration on the surface of the substrate, their reactivity declines because other molecules cannot reach the reactive heads of the molecules (Smith, et al., 2004). The graph in Figure 4 displays large peaks, which signify that a monolayer with significant coverage formed on the electrode. Thus, the molecules were most likely in a near-vertical configuration, which would indicate that the reactive heads of the molecules were exposed to other molecules and were available to react.

Bonding Thiolated ssDNA to the Quinone Monolayer- In order to determine if thiolated ssDNA had reacted with the monolayer, the CVs were recorded over time, and the shifts in formal potentials were compared. Each of the plots in Figure 7 (See Appendix) is the result of overlaying four cycles of data. A clear shift in the formal potential of the biosensor was observed when the final CV was compared to the initial CV, as is displayed in Figure 7. No other reagents were added to the electrochemical cell during this time frame. The shift of the formal potential occurred to the left, signifying that the peak anodic potential became less positive and the peak cathodic potential became more negative. Repeated trials displayed consistent and reproducible results.

Testing the Functionality of the Biosensor- Treatment Group - In order to test the ability of the biosensor to detect the target DNA molecule, the biosensor was exposed to a complementary segment of ssDNA. In all three trials, the formal potential shifted as in Figure 8 (See Appendix). Each of the plots in Figure 8 was the result of overlaying at least ten cycles of data. The data indicated that a reaction had occurred between the molecules in solution and those forming the biosensor, causing the formal potential of the biosensor to become more negative. Since the target molecules were complementary to the ssDNA in the biosensor, this reaction must have been the hybridization of the segments of DNA.

Control Group - The biosensor was exposed to the control solution containing segments of non-complementary DNA to test if non-specific bonding would occur. After the biosensor had been exposed to this solution for approximately six hours, electrochemical data were collected once more and at least ten cycles were overlaid with the initial data as in Figure 9 (See Appendix).

The data showed that a very slight shift in the formal potential occurred leftward as the result of exposure to the non-complementary DNA solution. One explanation is that this shift is a result of adsorption, which likely does not affect the electrochemical properties of a material as much as bonding does, and may explain why the shift
is minimal. Repeated trials also reproduced this result. According to Bamdad (1998), it is not uncommon for minimal nonspecific adsorption (a buildup of molecules on the surface of a solid) to occur as the result of soaking SAMs in solution if triethylene glycol-terminated thiols, which are designed to resist nonspecific binding, are not incorporated in the monolayer. Since the leftward shift was approximately the same each time, some of the molecules in solution likely adsorbs onto the biosensor as a result of exposure.

Validating the Functionality of the Biosensor - To determine if there was a difference between the detection of the treatment (complementary DNA) and control (non-complementary DNA), the shift in formal potential for each trial was calculated and compared to the other trials. Each of the peak anodic and cathodic potential values in Table 1 (See Appendix) is substantiated by at least ten cycles of data.

The actual initial values of the formal potentials themselves were not considered because they are affected by environmental conditions, such as electrolyte ion concentrations. Instead, the shifts in these values were analyzed, since environmental conditions remain constant throughout the course of the detection. The data demonstrated that the shifts in the formal potentials of the treatment group were almost twice as great as the shifts of the control group. None of the treatment trials had lesser, or equal shifts when compared to the shifts of the control trials. This observation may be explained by the fact that when molecules bind, their chemical and electrochemical properties are altered more significantly than if they simply attach to one another through weak attractions. Since the complementary DNA hybridized with the DNA incorporated in the biosensor, a greater change in the electrochemical properties of the biosensor was expected for the treatment group than that for the control group. When the data were compared, the error bars for each group were separated by at least one standard deviation see Figure 10 in Appendix.

Conclusions: A new biosensor using two layers of molecules and cyclic voltammetry for measurements was successfully developed and tested. The data collected during the testing process indicate that the biosensor detected the target biomolecule, a segment of complementary DNA. Testing with non-complementary DNA demonstrated that the signal generated by non-target molecules were significantly smaller. Based on existing data, statistical analysis (See Appendix) indicates that this difference in the signal change is significant. Thus, this biosensor can be used to detect specific molecules and is not sensitive to foreign molecules. Since the biosensor can be easily modified by changing the molecules forming the second layer, a wide variety of biomolecules can be detected using the same equipment and techniques.

One of the major advantages of this biosensor lies in the brevity of time required for detection. Routine checks for biological agents in the environment may become more feasible due to the ease with which this biosensor is created and operated. More extensive tests on the exposure time will be conducted to determine if detection time could be shortened further. The biosensor is expected to be capable of detecting a wide range of biomolecules for a variety of applications, and further research on different types of molecules is recommended.

LITERATURE CITED


ACKNOWLEDGMENT

I would like to acknowledge my mentor, Dr. Scott Trammell for teaching me background information in analytical chemistry, helping me develop my techniques in electrochemical research, and helping me determine the feasibility of my project. He gave me the support and guidance that I needed to develop my project idea, providing me with the materials and instrumentation necessary for the project.
Appendix

Figure 3. Characterization of the Clean Gold Electrode

Figure 4. Characterization of the Gold Coil with Quinone Monolayer
Figure 7. Time Progression of Quinone Monolayer and ssDNA Reaction

Figure 8. Time Progression for Biosensor Exposure to Complementary ssDNA
Figure 9. Time Progression for Biosensor Exposure to Non-complementary ssDNA

### Table 1. Electrochemical Data

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<tr>
<th>Type and Trial</th>
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<th>Peak Cathodic Potential (mV)</th>
<th>Formal Potential (mV)</th>
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<td>After</td>
<td>Before</td>
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<td>0.00</td>
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<td>123</td>
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<tr>
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<tr>
<td>Complementary Trial 3</td>
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<td>128</td>
<td>3.00</td>
</tr>
</tbody>
</table>
Statistical Analysis Calculations

To determine if the results were statistically significant, a preliminary statistics test was run at $\alpha$-level 0.01.

$H_0$: $\mu_T - \mu_C \leq 0$

$H_a$: $\mu_T - \mu_C > 0$

To conduct the difference in means hypothesis test, it was assumed that the true population distribution of the mean shift in the treatment electrochemical data and the mean shift in the control electrochemical data were normally distributed. In this experiment, three trials each were run for the treatment and the control ($n_T=3$ and $n_C=3$).

The test statistic were

$$t = \frac{(9.2 - 16.3) - (0)}{\sqrt{\frac{4.083}{3} + \frac{5.583}{3}}} = 3.992$$

which followed a t-distribution with corresponding degrees of freedom of

$$df = \frac{(1.861 + 1.361)^2}{\frac{1.861^2}{3 - 1} + \frac{1.361^2}{3 - 1}} = 3.906,$$

which rounded to 4 degrees of freedom.

$V_T$ and $V_C$ were defined as

$$V_T = \frac{s_T^2}{n_T} = \frac{5.583}{3} = 1.861,$$

and

$$V_C = \frac{s_C^2}{n_C} = \frac{4.083}{3} = 1.361.$$
The means were calculated to be

\[
\bar{x}_T = \frac{9.5 + 11.0 + 7.0}{3} = 9.166, \quad \text{and} \quad \bar{x}_C = \frac{14.5 + 19.0 + 15.5}{3} = 16.3
\]

\[
s_T = \sqrt{\frac{\sum (x - \bar{x}_T)^2}{n_T - 1}} = 2.363, \quad \text{and} \quad s_C = \sqrt{\frac{\sum (x - \bar{x}_C)^2}{n_C - 1}} = 2.201.
\]

By matching the t-value with the correct degrees of freedom in the tail area for t-curves, the p-value was found to be 0.008. Since 0.008 < 0.01, the null hypothesis, H_0: \( \mu_T - \mu_C \leq 0 \), was rejected and the alternative hypothesis, H_a: \( \mu_T - \mu_C > 0 \), was supported. The data suggest the mean shift in the treatment electrochemical data is significantly larger than the mean shift in the control electrochemical data.

These results, although significant, are preliminary due to sample size. Since only three trials were run for the treatment and control, normal distribution of the mean shift in the treatment electrochemical data and the mean shift in the control electrochemical data could not be confirmed. A greater number of trials will be required to validate the normality assumption.
SECOND PLACE

THE EFFECT OF BAMBOO HARDWOOD FLOORING AND OAK HARDWOOD FLOORING ON DEFLECTION

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ABSTRACT

Bamboo flooring is a new type of product that can change the way homes are built and the way that homes affect the environment. The purpose of this study was to determine if different types of hardwood flooring have any effect on the deflection of flooring. Convenient samples were tested using a hydraulic press, and the force was measured using a pressure gauge. The modulus of elasticity was determined using Young’s Modulus. The results were analyzed using two t-tests that yielded no statistical difference between the moduli of elasticity of bamboo and that of oak hardwood flooring. There was no statistical difference between bamboo and oak hardwood flooring in the amount of loads allowable to meet the International Building Codes on deflection. The researcher concluded that there is no difference in deflection between bamboo hardwood flooring and oak hardwood flooring. Due to bamboo’s fast regeneration rate, bamboo hardwood flooring is recommended to improve the environment’s health.

THIRD PLACE

A MODEL OF THE EFFECT OF CHIRAL ANGLE ON THE YOUNG’S MODULUS OF SINGLE WALLED CARBON NANOTUBES

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ABSTRACT

The purpose of this experiment was to investigate the physical properties of carbon nanotubes by using a chicken wire model so the properties of nanotubes could be explored without the expensive and technical equipment usually associated with carbon nanotubes. The hypothesis stated that if the chiral angle of a single walled carbon nanotube is changed then the nanotubes with chiral angles between 0° and 30° (chiral nanotubes) will be tested to have the highest Young’s modulus because previous scientific experiments have shown these results. The experiment was completed by cutting chicken wire into sheets and then by rolling them a variety of ways to form various cylinders. Thus a zigzag nanotube, chiral nanotube, and armchair nanotube were made, each type with a different chiral angle. Then weight was added to these nanotube models, the change in length resulting from the force of that weight was recorded, and the Young’s modulus was found using that and other collected data. The results proceeded as predicted – in accordance with research done prior to the experiment. The mean Young’s modulus of the armchair nanotubes was the lowest at 16540 Pa, the middle value was that of the zigzag nanotubes at 45650 Pa, and the highest was the chiral nanotubes at 102400 Pa. The data turned out this way because the chiral angle changed the alignment of the hexagonal patterns (carbon-carbon bonds in nanotubes) and affected the distribution of weight amongst them thus resulting in either more or less disruption and more or less stretching.
HONORABLE MENTION

THE EFFECT OF THE AMOUNT OF WATER ADDED TO A LOAMY SOIL MIXTURE ON THAT SOIL MIXTURE'S ABILITY TO SUPPORT WEIGHT

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ABSTRACT

The purpose of this experiment was to determine what effect different amounts of water added to a loamy soil mixture would have on the soil's ability to support a constant weight. The hypothesis stated that if the amount of water added to a loamy soil mixture increased then the amount soil compressed decreased. Five different coffee cans were filled with a loamy soil mixture made of sand, silt, and clay. Different amounts of water (0 oz, 1.6 oz, 3.2 oz, 4.8 oz, and 6.4 oz) were added to the soil mixture to represent the five different independent variables. The coffee cans were placed in a holder beneath a sand-filled pipe suspended from a tri-pod. The pipe (a constant weight) was lowered onto the soil mixture for a full minute. Fifteen trials were tested for each independent variable. In summary, the results were that the soil compressed in greater amounts as more water was added to the mixture until during trial five the constant weight sank nearly to the bottom of the coffee can because its contents were entirely mud. The hypothesis was not supported by this experiment. The experiment found that with more water added, more soil shrinkage was visible. If the soil was more compacted to begin with, this would not have happened because the soil would have taken longer to absorb the water.

HONORABLE MENTION

THE EFFECT OF TUBERCLES ON THE LEADING EDGE OF A WING ON DRAG

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ABSTRACT

The experiment was performed to determine if adding bumps to the leading edge of a wing would affect drag in any way. The experimental procedure involved the creation of a four foot long wind tunnel to test two sets of wings, one with a bumpy leading edge and one with a smooth edge. Each wing was tested by measuring the force with which the wing pressed against a scale when blow on by a fan. This was the numerological value attributed value. The drag produced by each wing was measured in grams, simply because it was the smallest unit that the scale could measure in. The average drag for the smooth edge wing was 15.84 grams, which was greater than the average drag for the bumpy edge of 10.16. This data supported the research hypothesis that the wing with the bumpy leading edge would produce the least amount of drag. The findings found in this experiment were also supported by research done by others. This research can be applied to topics as varied as wind turbines, ceiling fans, and airplanes. Each of these technologies rely of the lift generated by a wing. Since this experiment shows a method to decrease the drag on wings while stiff producing the same lift it could have far reaching application.
HONORABLE MENTION

THE EFFECTS OF GAMMA RADIATION ON GEL-FORM RESINS

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Central Virginia Governor's School, Lynchburg, Virginia 24502

ABSTRACT

The purpose of this study was to analyze the effects of gamma radiation on gel-form resins. This study is important because it will show if this material is affected by gamma radiation. Resin beads are used to purify water in nuclear reactors by absorbing anions and cations. This investigation evaluates anion resin performance. If gamma radiation degrades the material at the doses used, the plant will need to control the dose so that the samples are not exposed to these levels of radiation, and to invest more money in changing out the resin beds more frequently. Terminal settling velocity and capacity tests were performed at a high school in Central Virginia from December 2008 to February 2009. The material was donated to the researcher by the manufacturer (Rohm & Haas) for use specifically on this project. Engineers from a local engineering firm assisted the researcher with testing. Testing was performed in accordance to ASTM procedures. Three groups of resin samples (250mL) were irradiated at 0, 50, and 100Mrads of gamma radiation. A single-factor ANOVA was performed on the data from the terminal settling velocity test. The null hypothesis $\mu_{0\text{Mrad}} = \mu_{50\text{Mrad}} = \mu_{100\text{Mrad}}$, the alternate hypothesis $\mu_{0\text{Mrad}} \neq \mu_{50\text{Mrad}} \neq \mu_{100\text{Mrad}}$. The P-value of the test was 0.0654 which was slightly greater than the alpha level of 0.05; the null hypothesis was accepted, meaning the gamma radiation did not have a significant effect on the resin.

OTHER PAPERS SELECTED FOR PRESENTATION:


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The Effect of Different Hull Designs on the Time Taken to Travel Down a Water Filled Gutter. Paul S. Welch, Deep Run High School, Henrico County Schools.

The Effect of Temperature on Piezoelectric Sensors. Alex H. Williams, Mills E. Godwin High School, Henrico County Schools.

The Effect of Two Motor Model Rocket Staging on Altitude. Catesby K. Wolski, George H. Moody Middle School, Henrico County Schools.
Abstract: The intent of this study was to develop a technique to identify potentially tornadic thunderstorms prior to tornadogenesis using infrared satellite images. The goal of the study was to discover a signature that has a lead time greater than 30 minutes. Satellite images of 10.7 \( \mu \text{m} \) were obtained for the life cycle of twenty known tornadic thunderstorms. The images were enhanced using ImageJ and examined for signatures visually and using pixel values. The lead time from signature formation to tornadogenesis was noted. Results were analyzed using t-test for significance. The warm-spot signature’s average lead time (30.5 minutes) was not significantly greater than 30 minutes. The notch signature’s mean lead time (36 minutes) was significantly greater than 30 minutes, but was not significantly greater than the warm-spot average lead time. The most likely cause of the warm-spot signature was airflow interaction with an overshooting top, as described with McCann’s paper on enhanced-V. A frontal occlusion is most likely the cause of the notch signature, because the shape of the notch mimics the structure of a “classic” tornadic supercell in which a frontal occlusion precedes a tornado. The warm-spot signature could be used in a wide range of thunderstorms, but would likely be associated with a high false alarm ratio, which would not be conducive for operational use. Isolated supercells are ideal for the notch signature, since it is difficult to notice in a bow-echo line. However, it would likely be associated with low false alarm ratios, leading to potential operational use.

Introduction: The United States, especially the Great Plains, is generally considered to be the tornado capital of the world. Each spring, the eyes of meteorologists focus on the Plains as warm air from the Gulf of Mexico clashes with strong low pressure systems moving out of Canada that are accompanied by cold Arctic air. This collision of air masses often results in violent tornado outbreaks that last for days and can spawn up to three hundred tornadoes over their duration. Tornadoes not only form in the spring, they occur in every month of the year, in a wide variety of conditions. Each year, tornadoes cause about $420 million in damage and kill roughly one-hundred people (Brooks and Doswell, 2001). Not much can be done by meteorologists to reduce the amount of damage caused by tornadoes; the majority of advances will come from increased knowledge of tornado wind flow and how this impacts the structural integrity of a building. However, meteorologists can save lives by increasing lead times on storm warnings. This study attempts to increase warning lead times on tornado formation by using geostationary weather satellites.

The main geostationary satellite system used by meteorologists is the Geostationary Operational Environmental Satellite (GOES) system developed by NASA. Satellites have been used since the 1960s to monitor the earth’s atmosphere. Early satellites were crude and did not have many capabilities other than taking pictures of clouds that were slowly processed, making the satellite an experimental and forecasting tool, rather than a monitoring tool. Satellites have progressed to monitor different wavelengths of infrared light, as well as visible light, and the images can be processed much faster due to increases in computer power, allowing current conditions to be monitored on a large scale basis. The current GOES satellites (11 and 12) take pictures under the visible wavelength (0.52-0.72 \( \mu \text{m} \)), and various infrared wavelengths including 3.9 \( \mu \text{m} \) (determines whether clouds contain water or ice), 6.7 \( \mu \text{m} \) (detects mid- to upper-level water vapor), 10.7 \( \mu \text{m} \) (regular infrared image, as seen on the Weather Channel), and 12.0 \( \mu \text{m} \) (detects low-level water vapor) (Weaver, 2002). Since the weather satellite’s inception, scientists have worked to be able to use its capabilities to protect life and property from all types of weather.

Satellites have been used to try to identify severe thunderstorms since the late 1970’s. Many people have associated severe thunderstorms with a warm spot shown by infrared satellite images. In a paper by Donald McCann,
a method was demonstrated that applied a mathematical curve to the image that produced a “V” shape in the thunderstorm near the warm spot. It was theorized that the “V” was produced by a wind flow that had been diverted around an overshooting top from the thunderstorm (McCann, 1983). The signature is now known as the enhanced-V and McCann determined that the median lead time for the signature was 30 minutes. In a study around the same time, Adler and Fenn determined that tornadic thunderstorms were often associated with a period of explosive height growth (around 3 m/s) about half an hour before tornado touchdown. The height growth was determined by the overall cooling of the clouds shown in an infrared satellite image (Adler and Fenn, 1981). However, in recent years, satellite research has focused more on rainfall and temperature studies due to the interest in global warming and its impacts on weather, and not on severe weather.

Tornadoes are caused by both supercell and non-supercell tornadoes, but supercell tornadoes are responsible for the majority of violent tornadoes (Johns and Doswell, 1992). Tornado formation is dependent on the wind flow into the storm and the instability of the atmosphere (Johns and Doswell, 1992). The strength and rotational potential of the storm’s inflow are critical in tornado formation (Johns and Doswell, 1992). As the inflow strength and rotational potential increase, the chance for the storm to produce a tornado also increases. Atmospheric instability (Convective Available Potential Energy or CAPE) is the measure of the energy in a parcel of air that allows it to rise. As CAPE increases, the air has more energy and allows the air to rise higher into the atmosphere and the thunderstorm to become stronger. A tornado does not necessarily need a lot of CAPE to form, as the inflow can have increased rotational potential and strength, and would thus need little instability to form a tornado (Johns and Doswell, 1992).

The purpose of this study was to find a qualitative method that determines tornadic thunderstorms before they turn tornadic using 10.7 μm satellite imagery. It was believed that when using infrared satellite imagery from NASA’s GOES satellites, tornadic thunderstorms would be identified with an average lead time of at least thirty minutes before a tornado touchdown. This lead time was based on the McCann median lead time of 30 minutes for the enhanced-V signature for severe thunderstorms. The focus of the study was to determine a method that can be used to identify storms and determine if its average lead time would lead to practical use in the issuing tornado warnings. Operational use and false alarm ratios were not the focus of the study and will be addressed in subsequent studies.

**Methods and Materials:** Twenty known tornado events that occurred within the past five years were selected from the Storm Prediction Center’s index of severe weather events (http://w1.spc.woc.noaa.gov/exper/archive/events/). The 10.7 μm satellite images of each of the tornadic thunderstorms were acquired from the Satellite Inventory Browser from the Space Science and Engineering Center at the University of Wisconsin (http://dcdbs.ssec.wisc.edu/inventory/). The images were enlarged and enhanced by enhancing the contrast by 5.0% and subtracting 30 from all pixel values using the image processing software ImageJ. Any noticeable signatures, either visually or using the pixel values, in the region and time of the known tornado formation were noted. The signature for the storm was noted and the signature was back traced until it disappeared from the satellite image. The lead time was determined by finding the difference between the time of tornado formation and the time of the first satellite image containing the signature. The average lead time of any signature found were compared to the hypothesized lead time of 30 minutes using a one-sided t-test.

**Results:** The warm spot signature appeared by itself on eight out of twenty studied tornadoes. The average lead time was 30.5 minutes with a standard deviation of 8.106 minutes. A t-test was performed with a null hypothesis stating that the average lead time was equal to 30 minutes. The p-value of 0.4332 was higher than the alpha level of 0.05. The null hypothesis cannot be rejected so it is possible that the results could have been due to chance (see Appendix for details on t-tests).

The notch appeared with or without a warm spot in 12 out of 20 studied tornadoes. The mean warning lead time was 36.5 minutes with a standard deviation of 7.669 minutes. A t-test was performed with the same null hypothesis as the previous test. The p-value of 0.0067 was lower than the alpha of 0.05. The significance test indicates that the null hypothesis was rejected and that the average lead time for the notch signature is greater than thirty minutes.
A two sample t-test was performed on the notch signature and warm spot signature lead times. The null hypothesis stated that the notch average lead time was greater than that of the warm-spot signature. The p-value (0.0595) was slightly higher than the alpha value (0.05). This indicates that the null hypothesis cannot be rejected and that the notch signature average lead time was not significantly higher than that of the warm-spot signature.

Discussion and Conclusions: During the study, two main features were noted in the identification of potentially tornadic thunderstorms. The first was a warm spot in the general area of tornado formation, which most likely coincides with the enhanced-V feature discussed by McCann. The other feature was a notch in the thunderstorm that appeared as a right angle in most cases. Sometimes, both features were present on certain thunderstorms, with the right angle feature generally appearing first.

The warm spot was easily identifiable using the image processing software. Since the software gave the value for each pixel, there was a region in the thunderstorm that had lower values than surrounding areas. On average, the warm spot had a 20-30 point lower pixel value than the surrounding colder areas of the thunderstorm. The warm spot also appears slightly darker when the contrast of the image is enhanced. The warm temperatures are indicative of an area of lower cloud tops or warm air. A picture of the warm spot signature is located in the Appendix (Fig. 1).

In McCann’s paper, the cause of the warm spot was attributed to an overshooting top. An overshooting top is a dome shaped structure on the cloud top caused by a particularly strong updraft that penetrates the equilibrium layer, or area where the temperature of the rising air equals the temperature of the air mass. If an overshooting top is present for more than ten minutes, then it is likely that the thunderstorm will produce severe weather (large hail, damaging winds, or tornadoes). There are three theories regarding how overshooting tops produce a warm spot on the satellite imagery. The first theory from Ted Fujita states that the “V” shape associated with the warm spot is caused by a flow of cold air being diverted around the top that causes a low pressure area behind the top that creates a V-shaped flow of cold air. The second theory states that as air is forced over the top, it flows down over the other side and creates a depression in the cloud top, leading to warmer cloud temperatures on IR satellite images. The third theory describes the overshooting top forcing airflow up, which in turn would mix with warmer stratospheric air, making the temperature of the cloud top warmer (McCann, 1983).

In all three cases, an overshooting top is necessary. Overshooting tops are generally associated with increased CAPE values (McCann, 1983). CAPE is essentially a measure of the buoyancy of air over the distance between the level of free convection (LFC) and the equilibrium layer. At the LFC, the rate at which a parcel of air loses heat is less than the atmospheric lapse rate. If the air is more buoyant it will move faster through this layer of the atmosphere and have more energy, resulting in higher CAPE values (Johns and Doswell, 1992). If the updraft is strong enough, the air parcel penetrates the equilibrium layer and a persistent overshooting top will form (McCann, 1983).

In an operational setting, the warm spot signature has several pros and cons. The signature is ideal for use in a line or cluster of thunderstorms. Also, an algorithm could be created to alert a computer of any such areas that may be an indicator of tornado development. A definite con is the fact that the warm spot is associated with all types of severe weather, not only tornadoes. This would lead to a high false-alarm rate and would not necessarily help those issuing tornado warnings. Also, the warm-spot signature needs a study to conclude the temperature difference between the clouds so that a computer can easily identify the signature.

The notch feature is a feature that is easily spotted on the satellite image. It consists of a notch that generally appears as a right angle on the southern side of the thunderstorm. There is a picture of the feature in the Appendix (Fig. 2).

It appeared that the notch signature on a satellite image is similar to the bow-echo signature used by meteorologists to identify the tornadic potential of a thunderstorm on Doppler radar. The air flow into a thunderstorm generally comes from the south. The tropical air from the south rises, creating an area of low pressure, which is the considered to be the center of the supercell. A gust front [cold front on the mesoscale (small scale) level] extends south of the low pressure area, and a warm front (also on the mesoscale level) extends north from the center. When the rear downdraft of the thunderstorm strengthens (which usually coincides with updraft weakening), the cold front overtakes
the warm front (occlusion) and a notch is created in the storm structure. This event signifies that there is a strong chance of tornado touchdown with the supercell. The notch created by the front occlusion is most likely what is seen in the satellite image (Klemp and Rotunno, 1983).

Like the warm spot signature, the notch has its strengths and weaknesses in an operational setting. The notch has a higher average lead time when compared to the warm spot signature, but it was not significantly greater. The notch signature was more easily identifiable than the warm spot using the naked eye. Also, the signature is only associated with storms that have strong chances of producing a tornado, thus leading to a low false-alarm ratio. The major weakness in this signature is that it can only be used with single supercells, and not with lines or clusters of thunderstorms. This can be a problem as, according to Doswell and Johns, a majority of violent tornadoes are not associated with isolated supercells, but rather with more complex storm structures such as bow echoes. Even with this weakness, the notch signature appears to have more upside than the warm spot in early tornado detection.

There were two potential sources of error in the study. Some of the tornadoes studied were produced from the same thunderstorm at different times. Ample time separated the touchdowns to make sure that the same tornado was not being studied. Each tornado can be treated independently, since scientists do not know exactly what causes tornado formation and it was assumed that one tornado did not influence another’s formation. The other error source was the exact time of signature formation. The satellite images were separated by three to ten minutes, and it was difficult to determine the exact amount of time that the signature was present prior to tornado formation.

If the study were to be conducted over again, more tornadoes would be studied to get a more accurate average lead time for each signature. Also, only one tornado from each storm would be studied to prevent any possible associated error. Further studies on the subject should include determining the approximate false-alarm ratios for each signature, as well as using different satellite channels (different wavelengths) to determine if a signature that can be found in all tornadic thunderstorms is present. Computer algorithms to detect warm spots and the notch signature could also be developed in subsequent studies. Progression’s in satellite technology, such as decreased time between images and faster processing speeds, would greatly aid in the study of tornadic thunderstorms by satellite.

Both satellite signatures had average lead times greater than the hypothesized 30 minutes (warm spot – 30.5 minutes; notch – 36 minutes). Statistical testing determined that the true average lead time for the warm spot signature was not necessarily above the 30 minute threshold. However, the notch signature’s true average lead time was above 30 minutes, according to the t-test. The research hypothesis was not supported for the warm spot signature, but it was supported for the notch signature.

The warm-spot signature was most likely caused by an overshooting top that McCann associated with the enhanced-V. The average lead time for the warm-spot was very close to McCann’s median lead time of 30 minutes for the enhanced-V. The problem with the enhanced-V is that it has been associated with severe thunderstorms, not just tornadic thunderstorms. The warm-spot method for identifying tornadic thunderstorms would likely have a high false-alarm ratio and would not be very useful in attempting to issue earlier tornado warnings.

The notch signature was most likely associated with a mesoscale front occlusion in a supercell. This frontal occlusion tends to precede tornado formation in supercells. The signature was similar to the bow-echo signature that accompanies some tornadic thunderstorms on a Doppler radar image. The notch signature appeared to have practical applications in the issuing of tornado warnings. It had a large average lead time, and since it was associated with a structure known to precede tornadogenesis, the signature would likely be associated with a low false-alarm ratio. While somewhat limited to isolated supercell thunderstorms, the notch signature could be useful in the quest to issue earlier tornado warnings.

As satellite technology continues to increase, research on tornadic thunderstorms will become easier. Satellites should be able to provide a three-dimensional look at the structure of tornadic storms in the future, potentially leading to the discovery of the mechanism that causes tornadoes to form. The benefits of satellite technology in forecasting severe weather, specifically tornadic thunderstorms, are great, and the use of satellite technology needs to be expanded into the area of issuing severe weather warnings.
LITERATURE CITED


Appendix

Figure 1: Warm spot signature example

The warm spot is denoted by the arrow and is difficult to see with the naked eye. The warm spot is located in the approximate area of the arrow tip. The pixel values given by ImageJ were used to determine where the area of warm clouds was located in the thunderstorm.

Figure 2: Notch signature example

The notch signature is pointed to by the arrow. This notch is particularly exaggerated, as most appear as a right angle. The signature is easily identifiable using the naked eye.
Table 1: Raw Data Table

<table>
<thead>
<tr>
<th>Place</th>
<th>Time</th>
<th>Date</th>
<th>Approx. Tornado Lead Time</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellis County, OK</td>
<td>23:21</td>
<td>5/4/2007</td>
<td>41 minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Clark County, KS</td>
<td>1:35</td>
<td>5/5/2007</td>
<td>24 minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Comanche County, KS</td>
<td>2:00</td>
<td>5/5/2007</td>
<td>45 minutes</td>
<td>Notch w/ warm spot</td>
</tr>
<tr>
<td>Kiowa County, KS</td>
<td>2:38</td>
<td>5/5/2007</td>
<td>40 minutes</td>
<td>Notch w/ warm spot</td>
</tr>
<tr>
<td>Custer County, NE</td>
<td>17:23</td>
<td>5/5/2007</td>
<td>23 Minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Osborne County, KS</td>
<td>22:52</td>
<td>5/5/2007</td>
<td>20 minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Roger Mills County, OK</td>
<td>1:32</td>
<td>5/6/2007</td>
<td>37 Minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Stafford County, KS</td>
<td>1:33</td>
<td>5/6/2007</td>
<td>25 minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Ellis County, OK</td>
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<td>5/6/2007</td>
<td>24 minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Barton County, KS</td>
<td>2:08</td>
<td>5/6/2007</td>
<td>38 Minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Ottawa County, OK</td>
<td>22:39</td>
<td>5/10/2008</td>
<td>29 Minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Newton County, MO</td>
<td>23:02</td>
<td>5/10/2008</td>
<td>43 Minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Craighead County, AR</td>
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<td>5/10/2008</td>
<td>26 Minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Crawford County, KS</td>
<td>22:00</td>
<td>5/4/2003</td>
<td>35 minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Camden County, MO</td>
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<td>5/5/2003</td>
<td>43 Minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Woodruff County, AR</td>
<td>2:10</td>
<td>5/5/2003</td>
<td>30 Minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Dyer County, TN</td>
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<td>5/5/2003</td>
<td>40 Minutes</td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Butler County, IA</td>
<td>21:22</td>
<td>5/25/2008</td>
<td>45 Minutes</td>
<td>Notch</td>
</tr>
<tr>
<td>Grove County, KS</td>
<td>21:38</td>
<td>5/23/2008</td>
<td>35 Minutes</td>
<td>Notch</td>
</tr>
</tbody>
</table>

Table 2: T-Test Information

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>Tornado warning lead time using satellite imagery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Warm Spot</td>
</tr>
<tr>
<td>Mean</td>
<td>30.5 minutes</td>
</tr>
<tr>
<td>Maximum</td>
<td>41 minutes</td>
</tr>
<tr>
<td>Minimum</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8.106 minutes</td>
</tr>
<tr>
<td>Number</td>
<td>8</td>
</tr>
</tbody>
</table>

T-Test Results

- Warm spot vs. hypothesized time (30 min) \( t = .1744 \) \( p = .4332 \) \( df = 7 \)
- Notch vs. hypothesized time \( t = 2.936 \) \( p = .0069 \) \( df = 11 \)
- Notch > Warm spot \( t = 1.656 \) \( p = .0595 \) \( df = 14.55 \)

For all tests, \( \alpha = .05 \)
SECOND PLACE

THE EFFECTS OF GAMMA RADIATION ON LEVELS OF NITRATE AND PHOSPHATE IN SOIL

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ABSTRACT

The purpose of this study was to determine the effects of various levels of gamma radiation on the content of phosphate and nitrate in soil. This study took place at a local high school during November and December of 2008. Four jars of soil were packaged and shipped to Penn State’s Breazeale Nuclear Reactor. One jar received no gamma radiation, one jar received 1.25 Mrads of gamma radiation, one jar received 2.5 Mrads of gamma radiation, and the last jar received 5 Mrads of gamma radiation. After the soil was irradiated, the researcher measured the levels of nitrate and phosphate in all samples of the soil by using the HACH SIW – 1 Soil and Irrigation Water Manual methods. A one-way ANOVA was run to determine if there was any significance in the data collected for both phosphate and nitrate. The p-value for phosphate (4.87 x 10^-45) deemed the data significant because it was less than alpha (0.05), and showed that increasing levels of gamma radiation cause increases in the levels of phosphate in the soil. The p-value for nitrate (1.74 x 10^-38) deemed the data significant because it was less than alpha, and showed that increasing levels of gamma radiation cause increases in the levels of nitrate in the soil. The researcher ran a Tukey Test and determined that there was a significance for both phosphate and nitrate levels between all four groups of the radiated soil (OMrads, 1.25 Mrads, 2.5 Mrads, and 5 Mrads). The original hypothesis, that the soil that was exposed to the most gamma radiation, 5 Mrads, would have the greatest amount of both nitrate and phosphate, was supported. In conclusion, the results of this experiment show that increasing levels of gamma radiation cause increased levels of nitrate and phosphate in soil.

THIRD PLACE

THE EFFECT OF UPDRAFT SPEED ON THE WIND SPEED RATIO OF A SIMULATED TORNADO

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ABSTRACT

The purpose of this experiment was to determine the effect of updraft speed on the wind speed ratio of a simulated tornado. Tornadoes are a big threat, especially in the U.S. It’s important to do research on them because if we can better understand them we can save lives. Understanding tornadoes can help with predicting them and other weather anomalies such as hurricanes. The tornado chamber built for this experiment simulates the atmosphere and wind you would see in a tornado. In this experiment, the tested wind speed ratio is the speed of rotation in the vortex divided by the vertical updraft speed. The independent variable was the updraft speed, and the dependent variable was the rotation ratio. The ratio was calculated by taking pictures of the angle of the mist in the tornado simulated in the tornado chamber and measuring it with a screen protractor application, and then converting it to a ratio. It was hypothesized that if the updraft speed increased, then the wind speed ratio would decrease. This would mean that at a higher updraft speeds, there should be more updraft than rotation. The levels were chosen by using a dimmer switch to control the speed of the updraft fan in the tornado chamber. Fourteen increments, or levels of the independent variable, were selected between 2.1 MPH and 11.0 MPH. The customary system was used because the anemometer
measured in MPH. Surprisingly, the results have shown the opposite of what had been hypothesized. As the updraft speed increased, the rotation increased at a higher rate than the updraft, suggesting that the rotation is generated by the vortex itself rather than being fueled by the surrounding environment. Possible future experiments to build on this include seeing if the same results apply at different scales of the chamber. If this should be repeated, improvements to the misting system to prevent condensation in tubes should exist.

HONORABLE MENTION

THE RELATIONSHIP BETWEEN ELEVATION AND THE AVERAGE POWER DENSITY OF RADIO FREQUENCY INTERFERENCE

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ABSTRACT

In this experiment the effect of elevation on the average power density of radio frequency interference (RFI) was investigated. The purpose of this experiment was to determine if there is a difference in the amount of RFI at different elevations. A point of low elevation and a point of high elevation at each of three locations were tested for the power of RFI at five different frequencies. Pearson Product Moment Tests were used to analyze the data and yielded that there is no significant relationship between elevation and the power of RFI. The results of this experiment support the findings of the Quiet Skies Project.

HONORABLE MENTION

THE EFFECT OF LATERAL COMPRESSION ON DIFFERENT GEOLOGICAL STRATA

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ABSTRACT

Lateral compression impacts how mountains are made, and even the outcome of an earthquake. In this experiment, different geological strata were placed under lateral compression. Based upon research it was believed that the trial with the most sand would have the most dramatic outcome, because the individual substance was smaller. The compression box used in this experiment was constructed using ¼ inch plywood, Plexiglas, wood glue, and nails; and then the experiment took place. In between each trial the compression box was thoroughly cleaned. The results demonstrating typical folding patterns were then recorded. This experiment resulted in monoclines, anticlines, and asymmetric folds. To improve this experiment, a metal scraper should have been added to the bottom of the compression wall, so no strata would be left behind. Also if a hydraulic compression pusher was used, so perfectly even force was applied to all strata.
OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of the El Niño/Southern Oscillation (ENSO) on the Strength and Number of Hurricanes in the Atlantic and Pacific Oceans. Layla A. Abi-Falah, George H. Moody Middle School, Henrico County Schools.


The Effect of Soil Composition on Angle of Repose. Hanna L. Brooks, Hermitage High School, Henrico County Schools.


The Effect of Solar Activity on the Earth’s Temperature and Environmental Change. Donald M. Knox, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Location on the Amount of Sky Glow. Irene Y. Koo, Deep Run High School, Henrico County Schools.

The Effect of Different Types of Solvents on Amount of Soil Runoff. Jane A. Luu, Hermitage High School, Henrico County Schools.


The Effect of Different Types of Clothing on the Rate of Decomposition. Samantha Rafalowski, George H. Moody Middle School, Henrico County Schools.
ENVIRONMENTAL SCIENCE A

FIRST PLACE

INTERNAL PARASITE DENSITY AND FISH KILLS IN VIRGINIA

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Abstract: Chronic fish kills in the Shenandoah River and James River watersheds have puzzled scientists in recent years. The primary victim, smallmouth bass (*Micropterus dolomieui*), is an important economic and recreational component to western Virginia rivers and play an ecological role in their overall health. This experiment was designed to determine if parasite density in smallmouth bass livers were more prominent in rivers that have been plagued by fish kills. Large parasite numbers in the liver stress fish by disrupting its function and making them susceptible to stress, lesions, and then death. Ten to 21 smallmouth bass were examined from each of five rivers in the Shenandoah and James watersheds, and the external area of their livers was inspected for a digenetic trematode, the white grub (*Posthodiplostomum minimum*). The control, South River, had 2.9 parasites per gram of liver. Fish kill rivers examined were the South Fork Shenandoah River (11.5 parasites per gram of liver), the James River (3.1 parasites per gram of liver), and the Jackson River (zero parasites observed). One additional river, the Maury River, in which no fish kills have been reported, had abundant numbers of parasites in the livers of the smallmouth bass (37.3). A Student's t-test (alpha = 0.05) showed that parasite loads on the livers of smallmouth bass in the South Fork Shenandoah River and the Maury River were significantly different from the control river. The James and Jackson Rivers showed no difference in parasite densities. The results were inconclusive and there was not enough evidence to make a definitive statement on parasite densities in livers and their role with the fish kills.

Introduction: In 2004, 2005, and 2006 catastrophic fish kills occurred in the North and South Forks of the Shenandoah River (Garman and Orth, 2007). These events affected the entire North Fork of the Shenandoah in 2004. In 2005, more than 160 kilometers of the South Fork of the Shenandoah River were struck, and in 2006, the unknown plague returned to the North Fork of the Shenandoah River. These fish kills eliminated up to 80% of the adult smallmouth bass populations in the areas affected (Blazer et al., 2007). The fish kills spread to the Cowpasture and the James Rivers in 2007 and the Jackson River in 2008 (Stephen J. Reeser, Virginia Department of Game and Inland Fisheries, personal communication). Causes of the fish kills are still unknown; however, many hypotheses are being investigated by a fish kill task force.

Some of these theories examined ammonia toxicity in the water and others investigated increases in water temperature (Downey et al., 2007). However, none of these studies have resulted in a definite conclusion. Some of the factors said to have contributed to the fish kills are the quality of the water and land use. Most of the research currently underway is focused on water quality monitoring and bacterial influences on fish mortality events (Stephen J. Reeser, Virginia Department of Game and Inland Fisheries, personal communication). The Shenandoah River watershed has a history of pollutant loading from multiple non-point contributors (Reeser, 2005). There have been several sources identified as contributors to the fish kills: deicing salts, domestic sewage, livestock and poultry waste, and commercial fertilizer (Garman and Orth, 2007). So far, none of these has been identified as the direct cause of the fish kills.

The researcher in this project was interested to test whether internal parasites played a role in these fish kills. There are many types of parasites that can be observed in fish, but the white grub (*Posthodiplostomum minimum*) is one of the dominant types. The hypothesis is: If parasite densities are stressors in the fish, then they will be greater in fish from the fish kill rivers. The independent variables in this experiment were the rivers that were selected. The constant was smallmouth bass. The dependent variable was the number of parasites in the livers of the smallmouth bass. The H₀: There is no difference between mean South River liver parasite densities and the fish kill rivers parasite means.

White grub is an aquatic fluke that can infest the kidneys, heart, and liver of smallmouth bass (Lane and Morris, 2000). White grub occurs in many freshwater North American fish. The white grub mostly infects centrarchid (sunfish, smallmouth bass) fishes, but some subspecies can infect cyprinid (minnows, carp) fish.
species. The parasite was originally oversight of the white grub is because of the small size (< 1 mm) of the parasite.

The researcher elected to study the liver because white grub can be highly concentrated in the liver of a fish. The liver assists in the digestion of food for the fish by secreting enzymes to breakdown fats. It can also be used as a storage area for fats and carbohydrates. A high concentration of white grubs will compress the liver and affect its functions (Lane and Morris, 2000). When the grub becomes too numerous, fish may not be able to detoxify contaminants or protect itself against bacterial infections or lesions (Blazer, 2008). Some smallmouth bass livers have been known to have at least 50% of their volume occupied by various parasites (Stephen J. Reeser, Virginia Department of Game and Inland Fisheries, personal communication).

This parasite requires three hosts to complete a life cycle. The primary host of the parasite is the great blue heron (Ardea herodias). The adult grub sexually reproduces in the heron's intestines. From there, the eggs are released from adult grubs and dropped into the water by the heron's feces. The eggs then hatch in the water and are released as free-swimming miracidia. They then infect aquatic snails and develop germinal sacs in liver tissue of the snails. The sacs then release another free swimming form, the cercariae, where they find a host fish (smallmouth bass). They penetrate the skin, and then are carried by the circulatory system into the liver, kidney, and heart. The heron then eats the infected fish and the cycle starts over.

Methods and Materials: The fish samples selected for this experiment were from the South River (Rockbridge County), James River (Botetourt County), South Fork Shenandoah River (Page County), Jackson River (Alleghany County), and Maury River (Rockbridge County). These locations (Figure 1) were chosen because fish kills were reported in all of them (Don Kain, Department of Environmental Quality, e-mail attachment) except for the South River, which was my control river. To date, the Maury River has also been free from fish kills, but it was examined because it directly flows into the James River, where kills have occurred.

Smallmouth bass were collected over the summer, 2008 at each location by fishermen or biologists and submitted to the researcher in a frozen state. Samples of ten to twenty one smallmouth bass were obtained at each location. The researcher's goal was to obtain twenty fish from each river, but this was not always possible. The fish were thawed prior to internal inspection. Latex gloves were used when handling the fish and livers.

In the lab, the fish were weighed to the nearest gram, measured to the nearest millimeter, cut open with scissors, and then the livers were extracted and weighed to the nearest tenth of a gram. The scale used to weigh the fish and their livers was an Ohaus Navigator NOH110 with a sensitivity of 0.5 grams. A Wolfe compound stereo microscope was used to view the livers at 7 x magnification.

The researcher placed each liver under the microscope and externally examined each side of the liver. Each white spot represented the cercariae (cyst) of a digenetic trematode called a white grub (Posthodiplostomum minimum). The number of cercariae was divided by the weight of each liver to obtain comparable numbers between each fish and river (Tables 1-5). Data recorded were the total length of the fish (mm), the weight of the fish (g), the number of parasites per gram (p/g). This process was completed for each fish in each river until all of the livers were viewed and inspected for parasites. A Student's t-test (alpha = 0.05) used to compare the averages of infected fish livers between the fish kill rivers and the control river (South River) (Voelker and Orton, 1993).

Results: A two-tailed Student's t-test was used to test the null hypothesis. This allowed for the comparison of a population that is normally distributed but the sample sizes are small enough to run statistical analysis. The level of significance was set at p = 0.05 and the t-value was calculated to test the null hypothesis. Data are summarized in Table 6.

In the South River, which was my control, the mean number of parasites per gram on the livers of the smallmouth bass was 2.9 p/g. This value was used as a basis of comparison with the other four rivers. If the other fish kill rivers' mean values were close or equal to 2.9 p/g, the null hypothesis was accepted, and if the means of the other fish kill river's were significantly larger or smaller than 2.9 p/g, the null hypothesis was rejected.
In the South Fork of the Shenandoah, the calculated t-value was 2.44 when compared to a table $t_{0.05, 37} = 2.021$. So, the null hypothesis was rejected in this case. The Jackson River had a 0.0 calculated mean value of parasites per gram on the livers of the smallmouth bass (none were found on any of the livers). The calculated t-value in this river was -2.16 and the table $t_{0.05, 36} = 2.021$, so the null hypothesis was accepted in this case. In the James River, the calculated t-value was 0.146 and the table $t_{0.05, 33} = 2.042$, so the null hypothesis was accepted. Finally, the Maury River had a calculated t-value of 3.88 and a table $t_{0.05, 29} = 2.042$, thus rejecting the null hypothesis in this river.

**Discussion and Conclusions:** The river that has been unaffected by fish kills, the South River, had a mean liver parasite density of 2.9 p/g. The rejection of the null hypothesis for the South Fork of the Shenandoah River showed that there was conclusive evidence that this river had significantly higher liver parasite density than the control river (South River). This was expected because there have been multiple fish kills in the South Fork of the Shenandoah River in recent years.

However, the rejection of the null hypothesis for the Maury River was surprising because the Maury River has had no reports of fish kills, but it is a direct tributary to a fish kill river: the James. The parasite density in the livers of the smallmouth bass in the Maury River were very high with a mean of over 35 p/g.

The Jackson River's null hypothesis was accepted. These results were very surprising to the researcher because the Jackson River had a fairly sizeable fish kill in 2008 (Stephen J. Reeser, Virginia Department of Game and Inland Fisheries, personal communication). The fact that there were zero liver trematodes may be due to low populations of herons or snails in the Jackson River, and these play an important role in the cycle of the white grub. However, this needs to be further investigated.

Finally, the acceptance of the James River's null hypothesis was interesting because it had fish kills in 2007 and 2008, yet had a low mean of 3.1 p/g.

The results were inconclusive because two rivers accepted the null hypothesis (Jackson and the James Rivers) and two rivers rejected the null hypothesis (The South Fork of the Shenandoah and the Maury Rivers). The researcher thought that the Maury River would have low parasite numbers because no fish kills have been reported there to date, and the Jackson and the James Rivers would have high parasite numbers because of their recent fish kills. There were many factors in the experiment that could have enhanced the results. First, more liver samples should have been taken from each of the rivers. However, with restricted time and money, these goals were not accomplished in this project. Another way to improve this study would be to collect the fish at the different locations over several years. Internal parasites in fish still need to be investigated because of the large presence of them in their vital organs, ultimately affecting their function. The sources of the fish kills are still debated today, and with more tests and research, the causes will eventually be identified.
LITERATURE CITED


Kain, D. E-mail attachment. 2007.


Reeser, S. J. Personal interview. 28 February 2009.


ACKNOWLEDGMENTS

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Table 6. Statistical summary

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Alpha = 0.05 for each test
SECOND PLACE

COMPARISON OF LARVAL SETTLEMENT AND SURVIVAL ON THE SHELL OF
THE EASTERN OYSTER Crassostrea virginica AND THE
ASIAN OYSTER Crassostrea ariakensis

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Chesapeake Bay Governor’s School, Tappahannock, Virginia 22560

ABSTRACT

Several researchers have begun to doubt the ability or possibility of restoring the Chesapeake Bay’s oyster reefs through the creation of artificial reefs. Previous studies have attempted different cultch types with little success. The shell being used at the present time is decaying at a faster rate than the living oysters are producing shell. Therefore, there will be a point at which the restoration work will run out of the C. virginica shell that is being used to construct the reefs. Although there is a steady decline in the available quantity of C. virginica shell, one more possibility has not been delved into: using a different species of oyster’s dead shell, that of the Asian oyster, C. ariakensis. This project’s aim was to show that there is no difference between the two species of oyster shell in their ability to accumulate C. virginica spat (settling larvae). The research was done in a closed system environment. The research now shows that there is no difference between the spatfall on a C. virginica shell and a C. ariakensis shell, and therefore the C. ariakensis shell may serve as a cultch in future restoration efforts. Also, the data shows a marginal advantage to juveniles and their survivability in the wild with C. ariakensis shell.

THIRD PLACE

INTERSPECIFIC COMPETITION FOR NUTRIENTS BETWEEN A SUBAQUATIC
VASCULAR PLANT (Hydrilla verticillata) AND PHYTOPLANKTON

Katherine J. Adams
156 Wood Lane, Aylett, Virginia 23009
Chesapeake Bay Governor’s School, Tappahannock, Virginia 22560

ABSTRACT

This study was conducted to test for an ecological interaction between phytoplankton and Hydrilla verticillata, an introduced species in the Mattaponi River. In order to test this, twelve buckets of river water with phytoplankton were used, six containing hydrilla and six without hydrilla. Three of each type of bucket had nutrients added, and three did not. Growth data was collected for a month by length of the hydrilla and cell count of phytoplankton. The data was then analyzed by t-tests and a two-way ANOVA, which for the most part resulted in very low p-values, hence statistically significant trends. This showed that the introduction of this grass, hydrilla, may be able to counteract eutrophication by depriving phytoplankton of nutrients.
HONORABLE MENTION

THE EFFECT OF THE NUMBER OF BLADES ON THE AMOUNT OF VOLTAGE GENERATED FROM A WIND TURBINE

Reid A. Barden
11209 Ensley Court, Henrico, Virginia 23233
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The purpose of this experiment was to determine the ideal number of blades on a wind turbine to maximize the amount of voltage it would generate. The hypothesis was that if different numbers of blades were used on a wind turbine to produce electricity, then the turbine with six blades would generate the most voltage. The experimenter assembled a Thames and Kosmos® Wind Power Alternative Energy Kit. He attached stainless steel wires to it. A Black and Decker (brand) leaf blower was placed at the same height as the turbine. A voltmeter was attached to the wires by rubber electrical tape. The leaf blower was turned on at the same time as the stopwatch. During each trial, the experimenter watched the voltmeter for the highest reading. After the thirty seconds was finished, the leaf blower was turned off and the experimenter recorded the amount of voltage produced. This was done for every level of the IV. The hypothesis was supported. It stated that the turbine with six blades would produce the most voltage. It produced, on average, 2.048 volts more than the three-bladed design, and 2.1829 volts more than the two-bladed design. It produced 4.293 volts, the three-bladed design produced 2.245 volts, and the two-bladed design produced 2.1101 volts, on average. The major finding in this project was that the more blades on a turbine the more voltage it will produce. The more blades means that more surface area will catch the wind and move the turbine faster. The hypothesis was supported because the six-bladed design generated more voltage than the two and three bladed designs.

HONORABLE MENTION

A STUDY IN THE ABSORPTION OF WATER BY KILN-DRIED Pinus ponderosa AS A FUNCTION OF TIME

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Patrick Henry High School, Ashland, Virginia 24005

ABSTRACT

The absorption of water in kiln-dried Pinus ponderosa is important for lumber manufacturers, to the distributors, to the carpenters. The purpose of this experiment was to discover how much water kiln-dried P. ponderosa would absorb as a function of time. Three sets of 15 samples of kiln-dried P. ponderosa were placed in 3 different 19 liter buckets of water for 8, 16, and 24 hours. After each designated time the samples were removed from the water, towel dried to remove the surface water, and then the moisture readings were measured using a Delmhorst moisture meter. The results showed that the 24 hour group had absorbed the most water.
HONORABLE MENTION

AN INVESTIGATION OF CELLULOSE ETHANOL - THE EFFECT OF DIFFERENT MATERIALS FOR CELLULOSE ETHANOL PRODUCTION ON ETHYL ALCOHOL YIELD

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H.B. Woodlawn, Arlington, Virginia 22207

ABSTRACT

With rising environmental and financial concerns, cellulose ethanol may be the future of fuel production. It is not made from food products and has the potential to reduce greenhouse gas emissions by 90% compared to gasoline and 10-20% compared to corn ethanol. The purpose of this experiment was to determine which material for cellulose ethanol produces the most ethyl alcohol: switchgrass, newspaper or sawdust. The hypothesis, based on outside research, was that switchgrass would produce the most ethyl alcohol. The materials were first boiled in water, followed by a pretreatment which unlocked the cellulose from its lignin seal. Sulfuric acid acted as the pretreatment in this experiment. Then hydrolysis occurred, which broke the cellulose down into glucose. The enzyme cellulase was used for hydrolysis. Before fermentation, a sugar test was run to look for the presence of sugar, and therefore the possibility of alcohol. The mash was then fermented and distilled. The still was re-built and updated from last year. Finally, the amount of ethyl alcohol was measured. The hypothesis proved invalid because the data was very inconclusive. The biggest problem was finding a temperature where the alcohol would boil and stay as a vapor through the still without distilling water. Other problems included the design of the still and the quantities of mash. The mash also sat for two weeks before it was distilled, so any alcohol could have evaporated. A second test will be run with a newly-designed still and more mash.

