

**Category AS**

**L01** The Effects of Commercial Pesticides Upon *Vanessa cardui*

**Abstract**

Pollinators, especially bees and butterflies, are experiencing recent population declines. Pesticides could be a possible reason. In this experiment, Painted Lady butterflies, *Vanessa cardui*, were tested because of their prevalence across multiple continents. The three pesticides tested were Neem Oil, RoundUp, and Pyrethrin. These pesticides were chosen based upon their widespread use across the world. Based upon research, the pyrethrin was predicted to be the most effective, as pyrethrin is a natural insecticide that interferes with arthropod nervous systems. The organisms were grown from larvae and tested on as adults. The organisms were then placed in habitats with 4% sugar solution. Around 7.5 mL of pesticides were sprayed upon the experimental groups twice a day, for one week. The results show that Pyrethrin was extremely effective in killing *Vanessa cardui* when compared to the other experimental groups and the control. The hypothesis was supported, as Pyrethrin had a 100% mortality rate across both trials. A one-way ANOVA significance test was performed, and the data was shown to be significant.

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**Category AS**

**L02** Determining the Media Selection of Earthworms

**Abstract**

A container will be constructed that will have four chambers. In each chamber, a different soil or media will be placed. Earthworms will be introduced to an area free of soil and allowed to move to a selected soil.

After 1- 3 days, worms will be counted to determine which medium worms selected.

Mediums used were sand, topsoil, cactus soil, and dried leaf material.

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**Category AS**

**L03** Reproduction rate of drosophila after being energized

**Abstract**

The purpose of this experiment is to observe the population rate of the drosophila melanogaster (fruit flies) through reproduction and death while they are hydrated by a diluted energy drink solution (25%, 50%,75%). The researcher selected 5 popular energy drinks to test the Drosophila melanogaster, (red bull, Rockstar, monster, spike shooter, and zip fizz). The researcher then mixed the energy drinks with distilled water to dilute them to a certain amount appropriate for the drosophila's. By diluting the energy drink to a certain percentage, it will be easier to determine which will have the greatest affect on the pupa, 1st, 2nd, and 3rd Instar, also which will make the drosophila death and reproduction rate increase. A test run of the experiment was ran and it was noted that the zip fizz molded too quickly, so it was taken out of the experiment. The researcher's hypothesis is that the spike shooter will have the greatest effect on the Drosophila's because it has had the most real-life cases of hallucinations, nausea, and in serious cases death. To separate the fruit flies into separate vials they must be anesthetized and put into the correct vials. To get the best results the researcher put 5 flies in total into one vial (3 females,2 males). The researcher must properly anesthetized, so no fatalities occur as they are asleep, when anesthetizing make sure no dead flies are put into the experimental vials. The researcher has to make sure no chemicals are inside of the water when mixing the energy drink solutions, the best water to use is distilled because it has no chemicals or added ions in the solution. Results are still being collected.

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**Category BE**

**L04** Incorporating Matrix Protein M2 in Influenza VLP to Improve Vaccine Production

**Abstract**

Influenza virus remains a heavy economic burden and poses pandemic threats to public health worldwide, causing 250,000-300,000 deaths annually and 3-5 million cases of severe illness. Over the last 15 years in the United States, reported efficacy of seasonal influenza vaccines has been less than 50% in all but four years and even as low as 19% during the 2014-2015 season. One of the primary causes of this inefficacy falls on the traditional egg-based platform, which suffers from a production timeline of 6-9 months. During this significant lead-up time before vaccines become available the virus has the opportunity to undergo mutations (antigen drift), rendering those vaccines in production largely ineffective. Virus-like particles (VLP), which mimic the three dimensional structure of the influenza virus but lack the viral genetic material and ability to replicate, have been demonstrated to be a safe, highly immunogenic alternative to the current egg-based vaccines. Taking advantage of cell culture platforms, VLP can also be produced in a much shorter timeframe (<3 months) and larger scale compared to traditional influenza vaccines.