OTHER PAPERS SELECTED FOR PRESENTATION:


The Effect of the Area of the Wind Turbine Wings and Wind Speed on the Efficiency of the Power Generator. Hakyna Akeksandrovych, Williamsburg Middle School, Arlington County Schools.

Factors that Influence Student Recycling Behavior. Melissa E. Baltrusaitis, Chesapeake Bay Governor’s School, Middlesex County Schools.


The Analysis of Biometric Data of Procambarus clarkii at Sweet Briar College. Blair R. Blanchette, Central Virginia Governor’s School, Lynchburg City Schools.


The Preferred Environment of the Procambarus clarkii on the Sweet Briar Campus. Andrew V. Brown, Central Virginia Governor’s School, Lynchburg City Schools.

Water Quality in the Blue Ridge Mountain Scout Reservation. James L. Chamberlain IV, Southwest Virginia Governor’s School, Pulaski County Schools.

Comparison of Insect Capture Rates in Red and Green Morphs in *Sarracenia leucophylla*. Duncan C. Conolly, Chesapeake Bay Governor’s School, Caroline County Schools.

The Effect of Different Types of Oil on the Amount of Pollution Produced when Burned. Kevin T. Cook, Patrick Henry High School, Hanover County Schools.

The Effect of CO$_2$ Emissions on Algae Growth. Christopher B. Cooper, Kemps Landing Magnet School, Virginia Beach City Schools.

The Effect of Position Relative to Width on the Dissolved Oxygen Content in a Native Trout Stream. Michael W. Crawley, Mills E. Godwin High School, Henrico County Schools.

Measuring Sky Glow in the Metropolitan Area. Emma R. Davidson, Williamsburg Middle School, Arlington County Schools.

The Effectiveness of Grass Shrimp (*Palaemonetes pugio*) as Detritivores. Anne J. Derby and Nathan T. Rose, Chesapeake Bay Governor’s School, Richmond and Lancaster County Schools.
Abstract: Rising sea level, frequent boat traffic, and increased number of severe storms have increased the intensity of erosional forces along saltmarsh shorelines throughout the Chesapeake Bay. Previous studies on defensive structures made out of natural materials, such as oyster cultch and live oyster reefs, have been successful in stabilizing shorelines in areas with wave energies similar to that of the Chesapeake Bay. This experiment measured the effectiveness of small-scale oyster embankments on the sediment accretion rate on adjacent shoreline compared to the erosion rate of the control, which had no treatment. Measurements were taken of the shoreline sediment height, the erosional scarp face, and the density of *Spartina alterniflora* shoots on the erosional marsh face in order to quantify the efficacy of the treatment. The control experienced a much higher rate of erosion than the treatments, which experienced accretion of sand and sediment in the undercut marsh face. A t-test statistical analysis showed a significant difference between the test sites and the control with a p-value of 0.017224. The oyster cultch method may prove to be a low cost alternative to the hard engineering solutions currently employed such as rip-rap and bulkheads while also providing an eco-friendly substrate and potential habitat for local organisms.

Introduction: The erosion of coastal ecosystems has intensified over the last several decades. Increased frequency of high wind events, such as tropical storms and northeasters, along with constant boat traffic has amplified the significant impact of sea level rise on the shoreline. To combat this, engineers have tried many different structural systems including bulkheads, revetments, jetties, stone reinforcements, and other rip-rap structures. These favored solutions harden the shoreline and often create unintended habitat loss (Benoit, 2007). The accepted methods for erosion control may work for a time but are very expensive and the heavy materials used to build them may sink in sediment just a few years later (Piazza et al., 2005; Luscher, 2005). These methods also use non-native materials that do not blend in with the environment (Piazza et al., 2005). There are now more natural methods and materials, called “living shorelines”, which slow down coastal erosion by the use of coir logs and marsh creation. Living shorelines are less costly to create than hard engineering solutions but tend to work best in low energy environments (Luscher, 2005; Barnard, 1994). If they are subjected to high wave energy, they will most likely have a limited effect (Meyer et al., 1997). An inexpensive way to protect the Chesapeake Bay marsh shorelines is needed that uses materials native to that habitat in a way that will not damage the local ecosystem. Oyster shells could prove to be a viable solution.

The oyster can be called an “ecosystem engineer” because they clean the water column, their reefs provide a habitat for many marine organisms, which can absorb wave energy and by doing so, stabilize the shoreline (Piazza et al., 2005). There have been multiple studies on the effects of oyster reefs or cultch beds on shoreline erosion. One such study in Louisiana showed that small fringing reefs slowed shoreline erosion in areas of low wave energies while having a relatively high rate of spat recruitment. Another study in Louisiana looked at how oyster cultch beds located near marshes could lower wave energy hitting the edge of the salt marsh. The study’s results show that in two of the three sites there was a noticeable difference in accretion and erosion rates between cultched and noncultched sites. All previous studies reported a dampening of wave energy, the stabilization of marsh sediment, and the creation of estuarine habitat at the majority of the sites protected by oysters (Meyer et al., 1997; Piazza et al., 2005). If live oysters can do this, there is no reason why just the oyster shells could not.

There are multiple reasons why Middlesex County Virginia was chosen as the site of this study. The county’s entire eastern shore is roughly 75% beach and is protected by bulkheads and groin fields; about one third of the beach is experiencing very high rates of erosion. Without intervention, most of the county’s beaches bordering
the Rappahannock and Piankatank Rivers will be eroded away destroying a substantial amount of habitat for estuarine organisms like blue crabs (Shellenbarger Jones, 2006). If this study is successful, it could serve as a possible alternative for the methods currently used in the area, creating a more natural living shoreline.

Methods and Materials: Obtaining a permit was necessary to conduct this experiment because the oyster shell treatment was to be staked down between mean high water and mean low water to create several breakwaters on the shore within the jurisdiction of the Middlesex County Wetlands Board. The application (#2008-0247) was reviewed at a public hearing of the board on May, 13 2008 where it was approved. The sampling sites were located along a saltmarsh on the Piankatank River in Middlesex County, Virginia (Figure 1). The treatments were protected by a breakwater line of three polyethylene plastic mesh bags filled with oyster shell cultch, which were placed parallel to the shoreline one meter out. This created a 3.0m x 0.5m x 0.3m span to form the breakwater. The control site had no oyster cultch treatment and therefore no backwater allowing the effectiveness of the treatment to be compared to a fully exposed shoreline.

Measurements taken from each treatment site were based from a central point of the breakwater, a steel stake, placed at the base edge of the marsh scarp. Another stake was placed one meter inland perpendicular to the shoreline to ensure measurements at each site were taken relative to the same baseline. The surface area of the erosional scarp was measured by taking a string from the bottom of the seaward stake and then running it along the sediment surface of the scarp then back to the seaward stake. If the surface area shows a decrease, there was accretion and if it increased, erosion occurred. The second measurement was to determine the amount of sediment accretion; this measurement was taken from the bottom of the seaward stake to the top of the marsh peat at the scarp (Appendix A). Data collection occurred monthly and before and after tropical storm Hannah. The shoot density of *Spartina alterniflora* was calculated by randomly tossing a 63.5cm² circular quadrat in three different areas in close proximity of each site, and then counting the number of shoots present in the quadrat. Significance of data collected on all parameters was calculated using a t-test assuming equal variance.
Results: The treatment sites experienced a 1.5cm average decrease in surface area and the control increased 76.5cm in surface area showing that the treatments experienced less erosion than the control (Figure 2). A statistical t-test produced a p-value of 0.017224 showing a significant difference between the test sites and the control (Appendix B).

The treatments also experienced vertical sediment accretion while the control showed net loss (Figure 3; Appendix C).

The shoot densities of *Spartina alterniflora* changed little over the duration of the experiment (Appendix D). A t-test gave a p-value of 0.266987 showing no significant difference in sites: 1, 2, 3, and 4 when compared to the control, which saw no net change in the shoot density of salt marsh grass (Appendix E). An important weather event that must be accounted for was tropical storm Hannah which affected the Chesapeake Bay region from September 5th - 6th. This caused significant damage to site 3 in all measured parameters and also drastically affected the control.
Figure 2. This graph shows the change in surface area from the original base line measured on July 20th 2008. Sites 2, 4, 5 showed overall accretion while site 3 showed slight erosion and the control and site 1 experienced significant erosion.

Figure 3. The treatment sites also saw and average accretion of 6.8cm while the control lost 2.2cm in height.
Discussion and Conclusions: The experiment tested the effects of the oyster cultch treatment on reducing erosion and the rate of potential sand accretion on a marsh face shoreline in the Piankatank River. The primary goal of this experiment was to see if the oyster cultch bags created conditions that would cause sediment accretion in the undercut marsh face. Based on the results the primary hypothesis can be accepted- the areas protected by oyster cultch treatment experienced much less erosion compared to the unprotected control ($H_0 = P < N$); in fact, 60% of the sites experienced measurable accretion. The t-test results showed that there was a significant difference in the scarp profiles between the test sites and the control with a p-value 0.017224.

All of the treatments experienced measurable accretion in sediment height. Treatments 1 and 2 on the north side of the control and treatments 3 and 4 on the south side all showed accretion while the control in the middle showed erosion. Site 5 furthest away from the control had the greatest accretion of sand. A significant factor that may have affected these results was the orientation of the treatment sites to the prevailing wind and waves. Orientation of site 5 was slightly different from all other sites because it faces southwest while the rest face due west. The measurements were taken on the marsh face at a point in the center of the breakwater. Since the waves came at an angle to the treatment and not perpendicular, the maximum effect of the treatment may not have been fully measured; because of the direction of site 5 the maximum effect may have been measured more accurately. Extending the treatment in length could be a way to overcome this bias in future studies. Another effect may have been caused by the large amount of erosion at the control where an approximately one meter square portion of the control broke off from the marsh face. A great portion of the marsh face was destroyed creating very large measurements of eroded surface area.

Modifications to the oyster cultch treatment that could yield a greater outcome would be to stack the bags thereby increasing the backwater protection. The larger buffer could be much more efficient at mitigating wave energy overall but especially during turbulent weather conditions. Many of the treatment sites were damaged during tropical storm Hannah and increasing the cultch size may have negated the amount of erosion experienced. For the long term, replacing the oyster shell in the bags with live oysters could lead to increased recruitment on the treatment over time. The addition of new oysters would increase the surface area of the barrier creating a more effective treatment.

Additional benefits of the oyster cultch treatment were observed when taking the measurements. Numerous juvenile blue crabs were taking refuge in the treatments and macroalgae grew on the bags suggesting that the cultch provides an ecological benefit to the local ecosystem as well.

A similar larger scale study on the effect of oyster cultch buffers conducted in Louisiana showed similar results (Piazza et al., 2005). In this study $25m \times 1.0m \times 0.7m$ oyster shell reef breakwaters produced significantly less erosion in low wave energy marsh shoreline when compared to the unprotected control. High oyster set and growth rates also suggested that the reef could be sustained naturally over time through oyster recruitment. Another study with even greater resemblance in North Carolina had substantial accretion rates in protected zones and moderate sediment loss in unprotected control sites (Meyer et al., 1997). The treatment was a $5m \times 1.5m \times 0.25m$ oyster cultch bed placed on the fringe of the marsh face. Over a 1.5 year period protected sites experienced at least 2.9cm of sediment accretion while the uncultched areas saw a loss on average.

With the success of this experiment’s oyster cultch treatment along with the success of similar treatments conducted in other states a version of oyster cultch shoreline for marsh erosion control is promising. The oyster cultch treatment used in this experiment proved to be an easy to install, relatively inexpensive, and effective engineering method for mitigating wave energy on erosional marsh shorelines in the Chesapeake Bay.
LITERATURE CITED


Appendices

Appendix A. This image shows the extent of the erosional scarp face at site 3, which was mildly damaged and experienced a great amount of sand accretion.

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Appendix B. Table showing t-test calculated from comparing the change in scarp profile of the control to that of the treatments.
## Appendix C

Table showing p-values calculated from a two-sample t-test assuming equal variances when the total vertical sediment accretion of the control was compared to that of the treatment.

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## Appendix D

This graph shows the root density of *Spartina alterniflora* over time.

Appendix D. This graph shows the root density of *Spartina alterniflora* over time.
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Appendix E. Table showing t-test calculated when the change in the root density of the treatments was compared to the change of the control.
SECOND PLACE

THE EFFECTIVENESS OF AN ARTIFICIAL HABITAT FOR JUVENILE BLUE CRABS

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Chesapeake Bay Governor’s School, Tappahannock, Virginia 22560

ABSTRACT

The Atlantic Blue Crab, Callinectes sapidus, population is steadily declining in the Chesapeake Bay region; it is 30 percent of what it used to be. Most of the decline in population is due to increased predation, loss of habitat, and weather impacts. For this project an artificial habitat was designed and built to provide the juvenile blue crabs in Pepper Creek shelter and protection from predators in the water. The Crabitat attracted more organisms than the crab pot. The Crabitat attracted more blue crabs over time than the crab pot. The Crabitat attracted and protected more juvenile blue crabs than the crab pot. The Crabitat was found to be preferred as opposed to a standard crab pot. A standard t-test showed a statistically significant p value (p<<0.05) for the comparison of abundance of blue crabs in a crab pot versus the Crabitat. Since the Crabitat was successful in its purpose of providing a shelter for juvenile blue crabs, this effort can be further developed and expanded to help restore the blue crab population.

THIRD PLACE

DETRIMENTAL EFFECTS OF NITROGEN AND PHOSPHOROUS IN RUNOFF FROM SMALL-SCALE ANIMAL FARMING ON DISSOLVED OXYGEN AND BIODIVERSITY IN CHESAPEAKE BAY TRIBUTARIES

Ruth W. Hedberg
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Chesapeake Bay Governor’s School, Tappahannock, Virginia 22560

ABSTRACT

This study was conducted to examine the effects of nitrate and phosphate pollution on the biodiversity of Coles Creek which receives runoff from a private animal compound. The study used similar Tipers Creek, with comparable conditions but no animal runoff, as a control site. This study measured nitrate and phosphate levels, determined dissolved oxygen saturation, and determined the effects of these factors on the biodiversity of impaired Coles Creek the study effectively determined that runoff from small animal compounds does have a detrimental effect on the biodiversity of tributary creeks.
HONORABLE MENTION

THE EFFECT OF X-RADIATION ON THE GROWTH OF LENTIL SEEDS

Griffin Q. Hundley
6201 Gibbsdown Place, Mechanicsville, Virginia 23111
Hanover High School, Mechanicsville, Virginia 23116

ABSTRACT

The purpose of this experiment was to determine whether x-radiation affected the growth of germinating lentil seeds. The hypothesis is that if the dose of x-radiation increases, the vertical growth of the lentils decreases, because the x-radiation in higher doses will harm the lentils. The seeds were taken to the Massey Cancer Center, where increasing amounts of x-radiation were delivered to the seeds using the Clinac 2100EX linear accelerator. After irradiation, the seeds were planted in potting cups, labeled by trial number and amount of radiation the plant received. The seeds were placed in a room with large windows which allowed for sunlight for the seeds. The seeds were given water every other day. Every week on Saturday the plants were measured, and three weeks of data were collected. In the first week, all the lentils grew well except for the groups receiving higher than 30Gy (Gray). After 30Gy, all the lentils had stunted growth. In the control and the 5Gy and 10Gy groups, some lentils measured around eight and nine centimeters. At weeks two and three, it was markedly evident from the measurements that the more 6MV radiation applied, the more cumulative the damage. This explains why as the dose increased, the amount of dead seeds increased and the health of the plants decreased. In the 90Gy and 120Gy groups, the amount of dead seeds was very high, and none of the live ones were very tall.

HONORABLE MENTION

THE EFFECTS OF VARYING SALINITIES AND SURFACES ON THE ECOLOGICAL SUCCESSION OF FOULING COMMUNITIES

Gufran H. Jarrar
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124 Martin Street, Bowling Green, Virginia 22427
Chesapeake Bay Governor’s School, Tappahannock, Virginia 22560

ABSTRACT

The purpose of this experiment was to find the most supportive conditions for the ecological succession of fouling communities, which contain filter-feeders that are indispensable to the water quality and health of the Chesapeake Bay because they feed on excess algae in the water column. The growth of these species may be part of the Bay’s solution to destructive algae blooms, darkened waters, and benthic hypoxia. This experiment investigated the effects of varying salinities and hard surfaces on the ecological succession of fouling communities. The abundance and diversity of organisms in this study was dependent upon two variables. Materials that are used for creating sea walls, such as wood, vinyl, and granite, were used as the surfaces suspended in water. Furthermore, these surfaces were placed at three sites with different salinities. Greater succession was expected in areas of higher salinities but the results of the experiment show otherwise. There was greater succession in areas of lower salinities, but this might have been due to the fact that certain species colonize earlier in the year at higher salinities than in areas with lower salinities. Granite surfaces and wood surfaces showed the most colonization overall. There was in fact a difference in the abundance and diversity of organisms at varying salinities and on different surfaces. In most cases, the effects of the variables in this experiment were very statistically significant and show that fouling communities are usually quicker to develop in places of lower salinities, but are more diverse in places of higher salinities. Riprap and wooden sea walls may be better at establishing these filter-feeding communities than vinyl sea walls.
HONORABLE MENTION

THE EFFECT OF COPPER AND ALUMINUM ON PROTISTS

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5209 Lakeland Drive SW, Roanoke, Virginia 24018
Roanoke Valley Governor’s School, Roanoke, Virginia 24015

ABSTRACT

The purpose of this experiment was to find which protist species would be the best to identify copper and aluminum pollutants. The hypothesis was if three protist species (E. gracilis, Navicula, and Chlorella) were exposed to copper and aluminum, E. gracilis would have the least growth, therefore being the preferred biosensor. It was also hypothesized that copper would inhibit growth more so than aluminum. Protists were exposed to aluminum sulfate, copper sulfate, or spring water (control) in test tubes. The spectrophotometer was used to measure the growth of each protist over time. The results did not support the hypothesis. Chlorella was a better biosensor, since it had statistically significantly less growth in copper and aluminum sulfates. When Chlorella was exposed to copper and aluminum sulfates, its average growth was inhibited by ten percent. E. gracilis, from its means, did not show much deviation from initial testing, because there was not much growth. Since Navicula and E. gracilis had no significant difference between the control and pollutants, these two species were make poor biosensors. In conclusion, both hypotheses were not supported. One error skewed the results. The experiment for Chlorella was repeated at a certain point due to disputable readings. When this happened, the stock beaker had grown for about 48-72 hours, while the others had only grown 24 hours before their contents were added to the tubes. Also, there are several modifications that could have been made to improve the experiment, such as more trials and measuring growth at multiple wavelengths. A future project might involve designing an efficient, transportable system using protists to test on-site locations.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of the Tide on the Salinity of the Water. Raleigh D. Dowd, Isle of Wight Academy, Isle of Wight Private Schools.

The Effect of Distance from Sewage Effluent on the Dissolved Oxygen Content of River Water. Hannah M. Fenster, Douglas S. Freeman High School, Henrico County Schools.

The Water Quality of Lake Chesdin, the James River, and the Appomattox River. Shelby N. Floyd, Appomattox Governor’s School, Colonial Heights City Schools.

The Effect of Polluting Water Source with Recyclables on Plant Growth. Jane M. Foster, Yorktown High School, Arlington County Schools.


The Effect of Nuclear Winter on Potato Crop Yields in India, Ireland, and Ohio. Derek J. Gale, Central Virginia Governor’s School, Lynchburg City Schools.


Quantitative Measurements of the Absorption of Lead Nitrate in *Hendra helix, Limna minor*, and *Salvinia minima*. Thomas M. Granger, Central Virginia Governor’s School, Lynchburg City Schools.


The Effect of Local Acid Rain on the Corrosion of Different Roofing Materials. Ashley M. Harper, Hanover High School, Hanover County Schools.

The Effect of Inoculate on Corn Silage. Leanna M. Horney, Southwest Virginia Governor’s School, Pulaski County Schools.

The Effect of the Altitude of the James River on the Amount of Nitrates. Stephanie S. Hwang, George H. Moody Middle School, Henrico County Schools.

The Water Quality of Sweet Briar Lake. Jonathan F. Koes, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Different Materials on the Absorbency of Oil Spills. Fei-Pi Lin, Deep Run High School, Henrico County Schools.
Abstract: Road deicers can cause damage in plant development due to salt toxicity. A newer deicer, *Bare Ground*, claims to be less harmful to the environment because it combines carbohydrates with chloride salt to provide stronger de-icing ability with less salt usage. *Lactuca sativa* are recommended by the Environmental Protection Agency for environmental bioassays. The problem of this experiment was to analyze if different road deicer solutions would affect the number of lettuce seeds germinated and radicle root length. The hypothesis stated that if different types of deicers were tested on lettuce seeds, then the number of seeds germinated and the radicle lengths would be greatest with water, but *Bare Ground* would produce greater seed germination and radicle root length than the five other deicer solutions tested: water, calcium chloride, sodium chloride, magnesium chloride and calcium chloride, and calcium chloride and sodium chloride. The independent variable for this experiment was the types of road deicer, and the control was water. There were 25 trials, each with 10 lettuce seeds exposed to a 3% concentration of the deicer being tested. Seed germination was greater for *Bare Ground* than for water. Radicle root lengths for seeds treated with water were significantly longer, which did support the hypothesis. Both *Bare Ground* and water performed significantly better on both radicle root length and seed germination when compared to the other four deicer solutions. *Bare Ground* produced the least amount of environmental damage to germination and root lengths of the deicers tested in this experiment.

Introduction: *Lactuca sativa*, or lettuce, is an angiosperm, which is classified in section *Lactuca*, subsection *Lactuca serriola*. The name derives from the Latin for milk, as the milk of wild lettuce was known to be a digestive aid and sleep-inducing agent in ancient Egypt and Greece (de Vries, 1997).

Lettuce seed germination is triggered by sufficient warmth (4-21°C), moisture, and light. The first step in germination is when the seed absorbs water and swells. As the seed begins to swell larger, the seed coat splits in half. The embryo of the seed then begins to develop the parts necessary for survival. First, the roots of the young plant begin to follow geotropism. Next, the stem begins to emerge from the seed and grows toward the light. The seed leaves are connected to the stem and begin to grow at a rapid rate as the seed reaches the stage of seedling. Once this begins, the seed leaves can begin to produce glucose for the seedling. The roots and stem will thicken and the seedling will grow into an adult plant (Frank, 2002).

Lettuce seeds are particularly useful for testing chemical substances in a bioassay. A bioassay is an experiment that uses living things to test the toxicity of chemicals. In lettuce seed bioassays, the seeds are placed in petri dishes containing chemical solutions or samples of sediment, water, or soil. Lettuce seeds may seem like an odd choice for bioassays of environmental samples. The reason they are used is that they are known to be sensitive to common environmental contaminants such as heavy metals and some types of pesticides, solvents, and other organic compounds. In particular, *Lactuca sativa* are recommended by the Environmental Protection Agency for bioassays due to their sensitivity to contaminants (Trautmann, 2001).

One environmental hazard in the winter months is road deicers. These products are designed to lower the freezing point of water and form a semi-liquid solution that it easier to shovel or plow. The most commonly used chemicals are sodium chloride, calcium chloride, and magnesium chloride (Civil Engineering Research Foundation, 1998). The Virginia Department of Transportation uses all of these chemicals for de-icing. Generally deicers are applied at a 15-30% solution rate by weight, but are diluted by water and snow in the environment.
The deicers are effective at different temperatures. Sodium chloride, or rock salt is inexpensive and effective at temperatures down to 20°F. Calcium chloride and magnesium chloride are more expensive but are effective at temperatures of –25°F and 5°F. Both are known to cause damage to concrete roads and metal bridges.

Road deicers are known to cause damage in plant development. Toxicities may occur when plant roots absorb salts from the soil. Salt may accumulate in the soil from water runoff mixed with de-icing salts (Costello, 2003). Both the sodium ions and chloride ions can cause damage. Crops growing on salt affected soils often show symptoms of Cl toxicity. This includes burning of leaf tips or margins. Tobacco, phaseolus beans, citrus, potatoes, and lettuce are very prone to Cl toxicity (Mengel & Kirby, 2004). Increases in salt ions in the soil can interfere with some plants’ abilities to absorb water. Sodium ions in the groundwater can also move into some plants, causing toxic damage. Concern has been expressed for potential damage in wetlands due to salt’s greater mobility in wet environments (Iltri, 1992).

Newer deicers have been developed that claim to be less harmful to the environment. Bare Ground is a newer deicer that uses carbohydrates mixed with chloride salt to provide stronger de-icing ability with less salt usage. The carbohydrates are distiller’s condensed solids (DCS), which are the byproducts of the process of producing ethanol from corn. Low molecular weight carbohydrates when used with an inorganic freezing point depressant such as chloride salt can have a synergistic effect on freezing point depression. Low molecular weight carbohydrates include glucose, fructose, and saccharides, which can be obtained from common agricultural products (Hartley, 2001). Bare Ground uses a mixture of 80% MgCl2 and 20% DCS to lower the freezing point to –20°F.

The motivation for conducting the experiment was to discover ways to keep Virginia roads safe during winter ice storms while not harming the environment. The problem of this experiment was to analyze if different road deicer solutions applied to lettuce seeds would affect the number of seeds germinated and seed radicle length. The hypothesis stated that if different types of deicers were tested on lettuce seeds, then the number of seeds germinated and the radicle lengths would be greatest with water, but Bare Ground would produce greater seed germination and radicle root length than other deicers tested.

The different types of road deicers, including water, was the independent variable in this experiment. The control for this experiment was the trials treated with distilled water. The number of lettuce seeds germinated and their radicle lengths was the dependent variable. The experimental design chart is included in the Appendix in Table 1.

**Methods and Materials**: Safety was an important concern when working with road deicers. To ensure safety, rubber gloves, a safety apron, and safety goggles were worn when working with all the deicer solutions. For each type of deicer, a solution of 30 g of the deicer and 1 liter of distilled water was prepared and labeled.

Twenty-five clean petri dishes were lined at the bottom of with pieces of filter paper, 10 lettuce seeds were placed inside in each dish, and the seeds were finally covered with an additional layer of filter paper. Once this was completed, 5 milliliters of the 3% percent deicer solution were added to each of the 25 petri dishes of seeds, and the dishes were labeled with the type of deicer. The 25 dishes of seeds with the distilled water solution acted as the control for this experiment. These procedures were repeated for the five levels of the independent variable—the Bare Ground Solution, the calcium chloride solution, the sodium chloride solution, the combined magnesium chloride and calcium chloride solution, and the combined calcium chloride and sodium chloride solution. The petri dishes were placed on a table exposed to sunlight during the day. In total, 150 petri dishes (25 control dishes and 25 dishes at each independent variable level) with 10 seeds in each were tested in this experiment.

The seeds were inspected each day for signs of growth. Then, 5 milliliters of the assigned deicer solution were added to each petri dish every day to maintain a moist filter paper. This process was repeated every day for a total of six days. After six days, the number of seeds germinated and the radicle lengths of the sprouted seeds in cm were recorded. This was the dependent variable. The final results were recorded on a data table and graphed. The standard deviation of each independent variable level was calculated as well. With this information, significance testing was conducted, using an online t-test calculator, to determine the significance of the results.
Constants of this experiment were the type of seed, type and size of petri dish, amount and type of filter paper, number of seeds per dish, source and temperature of water used to dilute the deicers, deicer solution concentration of 3%, and the location the dishes were kept.

Results: By the sixth day of the experiment, the number of seeds germinated ranged from a high of 217 for Bare Ground to a low of 0 for sodium chloride. The results are displayed in Figure 1 below.

Figure 1.

The Effect of Different Types of Deicers on Lettuce Seed Germination
Total Number of Seeds Germinated of 250 Tested

<table>
<thead>
<tr>
<th>Type of Deicer (3% Solution)</th>
<th>Number of Seeds Germinated by Day 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>207</td>
</tr>
<tr>
<td>NaCl</td>
<td>0</td>
</tr>
<tr>
<td>B Grd (MgCl2+ DCS)</td>
<td>217</td>
</tr>
<tr>
<td>CaCl2+ NaCl</td>
<td>39</td>
</tr>
<tr>
<td>Mg Cl2 + CaCl2</td>
<td>11</td>
</tr>
<tr>
<td>CaCl2</td>
<td>99</td>
</tr>
</tbody>
</table>
The mean number of seeds germinated was highest for Bare Ground (9.32, with a range of 10 to 7) and second highest for water (8.28, with a range of 10 to 4). The mean radicle root length was greatest for water (0.69 cm, with a range of 1.13 to 0.13) and second-greatest for Bare Ground (0.43 cm, with a range of 0.98 to 0.1). The results are displayed in the table below.

Table 2. The Effect of Different Deicers on Lettuce Seed Germination

| Mean Number of Seeds that Germinated and Radicle Root Length of Germinated Seeds |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Deicer                          | Water           | NaCl            | Bare Ground     | CaCl₂ and NaCl  | Mg Cl₂ and CaCl₂ | CaCl₂           |
| (Control)                       | (MgCl₂ + DCS)   |                 |                 |                 |                  |                 |
| Number of Seeds that Germinated |                 |                 |                 |                 |                  |                 |
| Mean                           | 8.28            | 0<sup>c</sup>   | 9.32<sup>a</sup> | 1.48<sup>c</sup> | 0.4<sup>c</sup>   | 3.56<sup>c</sup> |
| Range                          |                 |                 |                 |                 |                  |                 |
| Maximum                        | 10              | 10              | 10              | 8               | 4                | 7               |
| Minimum                        | 4               | 0               | 7               | 0               | 0                | 0               |
| Number of trials (10 seeds per trial) | 25             | 25              | 25              | 25              | 25               | 25              |
| Radicle Root Length (cm)       |                 |                 |                 |                 |                  |                 |
| Mean                           | 0.69            | NA              | 0.43<sup>b</sup> | 0.06            | 0.11             | 0.07            |
| Range                          |                 |                 |                 |                 |                  |                 |
| Maximum                        | 1.13            | NA              | 0.98            | 0.2             | 0.45             | 0.80            |
| Minimum                        | 0.13            | NA              | 0.10            | 0.1             | 0.03             | 0.02            |
| Total number of germinated seeds measured | 207         | 0               | 217             | 39              | 11               | 99              |

<sup>a</sup> = This means that these results were significantly greater than the control at 99 % confidence.

<sup>b</sup> = This means that these results were significantly less than the control, but significantly greater than the other test variables at 99 % confidence.

<sup>c</sup> = This means that these results were significantly less than the control, and significantly less than the Bare Ground test results at 99 % confidence.
Statistics testing (t-test) was performed on the results. The t-test shows the ratio of the difference in the two means to the amount of variation in the data. (i.e. the ratio of the difference between the means for water and Bare Ground, divided by a measure of the variability in the data for both water and Bare Ground). In a t-test, a t value is calculated based on the degrees of freedom (number of data points in the two groups minus two) and compared to the results in a t-table at different p levels. A p level is the probability of obtaining a result assuming there are no real differences between the groups. The lower the p level, the more likely it was that the results did represent a real difference between the variables, and not just a random result in this experiment. A p value < 0.01 was considered significant, and a value < 0.001 was considered highly significant. A statistics website was used to calculate the t and p values (Pezzullo, 2008).

Bare Ground produced the highest rate of seed germination, followed by water, which outperformed all other deicers. Bare Ground performed significantly better than water in seed germination, with t(48) = 2.99, p < 0.01. Water, however, performed significantly better than calcium chloride, the next best-performing deicer, with t(48) = 8.94, p < 0.01. Water was also significantly better at seed germination versus NaCl, CaCl₂ plus NaCl, and MgCl₂ plus CaCl₂, since these variables had lower seed germination rates than calcium chloride.

In terms of radicle root lengths, water performed significantly better than Bare Ground with t(424) = 14.14, p < 0.001. The seeds treated with Bare Ground had significantly shorter radicle root lengths than the seeds treated with water. Bare Ground did however produce significantly longer radicle root lengths than any of the other deicers. For Bare Ground compared to calcium chloride, t(314) = 19.0, p <0.001. The full data set, including results of each of the 25 trials for each level of the independent variable is provided in the Appendix in Table 2.

Discussion and Conclusions: These results did not completely support the hypothesis that the number of seeds germinated and the radicle lengths would be greatest with water, but Bare Ground would produce greater seed germination and radicle root length than other deicers tested. Seed germination was actually higher for Bare Ground than for water. Radicle root lengths for the seeds treated with water were longer than those for Bare Ground, which did support the hypothesis. In addition, Bare Ground did significantly outperform all other deicers tested, both in terms of seed germination and radicle root length, which was consistent with the hypothesis.

Water was expected to perform better on both seed germination and radicle root length because the salts in deicers contribute to salt toxicity in plants, especially lettuce (Mengel & Kirby, 2004). However, the hypothesis was only partially supported because Bare Ground performed statistically better than water in rate of seed germination. The seed would have absorbed both the carbohydrates (DCS) and the salts when it was watered with Bare Ground (Frank, 2002). It is possible that the carbohydrates helped to bring on germination because they provided nutrients to the seed. However, once the seeds germinated, the salts in the deicer harmed the new plant and caused the shorter radicle root length.

The variables of CaCl₂ and NaCl, Mg Cl₂ and CaCl₂, CaCl₂ and NaCl all performed significantly worse than the control and significantly worse than Bare Ground on both seed germination and radicle root length. This is consistent with the idea that higher salt concentrations are toxic to plants (Costello, 2003). This is also consistent with the idea that Bare Ground causes less environmental damage than other road deicers (Hartley, 2001). The experimenter concluded that Bare Ground created the least amount of environmental damage of the deicers tested, but it still damaged the plant's radicle root length.

The experimenter could have improved this experiment in several ways. An independent variable of only water and DCS would have helped to show if the DCS was responsible for the increased seed germination with Bare Ground. Different concentrations of the same type of road salt could have been tested to determine if seed germination would have occurred at lower concentrations of deicers.

This experiment was worthwhile because it showed that alternative deicers could potentially reduce harm to the environment.
LITERATURE CITED


### Table 1

**Experimental Design Diagram**

<table>
<thead>
<tr>
<th>Title</th>
<th>The Effect of Different Types of Road Deicers on Lettuce Seed Germination and Radicle Root Length</th>
</tr>
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<tbody>
<tr>
<td><strong>Hypothesis</strong></td>
<td>If different types of road deicer are tested on lettuce seeds, then the number of seeds germinated and the radicle lengths will be greatest with water, but <em>Bare Ground</em> will perform better than the other levels of the IV.</td>
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<tr>
<td><strong>Independent Variable (IV)</strong></td>
<td>Types of Road Deicer</td>
</tr>
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<td><strong>IV Levels:</strong></td>
<td>Water 100 % NaCl, <em>Bare Ground</em> (80 % MgCl₂ and 20 % DCS), Mixture of 70 % CaCl₂ + 30 % NaCl, Mixture of 33 % MgCl₂ + 67 % CaCl₂, 100 % CaCl₂</td>
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<tr>
<td><strong># of Trials</strong></td>
<td>25, 25, 25, 25, 25</td>
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<td><strong>Control:</strong></td>
<td>Distilled Water (25 trials)</td>
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<tr>
<td><strong>Dependent Variable (DV)</strong></td>
<td>Number of lettuce seeds germinated by day 6, Radicle root length of germinated plants on day 6</td>
</tr>
<tr>
<td><strong>Constants (C)</strong></td>
<td>Location of experiment, number of seeds per trial, amount and concentration of deicer solution, location of the petri dishes, and source of the water.</td>
</tr>
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</table>
TABLE 2
The Effect of Different Deicers on Lettuce Seed Germination and Radicle Root Length
Number of Seeds that Germinated by Day 6 and Variance of Results

<table>
<thead>
<tr>
<th>Trial</th>
<th>Water</th>
<th>NaCl</th>
<th>Bare Grd</th>
<th>CaCl₂⁻NaCl</th>
<th>MgCl₂⁺</th>
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<td></td>
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<td>(MgCl₂ + DCS)</td>
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<td>Mean</td>
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<td>3.56</td>
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<td>Avg. Dev</td>
<td>1.23</td>
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Note--10 seeds per trial.
The Effect of Different Deicers on Lettuce Seed Germination

Radicle Root Length in cm for Sprouted Seeds on Day 6

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SECOND PLACE

THE EFFECTS OF *Spartina Cynosuroides* VERSUS *Phragmites Australis* ON FIDDLER CRABS THROUGH SEDIMENT DEPOSITION AND BURROW STABILITY

Hillary D. May  
1409 Tranquility Road, Reedville, Virginia 23539

Caleb S. Smith  
P.O. Box 64, Caret, Virginia 22436  
Chesapeake Bay Governor's School, Tappahannock, Virginia 22560

ABSTRACT

*Spartina cynosuroides* and *Phragmites australis* are two plant species, native and invasive, respectively, that are most predominant in marshes along the Chesapeake Bay and its tributaries. Vegetation, such as these two species, has a very strong impact on fiddler crabs (*Uca Pugnax*), a key species in marsh health. This study was designed to determine how each species, *S. cynosuroides* and *P. australis*, affected the fiddler crabs through sediment deposition and burrow stability. To determine the effects, two marsh sites were chosen and tested. Sediment deposition was tested by placing ceramic tiles in the marsh for a period of one month to collect sediments. Sediment composition was tested through samples taken with a corer. The data found was tested statistically to draw conclusions that can be used to determine which species, *S. cynosuroides* or *P. australis*, provides a better marsh habitat for fiddler crabs, and therefore will be a healthier marsh overall.

THIRD PLACE

THE RELATIONSHIP OF WOODY AND HERBACEOUS VEGETATION IN ABRAM'S CREEK WETLANDS PRESERVE

Mitchell J. Oliver  
932 Breckinridge Lane, Winchester, Virginia 22601  
Mountain Vista Governor's School, Warrenton, Virginia 20187

ABSTRACT

The purpose of this study is to investigate the relationship between the rare herbaceous plant species and woody tree and shrub species in the Abram’s Creek Wetlands Preserve. It is hypothesized that the woody species are causing the decline of the herbaceous species. Data on the dominance and density of both the rare herbs and the woody plants was collected from forty individual 400 square-foot plots within Meadow Branch Marsh and Lower Marsh. The rare herbs observed were Willow Aster, *Aster praealtus*, and Spotted Joe-Pye Weed, *Eupatoriadelphus maculatus*. The dominance of the woody vegetation was plotted against the dominance of both Willow Aster and Spotted Joe-Pye Weed for a visual representation and tested with the Pearson Product-Moment Correlation Coefficient equation for statistical significance. The dominance of the Spotted Joe-Pye Weed versus the dominance of the woody vegetation had an inverse correlation $r = -0.928$, $p < 0.001$. The relationship between Willow Aster and woody dominance had an inverse correlation $r = -0.936$, $p < 0.001$. 

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HONORABLE MENTION

THE EFFECT OF THE NUMBER OF WINDMILL BLADES ON POWER PRODUCTION

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ABSTRACT

The purpose of the experiment was to find out which number of windmill blades worked the best at power production. This is important because if windmills are to be used to create natural energy, the correct number of blades should be used to make them more efficient. To test the hypothesis, a blower fan was set up along with a small scale windmill. The fan blew air at the windmill with different numbers of blades screwed in. The data showed that five blades worked the best overall with mean powers of 17.97 milliwatts on low fan power, 35.83 milliwatts on medium fan power, and 62.33 milliwatts on high fan power. However the windmill with six blades did the best with the fan power on high with a mean of 63.33 milliwatts on high, but did second best with the fan on low and medium with means of 14.6 and 32.2. The windmill with two blades produced the least power with of .92 milliwatts on low, 4.95 milliwatts on medium, and 9.92 milliwatts on high fan power. The windmill with tree blades came in third in power production with the means of 6.72 milliwatts, 14.67 milliwatts, and 31.7 milliwatts on low medium and high fan power in that order. There were some conclusions drawn from the data. The windmill with five blades worked the best because it had an odd number of blades increasing the stability and it did not leave enough space for air to pass by the blades; in turn capturing almost all of the available energy. The windmill three blades in this windmill model allowed too much space for the air to travel by and the even number of blades were unstable. Unfortunately, in the real world of energy production, using six and five blades would be much more costly than three or two blades. If a way was found to decrease the cost of blade production, five blades should be used.

HONORABLE MENTION

INTRASPECIFIC AND INTERSPECIFIC COMPETITION IN TWO SUSPENSION FEEDING BIVALVES: EASTERN OYSTER (Crassostrea virginica) AND HOOKED MUSSEL (Ischadium recurvum)

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ABSTRACT

The Eastern Oyster (Crassostrea virginica) is no longer abundant enough to filter the amount of water that its pre-colonial ancestors did within days. Due to rising pollution levels in the Chesapeake Bay and oyster scarcity, it is desirable to search for alternative ways of filtering the waters of the Chesapeake. A possible candidate filtrating species can found within the mussel family. Mussels are not as efficient filterers, but are capable of making a home on virtually any hard-submerged surface. This willingness to inhabit anywhere may make up for the lacking filtration abilities of the mussel. This comparison scrutinized the hooked mussel to see if it could make a significant
impact on the water clarity of the Chesapeake Bay. In addition, it may be seen if it was a competition to feed on phytoplankton that spurred differences in clearance rates of the oyster and hooked mussel. Testing proved that oysters were the better filter feeder and did not compete against each other until the food source became scarce. The hooked mussels had similar results when tested interspecifically with oysters. When tested comparatively against oysters of similar size, mussels were quite efficient, trailing not too far behind an all oyster ecosystem, having a similar clearance rate, but taking slightly more time to do so. When a hooked mussel and oyster combined their efforts, the results showed no improvement in filtration as previously was thought.

HONORABLE MENTION

THE RATE OF MOLTING OF THE BLUE CRAB (*Callinectes sapidus*) IN DIFFERENT COLORED ENVIRONMENTS

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ABSTRACT

This study proposes that the blue crab, *Callinectes sapidus*, has a statistically significant difference between molting rates depending on the color of its surroundings. Because crabs are especially vulnerable during their "soft" stage after molting, and because they seek out shade and shelter such as meadows of Submerged Aquatic Vegetation (SAV) or saltmarshes, quicker molting times are expected in habitat with darker colors. Darkness also indicates shade and shelter from predators. This study investigated the molting times of juvenile blue crabs in dark versus light environments, and the results supported the alternative hypothesis (p<0.05). This project could help watermen to speed up the process of waiting for a pre-molt, or "peeler" crab to become a post-molt crab, which can then be sold as a "softshell" crab. It could also provide a strong argument for the need to protect and restore SAV.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Greywater on Plant Growth. Ellie P. Manspile, George H. Moody Middle School, Henrico County Schools.

Oyster Aquaculture and the Ecological Services It Provides for the Chesapeake Bay. Danielle C. Martin, Chesapeake Bay Governor's School, Gloucester County Schools.

Substrate Preference of Fouling Organisms in Mobjack Bay, Virginia. Lorrin M. Massengill, Chesapeake Bay Governor’s School, Gloucester County Schools.

The Effect of a Culvert under a Highway on the Water Quality of a Stream. Alicia F. Mau, Yorktown High School, Arlington County Schools.


How Information Influences Recycling. Rachel D. Moore, Central Virginia Governor’s School, Lynchburg City Schools.


The Effects of Fertilizer on Phosphate and Dissolved Oxygen Levels. Brittany E. Noah, Isle of Wight Academy, Isle of Wight Private Schools.

What’s the Effect of Width and Depth of a Riverbed on Speed of Water? Nina K. Oleynik, Thomas Jefferson Middle School, Arlington County Schools.

Filtrations Effect of Water Quality and Contamination Control. Marie L. Orton, Southwest Virginia Governor’s School, Pulaski County Schools.

The Effect of Industrial Effluent on Biological Oxygen Demand. Samuel W. Purdom, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Fertilizer and Pesticide Usage on Nitrate Levels in Groundwater. Divij Rajesh, George H. Moody Middle School, Henrico County Schools.

The Effect of the Type of Filter on the Level of Turbidity. Dana A. Raphael, Williamsburg Middle School, Arlington County Schools.

The Effect of Age on the Amount of Bio-Energy Produced. Maya Ravindran, George H. Moody Middle School, Henrico County Schools.

The Effect of Extraction Methods on Oil Spills. Francisco E. Rodriguez-Hernández, Gunston Middle School, Arlington County Schools.
SETTLEMENT, GROWTH AND SURVIVAL OF EASTERN OYSTERS ON THREE REEF SUBSTRATES

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Abstract: Native oyster reef restoration in the Chesapeake Bay has remained largely ineffective due in part to a lack of suitable substrate for oyster settlement. As the cost of raw oyster shell increases due to its dwindling supply, ‘alternative’ oyster reef substrate is becoming a more cost-effective alternative to oyster shell for modern restoration efforts. In addition to the abundant materials available for use as alternative substrate, low cost and three-dimensionality make such substrates desirable for oyster reef restoration. In this study, three-dimensional alternative substrate was utilized to contrast oyster settlement, growth and survival on loose oyster shell. In both a field and tank study, three replicates containing concrete “oyster castles”, oyster shells and oyster shells embedded in concrete were created. Eyed-larvae were remotely set on each of the experimental units within the tank and field studies. At fixed intervals, oyster shell length and survival were recorded. Although the field larval deployment proved ineffective due to high wave-action and high sedimentation, the tank study was successful. After ninety days, the concrete “oyster castles” recruited four times more oysters than oyster shell embedded in concrete and two times more than oyster shell. This study concluded that alternative substrate is suitable for oyster reef restoration and that larvae should be deployed in a controlled tank setting onto conditioned substrate with subsequent transport to suitable field reef restoration locations post-oyster maturation, commonly known as “remote setting”. Future restoration efforts should make use of the oyster castle design to maximize larval deployment efficiency while simultaneously minimizing the cost of reef restoration.

Introduction: Prior to the European colonization of North America, the native Eastern oyster, *Crassostrea virginica*, population of the Chesapeake Bay was described as being so abundant that they “lay as thick as stones” throughout the Bay and its tributaries (USACE, 2008). Native Americans made use of this abundant food source by sustainably harvesting a small amount of oysters from the intertidal zone (Mountford, 2001). Post-colonization, oysters became a staple in the diet of the colonists as they were a plentiful, constant food source and were relatively cheap to harvest. As the Industrial Revolution came underway in the late 18th and early 19th centuries, oyster harvesting hit its peak with the introduction of new, modern forms of harvesting such as dredging (USACE, 2008). During this time, phenomenal amounts of oysters were harvested and exported internationally, bringing economic prosperity to the region and the development of a pitfall for the future of the Chesapeake Bay oyster populations (USACE, 2008).

Naturally, without human intervention, oysters form three-dimensional reef structures, these reef structures are composed of stratified layers of oysters. Upon spawning of oysters in the reef, larvae develop and search for suitable substrate to adhere to permanently (Congrove et al., 2009). Usually, the larvae will settle on available shell space in the reef. Once this suitable location is determined, the larvae will adhere to the substrate and begin to grow. Generation after generation, the reef continues to grow as the cycle of life and death on the reef is perpetuated.

However, as methods of oyster harvesting evolved from hand-tonging to mechanical dredging, the dynamics of oyster reefs changed rapidly from three-dimensional oyster reef to individual flattened structures (Lenihan and Peterson, 2004). With dredging, the rock-like reefs that had taken hundreds of years to be created were flattened in an attempt to efficiently harvest large amounts of oysters. Not only were the reefs destroyed, but the harvested oyster shell was also removed from the Bay’s ecosystem (USACE, 2008). With the removal of shell for agricultural and construction uses, suitable and available substrate for oysters to settle on had become severely limited.
One key issue many oyster restoration researchers have attempted to alleviate is the issue of substrate availability for oyster settlement. Many forms of alternative substrate, such as granite riprap and concrete cinderblock, have yielded promising results in terms of spat settlement and growth. In 2006, an experiment by the Virginia Institute of Marine Science yielded data showing excellent recruitment and growth of oyster spat on granite riprap in Lynnhaven, Virginia (Burke, 2008). This research was an important step in showing the ability of oysters to preferentially settle on alternative substrate when available. In 2006, under the same Virginia Institute of Marine Science project, high recruitment of oyster spat on concrete cinderblock was also noted. Alternative substrate may preferentially be settled upon as opposed to loose shell because the alternative substrate mimics the three-dimensional structure of natural reefs (Burke, 2008). The three-dimensional nature of alternative substrate allows the oysters to be oriented above the benthic floor and to escape some of the sedimentation and much of the predation faced by those that settle on loose oyster shell on the bottom. The reef-mimicry capacity of alternative substrate has the potential to yield higher, healthier population counts of oysters than loose shell reefs which are currently being used. As the cost of raw oyster shell increases due to its dwindling supply, alternative substrate is becoming a more cost-effective alternative to oyster shell for modern restoration efforts.

As of June 2008, Congress has appropriated $58 million dollars toward oyster restoration efforts (Fahrenthold, 2008). Currently, the greatest hurdle hindering restoration progress is suitable substrate availability. In 2008, the Allied Concrete Corporation, in conjunction with The Nature Conservancy, developed a new form of alternative substrate known as the “oyster castle”. The substrate is designed in a style reminiscent of LEGO-style building blocks and is composed of limestone gravel, concrete and crushed oyster shell. Due to the stackable nature of the block, three-dimensional reef structures can be constructed easily and cost-effectively. This pilot study, which was conducted during the summer of 2008 through the Virginia Summer Residential Governor’s School Mentorship Program at the Virginia Institute of Marine Science, was designed to assess the viability of these engineered structures in oyster reef restoration efforts.

This pilot study, which included a field and tank component, compared three response variables: 1) settlement, 2) growth and 3) survival of oysters, on the “oyster castles” to that of raw oyster shell and oyster shell vertically embedded in concrete. During the experimental design phase, working hypotheses for the three response variables were established: 1) substrates would perform better in the tanks than the field study due to higher predator density in the wild and 2) concrete “oyster castles” would perform as well or better than loose and embedded oyster shell. The null hypotheses were: 1) that there would be no difference in oyster larvae settlement and growth rates on the different substrates, and 2) there would be no notable difference in field and tank oyster settlement and growth rates.

**Hypotheses**

**Tank vs. Field Settlement**

H₀: TS > FS Where: TS = Total tank oyster settlement  
H₁: TS = FS FS = Total field oyster settlement

**Tank vs. Field Growth**

H₀: TG > FG Where: TG = Total tank oyster growth  
H₁: TG = FG FG = Total field oyster growth

**Oyster Castle Settlement and Growth vs. Oyster Shell Settlement and Growth**

H₀: OC > OS Where: OC = Oyster Castle settlement and growth  
H₁: OC = OS OS = Oyster shell settlement and growth
Oyster Castle Settlement and Growth vs. Embedded Oyster Shell Settlement and Growth

H₀: OC > ES
Where: OC = Oyster Castle settlement and growth
H₁: OC = ES
ES = Embedded oyster shell settlement and growth

Methods and Materials: Three substrates were tested in the intertidal zone of the York River along the Virginia Institute of Marine Science (VIMS) waterfront property (“field study”) and in VIMS’ outdoor flow-through tank facility (“tank study”). As part of a balanced analysis of variance (ANOVA) experimental design, six sets of experimental units (three control, three experimental) were created using four (4) oyster castles, one (1) tray of raw oyster shell with 16 shells per 0.25m x 0.25m quadrant (each tray had four quadrants), and one tray of vertically-embedded oyster shell in a 0.5m x 0.5m base of concrete (Quikrete underlayment concrete) per replicate (Appendix A). Substrates were conditioned for two months to ensure the physical and chemical characteristics of the substrate surface were suitable for larval settlement. Three experimental replicates were surrounded with silt fence after two months while the three control replicates remained in place (Appendix B).

The tank study was conducted in three tanks with ambient York River water pumped through them (Appendix C). Just as in the field study, six sets of experimental units (three control, three experimental) were created (Appendix D). Substrates were conditioned for two months within the tanks. A custom air supply system was created to ensure the tanks received adequate oxygen. After the conditioning period, the tanks were separated with silt fence with the control replicates on one side and the experimental replicates on the other (Appendix C). To deter settlement on the surface of the fiberglass tanks, a single coat of petroleum jelly was liberally applied.

Prior to releasing the larvae, water flow in the tanks was ceased and air flow was kept to a minimum. Roughly six million larvae were divided over the six (6) replicates between the field and tank; approximately 950,000 larvae were deployed per replicate. The settlement and growth of the oysters was recorded at 15-, 45-, and 90- day intervals post-deployment. These intervals were selected for practical and biological purposes. Fifteen days is the minimum time for complete settlement of larvae and adequate growth for effective visual assessment (Burke, 2008). Forty-five days (six weeks) is generally understood to be the end of a critical period of post-settlement mortality where surviving spat are then called “recruits”. Ninety days was selected as the final sampling period for two reasons: 1) Growth slows dramatically when water temperature drops (~90 days = November 1st), and 2) twelve weeks was ample time for the oysters set in the 2006 VIMS remote field larval experiment to show differences in growth and survival between substrates (Burke, 2008).

Results: Within the experimental replicates of the tank study, the mean live oyster count for the: 1.) raw oyster shell (OS) was 57.0 (± 13.0 SD), 2.) “oyster castles” (OC) was 123 (± 23.9 SD), and 3.) vertically embedded oyster shell (ES) was 34.3 (± 15.9 SD) at the 90-day interval (Figure 1). Within the experimental replicates of the field study, the mean live oyster count for the: 1.) OS was 16.3 (± 10.1 SD), 2.) OC was 20.3 (± 6.8 SD), and 3.) ES was 7.0 (± 4.4 SD) at the 90-day interval (Figure 1).
Analysis of variance (ANOVA) statistical tests were conducted (Appendix Table A) to detect any statistical differences in live oyster count within and between the fixed factors (field v. tank, control v. experimental, OS v. OC v. ES). Student-Newman-Keuls (SNK) *post-hoc* comparison tests were conducted when significant interaction effects were detected between fixed factors. The two-way ANOVA test for the tank study revealed significant treatment effects for both fixed factors and did not contain an interaction effect. The three-way ANOVA tests, which included all three fixed factors and potential interactions (i.e. control/experimental X substrate type), registered significant differences for all three fixed factors and at least one significant interaction effect across all three sampling intervals.

**Discussion and Conclusions:** Within the tank study, the oyster castles received, on average, greater recruitment than the raw oyster shell and the vertically embedded oyster shell (Figure 1). The ratio of the settlement on the three different substrates within the tank experimental units at 90-days shows a trend of recruitment on the “oyster castles” nearly four times that of the vertically embedded oyster shell and two times that of the raw oyster shell (Figure 1). This ratio, which developed over the course of the data collection intervals, is due to the natural spawning events of oysters in the York River and subsequent natural settlement on the replicates. The size frequency
histograms (Appendix E & F) provide further confirmation of this phenomenon. In addition, oysters on the “oyster castles” (Appendix G) grew to a larger size on average than the loose oyster shell (Appendix H) and embedded oyster shell (Appendix E & F). As shown in Figure 1, the ratio of settlement, the large difference in the mean live oyster count over time (Day 90: OC > OS > ES), and the total number of larger oysters show that the “oyster castles” outperform the oyster shell in terms of preferential settlement and growth.

Recruitment in the field was almost entirely due to natural settlement. The paucity of “remotely-set” oysters confirmed the relative ineffectiveness of the field enclosures; high wave energy in the area was the major source of disruption. In a 2006 VIMS study, silt fence was used effectively to deter triploid oyster larvae from escaping the experimental replicates; only 1 in 60 oysters sampled outside of the experimental replicates was a triploid (Burke, 2008). The failure of the larval deployment in this field study was discovered early on with the observation of little difference between experimental and control replicates. Subsequent interaction effects noted in the three-way ANOVA tests support this observation (Appendix Table A).

Although the field larval deployment proved largely ineffective, results suggest that oyster larvae that settled on the substrate from natural spawning events in the York River did so not because of the presence of other oysters on the substrate, but because the substrate was suitable for settlement. The presence of small oysters at the 90-day interval attests to this claim. In addition, the failure of the field study to yield an acceptable number of remotely-set recruits shows that larvae should be deployed in a controlled tank setting, rather than field setting, in order to maximize recruitment with later deployment into chosen areas for restoration.

In areas of regular recruitment, seeding of substrate by the controlled deployment of oyster larvae may not be necessary. If substrate is placed in a tank with ambient river water passing through it and given adequate time to condition, natural settlement may be sufficient for recruitment on material that can then be used in field restoration efforts. This method could greatly reduce the difficulty and costs involved with the production and controlled deployment of oyster larvae. Potentially, the need for controlled deployment could be replaced by natural settlement catalyzing reef restoration on strategically placed substrate material.

The physical and chemical makeup of the “oyster castles” facilitated oyster settlement. The preferential nature of oyster larval settlement is evidence that alternative substrate can serve the needs of restoration. “Oyster castles” can reduce the cost and difficulty of oyster reef restoration efforts by producing a large amount of inexpensive three-dimensional surface area for oyster settlement. This substrate has the potential to yield high recruitment and growth of oysters in a relatively short timeframe. Future restoration efforts should make use of the oyster castle design to maximize larval deployment efficiency while simultaneously minimizing the cost of reef restoration.
LITERATURE CITED


Appendices

Appendix A. Field deployment layout showing six experimental units containing the three substrates.
Appendix B. Layout of experimental and control replicates in the field study. Circles represent silt fence enclosing experimental replicates.

Appendix C. Outdoor tank facility setup showing the three fiberglass tanks used in the tank study. Note the silt fence separators mounted just prior to oyster larvae deployment.
Appendix D. Layout of experimental and control replicates in the tank study. The center line in each tank represents separation by the silt fence.
Appendix E. Size frequency histogram of shell heights of all live oysters in the tank experimental replicates at 90 days post-deployment.
**Appendix F.** Size frequency histogram of shell heights of all live oysters in the tank control replicates at 90 days post-deployment.

**Appendix G.** Oysters set on an “oyster castle” from one of the tank experimental replicates at the 90-day post-deployment interval.
Appendix H. Oyster set on some of the oyster shell from one of the tank experimental replicates at the 90-day post-deployment interval.

Tables:

### Three-Way ANOVA

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<th>Day 90</th>
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### Two-Way ANOVA for Tank Study

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<tr>
<td>Interaction Effects</td>
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</table>

Appendix Table A. Table showing the fixed factors used in both the Three-Way and Two-Way analysis of variance (ANOVA) tests and interaction effects thereof. The response variable for each test was live oyster count. (‘X’ indicates detection of significant treatment effects; ‘-’ indicates no detectable effects)
SECOND PLACE

THE EFFECT OF DISTANCE FROM THE ORIGIN OF THE STREAM ON THE STREAM WATER QUALITY GRADE

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ABSTRACT

Water quality surveyors determine how the environment surrounding the stream affects the water quality of the stream. An experiment was designed to determine how the water quality changes as the distance from the origin of the stream increases. It was hypothesized that if locations at different distances from the origin of the stream were tested, then the point furthest from the origin of the stream would exhibit the lowest water quality grade. Chemical tests were performed on the water at each site as well as benthic sampling. These results were evaluated to determine the overall water quality grade, the grade for each chemical test, and the grade for the benthic sampling of each site. The results suggested that the site zero meters from the origin of the stream and the site 1,400 meters away from the origin of the stream exhibited the highest water quality grade. This result may be associated with the high level of riparian buffers at both sites.

THIRD PLACE

COMPARISON OF HERBIVORY DIFFERENCES BETWEEN NATIVE SUGAR MAPLE AND NON-NATIVE JAPANESE MAPLE

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Home Schooled

ABSTRACT

This project compares insect herbivory levels between native Sugar Maples (Acer saccharum) and non-native Japanese Maples (Acer palmatum). Leaves were gathered from 30 trees of each species and were analyzed for chewing, piercing and mining damage from herbivores. Most of the data did not show a significant difference between herbivory levels and types. This result suggests that the environment has adapted to the introduction of the Japanese Maple tree.
SYNTHETIC BAIT VERSUS NATURAL BAIT, DO FISH SHOW A PREFERENCE?

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ABSTRACT

Bloodworms (*Glycera dibranchiata*) and Penaeid shrimp are a vital part of the ecosystem, the habitat that they live in, and are also an important part of the environment. Many bloodworms and shrimp are harvested for bait, which results in the decline of the population and the destruction of the habitat that the organisms live in. Use of synthetic baits, which uses chemically released scents, may help to slow the destruction of the shrimp and bloodworm population and environment. A common synthetic bait used is called Fishbites, which uses chemical scents and tastes to draw fish in to the bait. The data were collected by putting two fishing rods with a bottom rig, a type of hook placement with one hook higher then the other, and putting Fishbites on one hook and the natural bait on the other. The placement of the bait was changed every time a fish was caught and when the fish was caught its size, species, and bait caught on was recorded. The resulting data showed that there was a slight difference in the amount caught by each bait, with the natural bait catching, overall, more fish then the synthetic bait. The data is not statistically significant, $p=0.1835$ for the shrimp and shrimp Fishbites category, and $p=0.2697$ for the bloodworms and bloodworm Fishbites category. This proves the hypothesis that the synthetic bait would perform as well as the natural bait since the different baits ability to catch fish was the same. Fishbites could replace natural bait as a primary way to catch fish and reduce the need to harvest the bloodworms and shrimp for bait.

OYSTER RESTORATION: SINGLE OYSTERS VS. AGGREGATIONS, WHICH DO STINGRAYS PREFER?

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ABSTRACT

*Crassostrea virginica* (Eastern Oyster) are native oysters that grow in the Chesapeake Bay. This native oyster has lost great numbers due to overfishing, disease, predators, and loss of habitat. To fix this problem, oyster restoration projects have been developed to replenish the bay of this sessile, filter feeding organism. Oysters grow as aggregations or in clusters, which helps to prevent predation, unlike in nature, oysters grown for restoration are grown from seed as single oysters. This experiment was conducted to determine if single oysters were more vulnerable to predators than oysters in aggregations. This study compared the predation prevention between the single oysters and aggregations. The oysters were placed on “tables” which were placed in Urbanna Creek. The oysters were left in the water for a week, then taken out, and measured by shell height and counted. The predation on the single oysters was greater than the aggregations. The study also revealed that single oysters and aggregations together are better than just singles at preventing predation. A t-test was performed and a significant value of $p=4.219\times10^{-2}$, which allowed the null hypothesis to be rejected. Overall, the experiment showed that aggregations of oysters prevents predation better than the use of single oysters.
ABSTRACT

The objectives of this study were to evaluate the effects of land use on spring water quality in karst areas. Two types of land use areas were examined; agriculture and forested. Both sites were cave spring resurgences in Giles County, Virginia. Karst spring water quality can often vary greatly depending on its area of discharge. Factors such as the way the land in the spring’s discharge area is used, the type of rocks the water is flowing through, and the amount of rain the previous few days affect the quality of the spring water. Previous studies suggest that farmland can contaminate the groundwater. This can increase bacteria, nitrate, phosphate, and sediment in the spring. Water was tested regularly from early October to January 7. The two major test sites were the New River Cave Spring, and Smoke Hole Spring. The New River Cave Spring receives water from a largely forested discharge area with approximately 20% non-forested land while Smoke Hole Spring’s discharge area is largely agricultural with roughly 70% grazing land. One day was spent going into the caves to measure the water quality of the streams in the caves. Tawney’s Spring, which has water from the same discharge area as Smoke Hole Spring was also periodically measured. Water at both sites was measured for bacteria, nitrate, phosphate, dissolved oxygen, alkalinity, pH, and clarity. The results from the different test sites were then compared to note the differences between a spring with an agricultural discharge area, and one with a forested discharge area. Significant differences in water between agriculture and forested test sites were noted. Agricultural land showed higher values for phosphate, nitrate, alkalinity, and bacteria. However, higher alkalinity may be due to a number of factors in addition to land use.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Soil Type on Ability to Absorb Acid. Emma M. Rodvien, Yorktown High School, Arlington County Schools.

A Comparative Assessment of Hiking, Mountain Bike, and Horse Trails. Sarah L. Ryan and Adam M. Rotche, Blacksburg High School, Montgomery County Schools.


The Effect of Different Household Liquid Pollutants on their Ability to be Absorbed by Soil. S. Reed Smith, George H. Moody Middle School, Henrico County Schools.

The Effect of Sewage Effluent on the Growth of Oysters. Ryan C. Speray, Chesapeake Bay Governor’s School, Gloucester County Schools.

The Potential of Recreational Fishermen to Collect Fisheries Data Using a Simple Survey. Randolph W. Stephens Jr., Chesapeake Bay Governor’s School, Gloucester County Schools.

The Effect of Different Insulating Materials on the Amount of Ice Left after Three Hours. James M. Sylvester, George H. Moody Middle School, Henrico County Schools.


The Growth and Survivorship of Geukensia demissa in Varying Salinities. Andrew C. Voight, Chesapeake Bay Governor’s School, King and Queen County Schools.


The Use of Madison Cave Isopods as an Indicator Species of Water Quality. Stewart M. Walker, Mills E. Godwin High School, Henrico County Schools.

The Effects of Greywater on the Growth of Pachysandra terminalis. James G. Whisnant, George H. Moody Middle School, Henrico County Schools.

The Effect of Different Types of Chemical Pesticides on Transmittance of Light through Chlorophyll a. Windsor R. Whitlock, George H. Moody Middle School, Henrico County Schools.

The Effect of Callinectes sapidus on Littorina littorea and Salt Marsh Health. Erica M. Williams, Chesapeake Bay Governor’s School, Mathews County Schools.

The purpose of this experiment was to determine if the presence of cidofovir enhances the radiation therapy in HPV positive and HPV negative cervical cancer cells. There will be two groups in the study: a drug group and a no drug group. Doses of radiation will be 0 Gy (control), 2 Gy, 4 Gy and 8 Gy; one group will have 10 μg/mL of cidofovir. It is believed that the HPV positive cells with no drug treatments will yield about the same numbers as HPV negative cells with drug and radiation treatment and that the HPV positive cells with drug treatment will yield more cell death. The hypothesis is formulated based on the fact that past research has shown effectiveness on HPV. Cells were cultured, seeded and treated with respective treatments. Results were then analyzed with an colonogenic assay. The data supported the hypothesis. The average plate efficiency for drugged CaSki and HeLa was 0.002031 and 0.014815 respectively which was lower than all other groups. The average efficiency for no drug CaSki was 0.025532, for no drug HeLa was 0.041866, for drugged HTB-32 was 0.051394 and for no drug HTB-32 was 0.053102. This trend was similar in all other doses of radiation. Cancer is uncontrollable growth of cells, a disease that scientists have been continuously looking for better treatment. Cervical cancer is one of the leading causes of cancer death in women in developing countries. Due to effectiveness of the treatment, it may become developed as a treatment for cancer expressing HPVs.
The explanatory variable in this study is cidofovir. Cidofovir, sold commercially as Vistide, is one of the drugs that inhibit HPV activity. Cidofovir is approved for treatment of cytomegalovirus retinitis in patients with AIDS, but it is also found to be effective on HPVs. The exact mechanism of this effect is not very clear, but it has shown to reduce the levels of E6 and E7. This reduction allows the levels of p53 and pRb to recover, restoring some of their normal functions (Hostetler et al., 2006). In this study, there is one dose (10 µg/mL) of cidofovir.

The response variable in this study is radiosensitivity of cervical cancer cells measured in number of colonies. There are HPV positive cells (CaSki and Hela) and HPV negative cells (HTB-32), established cervical cancer cell lines. Radiosensitivity is the sensitivity to radiation. There will be 4 doses of radiation: 0Gy (the control), 2 Gy, 4 Gy, and 8 Gy. Cell survival will be observed by colonogenic assay.

The purpose of this experiment is to determine if the presence of cidofovir enhances the radiation therapy in HPV positive and HPV negative cervical cancer cells. There will be two groups in the study: a drug group and a no drug group. Doses of radiation will be 0 Gy (control), 2 Gy, 4 Gy, and 8 Gy; one group will have 10 µg/mL of cidofovir. It is believed that the HPV positive cells with no drug treatments will yield about the same numbers as HPV negative cells with drug and radiation treatment and that the HPV positive cells with drug treatment will yield more cell death. The hypothesis is formulated based on the fact that past research has shown effectiveness on HPV.

Methods and Materials: HPV positive, CaSki and Hela (both from ATCC® The Global Bioresource Center™), and HPV negative, HTB-32 (ATCC® The Global Bioresource Center™), cancer cells were cultured in cell culture flasks at 37°C in RPMI 1640 media supplemented with 10% fetal bovine serum and penicillin/streptomycin. Before experiment, the cells were split to two flasks: drug and no drug; after the cell attachment overnight, 100 µg of cidofovir was added to one flask with 10 mL of media yielding a concentration of 10µg/mL. No drug was to the other flask for the control. After forty-eight hours, media was aspirated out of the flasks, which were washed with PBS to clean out any excess proteins. Two mL of trypsin was added to each flask to digest adhesion protein so the cells can be easily detached. Ten mL of media were added to neutralize the trypsin and 100 µg of cidofovir were added to the drug flask. Cells were shaken and blown off the surface of the flask by pipetting generating single cells suspensions. Cells were counted using hematograph and then diluted to 200, 300, 600, and 2000 cells per mL. Twelve 6-well plates were split into three groups: 4 were in the drug group and 4 were in no drug group; each plate was labeled 0 Gy, 2 Gy, 4 Gy, and 8 Gy corresponding to the dose of radiation. The cells were seeded in four 6-well plates with no drug cells in the top row and drug cells in the bottom row. For each radiation dose, there are three wells (trials) per type of cell because there were limited materials for a high school student. For control (0Gy), 200 cells were seeded per well by adding 1 mL of diluted 200 cells/mL; for 2 Gy, 4 Gy, and 8 Gy, 300, 600, and 2000 cells were seeded per well respectively. After overnight attachment, cells were treated with radiation using Cesium-137 radiator at MCV Labs at respective doses. After treatment, the media was replaced with 3 mL fresh media. Cells were maintained for six days. Cell were fixed with 3:1 methanol-acetate solution and then stained with 0.5 % crystal violet stain. Colonies containing thirty or more cells were counted. Results were analyzed using analysis of variance (ANOVA) and student’s t-test.

Results and Discussion: The colonogenic assay results are shown in Table 1 through Table 9 and Graph 1, Graph 2, and Graph 3. The research hypothesis stated that the HPV positive cells with no drug treatments will yield about the same numbers as HPV negative cells with drug and radiation treatment, but the HPV positive cells with drug treatment will yield more cell death. ANOVA tests were performed for data from each cell line. The null hypothesis was the there would not be a significant different among all doses of radiation and cidofovir. However, all data yielded statistically significant results. The p-value for CaSki cells was 3.0799x10^-6, for HeLa was 2.0118x10^-14, and for HTB-32 was 3.0398x10^-6, all of which are smaller than the alpha value of 0.05, rejecting the null hypothesis. This means that the treatments of radiation and cidofovir were effective. However, the ANOVA test did distinguish whether the or not the cidofovir enhanced the treatment. Upon further analysis, the average plate efficiency of the drug and no drug levels in each cell line were compared. In CaSki cell line, which is a HPV positive cell line, at 0Gy, the no drug average efficiency was 0.025532 whereas the drug average efficiency was 0.002031. This trend continues in the data from the same cell line. There is a dramatic decrease implying that the cidofovir treatment increased the cell deaths. The decrease is also represented in the HeLa cell line, a HPV positive cell line, which further supports the research hypothesis. In the HPV negative cell, HTB-32, the no drug average efficiency at 0 Gy was 0.053102 and the drug average efficiency was 0.051394. There is not a big difference between the drug treatment and the no drug treatment. The trend continues among the HTB-32 cells implying that the drug treatment did not influence the cell deaths also supporting the research hypothesis.
Additionally when referencing the survival curves (Graphs 1 and 2), there was no significant difference between the two cell lines without drug treatment. After treated with cidofovir, the CaSki cells and HeLa cells (HPV positive) showed a lower survival curve, indicating that the cells were sensitized by the drug. The HTB-32 (HPV negative) did not show change in survival curve with the drug indicating that the cells were not sensitized by the drug. These trends shown on the graph supports the research hypothesis. When treating cells with cidofovir, whether or not the cells express HPV does have an effect on the number of colonies of cervical cancer cells.

**Conclusion:** The purpose of this experiment is to determine if the presence of cidofovir enhances the radiation therapy in HPV positive and HPV negative cervical cancer cells. In both HPV positive and HPV negative cells, as the radiation dose increases, the number of colonies of cervical cancer cells decreased. However, in HPV positive cells, the treatment of cidofovir further decreased the number of colonies whereas cidofovir did not have a significant effect in HPV-negative cells. This supports the research hypothesis and corresponds with findings in the literature. Studies have shown that cidofovir reduces the levels of E6 and E7 caused by the HPV, allowing tumor suppressor levels to restore. Additionally, the HPV negative cells most likely have mutated tumor suppressors. Even with lower E6 and E7 levels, mutated p53 and pRb cannot induce apoptosis.

To improve this study, treatment should be maintained for longer time or introduce other doses of the drug. In further studies, a Western blot should be performed to measure levels of the proteins. A study that does not involve radiation should also be involved to see if that cidofovir alone has an effect on HPV associated cancers.

**LITERATURE CITED**


ACKNOWLEDGMENTS

I would like to thank Dr. Shiyu Song, M.D, Ph.D. for purchasing materials, Zachary Bradley for radiating cells, and VCU/MCV labs for other materials.

Appendix

Raw Data Table 1

<table>
<thead>
<tr>
<th>CaSki: No Drug</th>
<th>Trials (Number of Colonies)</th>
<th>Average</th>
<th>Plate Efficiency</th>
<th>Survival Fraction</th>
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Raw Data Table 2

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<th>Trials (Number of Colonies)</th>
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<th>Plate Efficiency</th>
<th>Survival Fraction</th>
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<th>Plate Efficiency</th>
<th>Survival Fraction</th>
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Raw Data Table 4

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<th>Survival Fraction</th>
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<td>4</td>
<td>3</td>
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<tr>
<td>4 Gy</td>
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<th>Survival Fraction</th>
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### Raw Data Table 6

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<th>HTB: Drug</th>
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<th>Survival Fraction</th>
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</tr>
<tr>
<td>8 Gy</td>
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Graph 1: Radiation Dose vs. Survival Fraction in CaSki and HTB

**The Effect of Cidofovir on the Radiosensitivity of Cervical Cancer Cells Expressing Human Papillomavirus**

![Graph showing survival fraction vs. radiation dose](image)
Graph 2: Radiation vs. Survival Fraction in HTB and HeLa

The Effect of Cidofovir on the Radiosensitivity of Cervical Cancer Cells Expressing Human Papillomavirus

Graph 3: Radiation Dose vs. Average Colonies per Cell Plated

The Effect of Cidofovir on the Radiosensitivity of Cervical Cancer Cells Expressing Human Papillomavirus

Table 7: The Effect of Cidofovir on the Radiosensitivity of Cervical Cancer Cells Expressing Human Papillomavirus

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>Dose of drug; dose of radiation</th>
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183
<table>
<thead>
<tr>
<th>Dose of drug; dose of radiation</th>
<th>HTB</th>
<th>0µg;0Gy (Control)</th>
<th>0µg; 2Gy</th>
<th>0 µg; 4 Gy</th>
<th>0 µg; 8 Gy</th>
<th>10 µg; 0 Gy</th>
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<tr>
<td>Mean (Plate efficiency)</td>
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<td>0.0272</td>
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<tr>
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Results of statistics (ANOVA: HTB):
H₀= μdrug=μno drug
H₁= μdrug≠μno drug
Drug vs. No Drug
F=16.6297 p-value=3.0398x10^-6 p-value<0.05 df=7 at α=0.05
Table 9: The Effect of Cidofovir on the Radiosensitivity of Cervical Cancer Cells Expressing Human Papillomavirus

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<th>Description</th>
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<td>Minimum</td>
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Results of statistics:
ANOVA: HeLa
H₀= μ_{drug}=μ_{no drug}
Hₐ= μ_{drug}≠μ_{no drug}
Drug vs. No Drug
F=203.4363 p-value=2.0118x10^-14 p-value<0.05 df=7 at α=0.05
SECOND PLACE

THE EFFECT OF DIFFERENT SURFACE MATERIALS ON THE CLARITY OF FINGERPRINTS

Allison S. Reid
531 Homewood Drive, Lynchburg, Virginia 24502
Central Virginia Governor’s School, Lynchburg, Virginia 24502

ABSTRACT

The purpose of this study was to determine if the surface material a fingerprint is recovered from affects the clarity of the fingerprint as described by the fingerprint quality assessment, scale. The study was conducted over a period of two weeks in December 2008 at a local high school. The researcher pressed fingerprints onto five different surfaces: a plastic lid, a metal locker, a steel dry erase board, a glass window, and a wooden door. The researcher used magnetic fingerprinting powder and a magnetic wand to detect each fingerprint, and then used tape to collect the fingerprint and place it on an index card. The fingerprints were then rated on a fingerprint quality assessment scale which ranged from 0 to 4 (0 being the lowest score and 4 being the highest). In total, twenty fingerprints were collected from each surface, and the results of the study were analyzed statistically using a one-way ANOVA test. The ANOVA test showed that the surface material did have a significant effect on the quality of the fingerprint, with a p-value of 3.05651 E -49, which was much lower than the set alpha level of 0.05. The tukey test showed a significant difference between the fingerprints recovered from plastic, and the fingerprints recovered from the other four surfaces. It also showed a significant difference between the fingerprints recovered from wood and the fingerprints recovered from the other four surfaces. This supported the original hypothesis that if fingerprints are collected from different surfaces, then the fingerprints will receive different scores on the fingerprint quality assessment scale. In conclusion, this study shows that the fingerprints recovered from glass, metal, and steel are clearer than fingerprints recovered from wood and plastic.

THIRD PLACE

THE EFFECT OF DIFFERENT LEVELS OF EXPOSURE TO ULTRAVIOLET B RADIATION ON PHYSICAL AND BIOLOGICAL DAMAGE TO DNA

Conan Zhao
8607 Millstream Drive, Henrico, Virginia 23228
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

There have been increasing numbers of skin cancer cases reported in the US, many of which are related to excess outdoor activities when UV radiation, especially UVB radiation, is at its peak. The purpose of this experiment was to discover the relationship between the amount of UVB radiation exposure and the amount of damage to Deoxyribonucleic Acid (DNA). It was hypothesized that if the amount of UVB exposure to DNA increased, then the amount of chemical and biological damage would also increase. To test this hypothesis, a plasmid DNA (pBR322) was exposed to UV light using an Ultraviolet Transilluminator for various time lapses. First, DNA samples were dissolved in water and added onto seven culture plates. After the water evaporated, the DNA samples were then placed in the UV Transilluminator and exposed for time lapses of 0, 0.5, 1, 5, 10, 15 and 30 minutes, respectively. Then, parts of the recovered DNA samples were transferred into E. coli cells and tested for biological damages by a colony count. The remaining samples were then run through an agarose gel electrophoresis for a physical damage analysis. The results showed that as the time of exposure to UVB light increased, the number of E. coli colonies formed was significantly decreased. Consequently, the DNA electrophoresis showed that as the amount of exposure to UVB increased, the intensity as well as the blurriness of the upper band (loose-form) of the
plasmid DNA increased. Compared to UVB, the physical and biological effects of UVA on DNA is much less significant. These results confirmed the biological and physical damages of UVB exposure to DNA. It may also provide evidence between excessive sunlight exposure and development of skin cancer or other skin diseases due to damages (mutations) in the chromosomal DNA of human skin cells.

**HONORABLE MENTION**

**THE EFFECT OF MITOCHONDRIAL TOPOISOMERASE I ACTIVITY ON MITOCHONDRIAL DNA REPLICATION**

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**ABSTRACT**

DNA topoisomerases are unique enzymes that aid in maintaining DNA integrity by actively monitoring, modifying, and maintaining the topology of the DNA strands during replication, transcription, recombination, and repair. During DNA replication, topoisomerase cleave and reanneal the two DNA strands to allow them to separate. Various forms of topoisomerases are known to affect the replicatory rates of their corresponding forms of DNA, and have served as targets for cancer treatments, especially camptothecin, an anti tumor drug. So far, however the targets have been nuclear topoisomerases and their effects on nuclear DNA. In this study we assess the effect, if any, that mitochondrial topoisomerase I (TOP1mt) has replication of mitochondrial DNA in mouse tissue. To implement the objectives of this study, DNA was extracted from various organ tissues of four mice. Age as a variable was accounted for as two of the mice were relatively older than the other two, and within each age group, one mouse served as the TOP1mt knockout and the other as the wild type (control) mouse. To study the possible changes in the rates of the propagation of mitochondrial DNA as a result of the knockout, gel electrophoresis was performed on all DNA samples, after polymerase chain reaction, and band densities were quantified. As expected, the wildtype mice did exhibit higher levels of replication than the knockout mice. The binding sites of the TOP1mt with mitochondrial DNA were found to be directly adjacent to the displacement, or D, Loop region. Any mutation in this sequence could result in sever mutations in the transcriptional control of mitochondria and possibly result in degenerative diseases often associated with aging, such as Alzheimer’s and Neurogenic muscle atrophy.

**HONORABLE MENTION**

**THE GENETICS OF ANTHOCYANIN DEFICIENCY IN Sarracenia L. PART III**

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**ABSTRACT**

_Sarracenia_ is a genus of pitcher plant found in wetlands of the Eastern United States and Canada. These carnivorous plants attract insects with nectar, color, and enzymes. Leaf and flower color are caused by anthocyanins and are controlled through genes. Anthocyanins cause the red color pigment, and the green pigment is due to a lack of anthocyanins. There are many variations of the red color pigment, including veining, splotching, and flushing. The red allele is dominant over the green allele. This experiment measured the inheritance of the red and green alleles through anthocyanin production in the F2 generation of _S. purpurea_ and _S. flava_ with different test crosses. Three of four homozygous-by-heterozygous crosses met expected ratios and have statistically significant chi-square values. In the only F2 generation self-pollinated heterozygote, it successfully yielded a statistically significant value
and met the only ratio of 3 red : 1 green predicted in the experiment. Offspring in the test cross heterozygous by recessive green met the expected ratio of 1 red : 1 green and was statistically significant. Phenotypes in the test cross clearly show red and green colors and exhibit no incomplete or partial dominance. In conclusion, the dominant/recessive mode of inheritance is supported for this anthocyanin gene and indicates that the green plant in Appalachicola National Forest represents another occurrence of the same mutation in another Sarracenia species.

HONORABLE MENTION

EVALUATING KLF2 AND KLF4 INTERACTION BASED ON KLF2 AND KLF4 CROSSINGS

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ABSTRACT

Research on 4 different crossings: KLF2+/− KLF4+/− by KLF2+/−, KLF2+/− KLF4+/− by KLF4+/−, KLF2+/− KLF4+/− by wild type (KLF2+/+ KLF4+/+), and KLF2+/− by KLF4+/− was conducted to determine if there is a significantly lower number of double heterozygous offspring than what would be expected for each crossing. This is important to more fully understand the interaction of these two genes. These genes are essential to successful cardiovascular development. It was expected that if any of the above four crossings were conducted, then there would be a significantly lower ratio of KLF2+/− KLF4+/− offspring than would be expected from a punnett square cross. Some offspring were genotyped using Polymerase Chain Reaction and Gel Electrophoresis. After finding the genotypes and conducting Chi square tests to determine if there was significant difference in ratios, it was found that the KLF2+/− KLF4+/− by KLF2+/− did not have a significantly different ratio from expected. KLF2+/− KLF4+/− by KLF4+/− had an insignificantly lower percent of double heterozygous offspring. The combination of KLF2+/− KLF4+/− by wild type and KLF2+/− by KLF4+/− also had a significantly lower percent of double heterozygous. This data suggests that double heterozygous offspring may be less viable and are less likely to survive, but more data is necessary to determine this. This is very curious because both the genes have an allele that should allow for sustained living (+). It is also possible that KLF2 is the determining factor for mouse survival. KLF4 may not be a factor in this study.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Eye color on Peripheral Vision. Brett A. Barden, George H. Moody Middle School, Henrico County Schools.

The Effect of the Number of Children in a Family Unit on the Number of Similar Fingerprint Patterns between Parents and Their Biological Children. Natalia C. Bell, George H. Moody Middle School, Henrico County Schools.

Fingerprints: Yours, Mind and Ours. Abigail W. Boshart, Thomas Jefferson Middle School, Arlington County Schools.

Effects of Specialization on Plant Mutation Rate. Kendrick C. Harrison, Blacksburg High School, Montgomery County Schools.

Comparison of Gene Locations Linked to Nicotine Dependence with Chromosomal Regions Correlated with Nicotine Dependence. Elise L. Huppert, Williamsburg Middle School, Arlington County Schools.

Determining Subcellular Localization of RAI1 Isoform C in COLS-7 Cells. Manavi Johri, Mills E. Godwin High School, Henrico County Schools.
Developing a Method to Incorporate Phosphoserine into Peptide Libraries in Order to Improve the Treatment of Breast Cancer. Grace K. Lee, Mathematics and Science High School at Clover Hill, Chesterfield County Schools.


The Effect of Storage Temperature on the Survival Rate of an Onion Cell’s DNA When Extracted from Its Cell. Abby Naughton, George H. Moody Middle School, Henrico County Schools.

Functional Expression of the Colon Cancer Oncogene, CDK8, in *Escherichia coli*. Bella P. Purdy, Shenandoah Valley Governor’s School, Augusta County Schools.
MICROBIOLOGY

FIRST PLACE

THE EFFECT OF SIGNAL PEPTIDES ON DNA VACCINES FOR MELANOMA

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Abstract: The development of DNA “vaccines” for cancers of non-vital organs is an exciting breakthrough in tumor immunology. Previously, a successful vaccine for melanoma was developed by utilizing a DNA vaccine encoding a rationally mutated form of a mouse melanoma antigen (MMA) that enhanced the avidity of MHC-peptide ligands. Later trials saw the effectiveness of the vaccine rise with the addition of chimeric fusion proteins that stimulated the immune response as adjuvants. It was noticed that a fusion vaccine construct in which the signal peptide region (first 34 amino acids) was cleaved after translation showed increased stability in vivo that could potentially enhance an immune response. The purpose of this experiment was to determine the effect on the stimulated T-cell immune response of deleting the signal peptide of the original, non-fused vaccine. It was hypothesized that the deletion of the signal peptide from the specific vaccine would generate a stronger immune response. The vaccine was constructed by first amplifying the target antigen excluding the signal peptide with polymerase chain reaction (PCR). The target antigen was inserted into a plasmid which was then transformed and “cloned” in E. coli. The genetic material was extracted, coated on microscopic gold particles, and injected into mice with a “gene gun.” Results from this study suggest the removal of the signal peptide from a vaccine encoding a rationally mutated MMA may decrease the generated immune response. However, results also suggest the removal of the signal peptide from a vaccine encoding a wild-type MMA may increase the immune response dramatically in comparison to a vaccine encoding a wild-type MMA. These results suggest that either rationally mutating a wild-type MMA or removing its signal peptide may enhance a generated immune response, but both modifications may decrease immune responses.

Introduction: The central aspect of all cancer immunology relates to overcoming the problem of tolerance. One of the major forces of the immune system, the T-cell, includes on its surface a molecule called a T-cell receptor that is responsible for recognizing specific antigen that is bound to the major histo-compatibility complex (MHC) located on most cells. These T-cell receptors are generated randomly in order to account for the vast array of possible antigen T-cells might encounter, and in this process many T-cells become specific for antigen that is part of the host organism called “self.” To prevent the immune system from attacking the host T-cells with high avidity for host-tissue are deleted during thymic development, but those with low or intermediate avidity survive (Janeway et al., 2005). Though this process ensures the host from autoimmunity, it poses a significant problem when fighting the onset of cancer. Since cancer cells are products of host cells, they are in essence invisible to the immune system because T-cells with limited affinity for self epitopes lack the costimulatory signals necessary for activation. The experiment described relies on the use of a recent approach to immunotherapy of cancer, DNA vaccination.

DNA vaccines are bacterial plasmids that encode one or more antigens of interest (Stan et al., 2000). The main purpose of these vaccines is to optimize the efficiency of antigen presentation. Once the DNA enters the tissue, dendritic cells or other professional antigen-presenting cells present transcribed and translated antigen that was encoded in the plasmid to T-cells in order to generate an immune response. Studies of vaccines that encode cytokines such as human growth hormone as well as antigens from malaria, tuberculosis, and influenza have demonstrated that DNA vaccines can generate CD8+ (cytotoxic) and CD4+ (helper) T-cell responses (Stan et al., 2000). Though there are many methods of vaccination, there is one technique that is being used increasingly in many scientific laboratories termed particle-mediated gene transfer (PGMT). In PGMT, microscopic gold grains are coated with the DNA of interest and, utilizing a burst of helium, are accelerated into tissue via a “gene gun.” The use of PGMT may result in higher transgene expression levels when compared to other means of DNA delivery (Rakhmilevich et al., 2001).
Recently, strategies have been developed for vaccines targeting cancer since there is better understanding about certain “tumor antigens” - antigens that are expressed by MHC molecules on the surface of tumor cells. The most prevalent tumor antigens are those that are over-expressed on cancer cells or are specific for tumors and their normal cell counterparts. However, since most immune cells that can “recognize” these antigens and generate an immune response have been deleted to preserve tolerance these antigens are still impossible to differentiate from “self.” Melanoma tumor antigens have been researched at length. These antigens, including tyrosinase, tyrosinase-related protein 1 (TYRP-1/gp75), and gp100, are expressed in both normal and malignant melanocytes. In an early study, mice vaccinated against TYRP-1/gp75 with a syngeneic (same species i.e. mouse) form of the antigen did not show an immune response. However, mice vaccinated with a xenogeneic (different species i.e. human) form of TYRP-1/gp75 developed an immune response to both human and mouse TYRP-1/gp75 (Weber et al., 1998). This showed that tolerance to the melanoma tumor antigen had been broken (Stan et al., 2000). In another study, it was shown that random mutations in TYRP-1 generated an immune response when mice were immunized with the mutated antigen (Engelhorn et al., 2006). Crucial amino acid differences in MHC epitopes that lead to higher affinity for native MHC molecules than the regular syngeneic peptide provide one mechanism to explain the breaking of tolerance by xenogeneic immunization. These epitopes that differ slightly from their regular counterparts, termed “heteroclitic,” represent a strategy to break tolerance to self. The small difference in sequence of amino acids can play a role in the strength of the bond between the MHC molecule and presented peptide, and can determine T-cell activation. Since activated T-cells do not require the same stimulation as naive T-cells, there is a greater chance of mounting an immune response targeted against the regular, non-mutated tumor antigen. For this reason, using site-specific mutagenesis to enhance MHC-peptide binding became a novel strategy for DNA vaccination (Stan et al., 2000).

Optimized versions of epitopes for MHC binding are currently predicted by computational algorithms. This capability is derived from the identification of primary and secondary MHC-binding anchor residues (Houghton et al., 2007). A rationally mutated form of mouse Tyrp-1 has already been created. Mutations were induced in the gene to form altered peptide ligands and enhance MHC binding. The optimized version of the antigen, Tyrp-1ee a.k.a. Sweet White Magic (SWM), induced CD8+ immune responses in mice against the non-mutated antigen (Guevara-Patiño et al., 2006).

In order to generate a greater immune response, antigen processing and presentation of peptides in the context of the MHC should be optimized. It has been shown that SWM deficient in glycosylation points (through point mutations) is more immunogenic than just SWM itself (Guevara-Patiño et al., 2006). Additionally, the presence of a signal peptide is required for glycosylation; proteins that do not have a signal peptide are not glycosylated. A previous study in the lab showed that the signal peptide of translated SWM protein is cleaved by the enzyme signal peptidase when fusion protein (foreign proteins used as adjuvants) vaccines were used. The cleaved protein product was shown to be SWM lacking a signal peptide (SWM-Δ1-34). A stability assay further provided evidence that SWM-Δ1-34 was more stable than full-length SWM in vivo. Protein trials confirmed that no sugars were added to SWM-Δ1-34 after translation, which may have led to improper protein folding and eventual degradation by the proteasome. An established pathway exists between recycled products of proteasomal degradation and the TAP molecule, which delivers peptides to the MHC for display to the immune system. Therefore, the lack of a signal peptide could lead to increased levels of antigen presentation and potentially an increased immune response.

The objective of this experiment was to determine if the signal peptide region of a SWM DNA vaccine for melanoma had an effect on the immunogenicity of the vaccine. It was hypothesized that a SWM DNA vaccine lacking a signal peptide would generate a stronger immune response as an effect of increased antigen presentation due to vaccine antigens being degraded by the proteasome.

**Methods and Materials:** Polymerase chain reaction (PCR) was performed first to amplify the antigen of interest. The template (Tyrp-1) was combined with upstream and downstream primers and nucleotides. Taq DNA Polymerase as well as its corresponding PCR buffer was utilized. The amplified PCR product and a sample of fresh plasmids were then digested with restriction enzymes _Ascl_ and _NotI_. The restricted PCR and plasmid products were then ligated together with the use of _T4 DNA Ligase_. (All enzymes purchased from New England Biolabs, Inc.)

The ligated plasmid was then transformed into chemically competent _E. coli_ (able to intake plasmids) by use of the heat-shock method. The _E. coli_ and plasmid product were mixed and allowed to incubate on ice for 30 minutes.
and then were placed in a 37°C water bath for 45 seconds. The *E. coli* and plasmid product were allowed to grow in antibiotic-free Luria-Bertani (LB) medium for 1 hour to allow time for the bacteria to express the ampicillin-resistance genes encoded in the plasmid. The bacteria were then plated using sterile technique on agar plates that contained ampicillin. The plates were incubated overnight at 37°C.

After incubation, samples of bacterial colonies were grown in LB broth while being shaken upright at 37°C. The tubes were then centrifuged to form a pellet of genetic material in order to prepare for plasmid mini-prep to extract plasmid DNA. The protocol and buffers for the mini-prep were purchased from Qiagen.

In order to verify if the correct insert had been ligated properly into the plasmid and subsequently cloned in *E. coli*, a restriction digest was performed with *AflII* (unique enzyme site specific for the insert). Verification was performed by visualizing the digested sample through agarose gel electrophoresis.

After the correct sequence was verified, the successful sample ligation reaction would again be transformed into competent *E. coli* through the heat-shock method using sterile technique. Bacteria were again incubated at 37°C overnight. Samples of colonies were inoculated into a flask containing 250 mL LB broth and shaken upright at 37°C for 16-18 hours. Cultures were then transferred to 250 mL centrifuge bottles.

A plasmid maxi-prep was then performed to extract a large amount of genetic material. The protocol for this event was also given by Qiagen. Briefly, the cell culture was first centrifuged then lysed. The supernatant underwent 3 centrifugation events to remove unwanted cell debris. An anion exchange column was primed with isopropanol and sodium chloride buffer. DNA was added to the primed column and adhered to the resin. It was washed with a medium salt buffer to remove cell debris. DNA was eluted from columns with a high salt buffer, then precipitated with isopropanol. The precipitated DNA was pelleted by centrifugation. The pellet was then washed ethanol, air dried, and resuspended overnight at 4°C in TE buffer.

This marks the last procedure participated in during the course of the research. A senior member of the lab carried out the following research.

Plasmid DNA was combined with microscopic gold particles to form pellets by following standard lab protocol for making “gene gun bullets.” Mice were then immunized with the “gene gun” once a week, for three weeks. Five days after the last immunization, an ELISPOT assay was performed to characterize the immune response.

Results: PCR was completed to amplify the sample of SWM-Δ1-34 and Wild-Type Tyrp1 (Fig. 1). A band in the J sample (SWM) corresponds to a band in the WT sample, showing that they are approximately the same molecular weight. DNA sequencing was performed to verify the correct templates were amplified.

Plasmid mini-preps were performed to extract genetic material from WT and SWM samples (Fig. 2). The product was digested with a restriction enzyme *AflII* unique to the fragment inserted into the plasmids. Colonies J2 and J3 feature inserts cleaved by *AflII*, yielding smaller fragments.

An ELISPOT assay was performed to characterize the immune response of four vaccine constructs (Fig. 3). The y-axis of the bar graph lists the four constructs that were injected into mice: wild-type Tyrp-1, wild-type Tyrp1-Δ1-34 (wild-type Tyrp-1 without signal peptide), SWM, and SWM-Δ1-34. The x-axis measures the stimulated immune response in terms of activated T-lymphocytes per 100,000. Three antigens were utilized to measure the T-lymphocyte response for each vaccine: an irrelevant peptide (control), a control peptide from the B16 melanoma cell line, and a peptide from the wild-type Tyrp-1 (antigen of interest). All samples did not respond to the irrelevant peptide. The deletion of the signal peptide from the wild-type Tyrp-1 vaccine led to a 3-fold increase in T-cell response when stimulated by the B16 antigen and a 20-fold increase in T-cell response when stimulated by the wild-type Tyrp-1 antigen. The removal of the signal peptide from the SWM vaccine led to similar T-cell responses when stimulated by the B16 antigen and a four-fold decrease in T-cell response when stimulated by the wild-type Tyrp-1 antigen.

Discussion and Conclusions: In this research, the signal peptide region was removed from a specific (SWM or Tyrp1ee) DNA vaccine to determine if the immune response stimulated by the vaccine was affected.
Fig. 1 and Fig. 2 demonstrate the construction and verification the DNA vaccine construct (SWM-\(\Delta_{1-34}\)).

Fig. 3 represents the results of an ELISPOT assay to characterize the immune response of four vaccines against non-mutated Tyrp-1. The vaccines in the assay include SWM and the constructed SWM-\(\Delta_{1-34}\) as well as wild-type Tyrp-1 and wild-type Tyrp1-\(\Delta_{1-34}\). This trial suggests that removing the signal peptide from SWM may decrease the strength of the T-cell immune response generated to the Tyrp-1 melanoma antigen. However, at the same time it appears the removal of the signal peptide from a wild-type Tyrp-1 may significantly increase its generated immune response. Indeed, the 20-fold increase in T-cell response for wild-type Tyrp-1 lacking signal peptide appears to outweigh the benefits of rationally mutating Tyrp-1 to create SWM.

This interesting observation raises the question as to what is causing the difference between the wild-type and SWM responses in relation to the signal peptide. SWM differs from wild-type Tryp-1 by ten point mutations. It may be possible that these ten point mutations in SWM are responsible for the construct to have less stability when the signal peptide is removed. Future experiments should test the stability of SWM-\(\Delta_{1-34}\) and Tyrp-1-\(\Delta_{1-34}\) in vivo, and explore the effects of combinations of the ten aforementioned point mutations on immune responses to pinpoint what is responsible for the decreased immune response of SWM-\(\Delta_{1-34}\).

This work yields information important to forward development of DNA vaccine for non-vital organs, specifically for melanoma.

**LITERATURE CITED**


ACKNOWLEDGMENTS

I would like to show gratitude to Dr. Alan Houghton for the opportunity to intern in his laboratory. My mentor Manuel Engelhorn provided superior guidance and expert insight throughout my experiment. Finally, I would like to thank Memorial-Sloan Kettering Cancer Center for allowing me the occasion and facilities to conduct this experiment.

Appendix

Fig 1.  

| J | WT | M |

Legend:
J – Sweet White Magic (no signal peptide)
WT – Wild-Type Tyrp1
M - DNA Ladder

Fig. 2

| W1 | W2 | W3 | M | J1 | J2 | J3 |

Legend:
W- Wild-Type
J- Sweet White Magic
M- DNA Ladder
Fig. 3

![Graph showing Spots / 100,000 CD8+ cells for different conditions: wt mTYRP1, wt mTYRP1 delta 1-34, optimized mTYRP1, optimized mTYRP1 delta 1-34. Bars indicate irrelevant, 455 wt, and B16 comparisons.](image)
SECOND PLACE
ACIDITY AFFECTS THE RATE OF PHOTOTACTIC MOVEMENT OF *Volvox globator*

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**ABSTRACT**

*Volvox globator* are one of the smallest organisms with eyespots containing the enzymatic pigment rhodopsin. Rhodopsin absorbs photons to generate membrane permeability and utilizes ion concentration gradients to signal flagella. Flagellar signaling triggers phototactic movement, or movement towards favorable areas of light. In humans, rhodopsin transmits signals from rod cells in the eyes to the brain. The purpose of this experiment was to determine the effect of acidity on the rate of phototactic movement of *V. globator*. The hypothesis was that if acidity deviated from the control (7.0), then the rate of phototactic movement would decrease. To test this hypothesis, *V. globator* were placed in Petri dishes containing culture mediums of varying acidity (pH of 6.6, 6.8, 7.0, 7.2, and 7.4). Phototactic movement was measured in millimeters per 30 seconds (mm/30sec) using a spectoscope and a grid beneath the Petri dish. Ten trials were conducted for each independent variable level, with each *V. globator* as one trial. The research hypothesis was supported and the null hypothesis rejected at the 0.05 level of significance by use of ANOVA. The major finding of this experiment was that the rate of phototactic movement of *V. globator* varied quadratically with changes in acidity, having a peak of 2.4 millimeters per 30 seconds at the control level (7.0). The parabolic trend that best fit the data is typical of enzymes. Given that rhodopsin is an enzyme and the primary controller of phototactic movement in *V. globator*, it can be concluded that this trend was caused by differing hydrogen ion concentrations and their effect on rhodopsin’s ability to transmit signals to the flagella. These results affirm the benefits of optical medications held at a neutral acidity level and pose implications for diseases caused by damaged or sparse rhodopsin, such as night blindness.

THIRD PLACE

**THE EFFECT OF DIFFERENT CONCENTRATED ANESTHETICS ON THE GROWTH OF* Escherichia coli***

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**ABSTRACT**

The purpose of this experiment was to determine if different concentrations of various local anesthetics, Marcaine, Naropin, and Lidocaine, have an effect in resisting the bacteria *Escherichia coli*. The independent variable was the different concentrated local anesthetics and the dependent variable was the growth of *Escherichia coli* measured by zones of inhibition. Twenty sterile, absorbent paper discs were soaked in 0.5% Marcaine and placed onto agar plates previously swabbed with the bacteria *Escherichia coli*. This process was then repeated for the other six levels of the independent variable. The plates incubated for twenty-four hours at room temperature, after which, the zones of inhibition of the discs were measured in millimeters and recorded and t-tests were performed. The results showed that all three anesthetics had a significant effect in reducing *Escherichia coli* in comparison to the control and that lesser concentrations of the anesthetics led to smaller zones of inhibition. The researcher’s hypothesis was supported in the sense that 0.5% Marcaine contained the greatest mean zone of inhibition at 4.15mm. All of the results in the experiment were statistically significant, except for that of 2.0%
Lidocaine versus 1.0% Lidocaine. The most likely explanation for this is due to different practical uses of Lidocaine as an anesthetic. The explanation for 0.5% Marcaine being the most bactericidal is due to its high cardiotoxicity. Practical applications include the use of one anesthetic over the other and the possibility to reduce drug concentrations, and thus adverse effects, while maintaining the same effects as full strength.

HONORABLE MENTION

THE EFFECT OF ULTRAVIOLET LIGHT ON THE SURVIVAL OF BACTERIA

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ABSTRACT

This experiment was designed to test ultraviolet light’s effect on the survival rate of bacteria. Bacterial populations exposed to ultraviolet (UV) light over short time durations were hypothesized to have lower survival rates than bacterial populations exposed to similar intensities of UV light over longer time durations. To test this hypothesis, twenty-five agar plates coated with serratia marcescens D1 bacteria were divided into five groups of five plates each. Half of each plate was covered by aluminum foil blocking the UV light, protecting a control group of bacteria underneath it, while the other half of the plate remained uncovered, exposing the experimental group of serratia marcescens D1. Each group of plates was then placed under an ultraviolet light for variable durations of time. The five plates in Group 1 were exposed to UV light for 15 seconds, with subsequent groups remaining under UV light for durations that exceeded the exposure time of the previous group by 200%. The longest time of exposure to UV light was 240 seconds (Group 5). The amount of bacteria was calculated by estimating the total area covered by bacterial colonies within 16 squares per half an agar plate. The number of squares containing amounts of bacteria on the experimental half was divided by the number of squares with amounts of bacteria on the control half. The decimal was subtracted from 1.00 to determine the percentage of bacteria killed by exposure to UV light. Using this method, Group 1 had a bacterial reduction of 68%, Group 2’s bacterial reduction was 81%, Group 3’s population was reduced by 87%, Group 4’s bacteria diminished by 92%, and Group 5’s reduction stood at 86%. The hypothesis was rejected because the group exposed to the least amount of UV light (Group 1) had the most bacterial colonies post-exposure. Group 4 had the least amount bacterial colonies and the highest reduction. This would suggest longer time exposures to UV light were more detrimental to the survival of serratia marcescens D1 bacteria than shorter UV light exposures.

HONORABLE MENTION

THE EFFECT OF DIFFERENT TYPES OF TOOTHPASTE ON ORAL BACTERIAL GROWTH

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ABSTRACT

Oral bacteria cause many diseases, from periodontal disease to heart attacks. To help kill these bacteria, toothpaste is used for oral hygiene by removing plaque and food. To study which toothpaste is the most efficient in killing the oral bacteria, four different Colgate toothpastes were tested to inhibit the growth of oral bacteria, exclusively *Streptococcus sanguinis*. It was hypothesized that due to the presence of Triclosan in Total Whitening, it may inhibit more oral bacterial growth than the other toothpastes. The two ways this experiment was conducted: (1) by measuring the diameter of the zones of inhibition of oral bacteria and *S. sanguinis* growth around the filter paper...
disks, containing different toothpaste solutions, and (2) by counting oral bacterial colonies after application of different toothpaste solutions. After 48 hours, the zones of inhibition (of the oral bacterial growth and the *S. sanguinis*) of Luminous and MaxFresh were about the same size. Cavity Protection could not inhibit the bacterial growth effectively. But, Total Whitening made the largest zones of inhibition. After 48 hours of incubation with different toothpaste solutions, very few colonies were found in the plates of Total Whitening. But there were too many colonies were found in the plates of the other toothpastes and control (Phosphate Buffer Saline, pH 7.4). In conclusion, Total Whitening worked the most efficient, because of its active ingredient, Triclosan, which helps reduce plaque and gingivitis. Through this experiment, it is confirmed that Total Whitening provides long-lasting anti-bacterial protection of the human teeth.