Despite this promising outlook, there are several challenges in producing VLP-based influenza vaccines. The high background of residual baculovirus (>10:1 compared to VLP) in the cell culture requires a multi-unit downstream separation process that suffers from significant losses in yield in order to obtain VLP with clinical grade purity. In order to tip the balance toward producing more VLP, it would be advantageous to incorporate the influenza matrix protein M2, which has been shown to play a significant role in the budding of influenza virus from infected cells. However, the inclusion of M2 into VLP has been left unrealized due to its ion channel toxicity in both mammalian and insect cell culture systems, resulting in decreased protein production. While the M2 viral inhibitor amantadine has been demonstrated to relieve this toxicity and restore protein expression, its effects on VLP production are unknown. In this project, I will study the addition of amantadine into the cell culture during baculovirus expression of HA, M1, and M2, determine the total number of VLP as well as the amount of HA and M2 incorporated in order to fully characterize the effect of amantadine on improving influenza VLP production for vaccine use.

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**Category BE**

**L05** Development of GI-Sustainable Probiotic Targeting Obesity

**Abstract**

High concentrations of the non-pathogenic bacteria *Christensenella minuta* in the gut microbiota are inversely correlated with obesity rates. Reduced weight gain has been causally linked to *C. minuta* in an animal study. The purpose of this project is to develop a *C. minuta*-based probiotic product that is able to survive in a simulated gastrointestinal tract during the harsh digestive process. Novel encapsulation techniques were developed by combining the freeze-dried process with single and double-encapsulation using calcium-alginate beads. Solid jelly was tested as a food vehicle for the encapsulated *C. minuta*. The samples were tested for viability after exposure to gastric acid and digestive enzymes. The viability of *C. minuta* in the product was monitored over 8 weeks of dry storage and 2 weeks in solid gelatin. The double-encapsulated beads had the highest dry survivorship after pepsin and acid-exposure of  $10^{7.84}$  CFU/mg, and of  $10^{7.6}$  CFU/mg after 8 weeks of dry storage. Double-encapsulated beads in jelly had a viability of  $10^{8.2}$  CFU/mg after 2 weeks. These results indicate that double-encapsulated *C. minuta* beads may become feasible as an oral probiotic supplement after human trials.

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**Category BE**

**L06** SMART Glasses model to assist visually impaired patients

**Abstract**

Visual deficits are one of the most disabling neurological problems after stroke. Homonymous hemianopia (HH) is the most common visual field defect observed. Homonymous hemianopia causes the patient to lose sight in half of the visual field in both eyes. Currently, the most common management for HH is occupational therapy and vision training, both being inefficient methods. SMART Glasses are perhaps the finest approach to assisting these patients. The underlying concept and purpose of the project is to produce a hardware / software model with open source technology to provide an enhanced visual sustenance for patients with HH. This project is based on four models. The first prototype includes an Arduino microcontroller, a lithium-polymer battery, a TFT display, and a camera module assembled on a perforated prototyping board. The second prototype includes an Arduino microcontroller with a smaller TFT display (128\*128 rather than 160\*128), and a camera module. The third hardware prototype is composed of a pre-programmed OLED display which reveals the ideal light emission, clarity, and contrast for image projection in the hardware of a pair of SMART Glasses. Finally, the fourth prototype was created in order to expo the potential of an OLED based on the conviction of processing through the hardware rather than software. The representation of these open source models proved to be difficult, however. Due to experimental aspect in the process of integrating open source software and hardware, the electronics are not sufficient enough to be used in a pair of SMART Glasses for patient use. Instead, they serve as models for future development in wearables for visually impaired patients. Primarily, the focus of these prototypes was to create a system using the OV7670 camera module, the "Arduino Pro Mini", and a TFT/OLED display. The processing power was not sufficient enough to integrate a system that can be implemented into a medical device. The fourth prototype shows that the system has to be processed through the hardware system rather than the software for the software increases efficiency.