**HONORABLE MENTION**

**THE EFFECT OF TIME EXPOSED TO ULTRAVIOLET RADIATION ON THE DISTANCE TRAVELED BY *C. elegans***

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**ABSTRACT**

Although ultraviolet radiation is invisible to the human eye, ultraviolet rays are much more harmful then they may seem. In fact, by directly damaging DNA molecules, ultraviolet rays can cause abnormal structures in DNA, thereby increasing the possibility of mutations in cells. *Caenorhabditis elegans*, a nematode worm, is a significant invertebrate because of the extensive knowledge concerning their complete genome. As a result, much is now known about the inner workings of *C. elegans*, including movement. The purpose of this experiment was to determine the effect of time exposed to ultraviolet radiation on the distance traveled by *C. elegans*. The hypothesis of the experiment was: if the amount of time *C. elegans* are exposed to ultraviolet radiation was increased then the distance moved by *C. elegans* would decrease. The independent variable was the amount of time exposed to ultraviolet radiation, measured in minutes. The control for the experiment was 0 minutes, and the control and all other levels of the independent variable—30, 75, 90, and 120 minutes—were each tested 30 times. The dependent variable of the experiment was the distance moved by *C. elegans*, measured in millimeters. The major finding of this experiment was that as time exposed to ultraviolet radiation increased, the distance moved by *C. elegans* decreased, until reaching a low of between 30 and 75 minutes after which it again began to increase. The data had a p-value of 0.0001 at an alpha-value of 0.05. This study suggests that increased amounts of proteins such as MAPKs and AP-1, which are involved in apoptosis, could be injected into ultraviolet radiation damaged areas of organisms to help combat the negative effects of ultraviolet radiation exposure.

**OTHER PAPERS SELECTED FOR PRESENTATION:**

Triclosan in Antibacterials and Its Effect in Leading to the Resistance of Bacteria. Fallon R. Bormann, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Various Combinations of Natural Antimicrobial Agents on the Growth of *Serratia marcescens*. Kelly R. Caine, Mills E. Godwin High School, Henrico County Schools.

Quantity of *E. coli* and Coliform on Restaurant Beverage Lemon Slices. Nicole A. Gerlich, Central Virginia Governor’s School, Lynchburg City Schools.


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The Effect of pH on the Growth of *Hydrodictyon* Algae. Matthew V. Jenny, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of a Location on Number of Bacteria Grown in a School Setting. Aaditya P. Kaushik, George H. Moody Middle School, Henrico County Schools.

The Effects of Desktop Surface Exposure Time on Bacterial Collection on Contact. Robert B. Lambeth, III, Central Virginia Governor’s School, Lynchburg City Schools.

The Effects of Dishwashing on Biofilms. Lydia B. Mansel, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Different Fabric Protection from UVC Rays on the Growth of Yeast. Adam E. Norman, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Different Cleaners on Removing *Escherichia coli*. Helen Novitsky, George H. Moody Middle School, Henrico County Schools.


The Effect of Different Concentrated Anesthetics on the Growth of *Escherichia coli*. Samuel M. Rubin, Mills E. Godwin High School, Henrico County Schools.


The Effect of Capsaicin on *Fusarium oxysporum*. Alan J. Tesh, Central Virginia Governor’s School, Lynchburg City Schools.

The Effects of Different Species of Algae on Removal of Phosphorus from an Aquatic Environment. Adam A. Underwood, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of the Amount of Bacterial Growth on the Type of Kitchen Countertop. Emily J. Worsham, Central Virginia Governor’s School, Lynchburg City Schools.

The Antibacterial Efficiency of Triclosan in Different Household Detergents. Aolin Zhang, George H. Moody Middle School, Henrico County Schools.
Abstract: HIV, the Human Immunodeficiency Virus, is known to impair levels of CD4+ T cells in the bloodstream, which are particularly vital in an immune response. Once T cells have fallen below a certain level, HIV is then considered AIDS. In this research, we used mathematical modeling as a means of better understanding the changes induced by drug therapy. The HBAMN-3 component model was used to model the dynamics of uninfected CD4+ T cells, infected CD4+ T cells, and free HIV virions in blood plasma. We plotted the solutions of the differential equations and experimented with the effects of certain parameters on the growth of HIV. Protease and Reverse transcriptase inhibitors were added to the system to observe the effect of each. The combination and number of drugs were varied, and the efficiency value of each drug was methodically manipulated. The main goal was to see which combination of drugs produced the best results in stabilizing T cell levels in the blood stream and deterring the onset of AIDS. We found that for each efficiency value, there were two possible equilibria. At or above a certain critical value for drug efficiency, the HIV afflicted system approached uninfected steady state equilibrium values, mathematically “curing” HIV. At values less than this critical value, the other equilibrium point was an attractor, and infection remained endemic with HIV only treated. The protease inhibitor proved to be more effective than the RT inhibitor in reducing viral load as was signified by a lower critical value. The HIV virion can be eradicated with drug effectiveness less than 80%, and an increase in number of drugs leads to a decrease in required efficiency. Critical values were found mathematically and graphically for all case scenarios. This research is valuable in seeing the effect of certain drug therapies on HIV dynamics. It may not be viable to experimentally test how much efficiency is needed for a drug to significantly reduce virion levels in an HIV patient, and Mathematical modeling can bypass any risks. For further research, the model could incorporate a more complex immune response.

Introduction: The Human Immunodeficiency Virus (HIV) is a virus that continuously plagues the human population and often proves to be fatal when it develops into AIDS. Thirty eight million adults and 2.5 million children were living with HIV at the end of 2007, and 2.1 million people had died from AIDS or AIDS related diseases in 2007 according to UNAIDS/WHO.

HIV is characterized as a retrovirus, and like all viruses needs a host cell to grow and reproduce. HIV attaches itself to a host cell, invades it, and proceeds to incorporate its viral DNA with the genetic code of the host’s DNA. The structure of HIV makes these processes more feasible (Tuckwell and Wan, 2004). A single HIV particle, a virion, consists of a core called the capsid, which contains two single stranded RNA, its genetic material, and three major enzymes: Reverse Transcriptase, Protease, and Integrase. The core is surrounded by structural proteins, p24, which are also encircled by additional matrix proteins, p17. The protective shell of the virion, known as the viral envelope, is a lipid bilayer consisting of embedded transmembrane gp41 glycoproteins, which are capped by extracellular gp120 glycoproteins (McKinley and O’Loughlin, 2006).

Once inside the respective host cell, viruses reproduce and multiply as part of their host cell’s mechanism. Viruses, however, do not replicate indefinitely. Rather, their activity is abated by the backbone of the body’s immune response, which consists of B and T cell lymphocytes. B cells carry antibodies, proteins, on their surfaces to bind to any foreign molecules, antigens, entering the human body. It binds to the antigen like a lock, either neutralizing it or marking it for destruction by other macrophages. Both B and T cells are equipped with specific antigen receptors located on their plasma membrane, and when antigens bind to the receptors, both cells divide and differentiate to produce effector cells, such as helper T cells, memory cells, plasma cells, and cytotoxic T cells. CD4+ T cells, which are helper T cells are particularly vital in the immune response and serve as activators of different components of the immune system including the signaling of CD8+T cells, cytotoxic cells, and B cells.
HIV, specifically, impairs levels of CD4+ T cells thereby suppressing the immune system and leaving the human body defenseless against other infectious agents (Tuckwell and Wan, 2004).

The virus life cycle paves the way for HIV infection and later, the onset of AIDS. This cycle begins with the attachment of one of the gp120 proteins to the CD4+ T cell receptor. This is accomplished with the aid of a co-receptor located on the host cell. The viral and cellular membranes of the T-cell fuse, and the genetic material and core proceed to the host cell’s interior leaving the viral envelope behind (Tuckwell and Wan, 2004). Inside the cytoplasm of the cell, Reverse Transcriptase (RT) units of virus copy viral RNA to produce DNA. RT then degrades the RNA strand and adds a complementary DNA strand to the recently produced one. The ends of the resultant double stranded DNA are joined non-covalently taking a circular form. This DNA is transferred into the nucleus and is inserted into the host cell’s genome by an enzyme, viral Integrase. This integrated viral DNA is now called proviral DNA. The proviral DNA can either remain dormant or can be synthesized by RNA polymerase to produce messenger RNA (mRNA) or more viral genome RNA. The RNA is then taken outside of the nucleus, and the mRNA is translated to produce more viral enzymes and structural proteins such as the ones described before (McKinley and O’Loughlin, 2006). Protease then cleaves the gag gene encoded long polypeptide proteins into four sub-units that later coat viral genome (Tuckwell and Wan, 2004). The gp41 and gp120 are inserted into the CD4+T cell membrane, and the newly created structural proteins surround the viral RNA to form the nuclear core. Finally, the new virion is released by budding (McKinley and O’Loughlin, 2006).

HIV undergoes three phases before officially becoming AIDS. In the first few weeks after transmission of HIV, the virus load is usually very high in the blood, and the patient exhibits flu-like symptoms. The virus then disperses to various organs in the body, and as a result, CD4+T cell counts decrease. At the end of the first phase, the virus load decreases tremendously, clinical symptoms disappear, and CD4+ T cell counts return to almost normal levels (Tuckwell and Wan, 2004).

The second phase of HIV is usually called the asymptomatic phase because very few clinical symptoms are exhibited and can range from few months to many years averaging about ten years. However, this does not mean that the virus remains latent; it continues to replicate while CD4+ T cells fall relentlessly (Tuckwell and Wan, 2004).

Many HIV patients do not enter the last phase because of a strong immune response, but if CD4+ T cells fall below 200 per $\mu L$, the patient is considered to have AIDS. With an impaired immune system, patients can no longer fight off viral infection and may even die from opportunistic infections (Tuckwell and Wan, 2004).

Much of the behavior of the natural world can be expressed in mathematical terms because they depend on relations and rates at which events occur. Equations are used to represent relations and derivatives represent rates. These types of equations are known as differential equations. The factors that describe a physical process are collectively known as mathematical modeling. This is particularly useful in studying the behavior of phenomena that are beyond experimental limitations. Many mathematical models based on a system of differential equations have been developed to study the viral dynamics and epidemiology of HIV.

One such model is the HBAMN 3-component HIV Model. This basic model consists of uninfected CD4+ T cells, infected CD4+ T cells, and free HIV virions in the plasma. The size (in unit of biomass) of each of these factors at a certain time $t$ can be signified by $x(t)$, $y(t)$, and $v(t)$, respectively (Tuckwell and Wan, 2004). Transcribing the dynamics of these quantities into mathematical relations results in the following system:

(1) $x' = s - \mu x - kxv$
(2) $y' = kxv - ay$
(3) $v' = cy - \gamma v - kxv$

Here, $s$ is the rate of production of uninfected CD4+ T cells in the body at a given time $t$, $\mu$ is the per capita death rate, $kxv$ is the infection rate by a virion, $a$ is the disappearance rate of infected cells, $c$ is the rate at which infected cells produce new virions in the plasma, and $\gamma$ is the death rate of HIV virions. Often the last term in the third equation is eliminated because it does not have significant effects on HIV dynamics. After virions begin manipulation of previously uninfected cells, those virions are no longer available to infect other cells. As a result, $v$
decreases at the same time as \( x \) decreases, and the equation can be rewritten as follows: 
\[
(3A) \quad \frac{dv}{dt} = cy - \gamma v
\]
(Tuckwell and Wan, 2000).

In the last couple of decades, many medical treatments for HIV have been proposed. The purpose of these medical practices is to prescribe highly active antiretroviral therapy to reduce viral load and to sustain high amounts of CD4+ T cells (Banks et al., 2005). Mathematical models can be used to analyze the changes in parameters these therapy drugs induce in order to control viral population dynamics. The two major drugs used in mathematical modeling are the reverse transcriptase inhibitors and the protease inhibitors. RT inhibitors are typified by the AZT (zidovudine) class. These drugs bind HIV encoded RT enzymes and prevent viral RNA from turning into DNA, thus preventing synthesis of more HIV virions and disabling the infection of CD4 cells by the virus. Protease inhibitors prevent gag-encoded inner core protein from being cleaved. As a result, the virus’s genetic material lacks a coat and newly created virions are noninfectious and cannot function properly (Perelson and Nelson, 2000).

Since RT inhibitors disable the infection of CD4+ T cells by the virus, they induce changes in the \( k \) parameter of the HBAMN – 3 component model causing RT to be less than 100% effective. Thus, the RT inhibitor causes the infection rate to change from \( k \) to \((1-r)k\), where \( r \) represents the efficiency of the drug. An \( r \) value of 1 exemplifies a 100% effective drug, which results in the eradication of the \( k \) term. Likewise, the protease inhibitor produces noninfectious virions from already infected cells. This causes the \( c \) parameter to vary in the HBAMN model. In this case, the rate of production of infected cells is reduced from \( c \) to \((1-q)c\), where \( q \) is the efficiency of the Protease inhibitor (Tuckwell and Wan, 2000). Hence, the HBAMN model can be rewritten to form a new system:

\[
(4) \quad \frac{dx}{dt} = s - \mu x -(1-r)k vx
\]
\[
(5) \quad \frac{dy}{dt} = (1-r)k vx - ay
\]
\[
(6) \quad \frac{dv}{dt} = (1-q)cy - \gamma v -(1-r)k vx
\]

In this research project, we will examine the HBAMN model for HIV dynamics in the blood stream. Then, by varying parameters of this pre-existing model, we will analyze the effect of multi-drug strategies involving a combination of three or more drugs known as “cocktails” on the optimal control of HIV and any steady states it may have. Surpassing barriers of physical limitations, we will see the effect these drugs have on lowering viral load and stabilizing amounts of CD4+ T cells. By doing so, we will see which combination of cocktail drugs produces the best results in deterring the development of AIDS.

**Methods and Materials:** Numerical Simulation using Mathematica®, a Computer Algebra System, was used to generate solution curves provided by respective differential equations. The system of differential equations typified by the HBAMN 3-component model was plotted using the following standard parameter values (Tuckwell and Wan, 2000): \( s = 0.272/\text{day/mm}^3 \), \( \mu = 0.00136/\text{day/mm}^3 \), \( k = 0.00027/\text{day/(virion/mm}^3) \), \( a = 0.33/\text{day/mm}^3 \), \( c = 50/\text{virion/CD4/day} \), \( \gamma = 2.0/\text{day} \). Each solution curve for \( x(t) \), \( y(t) \), \( v(t) \) was plotted separately as a function of \( t \). An additional curve, \( x(v) \), was plotted with \( x \) being a function of \( v \) [See APPENDIX B, code 1]. The parameters were varied to see the effect of each one on the uninfected and infected CD4+ T cell levels and virion levels. The Protease and RT inhibitors were then added separately to the system to see the effect of each on the stabilization of T-cell levels. The effectiveness of the drugs was varied by increasing and decreasing the \( r \) and \( q \) parameter values.

The two graphs for HIV dynamics were then combined one lacking drug treatment and one with treatment present. The two different equations were displayed on the same \( x(t) \) graph with different bounds; the original HBAMN 3-component system set from 0 to 2000 days and the inhibited system set from 2000 to 5000 days [See
APPENDIX B, code 2, code 3]. This way the effect of each drug on HIV dynamics can be clearly seen when the
drug perturbs the system 2000 days after infection. Two cases for each inhibitor were studied. In the first case, the
inhibitor “cured” HIV by allowing CD4 levels to reach original, equilibrium values [See APPENDIX B, graph 4]. In
the second one, the inhibitor treated HIV by increasing CD4 levels, but wasn’t strong enough to eradicate infection
completely. Therefore, infection still remained endemic after application of the treatment [See APPENDIX B, graph 3].

Both inhibitors were then added to the same system to observe the combining effect of the two drugs [See
APPENDIX B, code 4]. Two protease inhibitors were added to the system, and two RT inhibitors were added to
another system. The system was then manipulated by changing the $r$ and $q$ values methodically. Cocktail drugs
were then studied by adding multiple drug strategies to the system. The first one studied was a three drug
combination known as a triple cocktail. This combination consisted of two nucleoside-analogue RT inhibitors and
one protease inhibitor [See APPENDIX B, code 5]. The number of drugs involved was then increased, and their
effects were observed. Other cases observed were: a triple cocktail with two protease inhibitors and one RT, three
protease inhibitors, and three RT inhibitors.

**Results:** Our main goal was to allow the drug to perturb the infected system and allow T-cell level counts
to approach the original uninfected steady state values. This is when the virion count, $v$, and infected T-cell level, $y$,
both approach zero indicating eradication of HIV. We found the steady state configurations for the 3-component
model in order to find the value of each variable when equilibrium is reached subsequent to infection. Each
differential equation was set equal to zero, and the system of equations was solved [See APPENDIX A]. This
system had two possible equilibrium points: $P_1 = \left(\frac{s}{\mu}, 0, 0\right)$ and $P_2 = \left(\frac{a\gamma}{k(c-a)}, \frac{s}{a}, \frac{\mu\gamma}{k(c-a)}, \frac{s(c-a)-\mu}{a\gamma} \right)$. Using
the standard parameters listed before, $P_1$ is now $\{200,0,0\}$ and $P_2$ is now $\{49.2137, 0.621422, 15.433\}$. This
indicates that 200 is the uninfected T cell equilibrium value. However, once a biological system is allowed to reach
equilibrium after HIV infection, T cell level counts in the blood stream approach 49.2137 [See APPENDIX B, graph 2]. This is when a drug is needed to prevent T cell numbers from dropping to AIDS inducing levels. After
adding the protease inhibitor and RT inhibitor separately to the system, it was observed that the protease inhibitor
was slightly more effective than the RT inhibitor. The system with the protease inhibitor approached a slightly larger
steady state value for $x$ than the one with the RT inhibitor [See APPENDIX B, graph 3, graph 5]. We found that on
addition of each drug, the drug didn’t necessarily need an effectiveness of 1 to eradicate virus completely. For each
efficiency, there were two equilibrium points: one being the original uninfected steady state value and the other
being a new equilibrium value [See APPENDIX B, graph 3, graph 4]. After manipulating the model, we found that
the graph approached the uninfected equilibrium values after a certain critical value was surpassed. For any
efficiency less than that value, the other equilibrium point would be the attractor point. In this case, HIV isn’t really
“cured”, but can be considered to be treated, and infection still remains endemic. We found the respective critical
values for each drug using the model and calculating it mathematically [See APPENDIX C]. In the model, we varied
the efficiency value until both equilibrium points equaled the original uninfected steady state value. For the RT
inhibitor, the critical value occurred at 0.754 and for the protease inhibitor, it occurred at 0.749. The critical value is
slightly higher in the RT inhibitor also indicating that the protease inhibitor is slightly more effective.

In order for the equilibrium point to be physically meaningful, the following inequality must be satisfied:
$s(kc-a) > \mu\gamma$. If this inequality holds true, then the new equilibrium point is the attractor. If it is reversed, then
the point is physically meaningless and $P_1$ is the attractor point while the new equilibrium point is a saddle point. In
reality, this is the desirable outcome. In terms of our model, T cell values cannot physically surpass 200, so when
this happens, the system will be forced to just approach 200.

We studied additional drug strategies, and found respective critical values graphically and mathematically
[See APPENDIX C].

**Discussion and Conclusion:** This research studied the HBAMN-3 component model and the effects
induced by cocktail drugs on the system. Solution curves were effectively modeled, and the effect of increasing the
number of drugs on the system was clearly seen. Individual protease and RT inhibitor drugs can be added to the
system with an effectiveness of less than 80% to eradicate virus completely. With the increase in number of drugs, the effectiveness of each drug becomes significantly lower. It may not be as feasible to procure a drug with as high an efficiency, but a combination of drugs with lower efficiency produces just as effective results. Also, it may not be viable to experimentally test how much efficiency is needed for a drug to significantly reduce virion levels in an HIV afflicted patient. Through mathematically modeling, the respective critical values for various combinations of drugs were found, and it can be assumed that HIV is mathematically cured at or above these efficiency values provided that the HBAMN model accurately portrays our body’s immune system. When treating HIV, a combination of protease inhibitors is slightly more effective than a combination of RT inhibitors. As the number of protease inhibitors increase, the difference in effectiveness of the two inhibitors is much more dramatic. For further research, the model could incorporate a more complex immune response. The HBAMN model considers a somewhat simplistic model compared to what goes on in our bodies. The critical values could be found under this more complex system.

LITERATURE CITED


APPENDIX A

Steady State Configurations for 3-component model

\[ x' = y' = v' = 0 \Rightarrow 3 \text{ possible equilibria} \]

\[ v' = cy - \gamma v - kxv \]
\[ 0 = cy - \gamma v - kxv \]
\[ cy = \gamma v + kxv \]
\[ cy = v(\gamma + kx) \]
\[ \frac{cy}{\gamma + kx} = v \]

\[ y' = kxv - ay \]
\[ 0 = kx \left( \frac{cy}{\gamma + kx} \right) - ay \]
\[ 0 = y \left( \frac{kxc}{\gamma + kx} - a \right) \]
\[ y = 0 \quad \therefore v = 0 \]
\[ x' = s - \mu x - kxv \]
\[ 0 = s - \mu x - kxv \quad (v = 0) \]
\[ s = \mu x \]
\[ x = \frac{s}{\mu} \]
\[ P_1 = \left( \frac{s}{\mu}, 0, 0 \right) \]
\[
\frac{kxc}{\gamma + kc} - a = 0
\]

\[
\frac{kxc}{\gamma + kc} = a
\]

\[
kxc = a\gamma + akx
\]

\[
kxc = akx = a\gamma
\]

\[
x(akc - ak) = a\gamma
\]

\[
x = \frac{a\gamma}{k(c-a)}
\]

\[
0 = s - \mu x - kx
\]

\[
0 = s - \mu \left(\frac{a\gamma}{k(c-a)}\right) - k \left(\frac{a\gamma}{k(c-a)}\right) \left(\frac{cy}{\gamma + kx}\right)
\]

\[
0 = s - \mu \left(\frac{a\gamma}{k(c-a)}\right) - y \left(\frac{ayc}{c-a}(\gamma + kx)\right)
\]

\[
y = \left[s - \mu \left(\frac{a\gamma}{k(c-a)}\right)\right]\left(\frac{(c-a)(\gamma + kx)}{ayc}\right)
\]

\[
y = \frac{s(c-a)(\gamma + kx) - \mu(\gamma + kx)}{ayc}
\]

\[
y = \frac{s(c-a)(\gamma + a\gamma/c-a) - \mu(c + a\gamma/c-a)}{kc}
\]

\[
y = \frac{s(c-a)(\gamma + a\gamma/c-a) - \mu(c + a\gamma/c-a)}{ayc}
\]

\[
y = \frac{s - \mu y}{a} \frac{y}{k(c-a)}
\]

\[
v = \frac{cy}{\gamma + kx}
\]

\[
v = \frac{cy}{\gamma + a\gamma/c-a} = \frac{s - \mu y}{a} \frac{y}{k(c-a)}
\]

\[
v = \frac{s(c-a)}{a} \frac{y}{k(c-a)} - \frac{\mu y}{k}
\]

\[
P_{2^*} = \left(\frac{a\gamma}{k(c-a)}\right) \left(\frac{s - \mu y}{a} \frac{y}{k(c-a)} \left(\frac{s(c-a)}{a} \frac{y}{k(c-a)} - \frac{\mu y}{k}\right)\right)
\]
APPENDIX B

HBAMN-3 component model (Mathematica code 1)

\[\begin{align*}
&a = 0.33; \\
&k = 0.00027; \\
&\mu = 0.00136; \\
&\gamma = 2; \\
&S = 0.272; \\
c = 50; \\
\end{align*}\]

(standard parameter values used for all codes)

\[\begin{align*}
&b = 0; \\
p = 5000; \\
s = 2150000; \\
\end{align*}\]

\[\begin{align*}
eqn &= \{x'[t] = S - \mu x[t] - k v[t] x[t], \ y'[t] = k v[t] x[t] - a y[t], \ v'[t] = c y[t] - \gamma v[t] - k v[t] x[t], \\
&x[0] == 200, y[0] == 0, v[0] == 0.0000004; \}
\end{align*}\]

\[\begin{align*}
tb &= \text{NDSolve}[\text{eqn}, \{x, y, v\}, \{t, b, p\}, \text{MaxSteps} \to s]; \\
\text{ParametricPlot}[\text{Evaluate}[\{v[t], x[t]\} /. tb], \{t, b, p\}, \text{AxesLabel} \to \{\text{viron level}, \text{uninfected CD4}\}, \text{PlotStyle} \to \text{RGBColor}[0, 1, 1], \text{PlotRange} \to \text{All}]; \\
\text{viron} &= \text{Plot}[\text{Evaluate}[v[t] /. tb], \{t, p, b\}, \text{PlotRange} \to \text{All}, \text{PlotStyle} \to \text{RGBColor}[1, 0, 0], \text{AxesLabel} \to \{t, \text{viron level}\}]; \\
\text{cd4} &= \text{Plot}[\text{Evaluate}[x[t] /. tb], \{t, p, b\}, \text{PlotRange} \to \text{All}, \text{PlotStyle} \to \text{RGBColor}[0, 1, 1], \text{AxesLabel} \to \{t, \text{uninfected CD4 level}\}]; \\
\text{infected} &= \text{Plot}[\text{Evaluate}[y[t] /. tb], \{t, p, b\}, \text{AxesLabel} \to \{t, \text{infected CD4}\}, \text{PlotRange} \to \text{All}, \text{PlotStyle} \to \text{RGBColor}[0, 0, 1]]; \\
\text{Show}[\{\text{viron}, \text{cd4}, \text{infected}\}]; \\
\text{NSolve}[\{0 = S - \mu x - k v x, 0 = k v x - a y, 0 = c y - \gamma v - k v x\}, \{x, y, v\}] \\
\end{align*}\]

HBAMN-3 component model with RT inhibitor (code 2)

(Additional parameter values to standard ones listed above)

\[\begin{align*}
&b = 0; \\
p = 2000; \\
b1 = 2000; \\
p1 = 9000; \\
s = 2150000; \\
r = 0.62; \text{(this value is variable, efficiency of drug)} \\
\end{align*}\]

\[\begin{align*}
eqn &= \{x'[t] = S - \mu x[t] - k v[t] x[t], \ y'[t] = k v[t] x[t] - a y[t], \ v'[t] = c y[t] - \gamma v[t] - k v[t] x[t], \\
&x[0] == 200, y[0] == 0, v[0] == 0.0000004; \}
\end{align*}\]
tb = NDSolve[eqn, \{x,y,v\}, \{t,b,p\}, MaxSteps \to s]

eqn1 = \{x'[t] == S - \mu x[t] - (1-r)* k v[t]*x[t], y'[t] == k v[t]*x[t] - a y[t], v'[t] == c y[t] - \gamma v[t] - k v[t] x[t],
\ x[0] \to 2070, y[0] \to 0, v[0] \to 0.5\};

tb1 = NDSolve[eqn1, \{x,y,v\}, \{t,b1,p1\}, MaxSteps \to s]

cd4 = Plot[Evaluate[x[t]/.tb], \{t,b,p\}, PlotRange \to \text{All}, PlotStyle \to \text{RGBColor[1,0,1]}, AxesLabel \to \text{"t","uninfected CD4 level"}]

cd4tr = Plot[Evaluate[x[t]/.tb1], \{t,b1,p1\}, PlotRange \to \text{All}, PlotStyle \to \text{RGBColor[1,0,1]}, AxesLabel \to \text{"t","uninfected CD4 leveltr"}]

Show[\{cd4,cd4tr\}]

fp = NSolve[\{0 == S - \mu x - k v x, 0 == k v x - a y, 0 == c y - \gamma v, 0 == k v x\}, \{x,y,v\}]

fptreatment = NSolve[\{0 == S - \mu x - (1-r)k v x, 0 == (1-r)k v x - a y, 0 == c y - \gamma v - (1-r)k v x\}, \{x,y,v\}]

HBAMN-3 Component model with Protease Inhibitor (code 3)
(Additional parameter values to standard ones listed above)

\(b=0;\)
\(p=2000;\)
\(b1=2000;\)
\(p1=5000;\)
\(s=2150000;\)
\(q=.76;\) (this value is variable, efficiency of drug)

\[eqn=\{x'[t] == S - \mu x[t] - k v[t]*x[t], y'[t] == k v[t]*x[t] - a y[t], v'[t] == c y[t] - \gamma v[t] - k v[t] x[t],\]
\[x[0] \to 2070, y[0] \to 0, v[0] \to 0.0004\};
\]

\(tb = \text{NDSolve[eqn, \{x,y,v\}, \{t,b,p\}, MaxSteps \to s]};

\(eqn1=\{x'[t] == S - \mu x[t] - k v[t]*x[t], y'[t] == k v[t]*x[t] - a y[t], v'[t] == (1-q)*c y[t] - \gamma v[t] - k v[t] x[t],\]
\[x[0] \to 2070, y[0] \to 0, v[0] \to 0.5\};
\]

\(tb1 = \text{NDSolve[eqn1, \{x,y,v\}, \{t,b1,p1\}, MaxSteps \to s]};

cd4 = Plot[Evaluate[x[t]/.tb], \{t,b,p\}, PlotRange \to \text{All}, PlotStyle \to \text{RGBColor[0,1,0]}, AxesLabel \to \text{"t","uninfected CD4 level"}]

cd4tr = Plot[Evaluate[x[t]/.tb1], \{t,b1,p1\}, PlotRange \to \text{All}, PlotStyle \to \text{RGBColor[0,1,0]}, AxesLabel \to \text{"t","uninfected CD4 leveltr"}]

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HBAMN-3 Component model with both inhibitor drugs (code 4)

\[ f_{\text{p}} = \text{NSolve}[0 == S - \mu x - k v x, 0 == k v x - a y, 0 == c y - \gamma v, 0 == k v x, \{x, y, v\}] \]

\[ f_{\text{p}}^{\text{treatment}} = \text{NSolve}[0 == S - \mu x - k v x, 0 == k v x - a y, 0 == c y - \gamma v - k v x, \{x, y, v\}] \]

Uninfected CD4+ T cell level with \( q = 0.62 \)

HBAMN-3 Component model with triple cocktail drug treatment (2 RT inhibitors with 1 Protease) (code 5)

\[ b = 0; \]

Generated through Mathematica®
p=2000;
b1=2000;
p1=5000;
s=2150000;
d=.2; (variable, efficiency of one RT inhibitor)
j=.2; (variable, efficiency of other RT inhibitor)
q=.6114; (variable, efficiency of protease inhibitor)

$$\text{eqn} = \{ \frac{dx}{dt} = S - \mu x(t) - k v[t] x[t], \quad \frac{dy}{dt} = k v[t] x[t] - a y[t], \quad \frac{dv}{dt} = c y[t] - \gamma v[t] \}$$

$$\text{tb} = \text{NDSolve}[\text{eqn}, \{x, y, v\}, \{t, b, p\}, \text{MaxSteps} \rightarrow s]$$

$$\text{eqn1} = \{ \frac{dx}{dt} = S - \mu x(t) - (1-j)(1-d) k v[t] x[t], \quad \frac{dy}{dt} = (1-j)(1-d) k v[t] x[t] - a y[t], \quad \frac{dv}{dt} = (1-q) c y[t] - \gamma v[t] \}$$

$$\text{tb1} = \text{NDSolve}[\text{eqn1}, \{x, y, v\}, \{t, b1, p1\}, \text{MaxSteps} \rightarrow s]$$

cd4 = Plot[Evaluate[x[t]/.tb],\{t,b,p\},PlotRange\rightarrow All,PlotStyle\rightarrow RGBColor[1,0,1],AxesLabel\rightarrow \{"t","uninfected CD4 level"\}]

cd4tr = Plot[Evaluate[x[t]/.tb1],\{t,b1,p1\},PlotRange\rightarrow All,PlotStyle\rightarrow RGBColor[1,0,1],AxesLabel\rightarrow \{"t","uninfected CD4 leveltr"\}]

Show[\{cd4,cd4tr\}]

fp = NSolve[\{0== S - \mu x - k v x, \quad 0== k v x - a y, \quad 0== c y - \gamma v \}, \{x,y,v\}\}

fptreatment = NSolve[\{0== S - \mu x - (1-j)(1-d)*k v x, \quad 0== (1-j)(1-d)*k v x - a y, \quad 0== (1-q)*c y - (1-j)(1-d)*k v x \}, \{x,y,v\}\]
APPENDIX C

Calculating critical values

In order for critical values to be reached, \( y \) and \( v \) must equal zero

\[
\frac{s}{a} \cdot \frac{\mu y}{k(c-a)} = \frac{sk(c-a)}{ak(c-a)} - \frac{\mu ay}{ak(c-a)} = \frac{sk(c-a) - \mu ay}{ak(c-a)} = 0
\]

\[
sk(c-a) - \mu ay = 0
\]

\[
sk(c-a) = \mu ay \quad \text{(critical value under this condition)}
\]

Now, we can add the drugs.

With RT inhibitor:

\[
sk(1-r)(c-a) = \mu ay
\]

\[
1-r = \frac{\mu ay}{sk(c-a)}
\]

\[
r_c = 1 - \frac{\mu ay}{sk(c-a)}
\]

\[
r_c = .754
\]

With Protease inhibitor:

\[
sk[(1-q)c-a] = \mu ay
\]

\[
sk(1-q)c - ask = \mu ay
\]

\[
sk(1-q)c = \mu ay + ask
\]

\[
1-q = \frac{\mu ay + a}{skc} + \frac{a}{c}
\]

\[
q_c = 1 - \frac{a}{c} \left[ \frac{\mu y}{sk} + 1 \right]
\]

\[
q_c = .749
\]

With both inhibitors:

\[
sk(1-r)[(1-q)c-a] = \mu ay
\]

\[
(1-r)[(1-q)c-a] = \frac{\mu ay}{sk}
\]

\[
(1-r)(1-q)c - a(1-r) = \frac{\mu ay}{sk}
\]

\[
(1-r)(1-q)c = \frac{\mu ay}{sk} + a(1-r)
\]

\[
1-q = \frac{\mu ay}{skc(1-r)} + \frac{a}{c} = \frac{a}{c} \left[ \frac{\mu y}{sk(1-r)} + 1 \right]
\]

\[
q_c = 1 - \frac{a}{c} \left[ \frac{\mu y}{sk(1-r)} + 1 \right]
\]

(critical values of efficiency \( q \) for given efficiency \( r \))
## Critical values table (table 1)

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<td>.644</td>
<td>.617</td>
<td>.586</td>
<td>.549</td>
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</table>

<table>
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<table>
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<td>.585</td>
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<tbody>
<tr>
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<td>.25</td>
<td>.3</td>
<td>.35</td>
<td>.4</td>
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<th>.3</th>
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<tr>
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<td>.25</td>
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<td>.35</td>
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### Triple Cocktail - 2 RTs and 1 Protease

\[
q_c = 1 - \frac{a}{c} \left[ \frac{\mu \gamma}{sk(1-r_1)(1-r_2)} + 1 \right]
\]

(critical values of efficiency \( q \) for given efficiency \( r_1 \) and \( r_2 \))

Mathematica code: critical=NSolve[((1-d)*(1-j)*(1-q)*c-a)-((\( \mu \)\( a \)*\( \gamma \))/(k*S))\( \leq \)0,Q]

### Triple Cocktail - 2 Proteases and 1 RT

To find critical value \( r \) with given \( q_1 \) and \( q_2 \):

Mathematica code: critical=NSolve[((1-D)*((1-j)*(1-q)*c-a))-(((\( \mu \)\( a \)*\( \gamma \))/(k*S))\( \leq \)0,D]

Where \( j \), \( q \), and \( D \) are \( q_1 \), \( q_2 \), and \( r \), respectively.

### Triple Cocktail - 3 Proteases

To find critical value \( q_3 \) with given value of \( q_1 \) and \( q_2 \):

Mathematica Code: critical=NSolve[((1-D)*((1-j)*(1-q)*c-a))-((\( \mu \)\( a \)*\( \gamma \))/(k*S))\( \leq \)0,D]

Where \( j \), \( q \), and \( D \) are \( q_1 \), \( q_2 \), and \( q_3 \), respectively.
**Triple Cocktail- 3 RTs**

To find critical value $r_3$ with given value of $r_1$ and $r_2$:

Mathematica Code: `critical=NSolve[((1-Q)*(1-d)*(1-j)*(c-a))-((\mu*a*\gamma)/(k*S))==0,Q]`

Where $j$, $d$, and $Q$ are $r_1$, $r_2$, and $r_3$, respectively.

**2 Proteases**

To find critical value $q_2$ with given value of $q_1$:

Mathematica Code: `critical=NSolve[((1-j)*(1-Q)*c-a)-((\mu*a*\gamma)/(k*S))==0,Q]`

Where $j$ and $Q$ are $q_1$ and $q_2$, respectively.

**2 RTs**

To find critical value $r_2$ with given value of $r_1$:

Mathematica Code: `critical=NSolve[((1-d)*(1-J)*(c-a))-((\mu*a*\gamma)/(k*S))==0,J]`

Where $d$ and $J$ are $r_1$ and $r_2$, respectively.
SECOND PLACE

SWITCHABLE NUMBERS

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ABSTRACT

The focus of this paper is subtraction cases of the form a-b=c, in which the minuend (a), the subtrahend (b), and the difference (c), all contain the same digits appearing the same number of times. An example of such a subtraction case is 954-459=495. The objective of this paper was to determine some of the properties characteristic to the numbers involved in these subtraction cases, and to find out how the numbers are distributed along the real number line. Throughout this paper the minuends of these subtraction cases will be referred to as switchable numbers. First, subtraction cases involving base-10 numbers were examined by algebraic means. It was found that divisibility by nine is a requirement for each of the numbers in one of these subtraction cases. Next, this was generalized for three digit numbers in base-B by a similar manner. It was discovered that for a number of any given length in base-B to be part of a subtraction case described above, it must be divisible by B-1. Finally, a computer program was developed in Java to find subtraction cases, and its output analyzed for cases with minuends less that 400,000. When the consecutive spaces between the minuends generated by the program were analyzed graphically, no specific pattern was visible. This seemed to suggest that the minuends of these subtraction cases follow a random distribution along the real number line. However, a linear regression seemed to approximate the number of minuends less than a certain value fairly well, resulting in a high r squared value of 99.5%.

THIRD PLACE

FINDING THE TRAVEL TIME BETWEEN PLANETS USING HOHMANN TRANSFERS AND A GRAVITATIONAL SLINGSHOT

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

The purpose of this study was to estimate the time of travel necessary to reach each of the planets in the solar system. Processes included multiple Hohmann transfers and one gravitational slingshot at Jupiter to reach the further planets of the solar system. Then, the Hohmann transfer was again applied to the nearer planets of Venus and Mercury and the travel times to those planets were also calculated. Results showed that traveling from Earth to Mars and from Mars to Jupiter required approximately 3.789 years. A gravitational slingshot was analyzed using the vector method of Bartlett and Hord to determine the exit velocity of a shuttle that was slingshot from Jupiter. This velocity was assumed constant and carried to the furthest extent of the solar system to determine the time necessary to reach the furthest planets under the assumption that the planets have a circular orbit. Several assumptions throughout the model restrict the true applicability of the findings; however, the accuracy of the Hohmann transfer is appropriately noted. Further research includes an economical comparison between using several Hohmann transfers or by using a gravitational assist to reach the desired destination. Additionally, calculus could be applied to correctly model how the velocity of a shuttle changes as the proximity to the sun decreases. Also possible for further research is the modification of the paper’s model to fit the true elliptical orbit of the planets.
HONORABLE MENTION

INVESTIGATIONS INTO THE CELLULAR TURING MACHINE: EXPLORING THE LIMITS OF MASSIVE PARALLELISM

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Mathematics and Science High School at Clover Hill, Midlothian, Virginia 23112

ABSTRACT

According to the Church-Turing thesis, developed in the 1930s, the Turing Machine (TM) is the mathematical embodiment of all computable processes. Physically impossible singular TM models more powerful than TMs, known as hypercomputers, have been proposed, along with models of multiple TMs operating on the same dataset- but such 'parallel' models are no more powerful than normal TMs. In this paper, the Cellular Turing Machine (CTM), the embodiment of the limit of massive parallelism- infinite processors- a countably infinite one-dimensional array of TMs serving as both data storage units and processors, is proposed. The power of the CTM is demonstrated by a definition of a CTM which solves the Post Correspondence Problem, an uncomputable decision problem which, given two sets of strings $X$ and $Y$ over the same alphabet, asks whether a sequence $i_0...i_n$ such that $X_{i_0}...X_{i_n} = Y_{i_0}...Y_{i_n}$ exists. Furthermore, a runtime analysis of the CTM over the membership algorithm for the language $L=\{a^n b^n\}$ is performed and shown to execute in $O(1)$ time, compared to $O(n^2)$ time on a regular TM, demonstrating the CTM's hypercomputational abilities, as well as its ability to compute computable functions in much less time than normal TMs.
THE EFFECT OF POLYSUBSTITUTED BROMINATED PYRROLE COMPOUNDS ON THE PRODUCTION OF TUMOR NECROSIS FACTOR (TNF) BY MACROPHAGES

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Douglas S. Freeman High School, Richmond, Virginia 23229

Abstract: Macrophages are one of the most important cells that aid the immune system in its crusade against harmful pathogens. Upon infection, macrophages are able to detect foreign invaders and destroy, or at least inhibit the spread of microbes. As part of the immediate cell response, macrophages are stimulated by the presence of pathogens and secrete proteins called cytokines. There are many types of cytokines, but one of the most important is tumor necrosis factor (TNF). In this study, a murine macrophage cell line was cultured and treated with varying amounts of polysubstituted pyrrole. This synthetically synthesized compound has had success in inhibiting the growth of tumor cells. The goal of the experiment was to determine whether this compound had any effects on the production of TNF. After performing an ELISA detecting TNF, the results indicated that as the dose of the drug increases, the production of TNF is reduced especially at 10nm. Production of TNF ceases completely by 100nm.

Introduction: Whether going to the park or hanging out at home, infectious organisms, or pathogens that cause diseases are always in the surrounding environment. Not all infectious organisms are harmful and some have been proven to be beneficial to its host, for example the bacteria E. coli in the digestive tract of humans. However, many different types of bacteria, viruses, yeasts, and fungi are pathogenic to its host, often causing infection and disease. To resist the harmful effects of infection, the host relies on a complex and unique system of defense containing organs, proteins, and cells called the immune system. The immune system is an organism’s most important form of defense against infection and without it, the host may suffer harmful effects throughout the body. Without damaging the host, a healthy immune system is capable of controlling the infection by eliminating or inhibiting spread and replication of the pathogen. New evidence suggests that the immune system can provide protection against certain tumors and further studies have discovered that the immune system can be manipulated to act against a tumor it previously produced no response to (Wood, 2006).

Polysubstituted brominated pyrrole (JG-03-14) is a molecular compound (see Figure 1) synthetically produced by Professor John T. Gupton. His extensive research led to the discovery of the JG-03-14’s oncologic properties in inhibiting mitosis by affecting the microtubules (Mooberry et al., 2007). It has been shown to inhibit the growth of murine and human tumors of leukemia and lymphomas. Although synthetically produced, Dr. Gupton’s drug is structurally similar to bioactive marine natural products, which has also proven to be cytotoxic to certain tumor cells (Gupton, 1999).

The immune system is composed of several important cells and proteins that aid the body in defense against pathogens. Upon infection, these cells and proteins are able to detect foreign “invaders” and produce an immediate cellular response. One of the most important defense cell that is involved in the immune system is the macrophage (Wood, 2006). Macrophages originate in the bone marrow, but eventually migrate to the tissue where they are ready to destroy any microbe it comes across. To make sure that healthy, non-pathogenic cells are not destroyed by mistake, macrophages have Toll-like receptors (TLR’s), similar to those found in Drosophila, to detect foreign molecules, such as lipopolysaccharide (LPS). Sensing the microbe, the macrophages will immediately become activated and signal for the production and secretion of soluble proteins called cytokines. The main cytokine secreted by macrophages is tumor necrosis factor (TNF) which aids the macrophages in killing the microbe directly as well as recruiting other cells to help destroy the pathogen.

The affect of JG-03-14 on the immune system will be important to understand if this drug is to be used for anticancer treatment. The observation of the macrophages’ ability to produce TNF in the presence of JG-03-14 will demonstrate the affect the drug has on the immune system.
Experimental Design - The proposed hypothesis for this experiment was the JG-03-14 compound will affect the production of tumor necrosis factor (TNF) produced by macrophages. The independent variable determined for this experiment was the varying amounts of the JG-03-14 compound used, thus the dependent variable for the experiment was the amount of TNF produced by the macrophages. In order to test the independent variable, 12 levels were used: 0.01 nanometer (nm), 0.1nm, 1nm, 10nm, 20nm, 50nm, 100nm, and 200nm. This experiment was conducted 3 times. This experiment had 4 controls: 2 negative and 2 positive controls. To confirm that the growth media and DMSO (the vehicle in which the drug is dissolved) produced no effect of the TNF, the macrophage was combined with media and in another well, macrophage was mixed with DMSO. The two positive controls consisted of macrophage combined with LPS and macrophage with LPS and DMSO.

Methods and Materials: RAW264.7, a murine macrophage cell line is used to observe the effects that JG-03-14 have on macrophage. These cells are isolated, grown, and maintained in the growth medium, RPMI-1640, which contains 10% heat-inactivated fetal calf serum, 1.5% sodium bicarbonate, 25mM HEPES buffer, 1% minimal essential medium vitamins, 1% glutamine, 1% nonessential amino acids, 100 units/mL penicillin, and 100µg/mL streptomycin. Once the cells are cultured, the macrophages are then placed in a twelve-well tissue culture plate: four controls and eight samples. Two wells are designated for the negative control: macrophages combined with media and macrophages mixed with DMSO (the vehicle in which the drug is dissolved). The purpose of the negative control is to confirm that the media and DMSO have no effect on TNF production. In the next two wells, macrophages are activated by 30ng/mL of LPS and another well containing macrophages, 30ng/mL LPS, and DMSO. These are the positive controls to stimulate the production of TNF without the drug. The remaining eight wells are each treated with macrophages, 30ng/mL LPS, and varying amounts of JG-03-14: 0.01nanometers (nm), 0.1 nm, 1nm, 10nm, 20nm, 50nm, 100nm, and 200nm. The treated cells are incubated at 37 degrees Celsius for 21 hours. After incubation, the supernatant (fluid surrounding the cells) is collected and placed into microfuge tubes, which are centrifuged to remove any cells that are present. The media containing the TNF is collected and analyzed using an Enzyme-linked Immunosorbant Assay (ELISA)[BD OptEIA Mouse TNF ELISA Set] provided by BD Biosciences. To start the ELISA, using the sandwich technique with the provided Antibody, Diluent and Enzyme in the kit, 100µL of Capture Antibody is placed into a 96-well tissue culture plate that is allowed to incubate overnight at 4 degrees Celsius. After incubation, the plate is removed of all liquids and washed 5 times using 300µL/well of wash buffer. To make sure that no other proteins bind to the walls of the wells, 200µL of Assay Diluent is added and incubated for 1 hour at room temperature. Again, the plate is removed of all liquid and washed 3 times. Next, using the samples collected earlier, 100µL of each sample and standard are placed in the wells and incubated for 2 hours at room temperature, which enables the TNF to bind to the antibodies attached to the wells. The plate is washed 5 times and filled with 100µL of Detection Antibody, which will attach to the TNF and signal the amounts of TNF present. After incubation at room temperature for 1 hour, the plate is washed 5 times and 100µL of the enzyme Streptavidin-HRP is then used to tag each TNF where it is incubated at room temperature for 30 minutes. This time the plate is washed 7 times with 30 second intervals allowing the wash buffer to soak in. 100µL of TMB Substrate Solution is then added. After 30 minutes in the dark, 50µL Stop Solution is added to the wells. After the ELISA is complete, a microtiter plate reader is used to assess the amount of TNF produced.

Results: The proposed hypothesis stated that the JG-03-14 will affect the production of tumor necrosis factor (TNF) produced by macrophages. The data collected supported this hypothesis and demonstrated that with higher dosages, TNF production seems to have been inhibited by the drug. In order to determine the concentration of TNF produced from each sample, the results are compared to a standard curve established prior to the experiment as demonstrated in Appendix A. After evaluating the TNF concentration of the samples, the results were graphed as shown in Appendix B. The concentration of TNF declines significantly when 10nm of the drug is used and by 100nm, TNF production has ceased completely. The four controls proved to be successful. Neither the medium nor the DMSO inhibited the macrophage. The macrophage activated by LPS had excellent results and it was proven that DMSO has no effect on LPS.

Discussion and Conclusions: It was hypothesized that the JG-03-14, when applied, will have an effect on the production of TNF produced by macrophage. Although TNF is not the only cytokine produced by the macrophage, it was specifically observed in this experiment because of its important role in the activation of the immune response. To test this hypothesis, a murine macrophage cell line, RAW264.7 was used to observe the effects of JG-03-14. These cultured cells were then placed into a 12-well plate, each well treated with LPS, and then exposed to varying amounts of JG-03-14. After an incubation period of 21 hours at 37 degrees Celsius, the supernatant of each sample was collected and TNF concentration was analyzed by an ELISA test.
The results collected supported the hypothesis because the drug JG-03-14 did have an effect on the production on TNF by macrophage. When the results were graphed, it showed that as the dose of the drug increases, the production of TNF is reduced. Thus, JG-03-14 does have an effect on the immune response. This is an important observation if this drug will be used to treat cancer, especially when using different drug concentrations.

This experiment proved successful because careful lab techniques including sterile cell culture techniques and accurate pipetting were implemented. During the ELISA test great caution was taken when pipetting to eliminate the possibility of error. For a continuation of the project, one could observe the production of other cytokines other than TNF. Instead of a murine macrophage cell line, it would be interesting to see how a human cell line will react to the drug. Because the macrophage cell line has been transformed, it reacts differently than a normal cell. Instead of using a cell line, one could culture cells taken from an organism.

**LITERATURE CITED**


**ACKNOWLEDGMENTS**

This experiment could not have been possible without the help of my science mentor, the university where the research project was conducted, and my mother. I would first like to thank my science mentor, a university professor for overseeing the research project. I would also like to thank the university for the allowing me to use their laboratory facility. Lastly, I wish to thank my mother for driving and accompanying me to all of my sessions in the lab. I am grateful that she was willing to sacrifice her time for me.
Appendices

Figure 1: Structure of the polysubstituted brominated pyrrole

Appendix A: Standard Curve of TNF production
Appendix B: Graph of TNF production

This Graph is representative of 3 trials
SECOND PLACE

THE EFFECT OF AGE ON THE ACCURACY OF A REGRESSION FORMULA FOR ESTIMATING STATURE

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

Upon the discovery of skeletal remains, the first task of the investigator is identification. Of the many methods of identification, the most basic is height. If the height of the living person is known, it can be used to locate possible individuals from a missing persons database or other resource. The living height of a skeleton can be determined by plugging the average humerus length in a height determining formula. Unfortunately, these formulas were developed utilizing skeletally mature subjects. In this study, it was hypothesized that these formulas would not provide accurate stature analysis of skeletally immature individuals. To test this theory, the humeri and height of eleven groups of twenty-five subjects, ages six to sixteen, were measured and recorded. The lengths of the humeri were averaged and put into the formula to calculate an estimated range of height. As was hypothesized, the formula increased in accuracy as age increased, peaking at ages twelve and thirteen. Because the result of the chi square test (43.785) was greater than the table chi square value (3.841), the probability of the data being due to chance is less than the chosen level of significance of 0.05. Therefore, the null hypothesis was rejected and the research hypothesis was supported. The results suggest several areas of further study. For example, additional analysis of gender differences and growth patterns may explain the declination in the accuracy of the formula for ages fourteen through sixteen. It is suggested that further studies utilize more precise means of collecting data.

THIRD PLACE

THE EFFECT OF OPERATING ROOM TEMPERATURE ON PATIENT TEMPERATURE AFTER SURGERY

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George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

During surgery, general anesthesia combined with a cold operating room (OR) environment can result in patients becoming hypothermic. The consequences of hypothermia include increased susceptibility to infection and impaired blood clotting. The purpose of the experiment was to test whether better OR thermostat control would improve patient temperature after surgery. The hypothesis was that if an OR temperature algorithm is used to actively raise the temperature in the operating room at certain vital times then the patient’s temperature will be higher than a patient whose OR temperature was unadjusted (control). Preliminary data was obtained by adjusting the thermostat in an OR from 16°C to 21°C and the mean time to change from baseline to target temperature was calculated. Thereafter an algorithm was used so that the temperature in an OR could be adjusted at critical portions during surgery (active “warm” group) compared to a control group where OR temperature was unchanged. Patient temperature was recorded on arrival in Post Anesthesia Care Unit. The mean patient temperature was 97.06°F for the active “warm” group compared to only 95.76°F in the control group (p=0.000048264). These data indicate that the algorithm created to reduce hypothermia was successful with the active group being 1.3°F warmer than the control group. This approach to OR thermostat control, by keeping the OR warm at key points while having a lower temperature during most of the surgery for the comfort of the OR staff, may reduce postoperative complications such as cardiovascular problems, pain, shivering, infection and bleeding.
HONORABLE MENTION

THE EFFECTS OF SMOKING LEGISLATION IN DIFFERENT STATES ON MORTALITIES DUE TO HEART DISEASE AND CHRONIC LOWER RESPIRATORY DISEASES

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

In many states, "clean air acts" or other legislation containing public smoking bans or restrictions have been passed in the last few years. These laws restrict smoking in workplaces, schools, restaurants, etc. The goals of these laws are to reduce smoking and environmental tobacco smoke, thus increasing public health. The purpose of this project was to investigate whether bans increase public health by studying the trends of mortalities due to heart and respiratory diseases. Using mortality data from the National Vital Statistics Reports, the mortality rates from all fifty states over seven years were compiled. It was hypothesized that the states with smoking bans would have a larger decrease (slope) in rate and a decreased rate in 2005 (most recent data), when compared with the national trend rate (control). T-tests for slope and chi-squares were run to test each part of the hypothesis. While the results of these tests were statistically significant, they did not support the research hypothesis when compared with state smoking legislation. The results seemed to provide evidence that smoking restrictions had no effect on a state's mortalities. However, this was contrary to previous studies, and many variables were confounded within the response variable, including the demographics of a state population (aging, i.e.) and the nature of the diseases studied (one can live with emphysema for decades, e.g.). Future studies could use longer sets of data and investigate other indicators of smoking ban success, such as smoking prevalence.

HONORABLE MENTION

THE EFFECT OF THE TYPE OF EXPOSURE ON THE RATE OF DECOMPOSITION

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ABSTRACT

Forensic Science professionals, such as medical examiners, who are tasked with determining the time since death, would benefit from the results of this study. If one understands that the materials in which a decedent is bound directly affects the rate of decomposition, one may take that into consideration when determining time of death. If more porous material is used, then the rate of decomposition will excel at a faster rate. In this study, the independent variable was the type of material used to encase the specimens. The dependent variable was the actual rate of decomposition, which was the time it took to observe a significant change in appearance and mass. Three of the four chicken wings utilized in each of the three trials were bound in various materials. Individual, equally sized pieces of either, newspaper, foil or plastic wrap encased each specimen. The constants of the experiment were the environment and the placement of each specimen within that environment. When comparing the control, an unwrapped chicken wing, and the specimens encased in foil, a significant difference in the rate of decomposition was observed. Insects were unable to penetrate specimen A (foil) causing significantly lower decomposition rates. This provided evidence supporting the theory that more permeable material significantly impacts the rate of decomposition. More porous material causes the rate of decomposition to excel at a faster rate than other less porous materials. Overall, temperature played a major role in insect activity and therefore the rate of decomposition.
HONORABLE MENTION

MODELING THE SPREAD OF DISEASE AT RADFORD HIGH SCHOOL

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Southwest Virginia Governor’s School, Pulaski, Virginia 24301

ABSTRACT

In the study of disease propagation, it is important to consider schools as crucial factors that account for the rapid spread of disease across a community. Especially in the high-school environment, interactions between individuals of a diverse population are inevitable. In this study, we attempt to characterize the social interactions of high-school students in Radford, Virginia by creating a social contact network based off a synthetic population. Data about Radford High students’ class schedules was gathered with help from the Radford High administration. Through collaborating with researchers at the Virginia Bioinformatics Institute, the data was used to create a social contact network that described the classrooms students shared with each other during a normal school day. Analytic measures and statistics were applied to the data set to characterize the population. Preliminary results show that the average Radford High student comes into contact with a large number of individuals each day. These results do not include information derived from after-school activity questionnaires, meaning the number of individuals that student comes into contact with may actually be much higher daily. Our findings could be used to help inform policymakers in the event of a pandemic outbreak. Since there is a relatively dense social network for this school, it may be plausible to hold partial-school closings or exclude classes with the highest “mixing-rate” from the school schedule. In the future, the social network of Radford High will be integrated into the larger population of the New River Valley, and disease evolutions will be further studied.

OTHER PAPERS SELECTED FOR PRESENTATION:


The Effect of Fitness Drinks on Heart Rate of Adolescents Ages 10-14 While Running. Daisy K. Banta, George H. Moody Middle School, Henrico County Schools.

The Frequency of Community Acquired Methicillin Resistant Staphylococcus aureus (CA-MRSA) Among Pediatric Atopic Dermatitis Patients with Skin Infections. Katherine E. Baumann, George H. Moody Middle School, Henrico County Schools.

The Effect of Slow Vs. Fast Music on the Human Pulse Rate. Kiara T. Bennett and Jeremy R. Brodmyer, Chesapeake Bay Governor’s School, Caroline County Schools.


The Effect of a Horse’s Gait on the Rider’s Heartbeat. Rachel L. Gagliardi and Lauren I. Shires, Deep Run High School, Henrico County Schools.


I’m C-ing Orange (Juice). Elizabeth A. Harrington, Gildersleeve Middle School, Newport New City Schools.

Novel Inhibitors for IL-1 Induced Systolic Dysfunction and Post-Infarction Cardiac Remodeling. Jessica L. Harrington, Mathematics and Science High School at Clover Hill, Chesterfield County Schools.

The Effect of Heat on a Football Player’s Range of Motion. Isabel S. Henderson, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Different Sports Drinks on a Person’s Pulse Rate after Swimming. Therese M. Igharas, George H. Moody Middle School, Henrico County Schools.

The Effects of Aged Garlic Extract on the Growth of Canine Osteosarcoma Tumor Cells in Vitro. Se W. Jeong, Roanoke Valley Governor’s School, Roanoke City Schools.

The Effect of Athleticism on Heart Rate Recovery. Lindsay N. Knight and Sarah C. Bales, Deep Run High School, Henrico County Schools.
Abstract: Post-myocardial infarction (MI) complications cause deaths of thousands of people every year. The source of these complications remains IL-1 production from Caspase-1 activation by numerous biological pathways inside the myocardium. Of the many pathways, P2X7 receptor, an ion channeling pathway, triggers Caspase-1 to produce more IL-1 when introduced to ATP or exogenous IL-1. By administering a 25mg/kg dose of PPADS (a receptor antagonist) P2X7R is inhibited and cardiac remodeling and systolic function can possibly improve. To test this hypothesis, non-infarct model and infarct models were established. Before and after administering PPADS or saline solution, echocardiograms were executed for both models, and arterial ligations simulated infarcts in mice. Variables measured include left-ventricular fractional shortening (LVFS), left-ventricular ejection fraction (LVEF), and left-ventricular end-diastolic diameter (LVEDD). According to ANOVA tests, there is a statistically significant difference between the PPADS data and saline data at a p<0.05. For the non-MI model, PPADS LVFS (90%±4) and LVEF (92%±4) were closer to the baseline than the saline LVFS (68%±1) and LVEF (73%±1). In reference to the MI models, the PPADS ranges for LVFS (16%±2), and LVEF (33%±3) were similar to the saline LVFS (14%±1) and LVEF (72%±2). On the other hand, the LVEDD of PPADS (4.23mm±0.13) was less than the saline’s range (4.94mm±0.1). These results demonstrated that PPADS inhibits P2X7R and promotes cardiac remodeling, but it moderately helps restore systolic function. Future studies may include P2X7 investigations in other organs.

Introduction: Acute myocardial infarction (AMI) is a major cause of morbidity and mortality worldwide. According to the American Heart Association, 62 percent of 1.2 million myocardial infarction (MI) patients survive from heart attacks (American Heart Association 2004), but unfortunately, 450,000 of the 62 percent die from post-MI complications (Zheng, 2001). Caused by a sudden block of blood flow to heart cells, AMI results in necrosis of these cells and unfavorable cardiac remodeling. Such complications result in AMI survivors at high risk of death years after the occurrence of the myocardial infarction. The unfavorable cardiac remodeling (scar tissue) mentioned above is produced by the heart cells’ response to cell necrosis and apoptosis resulting from the myocardial infarction in the form of inflammation. Abbate, 2008, observed that most tissue damage occurs in the left ventricle of the heart, which pumps the blood out of the heart (Abbate, 2008). Inappropriate heart tissue reconstruction could possibly lead to sepsis, a severe syndrome caused by changes in heart structure and the dysfunction of several organs (Fernandes, 2007). Inflammation plays a key role.

In post-MI remodeling, Interleukin-1 (human cytokine) is a key player of the heart’s natural response to cell death. In reaction to tissue injury, IL-1, is produced during acute myocardial infarction. IL-1 in the cell can be produced by many different biological pathways (Abbate, 2008). There exist the IL-1R, the MyD88 , IRAK, and P2X7 pathways (refer to picture 3). Among these pathways, P2X7 plays a major role in the activation of inflammasome, Caspase-1, activation, which ultimately activates IL-1 (refer to picture 4).

The P2X7 receptor, located on the outside of the cell membrane, functions as one of the many activators of IL-1. Although very little is known about this specific pathway, P2X7 contributes two very important factors in the production of IL-1. First, P2X7R (receptor) is the fastest mode to IL-1 production. Then, this receptor may play a role in positive feedback to produce more IL-1 when exogenous IL-1 is introduced into the system (Dinarello, 1987). Many different molecules can activate P2X7 to trigger the diverse pathways following the receptor. In IL-1 production, the human heart excretes ATP to phosphorylate the P2X7R (refer to picture 1). This activation of P2X7 receptor opens important ion channels (as seen in picture 1), which introduce Na+ ions and eliminate K+ ions. These ions then power NADPH to subsequently activate Caspase-1, inducing mature IL-1 (Hewison, 2008). Compared to
other IL-1 pathways, P2X7 quickly activates IL-1 production, due to its ion channels. Within 30 minutes of ATP exposure, the P2X7 pathway produces large concentrations of IL-1, mainly caused by the rapid ionic activation (Kahlenberg, 2004). Also, it has been found that this pathway has the ability to induce other IL-1 pathways, such as Phospholipase-D and PI3K pathways (Kahlenberg, 2004). Because of this, one can conclude that P2X7 is possibly the grand pathway of mature IL-1 creation. In accordance with Kahlenberg’s work, after 5 minute exposure to IL-1 from inflammation response, ATP concentrations increase dramatically (observe graph 1) (Kahlenberg, 2004). For this reason, inhibiting the P2X7 receptor would efficiently reduce IL-1 production in infarct mice, which would consequently improve cardiac remodeling of the left ventricle.

In response to tissue trauma, P2X7 can possibly play a role in positive feedback of IL-1. Heart cells always try to keep the concentration of IL-1 at homeostasis, but in acute myocardial infarction, these cells commence ATP production, which activates Caspase-1, and then produces IL-1. To immediately replace the necrotic and apoptotic cells in the heart, P2X7 triggers a process of positive feedback, where IL-1 induces more IL-1 (Kahlenberg, 2004). According to graph 5, certain concentrations of IL-1 induce higher concentrations of IL-1 (Dinarello, 1987). Therefore, the amount of IL-1 introduced equals that produced. Obviously, the high concentrations of IL-1 creates scar tissue in the left ventricle, causing immense difficulties in pumping blood out into arteries (the heart’s main function). Therefore, a P2X7 inhibitor could possibly stop this mechanism of IL-1 production.

PPADS, also known as pyridoxal-phosphate-6-azophenyl-2’ , 4’-disulfonic acid, acts as a P2X7 antagonist, and inhibits IL-1 production. As found in other research, PPADS reduces inflammation from spinal chord injury. In spinal chord injury, Borsani’s results demonstrated that the disruption of P2X7R has been shown to eliminate chronic inflammatory and neuropathic pain (Borsani, 2008). From this same in vivo study, the mice were administered a 25 mg/kg dose of PPADS to calm spinal chord pain and reduce inflammation. Higher doses of 50 mg/kg and 100 mg/kg seem to have the same effect on the state of inflammation, or lack of, of the mouse’s spinal chord (Borsani, 2008). Utilizing PPADS in P2X7 inhibition can possibly mean inhibiting Caspase-1 activation, but also blocking all IL-1 pathways before Caspase-1 (refer to picture 2) (Kahlenberg, 2004). The formulated hypothesis states that P2X7 inhibition will prevent adverse cardiac remodeling by inhibiting inflammatory response to secreted IL-1. In addition, if PPADS proves to be a proficient inflammatory inhibitor, then post-MI complications should be inexistent, reducing the amount of pacemakers needed in post-MI patients. A control in the preliminary studies and infarct model (using 0.01% saline solution), serves as a means of comparison between the PPADS drug and the lack of drug, just IL-1. In the preliminary trials that study systolic function of the mouse’s heart, the injected IL-1 modulates the sham mice undergoing standard operation procedure but no arterial ligation. The IL-1 produced in the sham mice should be remarkably greater than in the PPADS mice. Thus, the purpose of the project is to understand how and why PPADS block the P2X7R and to observe the effects of this inhibition on cardiac remodeling.

To evaluate the reduction of inflammation, cardiac remodeling and systolic function of the mice are observed. And to further assess the pejorative or positive effects of the PPADS drugs, certain variables are studied. Using an echocardiogram technique, the fractional shortening (%), ejection fraction (%), stroke volume (ml), heart rate (HBPM), left ventricle end-systolic diameter (mm), and left ventricle end-diastolic diameter (mm). Fractional shortening (FS) is the percent of movement the left ventricle contract to squeeze blood out. In the infarct model portion of the experiment, the FS is calculated using the formula (LVEDD-LVESD)/LVEDD=FS, where LVEDD and LVESD are explained below. Instead, the ejection fraction, always measured in percentage, is the fraction of blood pumped out of the left ventricle with each heart beat. Both of these numbers are important to understand how well the heart works after an MI. Also, the LVEF is easier to use for cardiologists, but the LVFS is a more accurate number. Stroke volume, measured in mL, is the amount of blood ejected from the left ventricle with each heart beat. Then, heart rate measures the heart beats per minute. Finally, LVESD and LVEDD (mm) are measured in the infarct model to observe the contraction and expansion of the heart. Because part of the left ventricle is scar tissue, observing specific parts of the heart, instead of just the FS and EF In order for the heart to have a successful cardiac remodeling, the LVESD and the LVEDD need to be elastic and small to pump blood; while, the fractional shortening and ejection fraction should remain in the top 60% percentile. Too small percentages indicate a heart that does not pump blood (Ebme, 2008).

Methods and Materials: For all activities involving mice, IACUC-approved procedures were followed, providing maximum care and respect to the mice. Any possible activities causing pain were muted with anesthetics (pentobarbital). Carcasses were disposed of through laboratory waste disposal company. In a BSL-2 laboratory, two different strains of Mus musculus (male/female laboratory mouse; about 250 g) were used for these procedures: MI

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(myocardial infarction) mice and non-MI mice, without the myocardial infarction. Using two strains ensured that effect of the drug was reproducible in both types. MI- mice are more prone to organ failure than non-MI mice.

Part I: Non-MI Model: Induced Systolic Dysfunction Evaluation - To observe the positive effects of the PPADS on inhibiting P2X7 and therefore stopping IL-1 production, induced by positive feedback, a set of non-MI mice was used to check systolic dysfunction. Before injecting drugs, the ejection fraction of each mouse was measured using the echocardiogram as a mode of comparison with the systolic dysfunction after four hours post drug administration. Then, one group was pretreated with normal 0.01% saline 5 mg/kg (control); another group received 5 microg/kg of IL-1beta. Afterwards, a third group was treated with 5 microg/kg of IL-1 beta and then 25mg/kg of PPADS (all IL-1beta given intraperitoneal at baseline). The PPADS is given along with the IL-1Beta to assess whether the PPADS stops the positive feedback inhibition of the P2X7 receptor and to simulate an infarct. After four hours, systolic dysfunction of the mice was measured with an echocardiography. Variables considered in the measurement of systolic dysfunction were ejection fraction, fractional shortening, heart rate, and stroke volume.

Part II: MI Model: Infarct-Caused Systolic Dysfunction Evaluation: Echocardiography, Surgical Procedure, and Histopathology - Before surgical procedure and treatment, all mice received echocardiography of the heart utilizing a 30 MHz echograph. From this evaluation, LVFS (%), LVEF (%), LVEDD (mm), and LVESD (mm), were measured. Wearing gloves at all times and taking necessary precautions, mice were sedated with 0.15 mg of pentobarbital. After fifteen minutes, the animals were mounted onto the platform, and the echocardiography probe was adjusted to receive a clear image of the left ventricle. After the echocardiograms, surgical procedure on the mice began. Injected with 0.15 mg of pentobarbital, the mice fell asleep and were then incubated and placed on their right side. Under surgeon supervision, the mice underwent surgical opening of the chest and ligation of the proximal left coronary artery for 6 mice for each group (saline and P2X7). Another group, comprised of 6 mice, sustained sham operations without coronary ligation. Subsequently, one group was pretreated with normal saline for seven days. Another group was pretreated with PPADS (25 mg/kg) drug then treated daily for seven days. Instead, half the sham received saline treatment, and the other half received PPADS treatment. Consequently, an echocardiography of each mouse’s heart was conducted, and the same variables as in the echocardiograms prior to operation were measured.

Hearts tissue is processed in immunohistochemistry and cardiomyocyte apoptosis and interstitial fibrosis. Using 10% triphenyl tetrazolium chloride staining infarct size was assessed. Two separate techniques were used to detect apoptosis relying on DNA fragmentation (terminal deoxynucleotidyl transferase-mediated dUTP nick-end labeling) and on caspase-3 activation (cleaved caspase-3) Leukocytes (CD45+ cells) were counted in the peri-infarct regions. Scar formation was assessed using Masson’s trichromic stain.

Discussion and Conclusions: Random-effects ANOVA for repeated measures was used to compare the measured parameters for echocardiography before and after the injection of PPADS (non-MI model) and before and after the operation (MI model) between the 4 different groups with the post hoc 2-sided Dunnett’s test to compare the PPADS and saline MI and non-MI groups. Unadjusted 2-tailed probability values are reported in relation to a p-value of 0.05. Degrees of freedom (N-k) and (k-1) are 7 and 1. IL-1Beta induced signal reduction in LVFS and LVEF four hours after baseline injection. As displayed in data table 3 and graph 4, the results showed that there was a greater increase of LVFS vs. LVEF in the PPADS data (69%±1 vs. 50%±3, p<0.001) than the saline data (38%±1 vs. 25%±2, p<0.001), where the p-value indicates that the probability that data is caused by chance alone is less than one in one thousand. This PPADS data represents a mean 32% and 27% reduction from the baseline of 100%. Pretreatment with PPADS was associated with preservation of LVFS and LVEF four hours after IL-1 administration. For the LVFS, PPADS was 90% of the baseline (100%). Compared to the saline LVFS (with a range of 68%±1), the PPADS has less reduction of LVFS with a range of 90%±1. The p-value for this test was equal to 0.08, indicating an 8 in 100 chance of having data caused by chance alone. Another test was conducted between saline and PPADS on LVEF data. Results of this test demonstrate PPADS’ LVEF to be 92% of the baseline (100%), with a range of 92%±4, which is greater than the saline’s 73%±1. At a p-value equal to 0.011, there is a chance equal to 1 in 1000 that results are caused by chance alone.

The P2X7 receptor is associated with post-infarction cardiac remodeling. Pre-infarctioned echocardiograms were similar in saline than in P2X7 and sham-operated (whole surgery expected the ligation). Post-seven-day echocardiographic data will be available for 6 saline mice, 4 sham, and 3 PPADS mice by the end of experimentation. In the infarct model, LVEDD was measured in addition to LVEF and LVFS. The LVEDD was
significantly greater in saline-treated mice versus the sham-operated mice. After seven days, the LVEDD of the saline-treated mice was 4.94mm±0.1 versus the sham-operated mice with a range of 3.7mm±0.1 at a p<0.001. This test demonstrates that heart enlargement occurs within operated hearts. Another two tests for the infarct model were based on the LVFS and LVEF of the saline and sham-operated mice. According to the results, the ANOVA test between saline (14%±1) and sham (42%±1) LVFS was statistically significant at a p-value less than 0.001. Instead, the test between the LVEF saline (72%±2) and sham (29%±2) resulted in a p-value less than 0.001. Therefore, post-infarction modeling is associated with a statistically reduction in systolic function of the heart. In addition to a comparative test between saline and sham-operated mice, there is another set of ANOVA tests between PPADS and the saline. As found in the results, treatment with PPADS was associated with a smaller LVEDD of 4.23mm±0.13 versus the saline of 4.94mm±0.1, resulting in a statistically significant test with a p-value equal to 0.011. In tests confronting saline and PPADS LVFS's, the PPADS range (16%±2) was greater than the saline range (14%±1) and the difference was statistically significant at a p=0.05. A similar trend is observable in the test between PPADS and saline LVEF's. Like the tests on LVFS, the tests on LVEF resulted with a p-value of 0.05 between PPADS range (33%±3) and saline range (72%±2). PPADS mildly improved the LVFS and LVEF but not the function of the heart. Graphs 1, 2, and 3 present PPADS compared to Anakinra, the primary IL-1 antagonist used in clinical studies (Abbate et al., 2008). As displayed in graphs 1 and 2, PPADS LVEDD and LVESD change mimics the one of Anakinra, proving the P2X7R inhibitor’s effective cardiac remodeling. Conversely, graph 3 reveals PPADS’ incapability to restore systolic function in MI mice when mimicking the saline’s pattern.

The preliminary results of the study suggest that the inhibition of P2X7 receptor may be a possible way to reduce the effects of IL-1 on systolic function and favorable cardiac remodeling after myocardial infarction. Found in Chizh’s and Borsani’s work, PPADS reduces not only inflammation in spinal chord injury, but also the amount of pain (Chizh, 2001) (Borsani, 2008). In clinical experiments, Chizh found that PPADS significantly reduces the neuropathic pain of the ganglia and the visceral pain of the heart, and only the first of the two is found in IL-1 inhibiting drugs (Chizh, 2001) The targeting of the P2X7R, can hopefully block all IL-1 production. Because of its ion channels, the P2X7 receptor quickly turns on Caspase-1 and almost immediately initializes IL-1 production within 30 minutes (Kahlenberg, 2005). In relation to this concept, using PPADS should allow P2X7 blocking to occur just as fast as the activation and automatically cease any IL-1 production. Since P2X7 is also known to activate the Phospholipidase-D and PI3K pathways (which always lead to IL-1 production), then PPADS would block not just the P2X7R but the entire IL-1 pathway. The P2X7 pathway is also involved in positive feedback when exogenous IL-1 is introduced. As found in Dinarello’s work, introducing IL-1 will cause P2X7 to produce the same amount of IL-1, and as the IL-1 output increases (increasing the concentration of IL-1 out of the cell), so will P2X7 function (Dinarello, 1987). Ergo, PPADS would also block this aspect of the P2X7 receptor, reducing inflammation and scar tissue in the left ventricle.

Another interesting finding remains in PPADS’ effective cardiac remodeling and its inability to restore systolic function in the infarct model. This result partially supports the research hypothesis that states If a mouse has an induced infarct, then PPADS will inhibit P2X7, blocking the positive feedback process and producing favorable cardiac remodeling. When MI mice were introduced to PPADS, the echocardiograms would display a normal heart, but an excessive dilatation while pumping blood. Although the reasons for this anomaly are still unknown, other research has found this to happen in rabbits’ urinary bladders. An article by Ziganshin et al. found that PPADS reduces the amount of pain in rabbits with urinary infection, but does not allow the bladder to contract well when disposing of urine (Ziganshin, 1993). In the field of cardiology, the exaggerated cardiac dilation produced from PPADS can possibly lead to heart failure. So, prevention of cardiac dilation can reduce the probability of heart failure and heart-failure-related mortality. Although this experiment is still in progress, many parts of the experiment can be altered. To ensure statistical significance, more animal trials should be added to the non-MI and MI models. Also, different combinations of P2X7 antagonists, such as KN-62, PPADS, and OxATP could be used to compensate each drug’s deficiency (inability to restore systolic function). Future studies may include investigations on PPADS’ ineffective restoration of systolic function using in vitro experiments, where the P2X7 receptor can be observed more closely. Also, PPADS should be tested on inflamed tendons, ligaments, or joints to observe scar tissue formation and organ function.

ACKNOWLEDGMENTS

I would like to thank my mentor Antonio Abbate from VCU Cardiology and my family who helped and supported me in the completion of this experiment.


Kahlenberg, Joanne. 2004. “Activation of Caspase-1 Signaling Complexes By the P2X7 Receptor Requires Intercellular K+ Efflux and Protein Synthesis Induced by Priming With Toll-Like Receptor Ligands.” Case Western University School of Medicine: 1-172.


Appendix

Graph 1. Time (days) vs. Left Ventricle End-Diastolic Diameter (mm): MI model

Graph 2. Time (days) vs. Left Ventricle End-Systolic Diameter (mm): MI model
Graph 3. Time (days) vs. Fractional Shortening (%): MI model

Graph 4. IL-1beta induces left Ventricular Systolic Dysfunction
Time (hours) vs. Ejection Fraction (% of baseline)

Graph 5. IL-1 induces IL-1 in P2X7 pathway (courtesy of Dinarello et al., 1987)
Picture 1. P2X7 Activation (courtesy of Kahlenberg, 2004)

Figure 9. IL-1α induces IL-1β in human MNC. MNC were incubated in the presence of 1 μg/ml indomethacin. Total (extracellular and intracellular) IL-1 was assayed using a radioimmunoassay. Indomethacin had no effect on the RIA.

Figure 1.4. The P2X7R is an ATP-gated ion channel that can induce pore formation with prolonged stimulation. The P2X7R is a double transmembrane protein with intracellular N- and C-termini. Upon stimulation with ATP, the receptor acts as a nonselective cation channel. Upon prolonged stimulation with ATP, the receptor induces the formation of a nonselective pore that will allow passage of molecules ≤900 kDa, depending on the cell type.
Figure 2. P2X7R Pathway (courtesy of Kahlenberg, 2004)

Figure 4.7. The activation of P2X7R results in the activation of caspase-1 by stable protein complexes. The induction of intracellular K⁺ efflux via activation of the P2X7R results in the formation of stable complexes which result in rapid caspase-1 activation in vitro. This is inhibited by both AG126 and BEL, suggesting that targets of these inhibitors are important for the initiation of inflammasome assembly in response to K⁺ release stimuli.

Figure 3. Other IL-1 Pathways
(courtesy of mentor Antonio Abbate)
Figure 1. IL-1β and caspase-1 are synthesized in pro forms that require cleavage for activation. A. The procytokine IL-1β is synthesized as a 33 kDa precursor in the cytoplasm and is unable to recognize its receptor until it is cleaved into a 17 kDa mature form. B. The cysteine protease, caspase-1, is synthesized as a zymogen in the cytoplasm. It is believed to undergo auto cleavage when oligomerized in a multimeric complex. The interleukin-1 converting ‘ICE’ activity is found in a heterotramer of two p20 and two p10 subunits from the c-terminus of multiple caspase-1 enzymes.

**EDD #1**

Preliminary Experiment: Systolic Dysfunction: No Infarct Model

**Title:** Role of P2X7 inhibition in Caspase-1 Inhibition and Cardiac Remodeling in Mice

**Hypothesis:** If exogenous IL-1 is given to a mouse along with PPADS, then PPADS will inhibit P2X7, blocking the positive feedback process and preventing systolic dysfunction.

<table>
<thead>
<tr>
<th>IV: medicine</th>
<th>Control (saline 0.01% 5mg/kg)</th>
<th>IL-1Beta (5 μg/kg)</th>
<th>PPADS 25 mg/kg + IL-1Beta (5 μg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 mice</td>
<td>8 mice</td>
<td>7 mice</td>
<td></td>
</tr>
</tbody>
</table>

Dependent Variables: ejection fraction (%), fractional shortening (%), heart rate (HBPM), stroke volume (mL)

Constants: strain of mice (non-MI), time between administration of drugs and echocardiography, method of drug administration (intraperitoneal), age of mice, approximate weight.

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**Picture 4. Caspase-1 Matures proIL-1 (courtesy of Kahlenberg, 2004)**

A.

![IL-1β](image)

B.

![Caspase-1](image)
**EDD #2**

Experiment: Infarct Model  
Title: Role of P2X7 inhibition in Caspase-1 Inhibition and Cardiac Remodeling in Mice  
Hypothesis: If a mouse has an induced infarct, then PPADS will inhibit P2X7, blocking the positive feedback process and producing favorable cardiac remodeling.

<table>
<thead>
<tr>
<th>IV: medicine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control: Saline 5mg/kg</td>
</tr>
<tr>
<td>6 mice</td>
</tr>
</tbody>
</table>

Dependent variables: fractional shortening, ejection fraction, left ventricular end-dyastolic diameter (mm), left ventricular end-systolic diameter (mm)  
Constants: strain of mice (MI), time between administration of drugs and echocardiography, method of drug administration (intraperoneal), age of mice, approximate weight, stress, chest opening (all part of the operation environment).
SECOND PLACE

STAYING ALIVE CPR: THE EFFECT OF MUSIC ON CARDIOPULMONARY RESUSCITATION

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ABSTRACT

Is it possible to increase the effectiveness of Cardiopulmonary Resuscitation (CPR) by training people administering CPR to time compressions with music? The objective of this study was to test the impact of music on CPR training. It was hypothesized that training people administering CPR to time their compressions to the beat of music that has a tempo of 103 beats per minute will help them produce a more accurate number of compressions than training them with no music. Thirty volunteers were asked to administer CPR compressions to a Recessa Annie mannequin three times. The first time, the participants were informed that the recommended number of compressions for CPR is 100 per minute, and then asked to administer compressions to the mannequin. The second time, the participants were asked to administer compressions to the mannequin while listening to a song (‘Staying Alive’) with a tempo of 100 beats per minute, and informed that if they timed compressions with each beat of music, an accurate number of compressions would be achieved. The third time, participants were asked to perform CPR compressions on the mannequin while remembering that timing compressions with music will produce an accurate number of compressions. Each trial lasted one minute, and the number of compressions administered by the participant was recorded. After experimenting, it was concluded that training people administering CPR to time their compressions with music significantly helped produce a more accurate number of compressions than training them with no music. Participants unanimously stated that the music was helpful in administering accurately timed CPR compressions.

THIRD PLACE

THE EFFECT OF EDUCATIONAL KINESIOLOGY (BRAINGYM®) ON THE MENTAL MATH TEST SCORES OF MIDDLE SCHOOL STUDENTS

Leander C. Unverdorben
11525 Bell Tower Court, Henrico, Virginia 23233
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

BrainGym® is a method known to help the brain become more efficient in learning. Twenty-three 7th grade students of Moody Middle School volunteered to participate in this study. After the initial mental math test BrainGym® exercises were done at the beginning of each math class for 2 weeks. At the end of the 2 weeks the same mental math test was taken by the students. Scores of 82.6% (19/23) of students were improved, 4/23 had stagnant or lower scores. The results showed statistically significant values for mean (p=0.001), median, and mode. In the first test 82.6% of the students scored in the range of 0-30% correct answers, 17.4% scored in the range of 30-60% correct answers. In the second test 52.2% of the students scored in the 0-30% range, whereas 47.8% of the students scored in the 30-60% range. The results of this study are consistent with other research published for kinesthetic effects of learning. This method, BrainGym®, might be useful in the daily school life. It could help students with learning disabilities as well as other students to improve their grades and help them learning easier, and last but not least have fun while learning.
HONORABLE MENTION

THE BIOLOGICAL EFFECTS OF SOUND WAVES AND MUSIC THERAPY ON CANCER CELL GROWTH

Katherine A. Rodriguez
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Deep Run High School, Glen Allen, Virginia 23059

ABSTRACT

Since many cancer treatments involve harsh, damaging procedures, some doctors in the oncology field use music to relax cancer patients and to stimulate their body systems. Many studies have shown that extremely high-frequency sound waves can significantly hinder the growth of cancer cells, while damaging healthy tissues as well. The purpose of this experiment was to determine whether the lower-frequency sound waves of music therapy affect cancer cell growth in a similar way. Different ranges of sound frequencies served as the independent variable in this experiment; sonication (15,000 + Hz), violin music (196 – 4,186 Hz), and cello music (65.4 – 220 Hz) were used. Different dosages of treatments were used to show trends in the amount of treatment vs. the amount of cell growth. Human breast cancer cells were separated into Petrie dishes and treated with the appropriate frequencies and dosages of sound. They were then left untouched in an incubator for approximately 4 days, and then counted using a Coulter counter. According to the data, sonication significantly hindered cancer cell growth, which supported the research hypothesis; the means indicated a decline in the amount of cells as the dosage increased. Neither violin nor cello music significantly affected the amount of cells that grew; however, the means indicated an increase in the growth of cells as the dosages increased, which was not predicted. Though music may not have a significant effect on cancer cell growth, it can still be a valuable tool to help cancer patients therapeutically.

HONORABLE MENTION

LITE CIGARETTES: TRULY “LITE” OR LIGHT ON THE FACTS?

Katelyn K. Rowland
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Thomas Jefferson Middle School, Arlington, Virginia 22204

ABSTRACT

The average smoker is constantly looking for a healthier cigarette. Through this experiment, the experimenter hoped to learn whether Marlboro Lites and Marlboro Non-Filtered Lites were healthier than Marlboro Regulars and Marlboro Non-Filtered Regulars. The cigarettes were tested with filters using a turkey baster, by comparing a clean filter to the filters exposed to each cigarette. The hypothesis was that the lite and regular cigarettes would produce the same amount of tar. It was found that lite and regular cigarettes perform the same in the Marlboro brand.
HONORABLE MENTION

THE EFFECT OF AGE ON ABILITY TO DETECT SOUND FREQUENCIES

Lesley E. Summerville
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James River High School, Midlothian, Virginia 23113

ABSTRACT

The "Mosquito," invented by Compound Security Company of Wales, Great Britain, was invented to discourage loitering, by emitting an ear-splitting, 17 kHz sound that only teenagers may hear. This study's purpose was to determine if people twenty years old and older could hear a 17 kHz sound, and to see if high frequency hearing decreased as people age. Seventy-eight test subjects, 25 males and 53 females, from 7 to 86 years old were tested at 17.4 kHz to see whether or not they could hear this tone. They were then tested over a range of decreasing or increasing frequency sounds to determine the highest frequency sound that could be heard. Results showed that children, teenagers, and people in their twenties could easily hear the 17.4 kHz sound, but that this disappeared by age 31. Only one subject older than 31 could hear the 17.4 kHz sound. Also, starting in the twenties there was a gradual decrease in the highest frequency tone that could be heard as people get older, with about 2 kHz lost for every 10 years of age. The differences between age groups were significant (p value of $2.72 \times 10^{-15}$). Significant loss of high frequency sound hearing was observed in some people starting at age fifty. It was concluded that some people older than twenty years old will be able to hear the "Mosquito" security device, and that loss of high frequency sound hearing develops and also worsens as we get older.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Different Pitches on the Human Ear’s Range of Hearing. Mark R. Meardon, George H. Moody Middle School, Henrico County Schools.

Which Pain Killer Dissolves the Fastest in Simulated Stomach Acid? Emma C. Merrill, Appomattox Governor’s School, Dinwiddie County Schools.

The Effect of Activity Level (Different Sports) on Lung Capacity. John Montgomery, George H. Moody Middle School, Henrico County Schools.

The Effect of Carbonation on Tooth Erosion. Madeline M. Pages, Williamsburg Middle School, Arlington County Schools.

The Effect of Different Brands of Pain Relievers on the Amount of Time It Takes for Them to Dissolve in Stomach Acid. Andrea A. Redden, Hanover High School, Hanover County Schools.


The Effect of Antioxidants on the Browning Time of Apples. R. Matthew Stewart, Thomas Jefferson Middle School, Arlington County Schools.

The Effect of Music Tempo on Runner’s Heart Rate. Wyatt C. Taylor, Mills E. Godwin High School, Henrico County Schools.

Finding Alternate Cures for Periodontitis: The Application of Common Juices and Green Tea to Break UP Plaque. Gregory S. Thompson, Central Virginia Governor’s School, Lynchburg City Schools.
The Effect of Ethanol Concentrations on the Heart Rate of *Daphnia magna*. Lindsey K. Treweek, Washington-Lee High School, Arlington County Schools.

The Effects of Blood Spatter on Different Types of Paint Surfaces. Monica R. Weaver, Shenandoah Valley Governor’s School, Augusta County Schools.

Fuzzy Brained Mice. Grace C. Williams and Valentina R. Colton, Gildersleeve Middle School, Newport News City Schools.

The Effect of Genres of Video Games on Blood Pressure and Pulse Rate. Austen J. Winkler, Deep Run High School, Henrico County Schools.


The Effect of the Sense of Smell and the Sense of Sight on the Quality of the Sense of Taste. Maggie H. Zhang, George H. Moody Middle School, Henrico County Schools.
Abstract: In this work, the geometric parameters that influence the permeability of a fibrous porous medium via 3D numerical simulations was studied. Three-dimensional virtual models resembling the microstructure of a fibrous medium were developed to be used in permeability calculations conducted by solving the Stokes equations in the void space between fibers. We, in particular, focused on the influence of the in-plane fiber orientation on the permeability of planar fibrous media. Comparing fibrous microstructures with different in-plane fiber orientations but identical porosities and fiber diameters, we demonstrated that the permeability of a fibrous medium is independent of the fibers’ in-plane orientation. This conclusion is of utmost importance for developing microscale numerical models for simulating fluid transport in fibrous porous media. The results obtained in this research are compared with available experimental and analytical studies in the literature and excellent agreement has been observed.

Introduction: Microbrous materials play essential roles in many biological, chemical, and mechanical systems and their permeability can be deemed as the most important property that dominates the transport phenomena in such media. Permeability of fibrous media has been vastly studied for the past decades and there are numerous publications reporting on fluid flows through different fibrous media and at different flow regimes.

Microstructure of fibrous materials, in general, can be considered to fall into three major categories: aligned structures, where axis of the cylindrical fibers are oriented either perpendicular or parallel to the flow direction (e.g., Spielman and Goren 1968; Jackson and James 1986; Chen and Papathanasiou 2006 and 2007), layered structures, where axes of cylindrical fibers lie randomly in the plane perpendicular to fluid flow (e.g., Spielman and Goren 1968; Jackson and James 1986; Koponen et al. 1998; Wang et al. 2006, Maze et al. 2007, and Zobel et al. 2007, Jaganathan et al. 2008a, 2008b, Tafreshi et al. 2009), and random structures, where fibers axes can be randomly arranged in any directions (e.g., Spielman and Goren 1968; Jackson and James 1986; Qi and Uesaka 1996; Clague and Philips 1997; Clague et al. 2000; Tomadakis and Robertson 2005).

In an attempt to study the influence of fiber orientation on the permeability of fibrous media, Stylianopoulos et al. (2008) developed 3-D fibrous media with three different fiber orientations and compared the permeability of isotropic random structures with that of "moderately" and "highly" oriented media. In this work, I present a similar, but more quantitative, study on the effects of fiber orientation and try to rectify some of the controversial conclusions that were made by Stylianopoulos et al. (2008). Here, I also model fibrous media with fibers of orthogonal orientation across layers and compare their permeabilities with those of the aforementioned microstructures to evaluate the significance of planar fiber orientation.

In the next section, I describe my algorithm developed for producing three-dimensional fibrous microstructures of different orientations. My numerical simulations are explained in Section 3, followed by a listing and discussion of my results in Section 4, where I compare the results of my simulations with the existing works in the literature.

Methods and Materials: Generation of Three-Dimensional Virtual Fibrous Media - For the purpose of generating 3-D virtual models of the microstructure of fibrous media, I developed a computer program, Virtual Media Generator. Virtual Media Generator was written in the Python programming language and can produce fibrous structures of different fiber diameters, porosities, thicknesses, and orientations. These media can be isotropic, layered and/or oriented. Virtual Media Generator can also generate disordered layered microstructures with orthogonal fibers. These fibers can be along the x and y directions only with equal and/or given probabilities. In this section, I describe my generation algorithm.

I developed my code's interface to prompt the user for the orientation of fibers in the target media. The user had a choice between unidirectional, orthogonal, layered random, and isotropic random fiber orientations. For
unidirectional and orthogonal media, the user may have specified the number of fibers per layer and the size of the domain. My code then utilized these parameters to generate layers of fibers containing the required number of cylinders in random locations across the plane. Hence, for unidirectional media, random points in the machine direction were selected and fibers of height equal to the sample size placed along them. The similar routine was used for orthogonal media, except that the alignment of the fibers alternated between layers orthogonally. In either of the aforementioned cases, the user had the ability to specify a minimum inter-fiber gap (to ease the meshing process, for instance) for the program to adhere to in generation of the target medium. For layered random media and isotropic random media, I used the μ-randomness algorithm to place fibers within the medium until the peak desired solid volume fraction was attained. Appendix A visually summarizes my code's process of media generation, whereas Appendix B compares two media with identical solidities generated by my code, and contains an example of a medium with fiber orientations alternating across x and z directions in terms of alignment. A minimum gap distance was enforced between the fibers and layers to avoid complications in generating the finite volume mesh (see the next section). Moreover, entry and exit zones were considered upstream and downstream of the medium to help establish a uniform flow field at the inlet and outlet boundaries (see the next section).

I designed Virtual Media Generator to perform all the calculations necessary for developing a 3D fibrous medium and generate a script file readable by the Gambit preprocessor of Fluent CFD code. In the development, I made certain that Virtual Media Generator computed the solid volume fraction of the media by accurately calculating the volumes of each fiber (or fiber segments) in the media. Computation of solid volume fraction logically differs across different types of media, and the formulas that I created to compute or approximate these solid volume fractions were categorized based on their orientation scope. Appendix B lists these various equations - the first equation applies to the orthogonal media generated by my code (and may be simplified for computation of unidirectional media SVF). Determination of layered random media SVF was not as trivial as orthogonal however; my scheme for rapidly approximating the volume involved generating a representational line for each cylinder in a layer, and then using one of my relevant volume equations to compute or approximate the volume of that respective cylinder. This process was repeated across layers, until the user-determined peak solid volume was reached. Concerning equations that I created can be found in Appendix B.

It is important to realize that this computed value of solid volume fraction was only an approximation, with sources of error in the layered random scheme including fiber overlap (which was not deducted from the final approximated volume value) and fibers spliced at corners (computed value was slightly higher than actual volume). The actual volume of the cylinders was be found using Gambit, and then be used to compute the precise solid volume fraction of the medium.

**Methods and Materials:** Governing Equations And Numerical Solution - In simulation of air flow within my virtual media, I assumed a steady state laminar flow, and used the Fluent computational fluid dynamics software to solve for the flow field using the finite volume method. The finite volume method is a numerical approach solving partial differential equations that reduces these equations to algebraic ones through integration over subdivisions or control volumes of given domain. The following are the governing equations of momentum and continuity:

\[
\frac{\partial p}{\partial x} = \mu \left( \frac{\partial^2 v_x}{\partial x^2} + \frac{\partial^2 v_y}{\partial y^2} + \frac{\partial^2 v_z}{\partial z^2} \right)
\]
\[
\frac{\partial p}{\partial y} = \mu \left( \frac{\partial^2 v_y}{\partial x^2} + \frac{\partial^2 v_y}{\partial y^2} + \frac{\partial^2 v_z}{\partial z^2} \right)
\]
\[
\frac{\partial p}{\partial z} = \mu \left( \frac{\partial^2 v_z}{\partial x^2} + \frac{\partial^2 v_y}{\partial y^2} + \frac{\partial^2 v_z}{\partial z^2} \right)
\]
\[
0 = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z}
\]

was interstitial void between the fibers of the generated geometry, and was meshed using tetrahedral elements. There are
regions where fiber-to-fiber distance was very small and regions where fibers are relatively far from each other. The grid size required to mesh the gap between two fibers around their crossover point was often too small. The computational grid used for computations needed to be fine enough to resolve the flow field in the narrow gaps and, at the same time, coarse enough to cover the whole domain without requiring an infinite computational power. The typical range for the mesh count for my permeability simulations was 4,000,000 to 27,000,000 cells. Appendix E depicts an example of a final tetrahedral mesh onto one of my code's generated structures.

The various boundary conditions of velocity inlet, pressure outlet, and symmetry, represented by Appendix D, were then defined, and the structure was exported to the Fluent CFD code. Here, the flow field was solved for with an inlet velocity of 0.1 m/s using the second order upwind scheme to a residual error of $1 \times 10^{-5}$. Each simulation typically ran for approximately 8 to 10 hours, depending on the number of cells. Pressure drop values were then obtained using the area-weighted averaging of pressure on the inlet surface, and the corresponding permeability was computed using Darcy's Law: $V = \mu^{-1}k \frac{Ap}{\Delta x}$

**Results and Discussion:** Domain Size Independence - My first step was establishment of independence of simulation-obtained permeability values from the size of sample in the x and z direction. I ran a series of simulations assuming a thickness of 400 μm. The solid volume fraction was carefully maintained at a constant 11% through careful dictation of the number of fibers per layer for a given sample size. I observed that for my orthogonal model, simulations for various sample sizes return almost alike values for permeability within an error percentage of 5% (a plot of the results can be seen in Appendix J). This allows the capability of assuming any convenient sample size for simulations that use my orthogonal model.

Establishing Importance of Orientation on Permeability - The next set of simulations I run are intended to compute the permeability of my orthogonal orientation media and my partially oriented media at various solid volume fractions for a given sample size and thickness. I assume a thickness of 300 μm and a sample size of 300 μm. In my orthogonal media, the choice of solid volume fraction is governed by the number of fibers per layer, and in the case of my simulations with the numbers of fibers per layers ranging from 3 to 13 fibers per layer, the range of SVF is approximately 5% to 24%. Refer to Appendix F for a tabulated depiction of how SVF varied with number of fibers per layer in my generated media. For my random in-plane media and the partially oriented media, solid volume fractions in this range are input to the code for direct generation of the appropriate media (in the range of approximately 9% to 24%). Note that two types of partial orientations were used: one set with a standard deviation of 15% from the in-plane horizontal, and the other with a standard deviation of 30%. Appendix G shows the visualization of my simulations for layered orthogonal and random in-plane fiber orientation media at a solid volume fraction of 6%.

At the culmination of each simulation, the pressure drop of the media is noted and translated to its corresponding permeability value using Darcy's Law. The simulations are verified against the analytical model of (Spielman and Goren 1968) and (Jackson and James 1986) for layered random media:

$$\frac{1}{4\phi} = \frac{1}{2} + \frac{\sqrt{\frac{K_{TD}}{k_{TD}}}}{r} K_1 \left( \frac{r}{\sqrt{\frac{K_{TD}}{k_{TD}}}} \right)$$

$$\frac{k}{a^2} = \frac{3}{20\phi} (-ln\phi - 0.931)$$

The obtained pressure drops were then plotted in order to determine the approximate level of agreement between my various porous media orientation models - a statistical test was not necessary (these are simulations), nor accurately possible due ever-differing solid volume fractions of the media generated by my code. Appendix H displays the plot of my orthogonal model's permeability in comparison to that of the planar random model simulation. As can be observed in given plot, the permeability of my orthogonal model demonstrates an obvious agreement with the that of the established layered random model - this ensues the fact that my orthogonal model, which is orders of magnitude easier to generate, trivial to mesh, and
relatively faster to simulate, can be used conveniently without risk of calculation discrepancy. Similarly, both my simulations of oriented media with either angular standard deviation of 15% and 30% show excellent agreement with the layered random model (and hence, my orthogonal model). The latter observations allows us to deduce that any source of error relating to fiber orientations should not be a significant factor of concern in harming the permeability calculations of a porous media simulation. In a more general theoretical sense, these observations imply that the in-plane orientation of cylinders in simulations of the permeability of nonwoven media is of insignificant importance. As such, I can assert that development of future numerical models of nonwoven media do not necessarily have to consider the in-plane orientation of fibers in their computations, thus greatly simplifying the work involved in simulating porous media.

Conclusions: In this work, I simulated the permeability of media containing fibers of either orthogonal orientation or random in-plane orientation. I created computer programs to generate media of these two forms at controlled solid volume fractions. I then compared obtained permeability of these two types of media and observed a very strong correlation between the two, allowing us to establish the insignificance of in-plane fiber orientation in numerical simulation of fibrous media. I also observed an excellent agreement of my simulations with analytical models in literature. My conclusion impacts future numerical models of fibrous media in that in-plane orientation of fibers is no longer a factor of importance in development of these simulations - this entails the important benefit that porous media researchers, especially those focusing on the nanoscale where meshing is complex and PDE solution more precision demanding, may now choose any convenient sample size, and use my orthogonal model to ease the generation and simulation process significantly.

Ideally, the ordered nature of my orthogonal model should now make it possible to generate entirely automated script files that perform media generation and conduct meshing independent of user intervention. Future work will concern development of this and related tools, and continue investigation of impact of other such characteristics of geometry on simulations of permeability of fibrous porous media, as well as related characteristics of these materials.

LITERATURE CITED


Stansbury, Susan. 2007. Nonwovens are huge in private label: annual PLMA show attracts a range of wipes, diapers and more. (PLMA Show). Nonwovens Industry. 38, 68.


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Appendix A - Flow Chart of Media Generation

The above flow chart is a summary of my Virtual Media Generator software’s media generation and solid volume fraction control algorithm. Notice how the user is first prompted for the type of media to generate, from a choice of unidirectional, layered orthogonal, layered random, and isotropic random fiber orientations. The program then inputs a set of generic parameters from the user, and then media type specific constants. It then proceeds with generation of media in a controlled manner from the perspective of solid volume fraction. Appendix C describes the equations that I formulated to control solid volume fraction in my code.
Appendix B - SVF Control Equations

The following are the equations I formulated to control solid volume fraction of the various media that I developed my code to generate. My derivation process has been omitted due to space constraints.

Layered Orthogonal Equations

\[
\phi_O = \left( \frac{1}{S_x S_z T} \right) \left( \sum_{l=0, l \text{mod} 2 = 0}^{n_l} n_{lf} \pi \left( \frac{d_f}{2} \right)^2 S_x + n_{df} \pi \left( \frac{d_s}{2} \right)^2 S_z \right) + \sum_{l=0, l \text{mod} 2 \neq 0}^{n_l} n_{lf} \pi \left( \frac{d_f}{2} \right)^2 S_x + n_{df} \pi \left( \frac{d_s}{2} \right)^2 S_z
\]

where \( \phi \) is the solid volume fraction, \( S_x \) is the size of the domain in the \( x \) direction, \( S_z \) is the size of the domain in the \( z \) direction, \( T \) is the thickness of the medium, \( G_i \) and \( G_o \) are inlet and outlet gaps respectively, \( n_l \) is the number of layers in the medium, \( l \) is the layer number that the code is currently on during computation of \( \phi \), \( n_{lf} \) is the number of fine fibers in a particular layer, \( n_{df} \) is the number of coarse fibers in a particular layer, \( d_f \) is the diameter of fine fibers in the medium, and \( d_s \) is the diameter of coarse fibers in the medium.

Layered Random Equations

\[
\phi_R = \left( \frac{1}{S_x S_z T} \right) \sum_{l=0}^{n_l} \sum_{j=0}^{n_{df}} \left\{ \begin{array}{ll}
V_P(d_f, \theta_f, c_1, c_2, S_x, S_z) & Y_R(0) < 0 \text{ and } 0 < Y_R(S_x) < S_z \\
V_o(d_f, S_z) & Y_R(0) < 0 \text{ and } Y(S_x) > S_z \\
V_P(d_f, \pi - \theta_f, S_z - c_1, c_2, S_x, S_z) & 0 < Y_R(0) < S_z \text{ and } Y_R(S_x) < 0 \\
V_o(d_f, S_z) & 0 < Y_R(0) < S_z \text{ and } 0 < Y_R(S_x) < S_z \\
V_P(d_f, \theta_f, S_z - c_1, c_2, S_x, S_y) & 0 < Y_R(0) < S_z \text{ and } Y_R(S_x) > S_z \\
V_o(d_f, S_y) & 0 < Y_R(0) < S_z \text{ and } Y_R(S_x) < S_z \\
V_P(d_f, \pi - \theta_f, c_1, S_z - c_2, S_x, S_y) & Y_R(0) > S_z \text{ and } S_z < Y_R(S_x) < S_z \\
V_o(d_f, S_y) & Y_R(0) > S_z \text{ and } Y_R(S_z) < 0 \\
\end{array} \right.
\]

Volume Approximation Equations

\[
V_o(d, h) = \pi \left( \frac{d}{2} \right)^2 h
\]

\[
V_P(d_f, \theta, c_1, c_2, S_x, S_y) = \frac{1}{2} \pi \left( \frac{d_f}{2} \right)^2 \left[ \left( \frac{\tan(\theta) c_1 - c_2 \sin(\theta)}{\tan(\theta)} \right) \right]^2 + \left( Y_R(S_x) + \sin(\theta) \left( \frac{d_f}{2} \right) \right)^2
\]

\[
+ \frac{1}{2} \pi \left( \frac{d_f}{2} \right)^2 \left[ \left( \frac{\tan(\theta) c_1 - c_2 + \sin(\theta)}{\tan(\theta)} \right) \right]^2 + \left( Y_R(S_x) - \sin(\theta) \left( \frac{d_f}{2} \right) \right)^2
\]

Unimodal SVF and Number of Layers

\[
\phi = \frac{n m_f \pi \left( \frac{d_f}{2} \right)^2}{ST}, \quad n_l = \frac{S_y + G_i d_f}{(G_i + 1) d_f}
\]

Fiber Border Representational Lines

\[
Y_R(X) = (\tan(\theta)) X + c_2 - (\tan(\theta)) c_1 \pm \sin(\theta) \left( \frac{d_f}{2} \right)
\]
Appendix C - Instances of Generated Media

The above is a top view of two of the media generated by my code. The left hand side displays the top view of my layered random code’s output visualized in the Gambit preprocessor for Fluent, while the right hand side figure displays an instance of the orthogonal medium generated by my code. Note that both media have approximately identical solid volume fractions.

Appendix D - Boundary Conditions

The figure above is an illustration of the boundary conditions applied to my code’s generated (and meshed) media. Flow is transverse to the fibers in this project, with either walls causing transverse flow having the boundaries of velocity inlet and pressure outlet. The other walls are symmetry, given the fact that the generated media is a microstructure sample of a larger porous medium.
Appendix E - Interstitial Void Meshing

This is an illustration of the final mesh on a medium generated by my code. Note that the inlet and outlet walls are meshed with quadrilateral face mesh, while the symmetry walls and the fiber cylinders are face meshed with triangular cells. The medium's interstitial void is then meshed with tetrahedral cells.