Concluding that a higher processing power to run the entire system led to researching off-the-shelf SMART Glasses that provide leeway for future improvements. Acquiring sufficient processing power with Digital Signal Processing (DPS) is not a major variable for future models because there is an abundance of technology already in the marketplace; however, the open source aspect provides challenges for creating a usable model. The foremost advantage of purchasing manufactured SMART Glasses is that supplementary variables such as head movement and light contrast can be accounted for. Additionally, efficiency aspects would be addressed through software edits rather than hardware or optical adjustments; therefore, patient safety and convenience would be improved.

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**Category BE**

**L07** Applying Dynamic Mechanical Analysis to Determine Properties Within Poly(vinyl

**Abstract**

The purpose is to make poly (vinyl alcohol) (PVA) hydrogels then test them using Dynamic Mechanical Analysis (DMA) to determine viscoelastic properties. The total goal is to determine if the gels will be effective templates for cell culturing and compatible to withstand large variances of stress and strain.

Osteoarthritis is the most common form of arthritis, it results in a breakdown of cartilage. When cartilage becomes damaged the best option is a joint replacement. The procedure removes the damaged bone and cartilage and replaces it with metal and plastic. Other materials could be used instead, such as hydrogels.

DMA measures mechanical deformation of a sample. Stress is derived from the idea that a certain force is required to change a material. Strain is a measure of the change in length divided by initial length. Elastic modulus is found by looking at stress/strain graphs.

The hypothesis was the gel with the lowest weight/volume percent (10%) would allow for more stress to be applied because of greater water content.

To make the gels: PVA was dissolved in water, aqueous solutions of acetic and sulfuric acid were added, and ending with dropwise addition of glutaraldehyde, the crosslinking agent.

DMA testing: compression attachment was used, sample was loaded onto platform, and a controlled force test was used.

The hypothesis was not supported. 20% gel sustained higher force values, as a result the elastic modulus was higher. The force had to be reduced so that lower w/v% gels would not reach complete deformation.

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**Category BI**

**L08** How to Resist Digestion

**Abstract**

The purpose of this project is to discover if refrigerating starch-containing foods make the starches in those foods more resistant to being digested by the body. In theory, the process of refrigeration after a food has been cooked creates these resistant starches. A resistant starch is one that is not broken down into glucose immediately upon entering the small intestines. These resistant starches result in smaller blood glucose levels in the body and less of an increase in the body's insulin levels ("Response to Three"). In order to test the digestion process of potatoes as resistant starches, a potato solution and enzyme solution will be used to simulate the digestion process outside the body. To make a potato solution, one potato will be boiled for twenty minutes, cut into three parts and then refrigerated. One part from each potato will be tested immediately while others will be left in the refrigerator for various time intervals (for example 12 hours).

For the enzyme solution, the enzyme diastase will take the place of amylase that is used by the body in digestion. Three grams of a diluted potato solution will be mixed with three grams of a diluted diastase solution. The instant the two solutions are mixed a timer will start and every five minutes for two hours the glucose level will be tested to measure the glucose concentration of the solution at that particular time. The glucose level indicates the amount to which the starch has been digested over a given period of time. Lower glucose levels would indicate that the starches are more resistant since they will then take longer to be digested. In the data analysis, a line of best fit will be calculated to the data, and the slopes and y-intercepts of the lines of the varying cases will be compared.

The varying times the potatoes are in the refrigerator and the naturally occurring cell structures of the food will be analyzed to determine the validity of the using resistant starches as a solution to combating high blood sugar levels. There are many potential applications for this project especially as with the implications of an alternative method of preparing starches for people diagnosed with diabetes. If refrigerating starches is proven to turn them into resistant starches and cause them to contribute to blood sugar less, then it will be a valuable piece of information that those patients can use.

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**Category BM**

**L09** Testing the Effects of Electronic Cigarette Liquids on the Heart Rate of Daphn

**Abstract** Testing the Effects of Electronic Cigarette Liquids on the Heart Rate of Daphnia Magna and Measuring the Absorption Using Polymer Hydrogels

The purpose of this experiment is to compare the effects of nicotine, additives, and flavorings in electronic cigarettes on the heart rate of Daphnia Magna and how long the effects can potentially last. The purpose of this experiment is to also determine the safety of flavorings in e-cigarettes.