Appendix F - Tabulation of Attempted Simulations

Sample Size Independence (Orthogonal)

<table>
<thead>
<tr>
<th>Sample Size, $S$</th>
<th>$T$</th>
<th>$d_f$</th>
<th>$n_{fl}$</th>
<th>$n_l$</th>
<th>$G_f$</th>
<th>$G_l$</th>
<th>$G_i$</th>
<th>$G_o$</th>
<th>Solid Volume Fraction, $\phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>400</td>
<td>10</td>
<td>1</td>
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<td>15</td>
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<td>400</td>
<td>10</td>
<td>2</td>
<td>28</td>
<td>3.0</td>
<td>4</td>
<td>15</td>
<td>15</td>
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<tr>
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<td>10.9955742876%</td>
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<td>400</td>
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<td>8</td>
<td>28</td>
<td>0.8</td>
<td>4</td>
<td>15</td>
<td>15</td>
<td>10.9955742876%</td>
</tr>
</tbody>
</table>

Permeability Simulations (Orthogonal)

<table>
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<tr>
<th>Solid Volume Fraction, $\phi$</th>
<th>$S$</th>
<th>$T$</th>
<th>$d_f$</th>
<th>$n_{fl}$</th>
<th>$n_l$</th>
<th>$G_f$</th>
<th>$G_l$</th>
<th>$G_i$</th>
<th>$G_o$</th>
</tr>
</thead>
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<td>300</td>
<td>10</td>
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<td>21</td>
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Appendix G - Velocity Vectors in Converged Simulations of Media

This figure is obtained from Fluent, after my processed and meshed media are loaded into the CFD code and simulated with the appropriate conditions. It displays the velocity vectors within the respective porous media.

Appendix H - Permeability Plot (Orthogonal)

The given figure is a plot of the relative permeability of my orthogonal model and the standard layered random geometry. The figure clearly demonstrates a strong agreement between the two models at a wide range of solid volume fractions, and thus effectively allows me to conclude the insignificance of in-plane orientation in permeability simulations.
Appendix I - Permeability Plot (Oriented)

The above plot depicts my simulations of media with fibers of various amounts of orientation (namely standard deviation of 15% and 30% from a mean of 0 degrees along the horizontal in-plane axis in the random number generator of my code). It is clearly visible that orientation has no impact on permeability values to a significant extent in disordered media.

Appendix J - Sample Size Independence

The above figure demonstrates how my orthogonal model is completely sample size independent, and hence allows future simulations to pick any convenient sample size, saving valuable CPU time and resources.
SECOND PLACE

CAN ANY HOUSEHOLD MATERIALS OFFER RADIATION SHIELDING AGAINST LOW LEVEL GAMMA RADIATION EXPOSURE?

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Washington-Lee High School, Arlington, Virginia 22201

ABSTRACT

This paper attempted to find whether any household materials could act as useful gamma radiation shields. The experiment’s hypothesis was that, of the household materials tested, only water and aluminum would offer some measure of gamma radiation protection, at least halving radiation exposure with approximately 1.25 centimeters of material. The shields tested were soil, ceramic, household insulation, glass, water, aluminum, and plastic. Lead, although not a household material, also was tested, for comparative purposes. The control was the radiation level without a shield. Variables such as distances, room temperature, and time of day were kept constant. The radiation source used was Cobalt-60. The radiation level was measured with a Geiger counter. The results of the experiment showed that no household materials halved radiation levels. Lead, however, did halve radiation levels. Different shields offered different levels of protection. In order of effectiveness, they were lead, aluminum, glass, plastic, insulation and water (equal), ceramic, no shield, and soil. Soil raised radiation levels, indicating that it perhaps has natural radiation. The hypothesis was not supported as aluminum and water did not halve radiation levels. Errors could have occurred because the Geiger counter used detected other forms of radiation other than gamma radiation and because thicknesses of shields were not kept exactly equal. The experiment could be improved by using a more sophisticated Geiger counter, by keeping the thicknesses of the shields exactly equal, by testing more thicknesses, and by conducting the experiment in an area with little ambient radiation. Finally, the density of materials was not taken into account, and it would be interesting to see if density of materials has any effect on radiation levels.

THIRD PLACE

THE EFFECT OF THE TYPE OF FUEL ON THE AMOUNT OF ENERGY RELEASED WHEN COMBUSTED

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George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The world is going through serious trouble having enough energy to power vehicles that are clean burning and use renewable fuels. Gasoline is used now, but it releases a lot of pollution. The bio-fuel ethanol and hydrogen have been suggested to be clean burning fuels and possible solutions to the fuel crisis. The purpose of this experiment was to compare gasoline, ethanol, and hydrogen to see which type of fuel had the highest enthalpy of combustion, or energy release. The hypothesis was that hydrogen would release the greatest energy. Gasoline and ethanol were combusted in a calorimeter to measure the release of energy and compared to the known enthalpy of combustion of hydrogen. The results of the experiment supported the hypothesis that hydrogen would release much more energy, while ethanol and gasoline released much less. Gasoline and ethanol released equivalent energy to one another. The conclusion is that hydrogen is the most efficient fuel and that gasoline and ethanol are roughly equivalent. Recommendations for research are made, suggesting the use of hydrogen-electric cars that generate electricity to separate hydrogen from water to burn as a clean and renewable fuel.
HONORABLE MENTION

THE EFFECT OF THE TYPE OF SPIN ON THE NUMBER OF ROTATIONS AN ICE-SKATER CAN DO

Mounika Bodapati
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George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The purpose of this experiment was to find the spin technique that when used would produce the maximum number of revolutions. There were five choices: Scratch, Sit, Layback, Alternate, and Upright spins. The experimenter hypothesized that the Scratch Spin would be the fastest out of the five. The experimenter found a figure skater, who could do all five spins, and asked if she would perform the trials and types of spins that were needed for this experiment. She was asked to do 10 spins of each type, 50 in all. The skater was video-taped while performing the desired spins. The video was uploaded onto a computer then played in slow motion, to be analyzed. The experimenter counted the number of spins and recorded the time it took for the skater to do that specified number of spins. The fastest type of spin was determined by calculating the number of spins per minute for each trial. The hypothesis was supported and it was determined that the Scratch Spin was the fastest spin of the five. The slowest spin was the Alternate Spin. The Scratch Spin was fastest because the arms and legs were brought closest to the axis of rotation during the spin and therefore, taking the most advantage of conservation of angular momentum. The Alternate spin, on the other hand, is the slowest because the arms, legs and parts of the body are pulled away from the axis of rotation during the spin, thus slowing the spin down.

HONORABLE MENTION

THE EFFECT OF THE ANGLE OF LIGHT ON SOLAR PANEL EFFICIENCY

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Yorktown High School, Arlington, Virginia 22207

ABSTRACT

The objective of the experiment was to understand how the angle of light affects solar panel efficiency. This knowledge could be essential when deciding future applications of solar power. This was determined by testing the voltage produced by a solar panel as the angle of light is adjusted. First, the voltage produced by the solar panel was recorded when the solar panel was parallel to the light source (at zero degrees) on its vertical axis. Then, the solar panel was adjusted using a protractor so that the light would hit it at an angle of 10 degrees and the voltage was recorded. This process was repeated with the voltage measured every 10 degrees until the voltage at 90 degrees had been recorded. The solar panel was then moved to its horizontal axis and the procedure was then repeated. The data collected showed that zero degrees produced the most voltage and decreased until 90 degrees, which produced the least voltage. However, there was little difference between the voltages for the different angles until after 50 degrees. Then, there was a much larger difference between the voltages. The statistics showed that the data from zero to fifty degrees was not statistically significant, but the data from 60-90 degrees was statistically significant. Thus, it was concluded that the angle of light does affect the solar panel’s efficiency to some extent, however the relationship is not linear and only extreme angles affect its productivity.
THE EFFECT OF MAGNET SIZE ON SUPERCONDUCTING LEVITATION HEIGHT

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

The purpose of this experiment was to determine how the size and pull force of a magnet affect the height at which it levitates above a superconductor. This could be important to magnetic levitation technology, which is in use in maglev trains, and which could be used as an efficient space delivery system. The hypothesis was that if magnet size were increased, then there would be no significant difference in levitation height. The independent variable was the size of the magnet being levitated, and the dependent variable was the height at which it levitated above the superconductor. Four different sizes of cubic magnet were used, with volumes of 3.2 mm³, 4.8 mm³, 6.35 mm³, and 12.7 mm³. There were 25 repeated trials for each group. For each trial, the rare-earth magnet was levitated above a small superconductor and the height that the magnet achieved was recorded. It was found that while levitation height increased with magnet size, it leveled off at about 6mm. T-tests revealed a significant difference between the mean heights of the first three magnets but not between those of the last two. The hypothesis was not supported. One out of the three null hypotheses was rejected. These results suggested that while levitation height increases with magnet size, there is a maximum height beyond which a superconductor cannot support a magnet of any size. Possible future topics include the effect of magnet shape on levitation height. If repeated, this experiment would be conducted on a much larger scale.

OTHER PAPERS SELECTED FOR PRESENTATION:

The Effect of Different PSIs and Different Temperatures on the Distance a Football Will Travel When Kicked. Matthew R. Anderson, Deep Run High School, Henrico County Schools.


The Effect of Pressure and No Pressure on the Length of Flight of a Tennis Ball. Carrie M. Anson, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effects of the Reflection of Sunlight off Different Reflector Substances on the Amount of Solar Energy Absorbed by Solar Panels. Benjamin J. Ashwell, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Temperature on the Bounce Height of Tennis Balls. Hunter August, Deep Run High School, Henrico County Schools.


The Effects of Shell Load on Shotgun Recoil. B. Brett Graham, Southwest Virginia Governor’s School, Pulaski County Schools.


Abstract: The Gestalt Theory can be summarized in the sentence “the whole is greater than the sum of its parts.” The Law of Closure may be used by the mind to complete incomplete symbols that resemble a familiar figure. The purpose of this experiment was to determine if the Law of Closure applies to pictographic languages such as the Japanese language. Volunteers from a local Governor’s School were given three days to study Japanese words. A flash card test was given with symbols that were either complete or had random pieces missing. The subjects’ answers were recorded and analyzed with a t-test that yielded no difference among the scores of tests taken on complete hiragana Japanese symbols and on hiragana Japanese symbols partially erased. The researcher concluded that Gestalt’s Law of Closure is applicable to the Japanese Language.

Introduction: The Japanese Language is an intricate language, consisting of thousands of symbols used daily. These symbols are based on a pictographic system that migrated over to Japan about 1500 years ago (Rutherford, 2003). Although the designs of these symbols can range from a few simple lines to a dozen complicated ones, the symbols should be recognizable and readable even if random parts of the symbol are missing, according to Gestalt’s Law of Closure (Friedenburg and Silverman, 2006). For these reasons, the history and usage of the Japanese hiragana alphabet and Gestalt’s Law of Closure will be examined, in addition to related literature.

There are many disputes over where the Japanese language originated. Many linguists believe that Japanese is an Altaic language, similar to Korean, Mongolian, and Turkish. However, there are several other linguists who believe it is an Austronesian language, connected to Papuan, Malayan, and some other Pacific languages (Hooker, 1999). The Japanese language system depends highly on politeness. Because of this, honorifics are used to show the proper respect for people depending on a person’s rank in society. These honorifics are like titles that are placed after the names of all but the closest of friends (Gilhooly, 2003).

The Japanese language consists of three main alphabets: hiragana, katakana, and kanji. Hiragana has a one-to-one relationship between the spoken syllable and written symbol. This alphabet is mainly used to express particles, topic markers, and verb endings in a sentence. Hiragana’s present orthography was arranged in 1946 by the Japanese government. Katakana, like hiragana, has a one-to-one relationship between the spoken syllable and written symbol. The sounds of hiragana and katakana are the same, but quite different on paper. Katakana symbols let the reader know that the word is foreign. It can also be used to express onomatopoeic terms or to put emphasis on words that in English would be bold, italicized, or in all uppercase letters. Kanji was officially introduced in Japan in 1981, in order to shorten the amount of space required to write. There are over 5000 kanji in use in Japan today (Gilhooly, 2003). These pictorial alphabets may pose interesting inquiries for Gestalt psychologists.

Gestalt-noun is an organized whole that is perceived as more than the sum of its parts. This is the basis of the Gestalt Theory, which was established in the early 1900s by German psychologists Wolfgang Kohler, Max Wertheimer, and Kurt Koffka. This theory explains that the eye and mind have built-in processes of configuration and arrangement that allow it to perceive forms and patterns as a whole rather than as separate pieces (Friedenburg and Silverman, 2006).

There are many principals affiliated with the Gestalt Theory. According to this theory, the mind will ignore gaps in information and fill in the space itself, if the figure seems to resemble a familiar structure (Mollenauer and Plotnik, 1986). For example, International Business Machines Corporations has a logo with blue letters IBM placed
in a white background. It also has white lines from the background crossing horizontally over the letters. The Gestalt Theory says the mind is able to recognize the letters because it perceives the logo as a whole, and recognizes the letters for what they are.

In 2006, a research study was conducted on Gestalt’s Law of Closure. The purpose of the experiment was to determine the amount of closure distinguished by the Times New Roman font and the Arial font. Each font was given to a group of eight random students, who then had to read the word typed in their assigned font. However, random pieces of the words were missing, as required to test Gestalt’s Law of Closure. Students had two seconds to read the word with the missing parts. These test scores were recorded and calculated to measure the difference, if any, among the quantity of incorrect answers given. The experiment concluded that there was no difference (Dyke, 2006).

In conclusion, the Gestalt Theory is a compilation of laws that support the theory that “the whole is greater than the sum of its parts” (Friedenburg and Silverman, 2006). The purpose of this experiment was to determine whether or not the Law of Closure applies to pictographic languages. The following null hypothesis was examined: there is no difference among the scores of tests taken on complete hiragana Japanese symbols and hiragana Japanese symbols partially erased in reference to Gestalt’s Law of Closure.

**Methods and Materials:** The subjects used in this experiment were twelfth grade governor’s school students from Augusta County. Sixteen volunteers from the governor’s school were given the same ten random Japanese words to study. The volunteers consisted of sixteen students ranging from ages seventeen to nineteen, seven of which were female and nine of which were male. The subjects took a test consisting of the ten random words, five of them being closed and the other five non-closed. See Appendix A for a list of the symbols used. The independent variable in the experiment was the closure and non-closure, and the dependant variable was the test scores of the comprehension tests See Appendix B for sample flashcards.

The Japanese closure experiment contained two types of words. The non-closure group consisted of five words, each words consisting of completely formed Japanese symbols. The closure group consisted of five words, but each word consisted of Japanese symbols that had been partially erased in random places in reference to Gestalt’s Law of Closure. The words for the tests were randomly selected from a Japanese-to-English dictionary and put into Microsoft Excel (Nakao, 1997). The erasing of parts of the symbols was performed using the computer program Microsoft® “Paint.”

Each subject was given the period of two days and was told to spend five minutes each day studying the words given. On the third day, the subjects were read the exact same instructions and given a test of the ten words. The subject was given a period of ten seconds to correctly identify the word shown. Subjects’ answers were recorded and analyzed in a Paired t-test of Two Samples for Means.

**Results:** A Paired t-test was used to test the null hypothesis. This procedure allowed for the comparison of the scores of the closed words and the scores of the non-closed words. Level of significance was set at p < 0.05 and a t-value was obtained for the following null hypothesis: there is no difference among the scores of tests taken on complete hiragana Japanese symbols and hiragana Japanese symbols partially erased in reference to Gestalt’s Law of Closure. Results supported the null hypothesis. No statistical significance was found between the symbols with closure (M = 1.63, S.D. = 1.2) and the symbols with no closure (M = 1.69, S.D. = 1.4). Therefore the null hypothesis was accepted, t (15) = -0.136, p = 0.89. See Appendix C for t-test results and Appendix D for graph.

**Discussion and Conclusions:** A research study conducted by Dyke (2006) concluded that there was no difference between the amount of closure a person perceives with Arial and Times New Roman font. However, for this experiment, the researcher concluded that there was no difference among the scores of tests taken on complete hiragana Japanese symbols and hiragana Japanese symbols partially erased in reference to Gestalt’s Law of Closure. Possible improvements to this experiment would be a larger sample size, and a longer time period given to study the words. Recommendations for future studies would be to perform the experiment using subjects fluent in the language being used, or to perform the experiment using different languages. By doing this, researchers would have a better depiction of how Gestalt’s Law of Closure really works, and therefore may have a better understanding of how the human mind works.
LITERATURE CITED


ACKNOWLEDGMENTS

I would like to acknowledge the faculty at my school for their time, assistance, and guidance during my work on this project.
APPENDIX A

An example of the Study Sheet Given to Subjects

0とがらす - Togarasu: to sharpen

なべ - Nabe: pan

かっこう - Kakkō: cuckoo

さいご - Saigo: end

よろい - Yoroi: armor

じごく - Jigoku: inferno

うさぎ - Usagi: rabbit

じつよう - Jitsuyō: usefulness

りく - Riku: land

でしゃばり - Deshabari: busybody
APPENDIX B
Sample Cards

なべ

above: non-closure sample
below: closure sample
APPENDIX C

Results

t-Test: Paired Two Sample for Means

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APPENDIX D

Average Charts

Average Test Scores

![Average Test Scores Chart](image)

Non-closure vs. Closure
SECOND PLACE

THE EFFECTS OF A FACE’S COLOR ON HUMAN'S INTERPRETATION OF MOOD

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ABSTRACT

Different color on faces may affect how a person interprets their mood. The purpose of the study was to determine if color affects the mood interpretation of a face. Volunteers were tested using a test created by the researcher. The test consisted of a series of faces of six different colors. Volunteers were requested to assign one of six different emotions to each of the faces. The interpreted moods of the faces were tested and analyzed using a chi-square test. Based on the results of the study, the researcher concluded that there was a statistically significant difference between the responses for the color orange versus the responses for the other five colors – red, green, purple, yellow, and blue. The responses given for orange consisted of a higher frequency of relaxed and bored interpretations compared to the other colors.

THIRD PLACE

THE DIFFERENCE BETWEEN A PERSON’S COMPREHENSION OF THE KING JAMES BIBLE AND THE SMS TEXT MESSAGE BIBLE

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ABSTRACT

A person’s comprehension may depend on the translation of Bible read. The purpose of this study was to measure a person’s comprehension on the King James Bible and the Short Message Service (SMS) Bible. The SMS Bible is a bible that was translated into text message format. Volunteers from a local Governor’s School were tested with a comprehension test after reading eight verses from either the King James Bible or the SMS Bible. The results were analyzed with a t-test to see if there was a difference and the results concluded that there was a difference. It was easier for people to comprehend the King James Bible. In conclusion, the King James Bible is an easier translation than the SMS Bible. This may be due to the fact that the King James Bible has been around a lot longer than the SMS Bible and the fact that not many people are familiar with the SMS translation.
HONORABLE MENTION

THE EFFECT OF TEXT COLOR ON SHORT-TERM MEMORY

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George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

This experiment was based on human’s short-term memory of various colors of text. The purpose of this experiment was to see if black text or colored text was more often remembered. The problem was: is there a color that is easier to remember than black? The hypothesis was if black text was used, then the percentage of words remembered would increase. In this experiment, 50 words were presented to 20 7th grade students, and they were asked to remember as many as they could in a 90 second period. The results of this experiment showed that black text was remembered many more times than colored text, blue text was the most remembered of the colored text, and that females were marginally better at remembering words than males. The results of this experiment support the hypothesis, which stated that black text would be remembered more often than colored text. The results showed that black text was remembered many more times than the colored text.

HONORABLE MENTION

THE EFFECTS OF SOCIAL INFLUENCE AND MOTIVATION ON CHEATING IN THE CLASSROOM

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

The purpose of this study was to find the effects of social influence and motivation on cheating in the classroom. Peer and significant figure perceptions, honor codes, academic performance, morality, and self-handicapping were the different social influences and motivations that were investigated. For this study, comparison was used as the control. A survey on social influence and motivation on cheating was created. The questions and answers were in a format of multiple select. A high school with a population of over 1,500 students was used and a sample size of 140 was obtained. The survey was administered to the students and the results were obtained and analyzed. It was observed that cheaters cited self-handicapping as their motive; non-cheaters cited morality as their motive; and the sample population cited that other students who cheat are motivated by academic performance and morality. The results also indicated that the reasons for cheating, not cheating, and others cheating were motivation and not social influence. It was proposed from the response of the cheaters and sample population citation of why other students cheat that the learning environment might be extrinsically goal oriented. The reason for non-cheaters citing morality as their choice might be caused by heavy moral development. Continual studies might include specific social influences and motivations being individually examined.
HONORABLE MENTION

THE DIFFERENT READABILITY LEVELS OF THE GOSPELS IN FOUR DIFFERENT TRANSLATIONS OF THE BIBLE

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ABSTRACT

The readability level of the Gospels in its different translations was affected by a variety of variables including its history, authorship, and the time period from which it originated. The purpose of this study was to determine the different readability levels among the Gospels of Matthew, Mark, Luke, and John in the four different bible translations, King James Version, New Revised Standard Version, New International Version, and The Message. Fifteen randomly selected chapters from each gospel in each translation were tested using the Flesch-Kincaid readability formula and the results were analyzed using a two-way ANOVA. The two-way ANOVA yielded a statistical difference between the Gospels and between the different translations. The researcher concluded that The Message translation had the easiest readability level for the four Gospels and the book of Matthew had the hardest readability level of the four Gospels. This disproved a previous research study on the readability level of the King James Version.

OTHER PAPERS SELECTED FOR PRESENTATION:


The Effects of Different Genres of Music on Concentration. Kiera S. Campbell and Shannon L. Carey, Chesapeake Bay Governor’s School, Westmoreland County Schools.

The Effects of High School Focus Areas on College Majors or Career Choices. Wilburt L. Carpenter, Appomattox Governor’s School, Dinwiddie County Schools.

The Effect of Sleep Deprivation on a Person’s Ability to Take Tests. Carolyn E. Grahn, Thomas Jefferson Middle School, Arlington County Schools.


The Effect of Distractions on Foot Reaction Time. Curtis J. Kapsak, Deep Run High School, Henrico County Schools.

The Effect of Different Types of Music on the Brightness of Artwork. Nasheya Rahman, George H. Moody Middle School, Henrico County Schools.

The Effects of Audio on Ability to Play Music Simulators. Matthew D. Vetano, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effects of Alcohol on Dreams. Whitney N. Winn, Chesapeake Bay Governor’s School, King William County Schools.

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PHYSICAL SCIENCE

FIRST PLACE

REFLECTION OF LIGHT BY PAINT: THE EFFECT OF PAINT SHEEN ON LIGHT REFLECTION

Perrin L. Falkner
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Swanson Middle School, Arlington, Virginia 22205

Abstract: The purpose of this experiment was to find the effect of different sheens of paint finish on light reflection for a given paint color. Sheen is the luster of a surface, where luster refers to how much light is reflected. It was hypothesized that if a given light source is shined on paint of the same pigment but different sheen, then the Hi-Gloss sheen will reflect the most light. Four sheens were used, Hi-Gloss, Semi-Gloss, Satin and Flat. To test the hypothesis, a reflected light-measuring system was built to accomplish the experiment. Four pieces of balsawood were painted with two coats of interior latex in Shangri La, a red pigment. The control, a black background, was used for comparison. The inside of the reflected light-measuring system was painted black and the bottom of it was used for the control. The paint samples were slid inside the box to measure the amount of light reflection in lux. Hi-Gloss sheen was found to reflect the most amount of light, while the control, black background reflected the least. Semi-Gloss, Satin, and Flat came after Hi-Gloss consecutively. The data was found to be reliable and repeatable for future trials. The results support the hypothesis.

Introduction: Paint is available in a variety of colors, water or oil base, and interior or exterior. Also, a given color of paint can be supplied in a number of different sheens. Sheen is defined as the degree to which a surface reflects light (Rossi, 2008).

The purpose of this experiment was to investigate the effect of different paint sheens on light reflection for a given paint color. It was hypothesized that if a given light source is shined on paint of the same pigment but different sheen, then the Hi-Gloss sheen will reflect the most light.

To make Hi-Gloss paint sheen have a smooth surface, certain chemicals are added to the paint. These chemicals are confidential to the public (Bentley and Turner, 1998). A ray of light that strikes the surface of Hi-Gloss would reflect directly back to the eye. Light that strikes the surface of a rough paint, such as Flat, is reflected also, but some of the light is lost. The angles of the surface reflect some light directly back to the eye, and the rest of the light is reflected away (Baierlein, 1992). This kind of reflection is referred to as diffuse reflection. Regular reflection occurs when a light strikes a surface such as a mirror and bounces off all at the same angle (Bentley and Turner, 1998).

The reflected light was measured in a unit called lux. Lux is a SI unit of luminance that takes into account the area over which light is reflected as well as the sensitivity of the average human eye to light at different wavelengths (Solaris, 2009).

Light can be thought of as traveling in waves. The distance between crests of a wave is known as a “wavelength” (Bentley and Turner, 1998). The visible light spectrum is made up of wavelengths ranging from 420-450 nanometers (violet) to 610-700 nanometers (red). When light interacts with a surface it can be absorbed, bounce off (reflected), or be bent (refracted). The combination of these possibilities determines what the eye sees (Baierlein, 1992).

The color of paint is made up of a substance called pigment. Pigment absorbs some wavelengths and reflects others. Black pigments absorb nearly all wavelengths of visible light while white pigments do not absorb much light (Bentley and Turner, 1998).
For this experiment, a red color of Behr Premium Plus interior latex paint (called Shangri La) was used. This color absorbs light throughout the shorter visible wavelengths, but not the longer ones.

The question is how does sheen of paint affect the light that is reflected off the surface?

**Methods and Materials:** The hypothesis was if a given light source is shined on paint of the same pigment but different sheen, then the Hi-Gloss sheen will reflect the most light. There were four sheens tested for amount of light reflection (lux): Hi-Gloss, Semi-Gloss, Satin, Flat. A black background was used as the control. The paint brand, number of coats of paint, size of light-measuring device and placement between light source, paint sample and light probe were kept constant.

To test this hypothesis, a reflected light-measuring system was constructed and measured the light reflected from surfaces painted with a red color Behr Premium Plus interior latex paint (called Shangri La) in four different commercially available sheens: Hi-Gloss, Semi-Gloss, Satin, and Flat. The light-measuring system was constructed from a 26.1 cm by 26 cm by 25.5 cm cardboard box painted with two coats of black tempera paint inside. One side of the box could be opened to place the different paint samples in. On the side opposite, a hole 12 cm in diameter was cut to mount the light source and another 1.7 cm in diameter about 3 cm away from the light source toward a corner of the box for the light probe. The light source, a soft white 60 watt light bulb with a metal shade, and the light probe, a device that measures luminance in the unit lux, were inserted in each separate hole, 2 cm and 3 cm under the top of the box, respectively. The light source was tilted toward the center of the box.

Four pieces of 24.5 cm by 25.5 cm balsa wood were cut to paint two coats of interior latex paint on. Each piece was painted with a different sheen. To measure the amount of light reflection, one paint sample was placed on the bottom of the box. The light source was turned on and after 10 seconds, the light probe, connected to a computer, recorded the amount of light reflection. This step was repeated 10 times for each paint sample (Hi-Gloss, Semi-Gloss, Satin, and Flat). For the control, black background, the bottom of the box was used in place of a paint sample, but measured in the same way.

**Results:** In general, the measurements tended to be very reproducible, with relative standard deviations better than one percent. However, two of the measurements for the Satin surface were probably affected by accidental tipping of the light source. These two outliers caused the relative standard deviation to be 5%. When they are excluded from consideration, the relative standard deviation falls into line with the other levels.

The black background (control) reflected ten times less light (0.03 lux) than the painted surfaces (about 0.3 lux). Although the painted surfaces covered a small range, average values for the painted surfaces differed from each other. Hi-Gloss reflected the most light, followed by Semi-Gloss, Satin, and Flat.

The box and whisker plot shows all of the data, including outliers. Whiskers, which represent error bars, show that Satin and Semi-Gloss overlap, meaning the light levels reflected were likely not significantly different. The outlying data for Satin surface show up as the circles, with the black circle being the extreme value. Otherwise, the differences between the levels are likely statistically significant because there is no overlap in data values. As seen in the data table, when the outliers are excluded, Semi-Gloss reflects significantly more light than Satin.

**Discussion and Conclusions:** It was not surprising that the black background absorbed more light than the reddish pigment of the painted surfaces. The light-measuring system was painted black inside because the background reflected light in the box needed to be low. Any extra reflection from the inside of the box could have directly affect the results.

The hypothesis was if a given light source is shined on paint of the same pigment but different sheen, then the Hi-Gloss sheen will reflect the most light. This hypothesis was supported. The amount of
light reflected by the painted surfaces is consistent with the hypothesized order of the paint sheens. The way the light box, source and light probe were set up allowed successful measurement of these differences.

For the Satin trials, an experimental error could have occurred. The light source shifted during the time the two outliers were measured. Afterwards, the light source was moved back into place and remained for the rest of the trials. To avoid outlying data, a new way to secure the light source to the light-measuring system would be important. The place inside the light-measuring system where the light source and light probe were mounted also could have been a problem. The light probe may have picked up some direct light from the light source due to the position the light source was in. If this experiment was done again, the light source should be mounted below the light probe to make sure as little direct light is measured as possible.

The difference in reflectivity between sheens is caused by surface texture. According to the authors of *Introduction to Paint Chemistry*, the smoother the surface, the more light is reflected directly back to the eye. The law of reflection states that a ray is reflected from a plane surface at the same angle with which it strikes the surface (Sobel, 1982). Bumpy surfaces will cause light to reflect in different directions. The eye, or measuring device, such as a light probe, will not pick up the light cast away in different directions.

In some situations, paint is required to be highly reflective. An example would be road paint. To make paint highly reflective, colors like yellow or white that absorb very little light are used. If Hi-Gloss paint were painted on the roads, even though it is highly reflective, it would soon lose that quality due to cars and pedestrians scuffing it up. To assure that the lines stay reflective under the wear of traffic, crushed glass or glass beads are added to the paint (Skumatz, 2007). The glass provides many surfaces for reflecting light in all directions. A light from a car that shines in one angle to the road paint will make the paint just as visible as a light from another angle.

Different sheens are important for painting houses. Highly reflective sheens with smoother surfaces are easier to clean. Hi-Gloss tends to be very durable and is usually used on interior trim, in kitchens and bathrooms. Painting the outside of a house requires durability and can be painted with Hi-Gloss too. For large interior spaces, such as walls or ceilings, less reflective sheens are used. Lesser reflective sheens are more eye appealing and forgiving of surface imperfections.

**LITERATURE CITED**


**ACKNOWLEDGMENTS**

Thanks to Kelly Falkner for helping analyze the data.
Appendix

Appendix 1

Fig. 6.4 Reflection at a surface of low gloss.

Appendix 2

Picture of the setup of the light-measuring device.
Appendix 3

Table 1  The effect of types of paint finishes on the light reflection

<table>
<thead>
<tr>
<th>Paint Finish</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
<th>Trial 5</th>
<th>Trial 6</th>
<th>Trial 7</th>
<th>Trial 8</th>
<th>Trial 9</th>
<th>Trial 10</th>
<th>Average</th>
<th>Std Dev</th>
<th>Range</th>
<th>%RSD</th>
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</thead>
<tbody>
<tr>
<td>Hi-Gloss</td>
<td>0.3053</td>
<td>0.3063</td>
<td>0.3086</td>
<td>0.3062</td>
<td>0.3080</td>
<td>0.3053</td>
<td>0.3053</td>
<td>0.3048</td>
<td>0.3058</td>
<td>0.3055</td>
<td>0.3058</td>
<td>0.0010</td>
<td>0.0031</td>
<td>0.21</td>
</tr>
<tr>
<td>Semi-Gloss</td>
<td>0.2885</td>
<td>0.2883</td>
<td>0.2883</td>
<td>0.2877</td>
<td>0.2880</td>
<td>0.2880</td>
<td>0.2900</td>
<td>0.2876</td>
<td>0.2900</td>
<td>0.2880</td>
<td>0.2890</td>
<td>0.0015</td>
<td>0.0045</td>
<td>0.15</td>
</tr>
<tr>
<td>Satin</td>
<td>0.2900*</td>
<td>0.3125*</td>
<td>0.2980</td>
<td>0.2865</td>
<td>0.2713</td>
<td>0.2712</td>
<td>0.2709</td>
<td>0.2722</td>
<td>0.2743</td>
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<td>0.2715</td>
<td>0.0021</td>
<td>0.0082</td>
<td>0.42</td>
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<tr>
<td>Flat</td>
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<td>0.2509</td>
<td>0.2508</td>
<td>0.2510</td>
<td>0.2504</td>
<td>0.2509</td>
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<td>0.2512</td>
<td>0.0019</td>
<td>0.0068</td>
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<tr>
<td>Black Background</td>
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<td>0.0346</td>
<td>0.0349</td>
<td>0.0349</td>
<td>0.0350</td>
<td>0.0348</td>
<td>0.0347</td>
<td>0.0348</td>
<td>0.0348</td>
<td>0.0003</td>
<td>0.0007</td>
<td>0.75</td>
</tr>
</tbody>
</table>

*These numbers were outliers compared to the rest of the data. These numbers were not included in the Average, Standard Deviation, or Range.

Appendix 4

![Figure 1: Light Reflection](image-url)

- x-axis: Type of Paint Finish
- y-axis: Amount of Light Reflected (lux)
Appendix 5

Light Reflection

Amount of Light Reflected (lux)

A  B  C  D  E
Hi-Gloss  Semi-Gloss  Satin  Flat  Black Background
Appendix 6

Fig. 1.1. The law of reflection. A ray of light, $I$, incident upon a mirror is reflected in the direction of the ray $R$. The dashed line $N$, is the normal (or perpendicular) to the surface. The angle of incidence, labeled $i$, is the angle between the incoming ray and the normal; the angle of reflection, labeled $r$, is the angle between the reflected ray and the normal. Angle $i$ equals angle $r$.

Even if the mirror is curved, there is at each point of the surface a normal direction (the dashed lines in the right-hand figure); the law $i = r$ still holds at each point.
SECOND PLACE

THE EFFECT OF TEMPERATURE ON THE RESISTANCE OF METAL

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ABSTRACT

Electric devices lose a lot of electricity through resistance. The purpose of this experiment was to find the temperature where metal offers the least resistance, which is information needed to make technology and other electronic items more efficient. The hypothesis was, “If the temperature is decreased, then the amount of resistance will also decrease.” The experiment to test this hypothesis was carried out by using an oven to vary the temperature of identical steel sheets and then measuring the resistance, carefully, with oven mitts for risk of burns, in Ohms with a multi-meter. The results seemed to follow the pattern of decreasing resistance as the temperature was decreased to each level of the independent variable. It was also found that there could be a possible link between the temperature and the variability of resistance as the temperature is increased. The hypothesis of this experiment was supported by the data collected and analyzed. Since particles gain more energy as the temperature increases, as stated in the Kinetic Theory of Matter, the resistance increases, because the movement of the particles increases along with it, slowing down the electric current with all the moving particles getting in the way. Future research could be conducted to find out what affects resistance the most and the least. Future experiments could be improved by using a wider range of temperatures. The data could also be improved by using a heavy-duty freezer to provide data for the lower part of the temperature spectrum.

THIRD PLACE

THE EFFECT OF LOCAL MECHANICAL INFLUENCE ON THE DIMENSIONS OF THE TENSEGRITY STRUCTURE (ICOSAHEDRON)

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ABSTRACT

The purpose of this experiment was to test the third condition of a tensegrity structure. It was hypothesized that if you apply force to one part of the tensegrity structure then a change in length of all tension elements will occur. This hypothesis was based on the third rule of a tensegrity structure. To perform this experiment a tensegrity icosahedron was built from PVC pipes (compression elements) and bungee cords (tension elements) and then applied force to each of its struts by compressing and expanding the icosahedron. The results of the experiment showed that each time force was applied to the tensegrity structure all of the struts would shift from their original positions. When the struts were pulled apart, the distances between all the pairs of compression elements increased and the structure expanded. When the struts were compressed, the distances between all the pairs of compression elements decreased and the icosahedron contracted. In conclusion, the experiment was a success. The third rule of a tensegrity structure was tested, and the hypothesis was proved to be correct. The results of the experiment are consistent with other research done on this topic. It is planned to make a tensegrity model of a spine to educate the experimenter in biotensegrity.
HONORABLE MENTION

THE EFFECT OF DIFFERENT TAE KWON DO STANCES ON HOW FAR A TEN POUND RUBBER BALL TRAVELS BECAUSE OF THE FORCE EXERTED FROM A PUNCH

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ABSTRACT

Which Tae Kwon Do stance will give a punch more force and make a ten pound rubber ball travel farther? In this experiment, the experimenter wanted to improve his Tae Kwon Do skills while applying science to the subject. To answer this question, the experimenter’s hypothesis was: If different Tae Kwon Do stances are tested from “Back Stance” to “Tiger/Cat Stance” to “Ready Stance” to “Fighting Stance” to “Horse Stance” to “Front Stance,” then the force exerted from a punch will increase in that order each time. The procedure was done in an orderly process. Testers of different ages and genders punched a ten pound rubber ball in different Tae Kwon Do stances. The distance traveled by the ball was measured in centimeters. The data was collected and different measurements and statistical data were found. The average force in centimeters for fighting stance was 67.3, back was 61.8, front was 59.3, horse was 56.5, tiger was 52.3, and ready was 46.1. Thus, the hypothesis was not supported. Also, the results showed the most powerful punch, the weakest punch, the standard deviations of the punches, the most consistent punch, etc. These results lead to many conclusions and improvements. Some include “hip action” findings, age or gender effecting ball distance, or better measurements. Overall, the experiment was interesting, successful, and educated the experimenter in not only Tae Kwon Do, but also the importance of research.

HONORABLE MENTION

THE EFFECT OF TEMPERATURE AND DISTANCE FROM OTHER BANANAS ON THE NUMBER OF BROWN SPOTS ON A BANANA IN A GIVEN TIME

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ABSTRACT

An experiment was conducted to see if consumers could place their bananas in certain conditions that allowed the bananas to ripen when it was more convenient for the consumer. The experimenter studied the effect of grouping and temperature on the ripening of bananas. The experimenter hypothesized that if fruits grouped together in a warm area were observed, then the fruit ripening would happen faster. The experimenter took 150 bananas and separated them into five “sets”. Each “set” was put in a different condition. The first set was the control, it had single bananas in room temperature. The next two sets contained bananas were grouped together, one set was in a high temperature at 87 degrees and another was in a low temperature in refrigeration. The two other sets had bananas that were single, one set in a high temperature, and another in a low temperature. The experimenter found that bananas in higher temperatures ripen faster and bananas placed in lower temperatures ripen slower. The most likely reason for this is that low temperatures reduce the amount of ethylene gas that fruits produce. Ethylene gas is a gas that fruits naturally produce that causes the fruit to ripen. This may be why bananas at lower temperatures ripen
slower. Furthermore, the experimenter learned that grouping the bananas increases the speed of ripening, but singling them out makes them ripen slower. When the bananas were grouped together the ethylene gas concentration was higher, so the ripening happened faster. Hence, the experimenter believes a consumer can now place bananas in conditions that are more convenient for the consumer, by controlling temperature and grouping.

HONORABLE MENTION

THE EFFECT OF CAST HEIGHT ON GIANT SWINGS

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Swanson Middle School, Arlington, Virginia 22205

ABSTRACT

The effect of cast height on the ability to complete a giant was investigated. Giant swings and casts are performed in gymnastics on bars. A giant is a skill where a gymnast swings a full circle around a bar. A cast is the motion before a giant where a gymnast pushes off the bar to receive momentum before the swing. A model was constructed for the experiment: a 91.3 cm brass bar was used to represent the gymnastics bar, and a galvanized steel banding strip was used as the model gymnast. The model gymnast was swung around the bar at cast heights of 90°, 45°, 0°, and -45°. The hypothesis was if the cast is higher, then the end height of the swing will be higher because the gymnast would have more time to complete the skill and the gymnast may receive more momentum from a higher cast. The null hypothesis was if the cast is higher, then the giant will be completed at a lower angle. The conclusion was that a 90° cast, the highest cast, affected the end of the giant positively followed by 45° cast, 0° cast and a -45° cast. The data showed a higher cast did affect the end height of the giant.

OTHER PAPERS SELECTED FOR PRESENTATION:


The Resonance Time of a Snare Drum as the Number of Tensions Rods and Turns Are Increase. Christian A. Brenke, James River High School, Chesterfield County Schools.

The Effect of Brand Name Drugs vs. Generic Drugs on Dissolution Time. Shelbie C. Dashiell, Isle of Wight Academy, Isle of Wight Private Schools.

The Effect of Trebuchet Projectile Arm Length on Projectile Distance. Lucas K. Dutcher, George H. Moody Middle School, Henrico County Schools.

The Gaussian Gun: Ball Bearing Size vs. Speed. Jackson C. Key, Isle of Wight Academy, Isle of Wight Private Schools.

The Effect of Different Lengths of Body Tube on the Altitude of Model Rockets. William E. Kunkle, George H. Moody Middle School, Henrico County Schools.

“Green” vs. “Non-Green” Insulation. Rachel E. Merriman-Goldring, Swanson Middle School, Arlington County Schools.

Which Insulator Works the Best? Nicole K. Orttung, Swanson Middle School, Arlington County Schools.
The Effect of Different Truss Bridge Design on the Amount of Weight Each Bridge Will Hold.  David H. Reardon, George H. Moody Middle School, Henrico County Schools.

The Effect of Different Temperatures on the Distance Rubber Bands Will Stretch.  Isabelle S. Stern, George H. Moody Middle School, Henrico County Schools.

The Effect of Different Types of Storage on the pH Level of the Drink.  Melynna Thai, George H. Moody Middle School, Henrico County Schools.

Rocket Aerodynamics: How Does a Design Change Affect Performance?  Gregory A. Turnbow, Homer L. Hines Middle School, Newport News City Schools.

The Effect of Cork, Rubber Balls, and Sawdust on the Distance and Speed of a Baseball.  James R. Vulcanoff, George H. Moody Middle School, Henrico County Schools.

The Bright Idea.  Reid F. Williams, Trinity Lutheran School, Newport News Private Schools.

The Effect of Type of Paper on How Far a Paper Airplane Flies.  Frederick J. Wolf and William A. Vogelsang, Williamsburg Middle School, Arlington County Schools.

Abstract: The purpose of this study was to determine whether or not the medium on which text is displayed has any effect on the ability to retain information. This study was conducted at a local middle school during December of 2008. Two classes of eighth grade students were randomly divided into two groups. One group read a story excerpt from paper, and the other read the same excerpt from a computer screen. Afterwards, these students took a brief test on the information from the passage. These tests were scored using the total points method, and a two-sample t-test was conducted to analyze the data. The mean test score for those students who read the passage from screen was 28.1%, while the mean test score for those who read from print was 81.9%. The alpha level was set at 0.05, and the p-value from the two-sample t-test performed was 1.93E-07. This supports the original hypothesis – students who read text from paper retained more information than those who read text from screen. In summation, the medium on which text is displayed significantly affects the ability to retain information.

Introduction: In the past decade, technology has made monumental advances. Nowadays, many students rely on electronic media sources to stay informed and research information. Online learning tools are becoming more and more prominent, especially in the world of education; in fact, many believe that electronic sources will someday replace traditional printed textbooks (Eshet-Alkalai and Geri, 2007). However, some question the effectiveness of online text compared to printed text (Gulbrandsen et al., 2002). This information has intrigued the researcher to question if the medium on which text is displayed has any effect on the ability of students to read and comprehend information.

A local high school student conducted this study over the course of one day at a nearby middle school. The researcher divided two classes of eighth grade students into two groups. Within each class, one group read a passage from a computer screen, and the other group read the same passage in print. After reading, all students took a test on information from the text. Test scores were recorded and analyzed. The independent variable in this experiment is the medium on which the information was displayed: either screen or paper. The dependent variable was students’ test scores.

Confounding variables include the possibility that the third period class communicated with the fifth period class about the post-test’s specific answers; however, the students had no incentive to cheat as they were told that the test would not affect their English grade in any way. Another confounding variable was the students’ possible knowledge of the literature used for testing. This possibility was eliminated as students were not informed of the text used in the experiment. The researcher specifically chose text to which the students had no prior exposure. The researcher hypothesized that if students read literature from screen and paper, then the group of students who read the text from paper would score higher on a post-test than students who read the same text from a computer screen.

The concepts necessary to understand this project are the general differences in reading between print and screen, differences in memory recall between electronic and print sources, and the new technologies resulting from an abundance of electronic media.

Reading comprehension is defined by Lenz (2005) as “constructing meaning from text.” Many scientific studies have reported noteworthy differences between reading from screen and paper. The most prominent difference is that in reading speed. Reading speed for screen text is reported to be 20%-30% slower than reading speed for printed text (as cited by Jones et al., 2005; Kurniawan and Panayiotis, n.d.). This significant difference is possibly due to the fact that “online reading creates a higher cognitive load on the reader compared to reading from

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print.” (Eshet-Alkalai and Geri, 2007). Many complain of experiencing “severe disorientation” as a result of reading electronic text, perhaps due to the fact that readers of online materials must scroll through multiple pages of text (Eshet-Alkalai and Geri, 2007; Jones et al., 2005).

In a poll conducted by Jones et al. (2005) 48% of those polled said they preferred reading from paper to reading from screen, despite the fact that an overwhelming majority reported that they were comfortable using the Internet and computers. According to Jones et al., (2005), “people often comment that they must print out a hard copy of a document that has been written on the computer in order to thoroughly read and evaluate what has been written.” Those polled reported that inconvenience, eyestrain, and presence of distractions were sufficient reasons not to read online articles. Some internet sources may introduce cognitive barriers that can confuse even the more competent students who have been long-exposed to online reading (Coiro, 2003).

English teacher Mark Bauerline (n.d.) asserts that strategies used while reading from an online page are completely different that those used when reading from paper. For example, when people view online articles, they read the first few sentences thoroughly, and then as their eyes continue down the page, they gradually read less information at a more rapid pace. This method is called the “F-pattern,” named so because the eyes trace the shape of an upper-case “F”. Bauerline continues in saying that Web page readers’ eyes jump around the page, reacting to bullets, colored text, pictures, and other “eye candy.” According to an eye-track study, a mere one in six participants actually read an online article line by line. The others scanned the page and skipped from one page to another, trying to get to the “meat” of the article. In a study conducted by Sutherland-Smith (2002) grade-school students “felt there was a necessity for speed in an Internet reading task.” Surprisingly, PDF files are not any more appealing to readers than regular internet text, and readers are not likely to read a PDF file unless it is printed out (Bauerline, n.d.). Clearly, there are many obstacles present when reading online text. The overwhelming differences between screen and print sources cannot and should not be ignored.

One of the most prevalent differences in reading electronic and printed text is in the ability to recall information. Though some hold that there is no significant difference between screen and paper in the ability to retain information, other findings imply that there is a higher level of memory recall for print media (Gulbrandsen et al., 2002; as cited by Jones et al., 2005). However, Jones et al., (2005) mention that the ability to memorize information is possibly dependent upon how motivated the reader is and on his or her “ability and willingness to learn information.” The same experimenters later discovered that, indeed, print recall showed a “far larger mean than screen recall,” and that those who read print “attempted to recall significantly more items that screen viewers.” This implies that print media perhaps possesses “more motivating qualities” that does electronic media (Jones et al., 2005).

Finally, there exists the idea that, in the future, electronic media will surpass and replace traditional print sources. Indeed, studies show that, presently, consumption of print information nearly equals that of electronic information. Furthermore, in approximately ten years, experts predict that 70% of all information “will be available in a digital format, whereas only 30% will be available in print (Eshet-Alkalai and Geri, 2007).” Coiro (2003), too, admits that in the future, it will be necessary for students to become adept at reading online sources, as the future will become digitized. This emergence of new electronic media means that educators must adapt and teach their students how to properly utilize Internet sources so that students, in turn, can gain as much information as possible. Readers of online text must often use different strategies when reading online sources, including using the cursor to keep one’s place (Sutherland-Smith, 2002; Bartlett, n.d.; Kurniawan and Panayiotis, n.d.). In an eye tracking study conducted by the Poynter Institute, researchers found that those who read print were more likely to be “methodical readers” than scanners (Quinn and Adam, 2008).

Despite the fact that many praise new digitized methods of education, others defend the classic textbook method. Mark Bauerline (n.d.) mentions that, in 2007, the National Center for Education and Evaluation and Regional Assistance found that “test scores were not significantly higher in classrooms using selected reading and mathematics software products.” Educators should act as a “counterbalance” to the rapid digitizing of text, he says, as online media threatens to replace classic printed text. Despite the fact that some experts oppose the use of digitized methods to educate students, studies unanimously show that electronic media is here to stay.

The purpose of this study was to determine if there was a difference in reading text on paper and text on screen with regard to reading comprehension in eighth grade students.
**Methods and Materials:** The experimenter conducted this study over the course of one day in a local middle school computer lab. Subjects were the students of two advanced eighth grade English classes. In each class, these students were randomly divided into two groups by drawing black and red checkers from a bag. One group read text (Appendix A) in PDF format from a computer screen, and the other read the same text from standard 8.5-by-11 inch computer paper. After the subjects finished reading, the experimenter administered a printed test (Appendix B) on information from the text. These tests were labeled in order to separate the tests of students who read from screen and those who read from paper. The color of these labels (which read either “paper” or “screen”) corresponded with the color of the checker that the subject chose prior to testing. The independent variable in this experiment was the medium (screen or paper) on which the information is displayed. The dependent variable was the subjects’ test scores. The scores of this test (measured in percent) were calculated by dividing points earned by total points possible and recorded in a table. The data was analyzed using a two-sample t-test and displayed graphically using a bar graph. The null hypothesis was that $\mu_{\text{Paper}}$ (test scores of students who read the text on paper) would be equal to $\mu_{\text{Screen}}$ (test scores of students who read the text from screen). The alternate hypothesis was that $\mu_{\text{Paper}}$ would be greater than $\mu_{\text{Screen}}$. (Ho: $\mu_{\text{Paper}} = \mu_{\text{Screen}}$; Ha: $\mu_{\text{Paper}} > \mu_{\text{Screen}}$) (See Appendix A for dialogue used during testing.)

The appropriate ISEF forms were completed to gain project approval from the Institutional Review Board. These forms included: Checklist for Adult Supervisor/Safety Assessment Form (Form 1), Student Checklist/Research Plan (Form 1A), Approval Form (1B), Risk Assessment Form (Form 3), and Human Subjects and Informed Consent Form (Form 4). The project was deemed ethical and plausible by the International Review Board.

**Results:** The results of this experiment show that eighth grade students who read a story excerpt in print scored significantly higher on a short post-test than did students who read the same story excerpt from a computer screen. The group that read from paper scored an average of 81.9%, while the group that read from a computer screen scored an average of 28.1% (Appendix D, Table 1, Fig. 1). A two-sample t-test was conducted to analyze the data, as shown in Table 2 of Appendix D. The alpha level was set at 0.05, and the p-value obtained was 1.93E-7, showing a clear and significant difference between the scores of those who read from paper and those who read from screen. The data supported the alternate hypothesis that the average test score of students who read the text on paper was greater than the average test score of students who read the text from screen. The data also supported the overall hypothesis that students who read from paper retained more information than students who read from screen.

**Discussion and Conclusions:** The purpose of this study was to determine if there was a significant difference in reading text on paper and on screen with regard to reading comprehension. The results of this experiment show that students who read text from paper retain more information than those who read text from a computer screen. Students who read from paper scored an average of 81.9% while those who read from screen scored an average of 28.1%. The two-sample t-test’s p-value of 1.93E-7 was far less than the alpha level set at 0.05, suggesting a clearly significant difference between the group that read the passage from print and the group that read the passage from screen. In conclusion, the results show that students can retain more information from paper than from a computer screen, which supports the original hypothesis – students who read from paper will retain more information than those who read from screen.

These results concur with Jones et al., (2005) who concluded that print recall’s mean is far greater than that of screen recall. However, not all scientific results support the idea that medium has a direct affect on the ability to retain information. Eshet-Alkalai and Geri (2007), for example, found that there was not a significant difference between those who read digital articles and those who read physical copies of the same articles.

Problems encountered during this study include initial difficulty in contacting an available teacher at the local middle school. This minor obstacle pushed back the planned testing date. Furthermore, after the teacher was contacted, only a handful of students from this teacher’s first period actually returned their informed consent forms, further delaying the testing date. In the end, the researcher used the teacher’s third and fifth period classes. These students promptly returned their forms, ad testing proceeded as planned. Potential confounding variables included the possibility that, prior to testing, students have exposure to *The Teacher’s Funeral*, the book from whence the excerpt came. The researcher suggests further investigation into the differences between printed text and digital text;
for example, it would be interesting to study how young children read these two mediums compared to older
generations, as there has been an increase in exposure to digital media in school environments.

**LITERATURE CITED**


Appendix A

Good morning, everyone. Today you will be participating in a scientific study designed to test the differences between reading from screen and reading from paper. First, you will be given 10 minutes to read an excerpt from The Teacher’s Funeral, a story written by Richard Peck. Then, you will take a written test on the information from the story. Part of this test will be multiple choice, and part will be short answer. This test will not count towards your six weeks grade in any way. All results will remain anonymous. You should not write your name or any other personal information on your test paper.

First I will divide you into two groups. When I come around, please choose a checker from the bag without looking. If you choose a black checker, you will read the story from the computer. If you choose a red checker, you will read the story from paper. Please take a seat and put your checker on top of your computer. Are there any questions?

You all may begin reading the passage. You have ten minutes.

Time is up. If you are on a computer, please exit out of the story. If you read the passage on paper, please pass the paper to the [right/left] and I will collect them.

Now I will pass out the tests. Make sure that the color of the word in the top right corner corresponds with the color of the checker you chose in the beginning of the session. You have 10 minutes to complete this test.