To conduct this experiment, control polymer hydrogels were made by heating 100 mL of water to 90°C, adding 6.2 grams of gelatin powder, and 5 drops of blue food coloring. Then allowing it to cool to 37°C and adding 3.5 mL of the gel to a cuvette, and the test was repeated six times. Similar gels were made for all strengths of nicotine- 24, 12, 6, and 0mg/mL, additives and flavorings. A UV spectrophotometer was used to determine the amount of e- liquid hydrogels absorbed at 12 and 24 hours. The second step of this experiment was to measure daphnia heart rate at 1, 5, and 10 minutes by adding one daphnia into 3.5 mL of water. This was repeated for all e-liquid constituents.

The hypothesis of this experiment that nicotine and flavorings will negatively (either increase or decrease) affect the heart rate of daphnia is supported because all strengths of nicotine including 0mg/mL increased the heart rate and all flavorings resulted in decrease or stopping the heart rate. The hypothesis that additives will not affect the heart rate is not supported because the additives resulted in increased followed by abrupt decline and ultimately stopped the heart in VG. The hypothesis of this experiment that the absorbance of the nicotine would be the highest, additives would be similar to control, and flavorings would be lower than the control is not supported. It can be seen through the results that the absorbance of nicotine was highest, additives were similar to control, but the flavorings were higher than control and lower than nicotine. This indicates flavorings can be continued to be absorbed in the system for longer period of time compared to control which increases concerns of safety of use of e-liquids.

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**Category BM**      **L10** Long non-coding RNA LINC00152 plays an oncogenic role via targeting MET and ST

**Abstract** In our research we plan to answer the following questions:  
1. Does linc00152 exist in esophageal adenocarcinoma cells?  
2. If yes, does it have high expression in esophageal adenocarcinoma cells?  
3. If yes, what is the role of linc 00152 in esophageal adenocarcinoma proliferation and invasion

The work we planned to do is:

- Grow esophageal adenocarcinoma celllines OE33, FLO1, and OE19
- Add treated SiRNA linc00152 to the above cancer celllines
- Count clone numbers of treated cellines at set time intervals after treatment
- Use Excel and GraphPad Prism for data analysis.

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**Category BM**

**L11** Engineering PD-L1 Specific Diabodies

**Abstract**

Engineering PD-L1 Specific Diabodies for PET Imaging

Scholar: Saaz Malhotra

School: Northville High School, Northville, MI, USA

PI: W. Barry Edwards. PhD; Mentor: Robert Edinger, PhD

Introduction: Programmed Death Ligand 1, or PD-L1, is a transmembrane protein upregulated in numerous tumors. By binding to the PD-1 receptors on CD8+ T-cells, these tumors can evade T-cells' cytotoxic effect, thus continuing to proliferate. Immunotherapies that block both PD-L1 and PD-1 have had great success in treatment, however, have not worked for all patients. The differences in patients may be due to the inaccurate assessment of PD-L1 expression levels, which have been positively correlated with patient responses. To accurately assess the levels in tumors, we are engineering PD-L1 specific diabodies to be used in conjunction with PET imaging. Diabodies are engineered noncovalent dimers of single-chain variable fragments (scFv) that consist of the heavy-chain variable (VH) and light-chain variable (VL) regions connected by a small peptide linker. They offer great potential as PET imaging agents due to their high affinity, stability, specificity, and short circulation times. Therefore, the goal of this project is to develop a PD-L1 specific diabody PET imaging agent to correctly identify PD-L1 expression levels in cancer patients.