Time is up. Please pass your tests to the [right/left]. After I collect your tests, you are free to go. Thank you all for participating in this study; you’ve been a big help.
Appendix B

If your teacher has to die, August isn’t a bad time of year for it. You know, August. The corn is earing, the tomatoes are ripening on the vine, the clovers in full bloom. There’s a little less evening now, and that’s a warning. You want to live every day twice over because you’ll be back in the jailhouse of school before the end of the month.

Then our teacher, Miss Myrt Arbuckle, hauled off and died. It was like a miracle, though she must have been forty. You should have seen my kid brother’s face. It looked like Lloyd was hearing the music of the spheres. Being ten that summer, he was even more willing to believe in miracles than I was.

You couldn’t deny Miss Myrt Arbuckle was past her prime. She was hard of hearing in one ear, no doubt, deafened by her own screaming, and she couldn’t whup us like she wanted to. She was a southpaw for whupping, and she had arthritis in that elbow, so while she could still whup, it didn’t make much of an impression.

Back in the spring when she called up Lester Kriegbaum for some infraction, nothing serious, he brought a book to the front of the room and read it over her knee while she larouped away at his far end.

So when you get right down to it, if you can’t hear and you can’t whup, you’re better off dead that teaching. That’s how I looked at it.

There was always talk about shutting down Hominy Ridge School anyhow. Now that me and Lloyd saw its end might be nigh, hope broke over us. It was surely too late to find another teacher who’d teach in a place like that.
Hominy Ridge was nothing but an out-of-date, unimproved, one-room country school house in the backwoodsiest corner of Indiana. They admitted it didn’t pay to keep it for just us straggle of kids who went there.

Dad was on the school board. Me and Lloyd hoped to encourage him to close down the school and drive all formal education out of this part of Parke County. For one thing, I’d been fifteen since winter and still hadn’t passed the eighth grade graduation exam.

Besides, I had me a dream, and school only stood in my way.

“Russell, will they have a funeral for Miss Myrt?” Lloyd looked up at me wondering.

“Of course they’ll have a funeral for her,” I said. “Did you think they’d just feed her to the hogs?”

But I knew how Lloyd thought. Regular people have funerals, but Miss Myrt was a teacher. As for a funeral, it was hot weather and the crops were in the ground, and the roads were dry, and the fair was over. “What else do people have to do?” I said. “They’ll turn out for Miss Myrt.”

“They better,” Lloyd said darkly. “She’s liable to set up in her coffin and take roll.”
Appendix C

1. In what month does Miss Myrt Arbuckle die?

2. “You want to live every day twice over because you’ll be back in the _______________ of school before the end of the month.”

3. What is Miss Myrt’s job?

4. How old was Miss Myrt when she died?
   a. Twenty
   b. Thirty
   c. Forty
   d. Fifty

5. Who is Lloyd? Is he younger or older than the main character, Russell?

6. “She had a southpaw for whupping, and she had _______________ in that elbow, so while she could still whup, it didn’t make much of an impression.”

7. “So when you get right down to it, if you can’t hear and you can’t whup, you're better off ________ than teaching.”

8. Where does Russell go to school?
   a. Bear Hill School
   b. Hominy Ridge School
   c. Keefer’s Mountain School
   d. Eagle Ridge School

9. “‘Of course they’ll have a funeral for her,’ I said. ‘Did you think they’d just feed her to the _______?’”

10. How old is Russell, and what grade is he in?
a. Russell is twelve and in fifth grade.
b. Russell is seventeen and in eighth grade.
c. Russell is fifteen and in eighth grade.
d. Russell is fourteen and in seventh grade.
Appendix D

Table 1. Test scores (%) of eighth graders who read screen text or printed text.

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<th>Screen Text</th>
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</thead>
<tbody>
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<tr>
<td>2</td>
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</tr>
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<td>3</td>
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<tr>
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<td>93.75</td>
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Mean: 81.94

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<th>Screen Text</th>
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</thead>
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<td>9</td>
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</table>

Mean: 28.13

Table 2. t-Test: Two-Sample Assuming Equal Variances Comparing Printed Text and Screen Text

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<th>Printed Text</th>
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<tr>
<td>t Critical one-tail</td>
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Fig. 1. Mean test scores (%) of eighth grade students who read screen text or printed text.
SECOND PLACE

THE EFFECT OF MUSICAL EXPERIENCE ON PREFERENCE OF TUNING SYSTEM

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ABSTRACT

As Western music has evolved, new tuning systems have been developed to complement music of differing styles. One of the oldest systems, Pythagorean tuning, makes use of whole number ratios to tune pitches, and tends to produce more overtones and resonance; unfortunately, it is difficult to tune modern instruments this way. In contrast, equal temperament, the most commonly used system today, separates pitches by a fixed frequency value, and is accommodating for frequently modulating modern music. The study evaluating the effect of musical experience on preference of tuning system hoped to determine if it was worthwhile to pursue new music technologies that allow for Pythagorean tuning. The study involved subjects of varying musical background listening to a MIDI sound clip that compared the two systems, and then subjects stating which tuning system they preferred the most. It was believed that more musically experienced subjects would prefer Pythagorean tuning. Raw data showed that generally, more musically experienced individuals preferred this system; however, because statistical analysis did not support this claim, the research hypothesis was not supported.

THIRD PLACE

MUSIC AND MEMORY

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ABSTRACT

The goal of this study was to determine whether or not there is a relationship between a high school student's instruction in music and his or her audio memory. It was hypothesized that student musicians would score higher on an audio memory test than non-musicians while the two groups would have similar scores on a visual memory test. Auditory testing was performed by reading aloud a list of ten nouns to students who then, after a period of time, were asked to write down all the words they could recall. Visual testing was performed by presenting students with a list to observe themselves momentarily. Then, after a period of time, they were asked to write down all the words they could recall. Results suggested that there is a correlation between musical instruction and auditory scores, while there was no statistically significant correlation between music and visual scores. The musicians and non-musicians scored a mean of 5.8333 out of 10 and 4.2500 out of 10 on the auditory tests respectively. It was concluded that there is a positive relationship between a student's musical instruction and his or her auditory memory.
HONORABLE MENTION

THE EFFECT OF SUBLIMINAL MESSAGES ON A PERSON’S CHOICE

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ABSTRACT

Subliminal messages have been used in many movies, songs, commercials, and various advertisements. A subliminal message is a type of message delivered inside of a medium message. A medium message is an unrelated media type or frequency that carries and contains a subliminal message. Usually subliminal messages are short flashes or sounds that are not recognized by the conscious mind, but they are noticed by the subconscious mind. The purpose of this experiment was to determine how subliminal messages would affect a person’s choice using the subliminal messages Coke, Skittles, and Abraham Lincoln. The subliminal message of Coke was placed into a medium message three times. The same process was used to create two other videos; one video containing the subliminal message of Skittles and the other Abraham Lincoln. Each video was shown to an experimental group containing 20 students and their choices were recorded. The t-test was used to test the following null hypothesis at a 0.05 level of significance: Subliminal messages have no effect on a person’s choice. For Coke subliminal message and Coke control (no subliminal message), the null hypothesis was rejected (t= 3.112 > 2.024 at df= 38; p<0.05). For Skittles subliminal message and Skittles control (no subliminal message), the null hypothesis was rejected (t= 7.184 > 2.024 at df= 38; p<0.05). For Lincoln subliminal message and Lincoln control (no subliminal message), the null hypothesis was rejected (t= 2.989 > 2.024 at df= 38; p<0.05). The data analyzed supported the research hypothesis that subliminal messages have an effect on a person’s choice. Previous experiments using audio subliminal messaging were researched. It was also found that audio subliminal messaging is not as effective as visual subliminal messaging. The results from this experiment supported this idea.

HONORABLE MENTION

THE EFFECT OF LIGHT ON THE SPEED OF PLANARIA AND KNOWLEDGE TRANSFERRED FROM ONE PLANARIA TO ANOTHER

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ABSTRACT

The purpose of this experiment was to see the effect of the amount of light on the speed of the planaria and knowledge transferred from one planaria to the other. The time it took for the first planaria to finish the maze was recorded. Then, the first planaria was fed to a second planaria, and this planaria was also timed on how long it took to finish the maze. For each trial, a new set of planaria was used. The average speed of the planaria with the independent variable of no light was 1876.7 seconds. The average speed of the second planaria after eating the first planaria with no light (for the effect on the knowledge transferred) was 1418.29 seconds. For both dependent variables, the means decreased once the numbers got to the 15 watts independent variable. The average speeds then increased when the bulb was changed to 35 watts, and then decreased from there. By the 75 watt independent variable, the average was zero because the planaria used for the trials for the 75 watt independent variable were unable to finish the maze. An ANOVA test was performed for both dependent variables and the p-value for both was less than 0.05. Therefore, the null hypothesis was rejected for the effect of the amount of light on the speed of planaria. Light had an effect on the speed of the planaria. But it was also concluded that light did not have an effect on the knowledge transferred because the second planaria performed better than the first planaria. This was
expected to occur because the first planaria transferred knowledge from the maze to the second planaria. All the averages from the second planaria were faster than the averages from the first planaria.

**HONORABLE MENTION**

**THE EFFECTS OF AEROBIC EXERCISE AND MENTAL ACTIVITY ON COGNITIVE FUNCTIONING**

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**ABSTRACT**

Research has shown that there may be a link between physical and mental activities and how the brain functions. The purpose of this experiment is to show that physical exercise produces better scores in a series of cognitive tests. It compares improvements in test scores after 3 types of activities: physical, mental, and nonactivity. The results of the experiment were that participants who played a memory game using cards or exercised had a greater improvement in memory, analogy, and math tests than the participants who watched television. These results suggest that physical exercise could be beneficial to humans by making them both healthier and more intelligent at the same time.

**OTHER PAPERS SELECTED FOR PRESENTATION:**


The Effect of Different Distractions on Memorization. Kelly R. Brubaker and Christine S. Lee, Deep Run High School, Henrico County Schools.


The Effects of Vision on Smell. Neha Choubey, Southwest Virginia Governor’s School, Radford City Schools.

The Effect of Political Identification on Perceived Media Bias. Paige M. Curtis, Mountain Vista Governor’s School, Winchester City Schools.

The Effect of Gender on the Ability to Identify Details of a Scene. Eleanor P. deButts and Natalie J. Yoder, Yorktown High School, Arlington County Schools.


Effect of Position on a Page on an 8th Grader’s Recall Ability. Ryan S. Densley, George H. Moody Middle School, Henrico County Schools.

The Effect of Media Influence on Kindergartner’s Toy Preferences. Kensley B. Elliott, Central Virginia Governor’s School, Lynchburg City Schools.

Short Term Memory Recall at Different Stages of the Aging Process. Kevin W. Fleming, Jr., Central Virginia Governor’s School, Lynchburg City Schools.
Responsiveness to Suggestion by Elementary and High School Students in Relation to Different Senses. Caitlin L. Hodges, Chesapeake Bay Governor’s School, King William County Schools.


The Effect of Advertisement Color on Number of Consumers Drawn to that Product. Allison E. Jaros, Deep Run High School, Henrico County Schools.

The Effect of One’s First Language on the Ability to Read Typoglycemic Words. Hayoung Lee, Deep Run High School, Henrico County Schools.

The Effect of the Duration of Time between Studying and Testing on Test Performance of Middle School Students. Talie K. Lerner, George H. Moody Middle School, Henrico County Schools.

The Effect of Age, Gender, and Ethnicity on Emotional Intelligence. Meher S. Malik, Mills E. Godwin High School, Henrico County Schools.
PSYCHOLOGY - LEARNING AND PERCEPTION B

FIRST PLACE

THE EFFECT OF SOUND ON SHORT-TERM VISUAL MEMORY

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Washington-Lee High School, Arlington, Virginia 22207

Abstract: The purpose of this experiment was to determine how sound affected the ability to remember. The sound was the independent variable while the dependent variable was short-term visual memory (represented by the number of words subjects remembered). The hypothesis was that if the intensity of sound is increased, then the number of words memorized will decrease because sound is distracting. To carry out this experiment, subjects were shown ten words on PowerPoint slides. First, no sound played while the presentation flashed up each word one at a time. The subjects were asked to recall and write down as many words as they could remember after the presentation. This process was repeated twice afterwards with two different sets of ten words and with different levels of sound playing in the background. The results were that from silence to 40 decibels of sound, the number of words remembered decreased. From 40 db to 70 db of sound, there was no statistically significant difference in the number of words memorized. In conclusion, sound has a negative effect on the ability to remember words, but the level of sound had no significant impact. Further research into this subject could include different independent variables such as age, level of education, and gender.

Introduction: Everyday people must remember different things—where they put their keys, phone numbers of their relatives. But how much can they really remember? More specifically, how are their memories affected by their surroundings? This experiment endeavors to discover that. Sound is a constant in our lives at varying levels. If a person tries to remember information, his or her memory will be affected by the sounds around them. This has an implication for everyone from the student who tries to study while listening to music to the worker in the cubicle who has to listen to the chatter of his or her colleagues. Memory is a deep, intricate process of the brain and is influenced by sound.

The purpose of this experiment is to determine how levels of sound affect a person's memory. The subjects will be asked to remember a series of words presented to them while different levels of sound play in the background. The independent variable will be the loudness, or intensity, of the sound while the dependent variable will be the short-term visual memory measured by the number of words remembered correctly.

To begin with, sound, the independent variable, is more complex than it seems. Sound is produced when an object vibrates and transfers kinetic energy to the surrounding molecules. These molecules vibrate and in turn pass on the kinetic energy to new molecules (McGrath, 2007). The movement of kinetic energy causes compressions (the place where molecules squish together) and refractions (the area where molecules are spread out). These move outward, making sound a longitudinal wave.

Because sound is a wave, the type of sound made depends on the frequency, wavelength, and amplitude. The wavelength and frequency determine the pitch of the sound. The frequency is the number of waves that pass through a point in space in one second (Richmond, 2002). The amplitude is the height of the wave. It determines the loudness of the sound.

As sound is traveling in longitudinal waves, it transports energy. The rate that the energy is conveyed, described in terms of watts, is called power. Sound intensity is measured in watts per square meter (Richmond, 2002). Humans cannot discern sound intensity directly, but they can hear loudness in a wide range. Because of this, a logarithmic scale for loudness was created. A decibel (db), named after Alexander Graham Bell, is the unit of loudness. Humans begin to hear sound at 0 db or $10^{12}$ watts per square meter. The intensity increases tenfold for every ten db. For example, 20 db is ten times as intense as a sound of 10 db and a hundred times as intense as 0 db. However, the loudness of a sound does not increase at the same rate as the intensity does. For instance, a sound with ten times the intensity of another is only heard
twice as loud. This means that 20 db is only twice as loud as 10 db.

In this experiment, the sound levels of 40 db and 70 db were used. Forty db is fairly soft and is the typical volume of a full room in a library. Seventy db is the same level of sound as a busy street. Sound is the strongest of senses since it is in constant use and captures attention while engrossed in other activities (Richmond, 2002). This statement implies sound can affect people even as they attempt to remember words by sight.

Not only is the independent variable complex, but the dependent variable (short-term visual memory) is also intricate. Memory is the process in which the brain receives and stores information (Doorey, 2008). The working memory, where short-term information goes, is believed to be in the prefrontal cortex while the long-term memory is in the cerebral cortex. The dependent variable can be broken down into two sections of memory: short-term and visual.

Visual memory is the memory we remember from sight. The order it flows through the brain is as follows. First a person gets environmental input that the sensory then registers at the visual auditory haptic. The working memory stores it for a short while and the information then proceeds to either the long-term store or creates a response (Baddely, 2004).

The second part of the dependent variable is the short-term memory. This is close in operation to the long-term memory, but has a shorter retention and may be a different system. As discovered by psychiatrists, Richard Atkinson and Richard Shiffrin in 1968, the short-term system is fed by a series of micro-memories associated with perception (Baddely, 2004). It was also discovered that short-term memory is acoustic since the occasions of error take place with words or letters that sound similar to the correct piece of information. In serial recall (the process or remembering in a specific order), the last items presented tend to be remembered the most, which is called the recency effect (Travers, 2007). Both these facts have implications for how sound is perceived over remembering sight. A normal human can remember five to nine units of information for twenty to sixty seconds (Doorey, 2008).

A similar study investigating the effect of distracting noises was conducted. The subjects were also shown words visually while noise played at intervals in the background. The findings were that subjects found it more difficult to memorize words with the noise in the background. The experiment cited the extra energy that the participants required to ignore the sound as a reason for distraction and claimed subjects remembered less because they were more focused on blocking out the sound (Morgan, 1917).

From this information, a hypothesis can be made. If the intensity of a sound is increased, then the number of words remembered will decrease because sound is distracting and hearing is a stronger sense than sight. Humans can only store a certain amount in their short-term memory through visual retention and with an added distraction, the amount they can remember will decrease.

Methods and Materials: The experiment was conducted in three parts. First, the subjects were shown ten words on a PowerPoint presentation in a silent environment (the control group). Each four-letter word was on its own slide written in capitals and was displayed for two seconds. After the presentation, the subjects were asked to recall and write down as many words as possible. The number they correctly remembered (which was checked for accuracy) was used for the dependent variable (short-term visual memory). In the second part, the process was repeated with the same people but with a different set of ten words and with forty decibels of sound (the independent variable) playing in the background. The experiment was repeated a third time with the same people, another group of ten words, and seventy decibels of sound playing in the background.

The words were generated randomly from a list of four letter words on the website www.scrabble.org (see appendix for list of words). The sound in the second and third parts was a recording of the pledge of allegiance being played over and over, and the subjects were assured that they would not have to remember any of it. A sound meter was employed to check the level of sound. Forty db and 70 db of sound were chosen because they demonstrated different benchmark levels of sound. Forty db is soft sound similar to a study setting in a library. Seventy db is a louder sound equivalent to a busy street. A total of
fifty subjects were tested. For the experiment, the type of sound (in the second and third parts) and the people participating remained constant in each trial, so the effect of the level of sound could be compared.

Results:

The Effect of Sound on Short-Term Visual Memory

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<th>Control (no sound)</th>
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<th>70 db of sound</th>
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<td>Standard Deviation</td>
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T Test Results Comparing Control to Each Experimental Group and 40 db to 70 db

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Zero, forty, and seventy decibels of sound playing in the background affected the number of words the subjects remembered. The mean value for words remembered was 5.52 when no sound was playing. The standard deviation was +/- 1.72 for this group. With forty decibels of sound playing, the average number of words remembered was 4.44 with a variation of +/- 1.59 in standard deviation. For seventy decibels of sound playing in the background, the subjects remembered a mean number of 4.06 words with a standard deviation of +/- 1.60. The data is fairly precise because there is little variation in the data for all groups with the standard deviation at most +/- 1.72. (The raw data is displayed in the appendix).

The T test results (used to determine if the data was statistically significant) are also displayed. At degrees of freedom (df) = 60 and a 0.05 level of significance, the calculated T value comparing the control to 40 db was 3.86. The critical T value was 2.00. Since $T_{calculated}$ was greater than $T_{critical}$ the results were significant at the 0.05 level. The null hypothesis was rejected. At df = 60 and a 0.05 level of significance, the calculated T value comparing the control to 70 db was 4.91. The critical T value was 2.00. Since $T_{calculated}$ was greater than $T_{critical}$ the results were significant at the 0.05 level. The null hypothesis was also rejected. At df = 60 and a 0.05 level of significance, the calculated T value comparing 40 db to 70 db was 1.56. The critical T value was 2.00. Since $T_{calculated}$ was less than $T_{critical}$ the results were not significant at the 0.05 level. The null hypothesis was not rejected.

**Discussion and Conclusions:** The purpose of this experiment was to determine the effects of sound on short-term visual memory. The testing discovered that with an introduction of sound, the number of words remembered decreased. Also, there was no significant statistical difference between the two levels (40 db and 70 db) of sound. The hypothesis was partly supported. As predicted, the words remembered did decrease from silence to some sound playing in the background. However, there was no difference with the first experimental phase of 40 db of sound and a greater or louder amount of sound at 70 db.

Compared with Morgan (Morgan, 1917), this experiment had similar findings. Both experiments discovered that less words were remembered with sound. Morgan found that increasing the noises in the background, led to a decrease in the words remembered. This experiment found no difference between the two levels of sound. Discrepancies can occur because the sound in the background varied between both experiments. Morgan looked at the effect of distracting noises while this experiment studied the effect of voices.

Inconsistencies in this experiment could occur in several places. Because of the testing effect, subjects may have improved at remembering words with more practice. To make this experiment more accurate, shifting the order that the experimental phases and control are presented to the subject would improve the accuracy.
Rather than keeping it in the same order of control, 40 db and 70 db, each subject would be shown the words in a different order. Subject one may be shown words in the order of 40 db, then 70 db, and then the control in silence while subject two could be shown the words in a different arrangement with 70 db, then the control in silence, and then 40 db. In addition, different words with different phases each time would also help the accuracy. Since some people may find certain words easier to remember than others, it would help if the group of words used with each phase of the experiment was jumbled. For instance, the control group would have ten words randomly chosen out of the thirty, thus making the words shown with the control group different each time.

Further research into this area could include the effect of different types of sound on memory. This experiment discovered the effect of voices speaking, but music or white noise may have different results. Building on this experiment, more levels of sound of the chatter from soft to loud could be tested to see if there is a point where the data becomes statistically significantly different. For example, while there was no difference between 40 db and 70 db, there may be a difference between 40 db and 80 db. Also, investigating different independent variables would be another suggested type of project. These include the effect of age on memory, the effect of the level of education a person has received, or the effect of gender. There are many opportunities to create similar experiments.

The implications of this project are far-reaching. People would be better off participating in activities, which require memorizing, in silence rather than any other place usually. For example, the student who wants to study for an exam the next day would remember more preparing in the silence of his or her room rather than in the library which would have a low level of sound. The business professional who must put together and memorize a presentation could more easily remember in a silent area rather than a busy street or the sounds of the office. This experiment's findings have implications for many people.

**LITERATURE CITED**


Appendix and Acknowledgments

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List of Words used Control Group for 40 db
Group
HUNT DOME
TOOK DESK
BITE STAR
LIES VIEW
DOTE RENT
CAMP H TAIL
HARD SMOG
WEAR DENY
MAN Y CARD
SURE ABLE

Group for 40 db
DONE
HALL
TOLL
HEAR
BALL
WAVY
ZOOM
PICK
ZERO
QUIZ

Thanks to Mrs. Fretts for helping me find human subjects!
SECOND PLACE

WHAT IS THE EFFECT OF DIFFERENT ENVIRONMENTS ON READING COMPREHENSION?

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Thomas Jefferson Middle School, Arlington, Virginia 22204

ABSTRACT

The purpose of this experiment was to study the effects of different environments on reading comprehension. Many of today’s adolescents are reading school assignments in negative environments that contain conditions that are not ideal for reading. Often times, they do homework in environments that are stressful and read while watching television, talking on the telephone, surfing the internet or socializing with family or friends. As a result, adolescents have reported having difficulty understanding what they are reading. The hypothesis investigated was, if the subject reads in a stressful, electronic or social environment, then the subject’s ability to comprehend will be adversely affected, but if the subject reads in an enriching environment, the subject’s ability to comprehend will be enhanced. To test this hypothesis, 90 high school level reading comprehension tests were taken and scored by one subject in four environments under 16 conditions. The environments were stressful, electronic, social and enriching. The test scores were recorded and placed on a data table. The test score means were put on a data table and graphed. The test results showed that reading comprehension tests taken in the enriching environment had the highest test score means followed by the stressful environment, the social environment and the electronic environment. The results of the reading comprehension tests are important because they show a direct link between negative reading environments and low reading comprehension test scores. Showing such a link was an objective of this experiment. Another objective of this experiment was to make adolescents aware of this connection so they can make better choices when selecting environments for reading.

THIRD PLACE

THE EFFECTS OF CAFFEINE ON THE MEMORY OF MICE

Julia G. Shreckhise
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Shenandoah Valley Governor’s School, Fishersville, Virginia 22939

ABSTRACT

Caffeine is widely used to help people stay awake and alert. However, people may not know how caffeine affects their memory. The purpose of this study is to determine if caffeine has an effect on the memory of mice. Mice went through a Morris Water Maze and their times were compared using a t-test. The results showed no difference between the times it took the mice that ingested the caffeine to go through the maze and the times it took the mice that did not ingest caffeine to go through the maze; therefore the null hypothesis was supported.
HONORABLE MENTION

THE EFFECT OF BACKGROUND NOISE ON MEMORY

Aravind Menon
6001 Glen Abbey Drive, Glen Allen, Virginia 23059
Deep Run High School, Glen Allen, Virginia 23059

ABSTRACT

Scientists noticed that noise had begun to influence the concentration and memorization skills the brain needed in certain situations. This began the study of a mental and environmental problem that is now named as “noise pollution”. It is produced when a type of sound is heard and the witness is unable to work to their potential due to the sound. The purpose of this project was to determine how sensitive the human mind was, when testing, to background noise. This also means, how background noise, or noise pollution, affected memory negatively. The hypothesis was that if background noise was played then memory would be harmed negatively. In a room, 40 participants were told to take three memory tests. During the tests, ten participants heard a blow horn go off from a speaker, ten participants heard a scream go off from a speaker, ten participants heard a whistle go off from a speaker, and ten did not receive any type of sound during the tests. The results indicated that background noise did, in fact, harm memory negatively. A t-test performed on the data indicated a significant difference between the means of the groups (t=2.95>2.101, t=11.61>2.101, t=7.59>2.101 and t=2.42>2.101 at α=0.05 and df=18). The data supported the research hypothesis that if background noise was played then memory would be harmed negatively. Based on the background noises played during the experiment, there appeared to be a direct correlation between noise pollution, or background noise, and the weakness of memory. Before it can be concluded, a survey would need to be made to determine other, more recurring sounds that are played daily in a normal humans life, and their influence on memory.

HONORABLE MENTION

THE EFFECT OF GENDER AND LEARNING STYLES ON MEMORY

Ana O’Harrow
5949 North 10th Street, Arlington, Virginia 22205
Yorktown High School, Arlington, Virginia 22207

ABSTRACT

The purpose of this experiment was to determine the effect of gender and learning styles on memory, also analyzing age and preferred learning styles of subjects. It was hypothesized that if women are tested, then they will have higher scores on visual/verbal testing, as their learning will have been stronger using this technique, and their memory of the items will have been stronger. Conversely, if men are tested, they will have higher scores on auditory testing, as their learning using this technique will have been more efficient, and their memories stronger. In addition, it is hypothesized that the age group of eighteen through thirty year olds will score the highest overall, followed by the younger and older age groups, and that very few participants will be aware of which learning style is the most successful. To test this hypothesis, participants were tested for one of three learning styles (visual/verbal, kinesthetic, or auditory), by being presented information using one of the three aforementioned learning styles, and being tested on their percent recall. Results largely did not support the hypothesis, as there were insignificant differences in most of the testing, due to human or procedural error.
Ridley Stroop broadcasted the phenomenon of the Stroop Effect, the hesitation that occurs when reading the color that a word is rather than the word, in 1935. This resolution caused an outbreak of psychological research pertaining to the human brain. The purpose of this experiment was to determine whether or not different styles of writing affected the time it took to complete a Stroop Test. The diverse styles that were tested consisted of a normal (left to right, size 12), backwards, upsidedown, vertical, small, large, cursive, French and Spanish cognates, counter-clockwise, and clockwise fonts. Ten trials were performed for each test. Each trial was recorded with a standard second timer. The results showed that the test written in a counterclockwise arrangement had the quickest average time of 7.466 seconds. Meanwhile, the test written in a normal pattern had the longest average time of 14.084 seconds. A t-test executed on the data indicated a difference between the means of the groups (t=0.076<2.101; t=1.832<2.101; t=1.859<2.101; t=1.082<2.101; t=0.321<2.101; t=1.522<2.101; t=1.578<2.101; t=1.607<2.101 at DF=18; p>0.05). The data did not support the research hypothesis that if Stroop Tests were written in a backwards font, then time would be the shortest. Considering the times found in this research, the relation between the style of a word and the recorded time is apparent, but before this information can be made official, the experiment should be retested with more trials, or in a different order as to abdicate the benefits that could be gained from the practice of the Stroop Effect. Also, using testers that belong to different age groups would be a good improvement because it would test both the reading rate and maturity level in accordance with the Stroop Effect.

OTHER PAPERS SELECTED FOR PRESENTATION:


Auditory vs. Visual Short-Term Memory.  Brooke E. Perry, Appomattox Governor’s School, Dinwiddie County Schools.

Does Utilizing Mnemonic Devices in Memorization Affect the Rate of Recall and Retention of Facts Compared to Rehearsal Memorization Technique?  John K. Pickard, James River High School, Chesterfield County Schools.


The Effect of Light Intensity on Human Reaction Time for Peripheral and Frontal Vision.  Roy Rinberg, Williamsburg Middle School, Arlington County Schools.

The Effect of Mirror Visual Feedback on Time Taken to Separate Colored Marbles with the Non-Dominant Hand. Renee J. Ritchie, George H. Moody Middle School, Henrico County Schools.

The Effect of Gender on Ambidexterity of Middle School Students.  Cara V. Salyers, George H. Moody Middle School, Henrico County Schools.

The Effect of Pleasing and Non-Pleasing Odors on Students’ Ability to Memorize Words. Claire A. Trainum, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effects of Visual and Audio Format on Learning Retention. Christina J. Trimarco, Appomattox Governor’s School, Chesterfield City Schools.


The Amount of Time It Takes to View an Optical Illusion Comparing the Dominance of Left and Right Eyes. Brittany Z. Vaughn, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Pitch on Perceived Sonic Intensity. Robert C. Wharton, Kenmore Middle School, Arlington County Schools.

Gifted Artists: Musicians vs. Non-Musicians (The Effect of Musical Education on Short-Term Memory Capacity. Brinay D. Wilson, Appomattox Governor’s School, Chesterfield County Schools.
Abstract: The purpose of this experiment was to find the effect of different police lineups on accuracy rate. The two different police lineups that were tested were simultaneous lineup and sequential lineup. The hypothesis was, if different police lineups were tested, then sequential lineup will have the highest accuracy rate. The project was chosen because of interest in forensic science/psychology, human behavior, and the human mind. After thinking through multiple projects, this one took the three subjects and tied them together. Police lineup tests that test different types of lineups had been conducted to protect many innocent people that have been arrested each year because of mistaken identity accusations. The experiment took place with many different steps. These steps included human subjects acting out a crime scene while being recorded, having other human subject testers view the recorded crime scene, and having the testers take place in a police lineup with criminal suspects. After the experiment was conducted, the results concluded that sequential lineup had the greatest accuracy rate. 75% of the testers of sequential lineup chose correctly as to who the criminal was. In simultaneous lineup, only 25% of the testers chose correctly as to who the criminal was. From the experiment process, a new and very interesting thing that was learned was that the human mind reacts differently simply to just the positioning of people. It was also learned in the research process that because of false accusations, thousands of innocent people have been arrested.

Introduction: The purpose of this experiment was to find the effect of different police lineups on accuracy rate. The two different police lineups that were tested were simultaneous lineup and sequential lineup. The hypothesis was, if different police lineups are tested, then sequential lineup will have the highest accuracy rate. The project was chosen because of interest in forensic science/psychology, human behavior, and the human mind. After thinking through multiple projects, this one took the three subjects and tied them together.

The two different kinds of lineups are generally laid out in different ways and have different effects on the human mind (Wells, 2008) (Kapardis, 2003). The first one, simultaneous lineup, consists of all the suspects standing side by side. These suspects are placed on one side of a one-way mirror. Placed on the other side, is the witness identifying which suspect they believe participated in the crime (Whitmore, 2008). The administrator/authority with this witness is prohibited from giving any hints or opinions about the suspects. From many sources that were visited, it is listed that when police officers or administrators give hints to the witness, it limits the witness’ perspective and causes them to believe what their instructor has told them (Schuster, 2007).

Many tests have also shown that simultaneous lineup is high in mistaken identities because of the way the lineup was conducted. By having each suspect standing next to one another, the human mind uses relative judgment (Schuster, 2007). This signifies that the person would compare the suspects to each other rather than to the actual scene from their memory.

The second lineup, sequential lineup, can be laid out in two ways. The first layout is having one suspect at a time come into the room on one side of the one-way mirror. The witness would view the suspect for a certain amount of time and the suspect will exit the room. This method would be repeated, without anything changed, throughout all of the suspects (Whitmore, 2008). The second layout is similar, except, instead of having the suspects actually entering the mirrored room, pictures of the suspects would be laid out. Administrators/authorities would still be prohibited from giving any hints or opinions about the suspects (Paulson, 2006).
Many of the sources that have been viewed have mentioned that sequential lineup is the most efficient lineup method. This is because instead of the human mind using relative judgment between the suspects, the mind takes in each individual and relates them to the actual scene in their memory (Wells, 2008).

Simultaneous and sequential lineups are the two most commonly used ways police lineups are conducted (Bartol, 2008).

**Methods and Materials:** First, all needed materials were gathered. Human subjects needed for filming were brought into the filming room. Each of the human subjects was given a script and blocking for a crime scene that was recorded. The humans were recorded with a video camera while acting out the scene. After that, the human subject actors were dismissed. The video camera was taken to a computer with a movie maker application. All of the pieces of the video were chronologically put together with transitional effects. The video was then burned to a blank CD Rom.

The next day, the eight different human subjects were brought into a room. Four of the human subjects were brought into a separate room to watch the video. Following that, the human subjects were brought into another room with a one way mirror. They had to wait exactly seven minutes before being tested. These four human subjects were only testing the simultaneous lineup. Five other human subjects were brought into the room on the lineup side of the one way mirror where they could not see the testers. One of them committed the crime in the videotaped scene. The other five looked similar to the actual criminal. Each human subject had a number on their shirt. The human testers were given a piece of paper with each of the numbers that corresponded to the suspects. Each human circled the number of the suspect who they thought committed the crime. Each human tester in this variable was considered a trial. The four human subject testers were dismissed.

The next four human subjects went through the same process, until after waiting seven minutes in the one-way mirror room. The sequential lineup was tested in this trial. Instead of the suspects coming out at the same time, each of the suspects came out by themselves on the lineup side of the one way mirror where they could not see the testers. The suspects stood for exactly one minute and then walked out. This was repeated until all of the suspects had been viewed. The testers were given a piece of paper and circled the number of the suspect whom they thought had committed the crime. Again, each one of the four human testers was considered a trial. After the humans were dismissed, the results were gathered and analyzed by counting up each of the trial/lineup’s choice and gathering the results onto a data table.

**Results:** From the experiment and testing, the result was that the sequential lineup was more accurate than simultaneous lineup. From the four trials, the three out of the four testers in the sequential lineup chose suspect 2 as the criminal, which was correct. As compared to simultaneous lineup, only one of the testers chose suspect 2 as the actual criminal. In addition, suspect 1 was chosen once during the simultaneous lineup and suspect 5 was chosen once during the sequential lineup. From the information, the results accepted the hypothesis.

During the experiment, there were different observations made. One of which was that during the crime scene, the actor who was the criminal was advised to keep slightly turning their head away from the camera while committing the crime. It was later discovered that the consecutive times the actor’s angle was turned away from the camera, it contributed to making the crime scene more like the sample crime scenes viewed and giving the video a more realistic feel as if the viewers were actually there. It was also noticed that when the suspects were brought out onto the field, they stood still and quiet. From research, it was stated that this contributed to the accuracy of the experiment. Another thing that was noticed was that the testers repetitively chose number 4 as the criminal. Also in research, many false accusations have been caused by numerous witnesses choosing the same incorrect suspect who lead the police to follow the witness’ judgment.
**Data Table 1:** The vertical groups that enlist of trials indicate the different trials for each type of lineup. Onto the left of the trials is the chosen suspect for each lineup connecting to each trial. The words in the parenthesis indicate whether the suspect chosen is correct, being the criminal, or incorrect, not being the criminal.

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<td>Trial Three</td>
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<td>Suspect 5 chosen (incorrect)</td>
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<tr>
<td>Trial Four</td>
<td>Suspect 1 chosen (incorrect)</td>
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**Graph 1:** This graph indicates the percentage correct for sequential lineup, and the percentage incorrect for sequential lineup.

**Graph 2:** This graph indicates the percentage correct and the percentage incorrect for simultaneous lineup.
Discussion and Conclusions: The experiment was conducted using a Sony Cyber Shot video camera, an area at CVS Pharmacy, a room with a one-way mirror, a different room with a television and DVD player, one blank CD Rom, a USB cord that connects a camera to a computer, a computer with a movie maker feature, a few extra props used for the scene (all black outfit, mask, shopping cart, purse, groceries, etc), and six 4×6” cards with suspect numbers written on each card. The experiment was performed by using the Sony Cyber Shot video camera to record a crime scene. The crime scene was held at a local CVS Pharmacy. There was a planned conflict and blocking for the scene. The scene was taped in different orders and angles. When brought to the computer, each part of the video was put together and arranged in chronological order. The next day, the testers were brought into the testing premises. Three of the testers went into a different room to watch the crime scene and then entered the field with the one-way mirror. These testers tested simultaneous lineup by viewing the 5 suspects (one of which is the actual criminal) at the same time and circling the number of the suspect they thought committed the crime. The three testers were then dismissed. The remaining three went through the same process, but instead of testing simultaneous lineup, the testers tested sequential lineup, which is when the suspects came out one at a time instead of all together. After the testers were dismissed, data was collected and analyzed.

The purpose of the experiment was to find the effect of different police lineups one their accuracy. The hypothesis was, if different police lineups were tested, then sequential lineup would have the greatest accuracy. One of the pieces of information that led to the hypothesis was about how the two different lineups affected the human mind. It was discovered upon sequential lineup that since one suspect comes out at a time, the witness uses their memory of the time they saw the suspect to try and recall who committed the crime. It was also noticed that when simultaneous lineup was taking place, the witness used their relative judgment of the suspects. This meant that the witness compared the suspects to each other rather than to the actual scene in their memory.

After the experiment was conducted the results stated that sequential lineup had a greater accuracy than simultaneous lineup. Out of the four trials for sequential lineup, three of the trial testers guessed correctly to who the criminal was. As compared to simultaneous lineup, only one out of the four testers guessed correctly. The results that were stated supported the hypothesis. An unknown problem that could’ve been encountered was that one or more of the testers could’ve had a memory defect and did not have the average human memory.

If the project were to be extended, something that would be changed is that there would be more independent variables used to be tested. Also, another thing that would be changed is the video quality. There would be more effort and time put into making the crime scene.

From the experiment process, a new thing that was learned was that the human mind reacts differently simply to just the positioning of people. It was also learned in the research process that because of false accusations, thousands of innocent people have been arrested. Something that will be remembered about this experiment was the accomplishment of recording a whole crime scene, editing it, and performing a complete jurisdiction act.
LITERATURE CITED

Bartol, Curt and Anne Bartol. 2008. Introduction to Forensic Psychology: Research and Application. SAGE.


SECOND PLACE

AN OBSERVATIONAL ANALYSIS OF AMERICANS’ PERSPECTIVE ON QUATERNARY EDUCATION

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Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT
An investigation was conducted to investigate the relationship between income and perception of quaternary education. The relationship was scrutinized through an observational study and the results were compared to previous analysis and inquiries. It was found that income is a factor when concerning the perception of quaternary education and the parental reinforcement of quaternary education on the future generations. This differs from previous studies, which suggests that an economic recession affected the sample. After several statistical tests, the data congregated in this study is statistically significant and thus, a nonrandom association can be claimed for both dependent variables. Despite the relative success, this study could not minimize the effects of lurking variables, which could have obscured a more plausible set of results. In addition, the sample size should be more inclusive and comprehensive. Other possible sources of errors include undercoverage, non-response and hidden bias. Nonetheless, this present study provided a superficial but an accurate description of Americans’ perception on quaternary education. It is suggested to further this research by incorporating a sample of the entire nation rather than a specific region.

THIRD PLACE

THE EFFECT OF GENDER ON CONFORMITY

Paul W. Duckworth
3808 English Horn Court, Richmond, Virginia 23233
Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT
This experiment was the effect of gender on conformity. The purpose was to find out whether, on average, males or females conform more often. The experimenter collected 40 subjects, 20 males and 20 females, all in grades 10-12. He then, one at a time, placed them each in a testing room with 4 other non-subject students, 2 males and 2 females, also in grades 10-12. The experimenter asked each group a series of 8 simple multiple choice questions with an obvious correct answer. Beforehand, the non-subjects were told to give the correct answer for the first 3 questions, and a unanimous incorrect answer for each of the last 5 questions. The subjects’ answers to the last 5 questions were recorded as either conforming, meaning they gave the same wrong answer as the non-students, or non-conforming, meaning they gave a different answer than the non-students. The experiment found that the females, on average, conformed more than males. A t-test was preformed and it was found that these results are not statistically significant. Though the difference between the male and female averages was not statistically significant, the results of this experiment still have some very important real world implications. These implications involve the discovery of how easily high school students can be potentially influenced by a group of their peers.
HONORABLE MENTION

THE SOCIOECONOMICS OF CHARITY: THE EFFECT OF ECONOMIC STATUS ON THE WILLINGNESS OF INDIVIDUALS TO DONATE TO CHARITY

Christopher D. Kime
2231 North Quebec Street, Arlington, Virginia 22207
Yorktown High School, Arlington, Virginia 22207

ABSTRACT

As defined by Dictionary.com, charity is “generous actions or donations to aid the poor, ill, or helpless.” But what kinds of people give? Is it the rich who can afford it or those less fortunate that know the true meaning of poverty? Socioeconomic status is the combination of various traits, such as economic position and education level, that combined determine how one is placed relative to others. One’s socioeconomic status is relative to the area they live in, and moving someone to a different location could drastically change their socioeconomic status. It was hypothesized that if a donation stand is set up outside of local area stores, then the store with the highest average annual income will have the highest percentage of people who donate. This was hypothesized because those that have more money have a greater capacity to donate, and generally might feel more compelled to do so. It was found that the average store had 24.2% of its customers donate their food. A chi-square test was performed between those entering the store and those leaving, and a P-value of 0.9812 was discovered. Because the P-value was greater than 0.05, the null hypothesis was accepted, and it was shown that there was not statistical difference in the rates of giving at these different stores.

HONORABLE MENTION

THE EFFECT OF MUSIC AND MUSICAL GENRES ON TASK PERFORMANCE

Samantha F. Spytek
3421 South Utah Street, Arlington, Virginia 22206

Lara L. Sierra
1600 North Oak Street #715, Arlington, Virginia 22209
Gunston Middle School, Arlington, Virginia 22206

ABSTRACT

Today’s technology makes it easy to have access to all sorts of media for communication and entertainment simultaneously. The Los Angeles Times reported about half of the student’s they surveyed do at least one other activity while completing their homework. Neuroscientists have concluded that even simple tasks can overwhelm the brain if we try to do them at the same time. Most of this work has been based on actively performing multiple tasks, not on learning while performing a passive task such as listening to music. The purpose of this experiment was to see whether listening to music affects the ability to complete a task. A dual-task paradigm was used to investigate this question. Participants were asked to perform two tasks simultaneously: listening to music while tapping a foot to the music’s beat and memorizing 7 two-digit numbers to be recalled in the correct order following the end of the music. For the control condition, the subjects did not listen to music, but performed the memorization task. Participants were able to recall more numbers in the control condition without music than in the test conditions with music. The genre of the music did not affect the participant’s performance of the memorization task. The results suggest that even performing a passive task such as listening to music can impair your ability to
learn something new. So, if students want to learn something new as well as possible, they should give their undivided attention to the new material.

**HONORABLE MENTION**

**DOES BURNING AFFECT EVIDENCE OF TRAUMA IN HUMAN REMAINS?**

Amelia J. Tyler  
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Southwest Virginia Governor’s School, Pulaski, Virginia 24301

**ABSTRACT**

In the field of Forensic Anthropology it is often difficult to discern whether trauma to human remains was caused during death or after death, especially if the victim was burned post mortem. The purpose of this experiment was to determine if trauma such as knife or gunshot wounds that occur during death is still visible after the bones have been exposed to fire. Ten bones of *Sus scrofa domestica*, domestic pig, were burned in a common household fire, five of which had been stabbed with a knife beforehand. Thirty volunteers with no previous forensic experience were then asked to identify whether each bone had been stabbed or not stabbed. It was concluded that the proportion of bones the subjects correctly identified (p=0.81 ± 0.1185) was greater than fifty percent (p-value less than 0.0001), meaning the stab marks were recognizable. Further studies should be done on this topic, such as whether professionals trained in Forensic Anthropology are better able to recognize the trauma, whether other types of weapons generate different results, or whether location of the trauma has any effect on its identification.

**OTHER PAPERS SELECTED FOR PRESENTATION:**

The Effect of Personality Types (Extroverts vs. Introverts) on the Location One Will Walk in the Hallway (Middle vs. Side). Olivia A. Behm and Alicia M. Talley, Deep Run High School, Henrico County Schools.

The Effect of Music Education on Students’ GPA. Jennifer L. Berry, Washington-Lee High School, Arlington County Schools.

The Effect of Family Interaction on Age of a Senior in a Nursing Home. Olivia P. Cavalieri, Mills E. Godwin High School, Henrico County Schools.

The Effect of Emotional Connection of Words on Processing the Color of the Word. Kristin D. Cecil, Hanover High School, Hanover County Schools.

The Effect of an Integrity Violation Committed by a Student on the Amount of Honors Courses Taken by a Student. Molly K. Farrell, Mills E. Godwin High School, Henrico County Schools.

The Effect of Incentives on Cheating. Thomas J. Folliard and Bryan P. Lowry, Deep Run High School, Henrico County Schools.

Teenage Preferences for a Long-Term Mate. Allyson D. Gallamore, Chesapeake Bay Governor’s School, King George County Schools.

Socialist, Former Socialist, and Capitalist Economies Based on GDP and GNP. Irina G. Klissourova, Mountain Vista Governor’s School, Winchester City Schools.

The Impact of Age on Short-Term Memory. Perry E. Lowder, Appomattox Governor’s School, Chesterfield County Schools.
The Effects of Music on Mood and Handwriting. Loren C. Maher and Margaret G. McGrann, Appomattox Governor’s School, Powhatan and Chesterfield County Schools.

The Effect of Ethnic Babies Based on Children’s Race. Sasha A. Pierre-Louis, Hermitage High School, Henrico County Schools.


The Effect of Video Advertising on Voter Perception. Justin M. Thompson, Chesapeake Bay Governor’s School, Gloucester County Schools.

The Effect of Several Social, Cultural, and Economic Characterizations on Self-Perception of Socioeconomic Status in Adolescents. Kenneth H. Whitescarver, Mills E. Godwin High School, Henrico County Schools.

The Potential for Risk Behavior in Extroverted Teens. Mackenzie A. Wright, Chesapeake Bay Governor’s School, Caroline County Schools.
Abstract: Today, Back Creek is a fishing location for outdoorsmen in Bath County and across the state of Virginia. Fishermen value the size of fish; thus, they are concerned with the environmental effects of the Bath County Pumped Storage Station. In this study, data provided by Dominion containing the size and weight of four species in Back Creek from 2002, 2005, 2006, and 2007 was analyzed. Dominion had collected this data with the purpose of discovering whether or not their environmental improvement structures near the pumped storage station were contributing positively to the Rainbow Trout, Brown Trout, Rock Bass, or Smallmouth Bass (four important species in the area). There was no control in this study because in f-tests, there is no comparison to the control. The data analysis showed that all of the research hypotheses, that there would be a significant difference in the size of all of the various fish species in Back Creek over time, could be accepted. More specifically, The Rock Bass and Rainbow Trout results show that they became significantly smaller over the five years. The Brown Trout results show that they became significantly larger over the five years. Finally, the Smallmouth Bass neither became smaller or larger, but fluctuated significantly over the five years. Improvements for future studies in the field would include an increase in data used for analysis. This would include data from 2003 and 2004, data from before the plant was operational in 1985, and generally more fish per species per year.

Introduction: Pumped storage stations play an integral part in creation and storage of energy for hundreds of thousands in the areas surrounding the stations, but it is not yet clear whether or not the stations may have an adverse effect of major fish species in those areas and whether or not environmental improvement measures can have a positive effect on any of the negative that the stations have. The Bath County Pumped Storage Station is the largest of several pumped storage stations around the world. The power stations work with the use of two reservoirs. One reservoir is located above the power station and the other is located below the station. Between the two reservoirs, the station consists of large tunnels with turbines at their ends. The tunnels can allow for 14.5 million gallons of water to flow through per minute. The flow of water allows for turbines to spin, producing great amounts of energy. The pumped power station works by storing this potential energy until it is needed by the residents of the surrounding area (Dominion Virginia Power, 2008).

The Bath County Pumped Storage Station was first operational in 1985, is located in Virginia’s Allegheny Mountains, and functions with the help of dams that could have an effect of fish species in Back Creek. Because the pumped storage system works by large amounts of water flowing through turbines from an upper reservoir into a lower reservoir during the day, water flow may disturb fish habitats by destroying habitats or causing changes in the dissolved oxygen levels of the water; thus, causing a decrease in size or number of various fish species in Back Creek. Any negative effect is said to be minimal though because the creek is supplemented by storage from the power station and the flow is increased in times of drought due to the use of these man-made dams (Dominion Virginia Power, 2008). Although the effects may be minimal, it is important that they are studied in this rural setting as well as in urban settings because of the possible adverse effects (such as habitat degradation) of a power station on the aquatic environment (Eliassen, 1971).

The results of this study could provide important information to other power companies worldwide that are concerned about the environment that surrounds their power stations. It is also important because most bodies of water, including Back Creek, are open to public fishing and recreation. In Bath County, a small town in the Allegheny Mountains, locals use the creeks, including Back Creek, as a source of fish for food and entertainment. The species of fish that are common to this area and important to local and visiting fishermen are the Rainbow
Trout, the Brown Trout, the Smallmouth Bass, and the Rock Bass (Dominion Virginia Power, 2008). The fishermen in the area would become upset if any company, such as a power company, builds a structure that has a negative impact on game fishing without later taking measures for the improvement of the surrounding environment.

The rationale of the study is to see if there is a significant change in fish size near the Dominion IA, and if so is it a negative change or a positive change. This would allow a researcher for Dominion as well as other plants to understand the effectiveness of Dominion’s environmental management in close proximity to pumped storage stations. The purpose of this study was to statistically analyze the data collected by Dominion during towed boat catches in Back Creek in a manner that would allow a researcher to discover the effectiveness of environmental improvement measures. If Dominion’s environmental management techniques within its IA had a positive effect on the size of various game fish, then other companies could apply the same techniques in their own IA’s near power storage stations. The research hypothesis for this study is that there will be a significant difference in the size of all the size of various game fish, then other companies could apply the same techniques in their own IA’s near power stations. The purpose of this study was to statistically analyze the data collected by Dominion during towed boat catches in Back Creek in a manner that would allow a researcher to discover the effectiveness of environmental improvement measures. If Dominion’s environmental management techniques within its IA had a positive effect on the size of various game fish, then other companies could apply the same techniques in their own IA’s near power storage stations. The research hypothesis for this study is that there will be a significant difference in the size of all the size of various game fish, then other companies could apply the same techniques in their own IA’s near power stations. 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The independent variable in this study is the time that data was collected. The data used in this study was collected during the years of 2002, 2005, 2006, and 2007. These years were used because after 2002 environmental improvement measures, like the creation of pools for the fish to live in and the building of structures that would protect trout and other fish from predators, were implemented by Dominion, Allegheny Power, Virginia Tech, and other partnering companies (Dominion Virginia Power, 2008). No control exists in this study because the most accurate control would be measures of fish size from before or immediately after the creation of the pumped storage station in 1985, but this data was not available. Data on fish size was collected each year using towed boat catches. In this scenario, a net is towed and fish are caught in the net and subsequently analyzed. Data on water condition, water temperature, pH, and dissolved oxygen levels was also collected at the time of each fish collection. All of the data was collected from the Improvement Area of the Bath County Power Station Lower Reservoir with the assistance of the Virginia Department of Game and Inland Fisheries (“Biological Monitoring”, 2006).

The dependent variable in this study is the size (length and weight) of the various game fish species in Back Creek. These species include the Rainbow Trout, Brown Trout, Smallmouth Bass, Rock Bass, and the Redbreast Sunfish. The Largemouth Bass, a close relative of the Smallmouth Bass was not recorded in the data, but its characteristics are very similar to the Smallmouth Bass. The Smallmouth Bass is predatory and will strike at a moving target, so they are a major game fish for fishermen in areas such as that along Back Creek. They feed by sight, so the water condition must allow for this to occur. Also, they live in areas that are between the temperatures of fifty degrees Fahrenheit and eighty degrees Fahrenheit (Davis and Lock, 1997). It is also important to note that Smallmouth Bass require a good deal of protein in their diets. If the protein is not available because the environment around the power station is not protein rich, then the Smallmouth Bass may not grow or prosper. The average Smallmouth Bass needs for its diet to contain at least 45% protein (Anderson et al., 1981). Another major game fish in the area is the Rainbow Trout because it provides a healthy meal option for consumers and fishermen. The Rainbow Trout typically live in areas where cool water and optimal living conditions can be found (Ladewig and Morat, 1995). Because the Smallmouth Bass and Rainbow Trout, as well as the other species listed, require specific living conditions (proper temperature, pH, and dissolved oxygen levels), they should not increase in size when the water conditions near the Bath County Pumped Storage Station are not present.

Methods and Materials: A large set of data was obtained from Environmental Biologist, Paul Vidonic of Dominion Resources, Inc. For analysis, the data was separated into the following categories: weight (in grams) of various fish species, length (in millimeters) of various fish species, water temperature, water pH, and dissolved oxygen levels in the water. The data was then analyzed for the mean and standard deviation. An analysis of variance (F) test was performed to determine whether or not there was a significant difference in the mean weight and length of each species.