Methods: Engineering the diabody antibodies was accomplished by mutagenesis PCR from three unique minibodies previously shown to bind PD-L1. This was accomplished using a two-step process in which the linker region between the VH and VL domains was truncated in order to allow for the diabody to properly fold and be active. Sequenced confirmed clones were subjected to PCR mutagenesis to remove the CH3 domain on the carboxyl-terminus tail and add on three additional amino acids (GGC) that will help in dimerization and stability. Diabodies were expressed in Expi293 cells and partially isolated using protein L columns. Finally, in vitro assessment of the diabodies was performed by surface plasmon resonance (SPR).

Results: Based on sequencing results, we have successfully engineered diabodies from all three clones with both 5 and 8 AA linkers. Expression of one of the clones (2c9) containing the 5 AA was partially purified.

Western blot analysis shows the correct molecular weight of the diabody and that both a monomer and dimer form exist. To determine the affinity of the diabody to PD-L1, the diabody was analyzed by SPR. Our preliminary results show little binding to the PD-L1 ligand. This may be due to the size of the linker (5 AA) or other variables inherent to SPR analysis. Results for the 8 AA are currently being analyzed as well as the diabodies of the other PD-L1 clones.

Conclusion: Diabody 2c9 with a 5 amino acid linker does not have the potential to be used as a PET imaging agent to accurately measure the expression levels of PD-L1 in tumors. More analysis is needed to assess the use of the remaining diabodies as PET imaging agents.

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**Category BS**

**L12** Hot or Not? A Study on the Scientific Formulas of Physical Attractiveness

**Abstract**

Rationale: Throughout history, humans have always been concerned with attractiveness. Even going back to the age of the hominids, attractiveness has been an important factor in mating. Although the standards of fashion have greatly changed over the years, people who were attractive many decades ago are still considered attractive today. The ability to understand how human biology affects what we are physically attracted to can give us an interesting perspective on our relationships, as well as insight into why we have those relationships in the first place.

Research Questions: Can physical attractiveness be reduced to formulas and ratios? How do specific physical characteristics change human perception of other people? How do age, gender, and fashion alter what the American population finds attractive?

Hypotheses: If the age of people tested is varied, the basic characteristics of attractiveness will be the same regardless of age because attractiveness of physical characteristics in both the face and body can be generally determined with specific formulas. These attractive characteristics will remain the same for both sexes, regardless of the fashion or style changes that mark different generations.

- A survey will be dispersed via email to students and faculty
- The survey will include images of people's faces and bodies that have been altered with Photoshop to have specific ratios of their features, facial spacing, and body size
- There will be 3-4 images of each person altered to different ratios, and the participant will have to choose which picture is most attractive to them
- There is no written component to the survey
- Participants will be ranking the images on a numerical scale (from 1-10), with questions asked about how important the altered traits are to the participant when determining attractiveness
- Questions will also be asked about personality traits that the participant might associate with certain pictures (i.e. confident, shy, rude, friendly, etc.)
- Survey will be conducted through Google Forms in order to keep the results anonymous
- Data collected through the form will be collected and organized to prepare for analysis

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*Abstract*

Many liver functions are regulated by intracellular  $\text{Ca}^{2+}$  dynamics, which strongly influence enzymatic activity of a wide array of proteins. To control, yet discriminate among so many functions simultaneously,  $\text{Ca}^{2+}$  signals are highly organized in time through the amplitude of  $\text{Ca}^{2+}$  spikes and the frequency of  $\text{Ca}^{2+}$  oscillations, setting the functional output of individual hepatocytes. Furthermore, the wave like transmission of  $\text{Ca}^{2+}$  spikes through liver lobules provides a mechanism to coordinate the functions of different metabolic zones as well as determine the extent of coordination, therefore making a more efficient means to regulate liver-specific functions such as bile flow.

Although the intracellular signaling cascade that regulates  $\text{Ca}^{2+}$  spiking is understood in detail, lobular scale features that shape waves are not completely established. Various studies have hinted that the presence of gap junctions, or cell-cell junctions, made of connexin proteins on cell surfaces makes transmission of  $\text{Ca}^{2+}$  from cell to cell possible in systems where calcium wave propagation is not normally exhibited. Thus far, connexins have been found to underlie drug-induced acute liver failure, hepatitis, cholestasis, non-alcoholic fatty liver disease, fibrosis, cirrhosis, hepatocellular carcinoma, and liver cancer via lack of synchronization in cell death. A quantification of this effect is yet to be found.

However, nearly all modeling research ignores obtaining accuracy in cell contacts due to the sheer difficulty in doing so. In this work, a computational modeling approach is adopted to identify the underlying characteristics of cell-cell connectivity that control lobular scale calcium waves while taking into account the variety in cell-connectivity within the actual liver.

Confocal microscopy and image analysis were used to quantify characteristics of liver tissue organization in cell-cell contacts. Using CompuCell 3D, a simulation software, a reconstruction was created in silico and optimized with cell-cell behaviors to match image data. Simulation among various connective structures revealed back-and-forth patterns in molecular movement and the potential importance of gap junctions in this movement. Further simulations found that the presence of gap junctions synchronizes waves, strengthens wave robustness, and maintains wave speed over time. Increased gap junction concentration in zones with calcium signalling inefficiencies was found to improve synchronization and robustness as well.

These results indicate the importance of gap junctions in the role of calcium wave propagation. Upon introduction of drugs that modulate connexin expression or gap junction activity, new perspectives may be opened for the establishment of new therapies in the hepatology field in the upcoming years. In the future, more powerful imaging and extension to three dimensional stochastic modeling will provide deeper insights.

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**Category CB**

**L14** Quantifying the Effects of Novel Mutations in Putative T2D Regulatory Loci

**Abstract**

Current methods for identifying genetic variants that predispose one to disease lack the ability to identify the mechanisms through which such variants cause disease. In addition, methods like the Genome-Wide Association Study lack the ability to identify personal genetic variants not prevalent in the population that may predispose one to disease. With the ever-increasing amount of genomic data that will be available, addressing these two issues is of vital importance to allow for the identification of new therapeutic targets, improve the drug development pipeline, and enhance personalized medicine.

The Self-Transcribing Active Regulatory Region Sequencing Assay (STARR-seq) functions by placing specific DNA barcodes in close proximity to enhancer sequences. Transcripts generated by specific enhancers have unique signatures (their barcodes) and can be attributed to specific enhancers. The effects on target gene expression of a wide range of enhancers can thus be tested quickly in parallel.

In this project, I developed a custom STARR-seq data-processing pipeline that processes hundreds of millions of STARR-seq reads and quantifies the representation of transcripts generated by enhancers in cDNA data. Using the pipeline, I was able to mechanistically infer the pathogenic mechanisms for how variants in regulatory loci associated with Type 2 Diabetes (T2D) cause T2D. In addition, using a technique called negative binomial generalized linear modeling, I was able to construct comprehensive databases for 10 T2D loci regarding exactly how any arbitrary mutation in the loci will modulate target gene expression.

The pipeline extends the STARR-seq assay's applicability by allowing it to be used to create highly specific portraits of the effects of novel mutations on gene expression through analysis multiple regulatory loci with unique mutations in parallel. In turn, it will provide meaning to highly personalized genomic data, allow one to understand how genetic variants induce disease, and identify targets for new therapies.

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*Abstract*

Many diseases that captivate our world occur due to misfolded proteins. Scientists are discovering that the misfolded proteins are the main cause of many serious diseases that affect millions of individuals each year. In Alzheimer's disease, proteins misfold and cause aggregates to form. These aggregates cause memory loss in these patients. In a healthy brain there are microtubules inside of neurons that help with communication between neurons. These microtubules are held together by a protein called tau protein. In Alzheimer's disease, the tau proteins become misfolded and detach from the microtubules. This causes tangles to form in the neurons which not only stop communication with other neurons but eventually kill the neurons. The tangles that form are aggregates or clumps of the tau protein.

While proteins regularly misfold, chaperones help misfolded proteins to regain their proper folding states. Some chaperones such as cyclophilin 40 help to disaggregate misfolded protein clumps. Baker et. al. (2017) have found a chaperone, CyP40, that dissolves aggregates of tau in mouse. This research has great potential in disaggregating the dangerous tangles in Alzheimer's patients.