Results: The results of measurements taken by environmentalists for Dominion were analyzed using length and weight of various fish species captured during the years of 2002, 2005, 2006, and 2007. The mean length and width of each species was found for each of the four years of data. The mean lengths of the Rock Bass over the four years were 157.44 mm, 145.69 mm, 154.36 mm, and 134.21 mm; respectively. This means that between 2002 and 2006, Rock Bass tended to grow in length, but were incredibly short in 2007. The mean weights for Rock Bass
over the four years were 135.46 g, 78.3 g, 77.54 g, and 61.1 g showing that the Rock Bass became smaller as the years passed. The mean lengths of the Rainbow Trout over the four years were 281.77, 274.74, 290.93, and 283.78 (all millimeters) showing there was an increase in length between 2005 and 2006, but no clear pattern in fish length. The mean weights of the Rainbow Trout from 2005 until 2007 were 244.96 g, 250.24 g, and 225.27 g showing an increase between 2005 and 2006, but a severe decrease in weight between 2006 and 2007. The mean lengths, in millimeters, of Brown Trout were 260.90, 246.98, 252.86, and 295.14, so the Brown Trout decreased in length between 2002 and 2005, but increased in length through 2006 and 2007. The mean weights for the Brown Trout in 2005, 2006, and 2007 were also calculated, in grams, to be: 173.04, 172.29, and 265.14. This means that the weight of Brown Trout was fairly constant between 2005 and 2006, but increased dramatically in 2007. For each of the four years, the mean lengths of Smallmouth Bass were 188.60 mm, 208.93 mm, 184.36 mm, and 204.10 mm showing great fluctuation over the years. The weights for each of the four years, in grams, were 144.56, 172.91, 96.88, and 143.28. Like the Smallmouth Bass lengths, the weights also fluctuated greatly over the years, but were nearly the same in 2007 as they were in 2002. In most of the data, the standard deviations were all under 10 (with the exceptions of Smallmouth Bass weight in 2002 at 12.15 and Smallmouth Bass weight in 2007 at 12.18). Because of the low standard deviations, it can be assumed that the data was fairly reliable and without a lot of variation.

The statistical analyses done on this data were a series of analysis of variance tests (ANOVA). This type of test was used to compare means over the years to determine whether or not there was any significant difference in the means over the years. All tests were done at a level of significance of 0.05 because this was appropriate for the study (because it is not a test on human subjects). The first ANOVA was done on weights on Rock Bass and resulted in an F value of 230.0460 with a p-value of -0.00, so the null hypothesis was not supported. The second ANOVA was done on weights of Rainbow Trout and resulted in an F value of 74.1225 with a p-value of 0.00, so the null hypothesis was not supported. The third ANOVA was done on weights of Brown Trout with an F value was 1637.5611 with a p-value of 0.00, so the null hypothesis was not supported. The fourth ANOVA was done on weights of Smallmouth Bass and resulted in an F value of 409.5380 with a p-value of -0.00, so the null hypothesis was not supported. A fifth ANOVA was done on the lengths of Rock Bass and resulted in an F value of 206.1439, with a p-value of -0.00, so the null hypothesis was not supported. The sixth ANOVA was done on the lengths of Rainbow Trout with an F value was 68.3812 with a p-value of -0.00, so the null hypothesis was not supported. The seventh ANOVA was done on the lengths of Smallmouth Bass with a calculated F value of 100.1873 with a p-value of 0.00, so the null hypothesis was not supported. In general, all null hypotheses were rejected, suggesting that there was a significant difference in fish size in Back Creek between the years of 2002 and 2007.

Discussion and Conclusions: The purpose of this study was to statistically analyze the data collected by Dominion during towed boat catches in Back Creek in a manner that would allow a researcher to find the effectiveness of environmental improvement measures. The major findings in all cases were that there were significant differences in both the weights and lengths of each of the four species gathered in Back Creek. The Rock Bass and Rainbow Trout results show that they became significantly smaller over the five years. The Brown Trout results show that they became significantly larger over the five years. Finally, the Smallmouth Bass neither became smaller or larger, but fluctuated significantly over the five years. Based on the mixed results of the study, it is unclear whether or not the environmental measures taken by Dominion helped the overall environment of the area of Back Creek that surrounds the pumped storage station. It is clear that the fishermen in Bath County would be pleased with the increase in size of the Brown Trout, but certainly unhappy with the decrease in size of the Rock Bass and the Rainbow Trout.

The study was not comparable to other studies because there are few pumped storage stations across the globe and their effects have either not been studied or have not been released. Despite the lack of previous research of this exact nature, the extra data provided by Dominion (about the water temperature, water pH, and dissolved oxygen levels in the water) could be used to reach possible reasons for the results obtained. Over the five years, the water temperatures were between 15.88°C and 14.39°C. The pH levels were between 7.4 and 8. The dissolved oxygen levels were between 11.1 and 13.04. Although the temperatures and pH levels were quite similar in 2002 and 2007, the dissolved oxygen levels were much higher in 2007 than they were in 2002. This means that the elevated dissolved oxygen levels may have played a greater role in the changes in size of each of the species than
pH or temperature. In general, the decrease in temperature, increase in pH, and increase in dissolved oxygen levels tended to allow for the existence of larger Brown Trout and smaller Rock Bass and Rainbow Trout.

In the future, improvements could be made to make this study more valuable to the biological and environmental society. A larger amount of data could be obtained each year so that the number of fish available for analysis would be greater. Also the use of data from each year between 2002 and 2007 could be used (data for 2003 and 2004 was not available from the source, Dominion). Finally, data from before the plant was built and operational in 1985 would be extremely valuable. With improvements, this already valuable set of results would become much beneficial to the scientific community involved in power plant research.

**LITERATURE CITED**


Appendix:

Table 1: Experimental Design Diagram

**Title:** The Effects of the Bath County Pumped Storage Station and Dominion’s Fish Habitat Improvement Structures on the Size of Various Fish Species in Back Creek

**Hypothesis:** There will be a significant difference in the size of all of the various fish species in Back Creek over time (between the years of 2002 and 2007). This change will likely be an increase in the size.

**Control:** No control.

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**Dependant Variable:** The size of the fish (measured and analyzed in both weight and length)

**Constants:** all data gathered at same general area, data gathered on same four species each time (rainbow trout, brown trout, rock bass, and smallmouth bass), all data gathered by professional environmentalists/ biologists
Table 2: 2002 Weight Statistical Data

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<th>Descriptive Information</th>
<th>IV: The year the data was collected in (2002)</th>
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<td>Variation</td>
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<td>Range</td>
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<td>2 SD</td>
<td>116.60-154.32</td>
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Table 3: 2005 Weight Statistical Data

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Table 4: 2006 Weight Statistical Data

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<th>Description</th>
<th>Rock Bass</th>
<th>Rainbow Trout</th>
<th>Brown Trout</th>
<th>Smallmouth Bass</th>
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<td>88.13-105.63</td>
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<tr>
<td>2 SD</td>
<td>63.68-91.4</td>
<td>232.76-267.72</td>
<td>156.13-188.45</td>
<td>79.38-114.38</td>
</tr>
<tr>
<td>3 SD</td>
<td>56.75-98.33</td>
<td>224.02-276.46</td>
<td>148.05-196.53</td>
<td>70.63-123.13</td>
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<tr>
<td>Number</td>
<td>115</td>
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Table 5: 2007 Weight Statistical Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Rock Bass</th>
<th>Rainbow Trout</th>
<th>Brown Trout</th>
<th>Smallmouth Bass</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV: The year data was collected (2007)</td>
<td></td>
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</tr>
<tr>
<td>Mean Variation</td>
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<td></td>
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</tr>
<tr>
<td>Range</td>
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<td></td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Maximum</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 SD</td>
<td>53.87-68.33</td>
<td>216.09-234.45</td>
<td>256.57-273.71</td>
<td>131.1-155.46</td>
</tr>
<tr>
<td>2 SD</td>
<td>46.64-75.56</td>
<td>206.91-243.63</td>
<td>248-282.28</td>
<td>118.92-167.64</td>
</tr>
<tr>
<td>3 SD</td>
<td>39.41-82.79</td>
<td>197.73-252.81</td>
<td>239.43-290.85</td>
<td>106.74-179.82</td>
</tr>
<tr>
<td>Number</td>
<td>114</td>
<td>23</td>
<td>28</td>
<td>39</td>
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</table>
Table 6: Inferential Statistics for Weight
ANOVA Tests per Species

<table>
<thead>
<tr>
<th>Species</th>
<th>α</th>
<th>Degrees of freedom</th>
<th>Critical F value</th>
<th>Calculated F value</th>
<th>MSG</th>
<th>MSE</th>
<th>Calculated p-value</th>
<th>p &lt; α, so reject the null hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock Bass</td>
<td>0.05</td>
<td>(3,491)</td>
<td>2.70</td>
<td>2230.0460</td>
<td>MSG: 483375.0762</td>
<td>MSE: 35475.6747</td>
<td>0.0000</td>
<td>so reject the null hypothesis</td>
</tr>
<tr>
<td>Rainbow Trout</td>
<td>0.05</td>
<td>(2,130)</td>
<td>3.09</td>
<td>74.1225</td>
<td>MSG: 10207.0672</td>
<td>MSE: 8744.2922</td>
<td>0.0000</td>
<td>so reject the null hypothesis</td>
</tr>
<tr>
<td>Brown Trout</td>
<td>0.05</td>
<td>(2,152)</td>
<td>3.09</td>
<td>1637.5611</td>
<td>MSG: 195242.7765</td>
<td>MSE: 8882.4699</td>
<td>0.0000</td>
<td>so reject the null hypothesis</td>
</tr>
<tr>
<td>Smallmouth Bass</td>
<td>0.05</td>
<td>(3,192)</td>
<td>2.70</td>
<td>409.5380</td>
<td>MSG: 139694.3392</td>
<td>MSE: 21375.7439</td>
<td>0.0000</td>
<td>so reject the null hypothesis</td>
</tr>
<tr>
<td></td>
<td>Rock Bass</td>
<td>Rainbow Trout</td>
<td>Brown Trout</td>
<td>Smallmouth Bass</td>
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<td></td>
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<td>-------------</td>
<td>-----------------</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Mean</strong></td>
<td>147.4358</td>
<td>281.7714</td>
<td>260.9032</td>
<td>188.5968</td>
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<td></td>
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</tr>
<tr>
<td><strong>Variation</strong></td>
<td>194</td>
<td>195</td>
<td>172</td>
<td>350</td>
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</tr>
<tr>
<td><strong>Range</strong></td>
<td>43</td>
<td>188</td>
<td>163</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>237</td>
<td>383</td>
<td>335</td>
<td>420</td>
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<tr>
<td><strong>Standard Deviation</strong></td>
<td>6.44</td>
<td>5.4593</td>
<td>5.7832</td>
<td>8.2991</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1 SD</strong></td>
<td>141-153.88</td>
<td>276.31-287.23</td>
<td>255.12-266.68</td>
<td>180.3-196.9</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>2 SD</strong></td>
<td>134.56-160.32</td>
<td>270.85-292.69</td>
<td>249.34-272.46</td>
<td>172-205.2</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>3 SD</strong></td>
<td>128.12-166.76</td>
<td>265.39-298.15</td>
<td>243.56-278.24</td>
<td>163.7-213.5</td>
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<td></td>
</tr>
<tr>
<td><strong>Number</strong></td>
<td>179</td>
<td>105</td>
<td>31</td>
<td>62</td>
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</table>

**Table 8: 2005 Length Statistical Data**

<table>
<thead>
<tr>
<th></th>
<th>Rock Bass</th>
<th>Rainbow Trout</th>
<th>Brown Trout</th>
<th>Smallmouth Bass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>145.6782</td>
<td>274.7358</td>
<td>246.9848</td>
<td>208.9333</td>
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<td><strong>Variation</strong></td>
<td>227</td>
<td>282</td>
<td>98</td>
<td>153</td>
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<tr>
<td><strong>Range</strong></td>
<td>25</td>
<td>220</td>
<td>202</td>
<td>125</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>252</td>
<td>502</td>
<td>300</td>
<td>278</td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>6.8151</td>
<td>6.5905</td>
<td>4.4102</td>
<td>6.2382</td>
</tr>
<tr>
<td><strong>1 SD</strong></td>
<td>138.86-152.5</td>
<td>268.15-281.33</td>
<td>242.57-251.39</td>
<td>202.69-215.17</td>
</tr>
<tr>
<td><strong>2 SD</strong></td>
<td>132.04-159.32</td>
<td>261.56-287.92</td>
<td>238.16-255.8</td>
<td>196.45-221.41</td>
</tr>
<tr>
<td><strong>3 SD</strong></td>
<td>125.22-166.14</td>
<td>254.97-294.51</td>
<td>233.75-260.21</td>
<td>190.21-227.65</td>
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<tr>
<td><strong>Number</strong></td>
<td>87</td>
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### Table 9: 2006 Length Statistical Data

<table>
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<tr>
<th>Descriptive Information</th>
<th>Rock Bass</th>
<th>Rainbow Trout</th>
<th>Brown Trout</th>
<th>Smallmouth Bass</th>
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<tbody>
<tr>
<td>IV: The year the data was collected in (2006)</td>
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<tr>
<td>Mean</td>
<td>154.3565</td>
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<td>252.8621</td>
<td>184.3606557</td>
</tr>
<tr>
<td>Variation</td>
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<td></td>
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</tr>
<tr>
<td>Range</td>
<td>150</td>
<td>202</td>
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<tr>
<td>Minimum</td>
<td>75</td>
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<td>Maximum</td>
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<td>375</td>
<td>312</td>
<td>277</td>
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<tr>
<td>Standard Deviation</td>
<td>5.5949</td>
<td>5.7999</td>
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<td>7.391</td>
</tr>
<tr>
<td>1 SD</td>
<td>148.77-159.95</td>
<td>285.12-296.52</td>
<td>246.32-259.4</td>
<td>176.97-191.75</td>
</tr>
<tr>
<td>2 SD</td>
<td>143.18-165.54</td>
<td>279.32-302.52</td>
<td>239.78-265.94</td>
<td>169.58-199.14</td>
</tr>
<tr>
<td>3 SD</td>
<td>137.59-171.13</td>
<td>273.52-308.32</td>
<td>233.24-272.48</td>
<td>162.19-206.53</td>
</tr>
<tr>
<td>Number</td>
<td>115</td>
<td>54</td>
<td>58</td>
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</tr>
</tbody>
</table>

### Table 10: 2007 Length Statistical Data

<table>
<thead>
<tr>
<th>Descriptive Information</th>
<th>Rock Bass</th>
<th>Rainbow Trout</th>
<th>Brown Trout</th>
<th>Smallmouth Bass</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV: The year the data was collected in (2007)</td>
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<tr>
<td>Mean</td>
<td>134.21</td>
<td>283.78</td>
<td>295.14</td>
<td>204.10</td>
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<tr>
<td>Variation</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>191</td>
<td>180</td>
<td>141</td>
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<tr>
<td>Minimum</td>
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<td>Maximum</td>
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<td>400</td>
<td>361</td>
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<td>Standard Deviation</td>
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<td>5.6183</td>
<td>8.4629</td>
</tr>
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<td>1 SD</td>
<td>128.06-140.36</td>
<td>277.44-290.12</td>
<td>289.52-300.76</td>
<td>195.64-215.56</td>
</tr>
<tr>
<td>2 SD</td>
<td>121.91-146.51</td>
<td>271.1-296.46</td>
<td>283.9-306.38</td>
<td>187.18-221.02</td>
</tr>
<tr>
<td>3 SD</td>
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<td>264.76-302.8</td>
<td>278.28-312</td>
<td>178.72-229.48</td>
</tr>
<tr>
<td>Number</td>
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<td>28</td>
<td>39</td>
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Table 11: Inferential Statistics for Length

<table>
<thead>
<tr>
<th>ANOVA Tests per Species</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>α=0.05</td>
<td>Degrees of freedom: (3,491)</td>
<td>Critical F value: 2.70</td>
<td>Calculated F value: 206.1439</td>
<td>MSG:24207.1219</td>
<td>MSE:19219.0952</td>
<td>Calculated p-value: -0.0000</td>
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<td>Rock Bass</td>
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<tr>
<td>Rainbow Trout</td>
<td>α=0.05</td>
<td>Degrees of freedom: (3,240)</td>
<td>Critical F value: 2.70</td>
<td>Calculated F value: 68.3812</td>
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<td>MSE: 8019.8067</td>
<td>Calculated p-value: -0.0000</td>
</tr>
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<td>Brown Trout</td>
<td>α=0.05</td>
<td>Degrees of freedom: (3,183)</td>
<td>Critical F value: 2.70</td>
<td>Calculated F value: 519.1062</td>
<td>MSG:48362.9335</td>
<td>MSE:5558.8913</td>
<td>Calculated p-value: -0.0000</td>
</tr>
<tr>
<td>Smallmouth Bass</td>
<td>α=0.05</td>
<td>Degrees of freedom: (3,192)</td>
<td>Critical F value: 2.70</td>
<td>Calculated F value: 100.1873</td>
<td>MSG:18112.2355</td>
<td>MSE: 11329.1163</td>
<td>Calculated p-value: 0.0000</td>
</tr>
</tbody>
</table>
Graph 1: Mean Weight

Graph 2: Mean Length
SECOND PLACE

THE EFFECT OF TOMMY JOHN SURGERY ON A PITCHER’S EARNED RUN AVERAGE (ERA)

Andrew R. House
13316 Teasdale Court, Richmond, Virginia 23233
Deep Run High School, Glen Allen, Virginia 23059

ABSTRACT

Pitchers in the game of baseball today face tremendous amounts of stress placed on their throwing arms. This is due to many variables that include the kinematics of the pitcher’s motion, height of pitcher’s mound, length of outing, and type of pitch thrown. Pitching itself is an unnatural motion for the human arm. Because of this stress more and more pitchers are damaging their ulnar collateral ligament in their elbow to the point that surgery is needed to replace the ligament with a tendon from somewhere else in the body. With this major work done on the elbow it can be considered that the pitcher’s effectiveness might be changed. The purpose of this project was to determine if there was any change in a pitcher’s effectiveness after having what has been named “Tommy John” surgery by testing Earned Run Average (ERA) before and after the surgery compared to the ERA of pitchers who had never had major Tommy John surgery. It was hypothesized that a pitcher’s ERA would rise after the surgery; he would be less effective after it. Five consecutive years of pitchers before surgery, pitchers after surgery, and pitchers who had never had Tommy John surgery at all were compared. The results showed that each group’s ERA remained consistent, with the group that had never had surgery having lower ERAs overall. A t-test performed on the data did not indicate a significant difference between the mean of the groups (t= 2.228 < 2.691738 at df = 10; p>0.05). The data did not support the research hypothesis that a pitcher will become less effective and his ERA will rise after having Tommy John surgery. Based on the comparison of ERAs in this research, there is no direct correlation between Tommy John surgery and a rise or fall in ERA as a result of it. Before this can be concluded however, a more controlled test needs to be done to control the large amount of variables to a manageable state.

THIRD PLACE

THE EFFECT OF GASOLINE GRADES ON GAS MILEAGE AND COST BENEFIT ANALYSIS

Todd W. Phillips
3813 Hackamore Lane, Richmond, Virginia 23233
Mills E. Godwin High School, Richmond, Virginia 23238

ABSTRACT

The independent variable in this experiment was the varying levels of gas octane levels at the Exxon gas station used to refill the car. No control group was needed. The dependent variable was the car’s gas mileage, measured in miles per gallon. The purpose of this experiment was to conduct an experiment to see if better octane ratings actually gave better performance or were just more expensive. Over the course of the experiment, a 2004 Toyota Sienna was driven about forty-four miles. Next, the car was filled up, measuring the prices of the three octane levels, the gallons used, the car's gas mileage estimator, exact mileage driven, and the price of the full-up. The exact gas mileage was calculated from the collected data. After repeated trials, the car was driven until the gas meter was below the one-eighth marker. Afterwards the car was refilled with the next octane level, proceeding from 93 to 87 to 89. An ANOVA was performed on the data, which was not statistically significant. Three t-tests were performed on the data. The results from one of the two-sample t-tests supported the research hypothesis that if the gas octane rating increased, then the gas mileage would increase. This implies that the data was most likely due to the independent variable between these octane levels instead of chance. A linear regression t-test was also performed on the car's automatic gas mileage estimator. Cost benefit analysis showed that 89 octane gasoline is
the least economically beneficial gasoline available. An expansion for this experiment would be to test different types of cars, such as SUVs, sedans, coupes, trucks, etc. A recommendation for this experiment would be to use more trials, if resources are available.

**HONORABLE MENTION**

**THE EFFECT OF WII BOWLING ON REAL LIFE BOWLING SCORES**

**William J. Luxhoj**  
11430 Ivy Home Place, Richmond, Virginia 23233

**Jacob L. Chambon**  
11016 Ellis Meadows Lane, Glen Allen, Virginia 23059  
Deep Run High School, Glen Allen, Virginia 23059

**ABSTRACT**

The Nintendo Wii introduced a new world of interactive gaming with its famous Wii Sports. This began a new study to see if practicing with Wii Sports improved real life skills. In this experiment, Wii Bowling was used to determine if practicing with the Wii increased real life scores at the bowling alley. The purpose of this project was to see if practicing with Wii Bowling would affect real life scores and improve skills and fundamentals. Twenty subjects were divided into four groups: Group 1, Group 2, Group 3, and Group 4. Next, all twenty subjects went to Bowl America to bowl five games each to determine the average score for each group before practicing with the Wii. Over a one week span, Group 1 practiced five games of Wii Bowling, Group 2 practiced ten games of Wii Bowling, Group 3 practiced fifteen games, and Group 4 practiced twenty games. One week later, all the participants went back to Bowl America to bowl five more to determine the average score of the group after practicing with the Wii. A t-test performed on the data indicated a significant difference between the means of the four groups (t = 0.16 >2.306; t = 0.71 >2.306; t = 1.21 >2.306; t = 1.01 >2.306; t = 1.64 >2.306; t = 0.6 >2.306). The data did not support the research hypothesis that if a person practices with Wii Bowling, then it will increase real life bowling scores. However, after analyzing all the data, there appeared to be a direct relationship between the amount of practice with the Wii and the range and variance for each group. In the experiment, the groups that bowled more Wii games had lower ranges and variances. Practicing with the Wii may not increase scores, but it can be concluded that the more a person practices with Wii Bowling, the more consistent the bowler’s scores will be at the bowling alley.

**OTHER PAPERS SELECTED FOR PRESENTATION:**

The Effect of Baseball Park Size on Batting Statistics.  W. Evan Brewster, Lee-Davis High School, Hanover County Schools.

The Effect of the Hours of Sports Played Per Week on Grade Point Average.  Caitlin G. Brusoski and Erica L. Dobbs, Deep Run High School, Henrico County Schools.

The Effect of Different Methods of Card Counting on a Player’s Score in the Card Game.  Maggie Byrd, Deep Run High School, Henrico County Schools.

The Effect of Strikeouts Per Nine Innings on Walks and Hits Per Innings Pitched.  Charles A. Canova, Deep Run High School, Henrico County Schools.

The Effects of a Player’s Rank Out of High School on Their Position Taken in the NFL Draft.  Trent G. Dean, Mills E. Godwin High School, Henrico County Schools.

The Effect of Using Postseason GPA and Runs Allowed to Calculate Team Performance on Predicting the Outcome of the World Series.  Matthew P. Freedlander, Deep Run High School, Henrico County Schools.

A Study of Accidents in the Workplace at a Concrete Plant in the Central Shenandoah Valley. Rebecca S. Hawes, Shenandoah Valley Governor’s School, Augusta County Schools.

How the 24 Second Shot Clock Has Affected Field Goal Percentage in the Game of Basketball in the National Basketball Association from the 1946-1947 Season to the 1961-1962 Season. Dylan T. Hudson, Shenandoah Valley Governor’s School, Augusta County Schools.

The Effect of Day or Night on the Batting Average of a Baseball Team. Ryan M. Katona, George H. Moody Middle School, Henrico County Schools.

The Differences in Scores of Soccer Matches in Different Months of the Year. Graham H. Lohr, Shenandoah Valley Governor’s School, Augusta County Schools.

The Ability of Two Different Strength Indexes to Predict NFL Game Results. David M. Morton, Deep Run High School, Henrico County Schools.


The Effect of Handedness on NHL Points per Game Average in the 08-09 Season. Tyler J. Wideman, Deep Run High School, Henrico County Schools.
MORPHOLOGICAL AND MOLECULAR PHYLOGEOGRAPHY OF A GIANT AMERICAN RIVER PRAWN, *Macrobrachium carcinus*

Alexander M. Kim  
4661 Buckhorn Ridge, Fairfax, Virginia 22030  
Thomas Jefferson High School for Science and Technology, Alexandria, Virginia 22312

**Abstract:** An important controversy in contemporary evolutionary theory is the amount of regional differentiation possible within amphidromous species, which inhabit freshwater as adults but have larvae which disperse through marine habitats. The amphidromous prawn *Macrobrachium carcinus*, North America’s largest freshwater arthropod, is an ideal test case for the notion that amphidromy is a homogenizing force prohibiting the evolution of island-specific clades. This prawn’s vast range (northern Gulf of Mexico to Southeastern Brazil) allows us to gauge whether predictions of limited population structuring hold true over large geographic scales. Since morphological differentiation can reflect genetic divergence, 2 discrete and 18 continuous physical characters from specimens throughout *M. carcinus*’ range were measured and subjected to cladistic analysis. Morphological data were also used to compare *M. carcinus* with putative sister species from West Africa and Pacific drainages of the Americas, *M. vollenhovenii* and *M. americanum*. These analyses suggest that prawns in certain localities are distinguishable purely on the basis of morphology, and that *M. carcinus* and *M. americanum* have only recently diverged from each other. mtDNA sequence data also demonstrate significant locality-based population structuring in *M. carcinus*, casting doubt on the uniformity of gene flow across *M. carcinus*’ range. Regional differentiation is confirmed as possible for amphidromous species, with novel implications for conservation and fisheries management.

**Introduction:** The prawns or freshwater shrimp of the genus *Macrobrachium* (Decapoda: Caridea: Palaemonidae) comprise “one of the most diverse, abundant and widespread crustacean genera” (Murphy and Austin, 2005). With over 200 described species, *Macrobrachium* is distributed throughout the tropics and subtropics, occurring on every continent but Europe and Antarctica (ibid.; Jayachandran, 2001). These long-armed prawns are remarkable not only for their diversity but also their great size, highly complex life cycles, and use for food by local populations and in aquaculture production.

Amphidromy and *M. carcinus* - *Macrobrachium carcinus*, like hundreds of decapod, gastropod, and fish species – inhabits freshwater as an adult yet has an amphidromous life cycle requiring several months of planktonic larval development in estuarine or marine environments prior to upstream migration back into freshwater (Lewis and Ward, 1965; Choudhury, 1971; Bowles et al., 2000). Amphidromy is thought to provide significant opportunities for oceanic dispersal (McDowall, 2007), and many amphidromous *Macrobrachium* pose the biogeographic challenge of “freshwater” species with transoceanic distributions.

*M. carcinus* ranges from the United States’ Gulf Coast to the Caribbean Islands, Mexico, and South America as far south as Santa Catarina, Brazil (Bowles et al., 2000; Mistakidis, 1966; Holthuis, 1952). With its lobster-like dimensions, this is the largest species of river shrimp occurring in the U.S. and, indeed, the Americas’ largest freshwater arthropod. Adult males can reach 300 mm in body length (not including the second chelipeds, which can exceed the rest of the body in length: Mistakidis, 1966) and weigh up to a kilogram.

Human and Ecological Significance - *Macrobrachium* are targeted by fisheries as far-flung as Micronesia (Buden et al., 2001), Mauritius, and the United States (Rabanal and Soesanto, 1985). Global aquaculture production of one species – *M. rosenbergii* – is projected to reach 700,000 to 1.4 million metric tons year⁻¹ by 2010 (up from 50,000 metric tons in 1993: New, 2005), rivaling the current magnitude of the entire marine shrimp farming sector. The large size of *M. carcinus* makes it, too, a desirable aquaculture candidate, and trials have begun in the United States and the Caribbean (New and Valenti, 2001).
Considering the size and omnivorous habits of Macrobrachium spp., the impacts of these prawns on energy cycling in their ecosystems can be substantial (Dudgeon, 1999). Furthermore, some species of Macrobrachium have been identified as having high potential as biocontrol for schistosomiasis-transmitting snails (Roberts and Kuris, 1990) and mosquito larvae (Collins, 1998).

Decline and Conservation Concerns - As Bowles et al. (2000) note, Macrobrachium in the United States appear to be declining throughout their wild ranges, largely due to the construction of water impoundments which disrupt their amphidromous migrations. In the lower Mississippi, reported catch yields of M. ohione plunged nearly 99% between the 1930s and early 1970s (Mermilliod, 1976). M. carcinus was once abundant enough to sustain a commercial fishery in 19th century Texas, but contemporary populations appear to be significantly sparser, and may still be declining (Bowles et al., 2000).

The gaps in scientific understanding of M. carcinus and its congeners in the United States are significant. Though aquaculture experiments indicate that M. carcinus may live for over 8 years (New and Valent, 2001), even fundamental facts like average lifespan are unknown. Informed conservation and fisheries management of M. carcinus cannot proceed without clarifying the evolutionary relationships between the populations in its vast distribution.

Controversy: Amphidromy and Heterogeneity - It has been argued that amphidromy prohibits the evolution of island-specific clades and may result in genetic continuity among rivers and among islands (Cook et al., 2008). However, some aspects of M. carcinus physiology and morphology challenge this position, indicating heterogeneity even between relatively proximate Caribbean populations.

Choudhury (1971) found that the optimum salinity range for maximum survival and development of larvae for Jamaican M. carcinus was 14‰ to 17.5‰; they metamorphosed into postlarvae in 56 to 65 days. However, Lewis and Ward (1965), working with Barbadian M. carcinus, reported best results rearing larvae at a salinity of 21‰; metamorphosis took 90 days.

In M. rosenbergii, a related amphidromous prawn occurring from Pakistan to northern Australia, analysis of the 16S rRNA mitochondrial gene and microsatellite loci revealed significant divergence of “eastern” and “western” clades on opposite sides of Huxley’s line (Chand et al., 2005; De Bruyn et al., 2004). Patterns of haplogroup diversity support the idea of rapid dispersal during Pleistocene glacial maxima followed by isolation during sea level rise (De Bruyn et al., 2007). Later morphological analysis (Wowor and Ng, 2007) revealed that the “eastern” and “western” forms are in fact easily separable by physical traits. M. rosenbergii, consequently, was split into M. rosenbergii sensu stricto (“eastern”) and M. dacqueti (“western”). Morphological divides within M. carcinus could indicate a similar taxonomic situation.

Observations of M. carcinus from the National Museum of Natural History’s preserved collections revealed that standard morphological keys were an insufficient representation of intraspecific variation. The “single, large, triangular tooth” on the the second cheliped (Bowles et al., 2000) was sometimes not one tooth but a line of dentition. The description of the second chelipeds as “typically unequal in length” (ibid.) was also untrue (author, pers. obs.).

Vicariance and Reunion - Seven species of Atlantic-drainage Macrobrachium appear to form geminate pairs with congeners from Pacific drainages, their common ancestors evidently separated by the closing of the Isthmus of Panama (Holthuis, 1952). M. carcinus closely corresponds to M. americanum, from Pacific drainages of the Americas (and, to a lesser extent, the West African M. vollenhovenii). Holthuis, noting that M. americanum and M. carcinus are so similar in morphology that they were long considered monospecific, expressed doubt about their taxonomic distinctness but did not revise their nomenclature (Holthuis, 1952).

The geographic separation of M. americanum and M. carcinus may have been breached in 1915 by the construction of the Panama Canal, which rerouted rivers over the dividing Cordillera and dramatically increased dispersal of freshwater fish (Smith et al., 1996). Whether M. carcinus and M. americanum also crossed between Pacific and Atlantic watersheds is unknown.
Research Objectives - (1) To measure a set of 18 discrete and 2 continuous morphological characters from *Macrobrachium carcinus* from localities in North America, Central America, the Caribbean, and South America (along with *M. americanum* and *M. vollenhovenii*); (2) to perform discriminant analysis and to construct a cladistic tree using these data; (3) to infer the evolutionary relationships between *M. carcinus* and its sister species *M. americanum* and *M. vollenhovenii*; (4) to compare morphological data against mtDNA sequence information from the cytochrome c oxidase subunit 1 (COI) gene region.

**Methods and Materials:** Morphometrics - Specimens of *M. carcinus* were collected in El Verde, Puerto Rico, and assembled from the alcohol-preserved collections of the Smithsonian Institution’s National Museum of Natural History. Specimens with missing or fragmentary second chelipeds, broken rostra, or damaged cephalothoraces were regarded as incomplete data and were excluded from analysis. See Appendix 1 for morphometric diagram and Appendix 2 for localities of origin.

The sex of each specimen was determined by examining the second pair of pleopods under a dissecting microscope for presence or absence of the appendix masculina, a stylet that occurs in male decapod crustacea, but not in females (Tombes and Foster, 1979).

The following morphological values were recorded (with all length measurements taken using Vernier digital calipers to an accuracy of 0.01 mm): number of teeth on the upper edge of the rostrum (RT: U); number of teeth on the lower edge of the rostrum (RT: L); and carapace length (CL), an indication of specimen body size (Kuris et al., 1987).

Measurements were also taken from both the left (L) and the right (R) second chelipeds (see Appendix 1, Fig. 1, and Appendix 4; cheliped segment definitions as per Short, 2004): minimum ischium length (IL-L-1 or IL-R-1); maximum ischium length (IL-L-2 or IL-R-2); merus length (MeL-L or MeL-R); carpus length (CpL-L or CpL-R); manus length (MnL-L or MnL-R); dactylus length (DL-L or DL-R); pollex length (PoL-L or PoL-R), measured from pollex tip to corner of juncture with dactylus; maximum palm diameter (PD-L-1 or PD-R-1); minimum palm diameter (PD-L-2 or PD-R-2).

Morphometric Data Analysis Techniques - The 18 continuous characters were normalized with respect to specimen size by expressing the cheliped lengths as ratios to the corresponding specimen’s carapace length. By pooling this data with the discrete rostral characters, matrices were assembled where y-axes corresponded to specimen IDs and x-axes to each specimen’s 20 characters (not including sex and carapace length): the upper and lower rostral tooth counts, 9 left cheliped ratios, and 9 right cheliped ratios.

Conventionally (Archie, 1985; MacLeod and Forey, 2002), continuous data is first analyzed by calculating pooled within-group standard deviation ($S_p$), defined as follows ($n = \text{sample size for character } i \text{ in taxon } j; S_p^2 = \text{pooled within group variance for character } i; k = \text{number of taxa}$):

$$S_p^2 = \frac{\sum_{j=1}^{k} (n_j - 1) S_j^2}{\sum_{j=1}^{k} (n_j - 1)}$$

$$S_p = \sqrt{S_p^2}$$

Since this study examines intraspecific as well as interspecific variation, each specimen was treated as a distinct taxon. Standard deviation (STDEV) for each continuous character was calculated over the set of all specimens’ values for that character. RT:U and RT:L (the discrete characters) were encoded for cladistic analysis without modification. Using STDEV, the continuous

Since this study examines intraspecific as well as interspecific variation, each specimen was treated as a distinct taxon. Standard deviation (STDEV) for each continuous character was calculated over the set of all specimens’ values for that character . RT:U and RT:L (the discrete characters) were encoded for cladistic analysis
without modification. Using STDEV, the continuous characters were encoded by generalized gap coding sensu Archie (1985).

Multiple discriminant analysis (MDA) was performed in StatistiXL, and Mesquite, a modular computer program for phylogenetic analysis (Maddison and Maddison, 2008) was used to construct cladistic trees based on the coded morphometric data. An distance-based equiprobable tree was generated and then improved through iterative subtree pruning and regrafting (with tree value calculated using the character matrix). Trees were constructed for the full set of specimens (both male and female), and then for males and females considered separately.

mtDNA Analysis - DNA was successfully extracted from 19 *M. carcinus* (9 from San Marcos, Texas, and 10 from El Verde, Puerto Rico), using Qiagen’s DNeasy Blood & Tissue Kit. A 450 bp fragment of the cytochrome oxidase c subunit 1 gene region was amplified using the COI primers COI-Mat-F (forward: GGA AAY GAYCAA ATC TAC AA) and COI-Mat-R (reverse: AAR GAT GTA TTT ARR TTT CG) and the Big Dye Terminator kit from ABI. The sequences were aligned in Sequencher using outgroups from NCBI’s Genbank (see Appendix 1, Fig. 7) and used to construct phylogenetic trees in PAUP (distance analysis with 10,000 neighbor-joining bootstrap replicates, retaining groups with frequency > 50%).

**Results:** (See Appendix 1, Fig. 2-7, for tree diagrams) - Data Analysis - MDA analysis of morphometric data revealed a nearly perfect distinction between *M. vollenhovenii* and *M. americanum/M. carcinus*, and a wide gap between *M. heterochirus* and the other species. *M. americanum* and *M. carcinus* were characterized by a very high degree of overlap, such that many specimens were closer to representatives of the other species than to their own. This lack of differentiability persisted when *M. carcinus* and *M. americanum* were differentiated by sex; maximum differences between conspecific males and females exceeded minimum interspecific separation. “Unknown,” a specimen labeled *M. carcinus* but morphologically most similar to *M. heterochirus* of the *Macrobrachium* known from the collection locality (Bowles et al., 2000), was closest to *M. heterochirus* but not very proximate.

Cladistic analysis of the morphometric data supported, for males, females, and combined data sets alike, the basal position of *M. heterochirus* (separated from the others at node 2) and an inability to exclusively distinguish *M. carcinus* and *M. americanum*. The second-most basal distinctions were between a clade mostly comprised of *M. americanum* from Pacific drainages on one hand and *M. americanum*, *M. carcinus*, and *M. vollenhovenii* on the other.

In several instances, the morphometric trees grouped terminal nodes in a way corresponding to locality (e.g., *M. americanum* from the Galapagos and from Lower CA in Fig. 4).

**Discussion and Conclusions:** Morphological and Genetic Results - Standardized Discriminant Function Coefficients for Funct. 1 (see Appendix 3) in MDA analysis revealed that MD-L-2/CL and MeL-L/CL had the highest classifying significance for all data sets. These characters are thus the most significant for distinguishing the *Macrobrachium* in this study – and potentially for the genus as a whole.

The extreme difficulty in distinguishing between *M. americanum* and *M. carcinus* (assuming distinct species status is warranted) suggests that the two taxa are relatively young and still in the process of differentiation. The prevalence of MDA overlap may suggest ongoing gene flow or cross-drainage migration through Panama-Canal-related watershed modification.

Correspondence between clades and regions of origin (as reflected in Appendix 1, Fig. 4-6) could suggest one of three possibilities: (A) The clades reflect evolutionarily differentiated regional populations; (B) the clades reflect locality- or region-specific environmental effects acting on a genetically uniform but morphologically plastic species; or (C) such clades exist due to convergent evolution or chance rather than closely shared ancestry. Possibility (A) implies a degree of genetic isolation from neighboring populations persistent enough to allow for evolutionary adaption of morphology to local conditions – genetic isolation inconsistent with the idea that amphidromy precludes the evolution of such clades (Cook et al., 2008). Provided that current species divisions are valid, however, (C) is at least partially correct.
The pronounced distinction in the morphological cladograms between (1) the isolated Galapagos and Lower California *M. americanum* (at the northern extreme of this species’ range) and (2) conspecifics from other localities as well as *M. carcinus* may indicate that similarity between *M. americanum* and *M. carcinus* correlates with proximity to a zone of recent divergence or ongoing genetic interchange (Panama being the most likely candidate). That the split between groups (1) and (2) is more basal than that between *M. carcinus* and *M. americanum* may be significant in light of the belief that the two American forms were believed to descend from West African forms similar to *M. vollenhovenii*. If convergence or misleading apomorphies in *M. americanum* are not responsible, trans-Atlantic gene flow via planktonic larvae may have persisted between ancestral *M. carcinus* and *M. vollenhovenii* after the predecessors of *M. carcinus* and *M. americanum* were separated by the closing of the Isthmus of Panama. Alternatively, trans-Atlantic colonization may have proceeded in the opposite direction, from America to West Africa.

The COI sequence results indicate significant differentiation between Puerto Rican and Texan *M. carcinus* (large enough to rival or exceed that between other distinct species in the analysis). The distinction between the two localities, whereby no specimen from one locality clustered with any from the other, had 100% consistency in bootstrap analysis – a clear example of an amphidromous species exhibiting intraspecific population structuring.

Many molecular studies on amphidromous fishes reveal a lack of such structure, sometimes across extensive ranges, and suggest continual gene flow across metapopulations (McDowall, 2007; Chubb et al., 1998). This study, by demonstrating the contrary for *M. carcinus*, indicates the need for a reconsideration of assumptions about population dynamics and dispersal abilities in amphidromous species. If populations exhibit significant locality-based genetic differentiation, they cannot be considered interchangeable (two distinct fisheries stocks) and restocking of extinct or depleted populations with specimens from other areas must proceed with great caution.

Future Objectives - Future research goals are: (1) To determine mechanisms underlying differences in dispersal ability between prawn populations; (2) To perform hybridization studies to investigate *M. americanum/M. carcinus* species validity with respect to the biological species concept; (3) To create conservation studies which account for the effects of local or regional extinctions on amphidromous organisms’ metapopulation and species viability.

**LITERATURE CITED**


ACKNOWLEDGMENTS

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Appendices:

Appendix 1 (Diagrams and Phylogenetic Trees)

Fig. 1: Visual guide to morphology of an idealized *Macrobrachium* sp. (isch. = ischium, CL = carapace length). Adapted from Short (2004), Fig. 1.
Fig. 2 (right):

Scatterplot of MDA scores for *M. americanum, M. carcinus, M. heterochirus*, and unknown (both males and females).

Funct 1: Eigenvalue = 15.068; Wilks’ $\lambda = 0.005$; $\chi^2 = 195.942$; df = 80; p < 1E-11.

Funct 2: Eigenvalue = 2.593; Wilks’ $\lambda = 0.086$; $\chi^2 = 91.812$; df = 57; p < 0.002.

Fig. 3 (left):

Scatterplot of MDA scores for *M. americanum, M. carcinus, M. heterochirus*, and unknown, separated by sex.

For Funct 1, Eigenvalue = 15.426; Wilks’ $\lambda = 0.001$; $\chi^2 = 257.980$; df = 140; p < 5E-09.

For Funct 2, Eigenvalue = 5.299; Wilks’ $\lambda = 0.013$; $\chi^2 = 157.221$; df = 114; p < 0.005.
Fig. 4 (above)

Distance-based cladistic tree of all specimens, male and female, constructed in Mesquite. For Fig. 4 & 6, *M. heterochirius* was set as the outgroup; for Fig. 5, *Unknown* ("*M. carinus*": Puerto Rico) was selected as the outgroup.
Fig. 5 & 6: Cladistic trees of all male specimens (above) and of all female specimens (below), constructed.
**Fig. 7 (above)**: Phylogenetic tree based on COI sequences of *M. carcinus*, *M. faustinum*, and *M. heterochirus*. Other taxa from NCBI’s Genbank.
## Appendix 2: Locality Data (Table 1)

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Appendix 3: Standardized Discriminant Function Loadings (MDA)

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<td>IL-R-2/CL</td>
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Table 2: MDA Weight for Species-Level Data (See Appendix 1, Fig. 2):

Numerical values indicate rankings of the morphological characters, from best to worst, in ability to distinguish between the predefined species groups in the first and second discriminant.
### Table 3: MDA Weights for Sex-Delineated Data (See Appendix 1, Fig. 2):

Numerical values indicate rankings of the morphological characters, from best to worst, in ability to distinguish between the predefined species groups in the first and second discriminant.

<table>
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<th>Character</th>
<th>Funct 1</th>
<th>Character</th>
<th>Funct 2</th>
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<td>MD-L-2/CL</td>
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<td>MD-R-2/CL</td>
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Appendix 4: Morphometry Illustrations

(Photos by author.)

A: Calipers measuring carapace length of a Puerto Rican *M. carcinus.*

B: Calipers measuring pollex length (from tip of immobile second cheliped finger to corner of its junction with dactylus) in *M. carcinus.*
SECOND PLACE

HEARING CAPABILITY OF THE LINED SEAHORSE (*Hippocampus erectus*)

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ABSTRACT

The detection of auditory stimuli in *Hippocampus erectus* has never before been tested, so there are absolutely no data available to assess the risk of sound exposure for this species. The objective of this project is to determine hearing sensitivity in *Hippocampus erectus* by recording auditory evoked potentials generated in the inner ear. These electrophysiological voltages will determine whether or not this species has the ability to detect sound and if so, their threshold of hearing as a function of frequency. To measure these voltages, a recording electrode is placed subcutaneously just behind the brain case, a reference electrode is placed subcutaneously in the posterior musculature, and a ground electrode is placed in the water of the test tank. A computer-controlled electronic filter and signal generator vary the sound pressure level, frequency, and duration of pure tones emitted by an underwater sound projector to create a defined stimulus. The auditory voltage signal from the electrodes is amplified using a bio-amplifier and recorded through an electronic data acquisition board which is also controlled by the computer. Prior to seahorse testing, a goldfish (*Carassius auratus*) was used to validate the testing procedure and data acquisition. The results of our study will provide auditory threshold data that can be used to help understand the potential effects of human-generated noise on *Hippocampus erectus* and other seahorse species.

THIRD PLACE

THE EFFECT OF DIFFERENT TYPES OF LIGHT ON TADPOLE DEVELOPMENT

Emilia R. Sens
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Washington-Lee High School, Arlington, Virginia 22201

ABSTRACT

The purpose of the experiment was to determine whether light has an effect on the growth rate and development of tadpoles. More specifically, it was designed to test the difference of growth and speed of metamorphosis between tadpoles placed under natural, full-spectrum light and those under red light. The independent variable was the type of light. Dependent variables were the growth in grams (quantitative) and the rate of growth and development to metamorphosis (qualitative). The hypothesis was that if tadpoles were placed under red light, they would develop faster than those placed under full-spectrum light. The only thing manipulated in the experiment was the type of light. Identical numbers of tadpoles were placed under each light and measured on a scale in grams every 5 days for 30 days total. After each recording, the averages of the weights were calculated for each group. These averages were charted on a line graph. Also, every week, pictures were taken of each group and the development was given a number from 1 to 3, with 1 being underdeveloped and 3 being extremely developed. Data showed that there was a significant difference between the masses of the tadpoles from the two groups. The tadpoles placed under the red light had a higher mass than those from the natural light group. The results suggested that the tadpoles in the red light group developed faster and had a higher average mass than those in the natural light group. Red light is shown positively affect the time to metamorphosis and the rate of development.
HONORABLE MENTION

THE EFFECT OF WATER DEPTH ON THE GROWTH RATE OF
Crassostrea virginica

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George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The oyster population of the Chesapeake Bay has been nearly destroyed by years of overfishing, declining water quality, and several parasitic diseases. Surface growth of oysters is the most popular method currently employed to raise oysters. A Taylor float, is used to contain the oysters at the surface. Surface water is subject to swings in salinity, temperature and nutrient content. These conditions are less variable at depths below the waters surface. The investigator hypothesized that oysters below the surface but above the bay floor would progress more rapidly than those at the surface. Three Taylor floats were constructed of pvc pipe and contained 100 seed oysters Crassostrea Virginica. The oysters had a mean size of 21mm from the hinge to the free edge of the shell. The floats were placed in the waters of the Chesapeake bay, arranged in a vertical configuration with one at the surface three and six feet of depth. The oysters were measured at approximately two month intervals during each of two growing seasons. The surface oysters served as the control group. The dependent variable was the mean oyster size at each level. The independent variable was the level at which the oysters were grown. Fifty oysters were measured at each level, at the start of the experiment and at four subsequent intervals. The oysters increased in size by over 300%. The average size of the oysters at each level were not statistically different from each other at all but the final measurement interval. At the final measurement interval, the oysters raised at the 6 foot depth were on average, and by a students T test significantly larger than the oysters raised at the surface, 77 mm at 6 feet vs 71 mm at the surface, P=0.02 . The results supported the investigators hypothesis.

HONORABLE MENTION

THE EFFECT OF THE TYPE OF SWEETENER ON THE POPULATION OF PAINTED LADY BUTTERFLIES

Brady K. Brown
2418 Jewett Drive, Henrico, Virginia 23228
George H. Moody Middle School, Henrico, Virginia 23228

ABSTRACT

The painted lady butterfly, one of 20,000 species of butterflies in the world, uses a straw-like tube called a proboscis to feed on nectar in the wild, or sugar solutions when in captivity. This experiment was designed to determine the effect of the type of sweetener provided on the population of the painted lady butterflies. The hypothesis stated that if painted lady butterflies are provided different sugar solutions, then the painted lady butterflies provided brown sugar would have the greatest population. It was supported. Four groups of 18 butterflies each were put in four different cages. A cotton ball containing two teaspoons of a sugar solution was placed in each cage. These solutions were brown sugar, stevia, Equal, and Splenda. In order to measure the population, the experimenter measured the number of deaths per day, the number of live butterflies each day, and the number of eggs in each cage each day. The butterflies fed brown sugar (0.25 deaths per day) had the lowest death rate, Splenda (0.33 deaths per day) had the second lowest death rate, Equal (0.34 deaths per day) had the third lowest death rate, and stevia (0.94 deaths per day) had the highest death rate. Butterflies fed brown sugar had the highest number of eggs produced (327 eggs), followed by Equal (219 eggs), followed by Splenda (50 eggs), and stevia (0 eggs).
HONORABLE MENTION

THE EFFECT OF CAFFEINE CONCENTRATION ON PLANARIAN LEARNING RATE

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Thomas Jefferson High School for Science and Technology, Alexandria, Virginia 22312

ABSTRACT

The effect of the caffeine concentration of water containing the *Dugesia tigrina* has a significant effect on planarian learning rate. The effects of caffeine in vertebrates have been widely studied, and so it can be posited that increased caffeine concentration will have a beneficial effect on learning rate, and therefore decreasing the time taken to exhibit a learned behavior. Previous studies suggest that increased intake of caffeine causes “rapid neuron firing,” which, in turn, is a likely candidate in the acceleration of learning rate. The objective of this experiment was to study the effect of caffeine concentration on planarian learning rate, specifically that of *Dugesia tigrina*. Planarians were placed in environments of varying caffeine concentrations, and classical conditioning was then used to illicit associative response from the planarians and derive planarian learning rate. Planarians were subjected to ten seconds of light, during which the planaria elongated, and after this ten seconds the planaria were shocked with low voltage electricity. This stimulus caused the planaria to curl. Immediately following the shock, the light was turned off, and planaria were left to elongate during a ten second dark period. Learning was achieved when planaria associated the period of light with the oncoming electric shock. Planaria exhibited this learned behavior remaining in a curled position once the light was turned on. This study suggested that increased caffeine concentration has a positive effect on learning rate, therefore lowering the amount of “light-shock-dark” cycles repeated before learned behavior was exhibited.

OTHER PAPERS SELECTED FOR PRESENTATION:

Identifying and Clarifying Evolutionary Interactions between Sweat Bees and Nematodes. Tara A. Adiseshan, Ramana Academy. Albemarle County Schools.

Oysters: Cleaning the Bay: *Crassostrea virginica* vs. *Crassostrea ariakensis* Part II. Alan P. Booth, Trinity Lutheran School, Newport News Private Schools.

The Effect of Diphenhydramine Hydrochloride on Egg Production of *Copepoda cyclopoidea*. Sanjeet Das, Pallavi Ravada and Ester Yang, Thomas Jefferson High School for Science and Technology, Fairfax County Schools.

The Effect of Commonly Consumed Antioxidant Beverages on the Mortality Rate, Cocoon Production, and Weight Gain of *Eisenia fetida*. Nichole H. Jannah, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Light Exposure on the Reproduction Rate of *Chlorohydra viridissima*. Alvina Jiao and Deki Tsering, Thomas Jefferson High School for Science and Technology, Fairfax County Schools.

The Effects of Natural Insecticides on *Pholcus phlanagoides*. Harrison W. Johnsen, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Melatonin on the Heart Rate of *Daphnia pulex*. Rebecca L. Kolkmeyer and Sonia B. Foley, Thomas Jefferson High School for Science and Technology, Fairfax County Schools.
The Effects of Nitrogen Fertilizer on the Population Size of *Artemia salina*. Ashlyn E. McCurley, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Food Type on the Food Preference of the Ant. Ricardo D. L. Pagulayan, Swanson Middle School, Arlington County Schools.

Effects of Caffeine on the Development of *Drosophila melanogaster* Wild Type and per -1- Mutants. Muntasir Rahman, Central Virginia Governor’s School, Lynchburg City Schools.

The Effect of Caffeine Concentration on the Number of Males and Hermaphrodites in a Single Progeny of *Caenorhabditis elegans*. Hannah Tam and Vivian Lu, Thomas Jefferson High School for Science and Technology, Fairfax County Schools.

The Effects of Gamma Radiation on the Growth of *Artemia salina*. Matthew D. Taylor, Central Virginia Governor’s School, Lynchburg City Schools.

Population Projections of Cargo and King’s 1990 Prediction Regression Formula on Sea Nettles and Striped Bass in the Chesapeake Bay. Frederick F. Twigg, Mountain Vista Governor’s School, Clark County Schools.

The Effect of Temperature on the Green Crab’s Heart Rate. Andrew A. Wu, Williamsburg Middle School, Arlington County Schools.