While recent studies are uncovering the importance of protein misfoldings, advances in computational biology are allowing us to conduct some of the work computationally.

In this project I first analyze computationally the interaction of CyP40 and the tau protein in mouse. Using the PyRosetta and InteractiveRosetta software I plan to analyze how the amino acids of the chaperone and the tau protein interact when they are docked. This analysis shows the portions of the two proteins that interact most strongly and allows us to computationally test some of the conjectures of the paper by Baker et.al. In addition, I plan to compare how the interaction changes when tau proteins of other organisms, such as humans, are considered. I will use NCBI's BLAST to identify other similar proteins and examine how the CyP40 interacts with them.

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**Category CB**

**L16** Black Lives Matter: Is Chemo the Cure?

**Abstract**

Breast cancer affects thousands of American women each year. The American Cancer Society predicted 252,710 new cases of breast cancer were to be diagnosed in 2017. Ten to twenty percent of breast cancer diagnoses will be triple negative. African American women are three times more likely to be diagnosed with triple negative breast cancer (TNBC) than Caucasian women. The goal of this project is to investigate how genetics may be involved in the effectiveness of chemotherapy for African American women with TNBC compared to their Caucasian counterparts based on patient response to neoadjuvant chemotherapy. It was determined at the conclusion of the research that chemotherapy is less effective for African Americans with TNBC than Caucasians with TNBC. After receiving chemotherapy, the percentage of Caucasian and African American women who achieved a pathological complete response (pCR) and those with residual disease (RD) were equal in terms of group comparison (pCR=28.6%, RD= 71.4%). However, the average tumor size for women with RD status was different for each group. The average tumor size for Caucasians was 3.46 cm and 4.16 cm for African Americans. The genes identified between Caucasians and African Americans with TNBC corresponded with the difference in tumor sizes between African American and Caucasian women who did not attain pCR and provide a possible explanation for the high breast cancer mortality rate among African American women.

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**Abstract**

Gene expression is a fundamental process essential for all living organisms. Changes in gene expression are implicated in many diseases, including cancer. Transcription is the first step of gene-expression in which information from DNA (deoxyribonucleic acid) is extracted in the form of RNA (ribonucleic Acid) by enzymes known as RNA Polymerases. In eukaryotes, DNA is packaged into chromatin with the help of nucleosomes, which are formed by wrapping 147 base pairs around a histone octamer—two copies of histones H2A, H2B, H3 and H4. Chromatin/nucleosomes pose a major impediment to all DNA dependent process, including transcription. Therefore, cell utilizes multiple mechanisms to unravel chromatin and make the underlying DNA sequences accessible to transcription machinery. The changes to chromatin structure are mediated either directly by post-translational modifications (PTMs) or through proteins that recognize such modifications.

In this study, I examined genome-wide occupancy of two different type of PTMs found in *S. cerevisiae*: acetylation (ac) and methylation (me) on histone H3. Acetylation neutralizes the positive charge on lysine amino acid residue to weaken histone-DNA interactions and is also implicated in recruiting chromatin remodelers to change chromatin structure. I found that H3K14ac and H3K9ac occupancies were strongly correlated with each other and were present primarily near the transcription start site (TSS), consistent with their role in promoting transcription. These modifications also correlated strongly with the H3K4 trimethylation (me3), which was also maximally observed on nucleosomes downstream of the TSS. In contrast, H3K36Me3 occupancy increased as a distance from the TSS, and peaked toward the end of the transcribed regions. These modifications were correlated with the presence of RNA Polymerase II occupancy, suggesting that both methylation and acetylation are coupled to transcription. We have also examined occupancy of a chromatin remodeler, RSC, on nucleosomes and find that it is most prominently present in the coding regions, and peaks at the plus 2 nucleosomes.

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**Category CB**

**L18** Impacts of Catastrophes on Ecosystems and Survivability of Species

**Abstract**

How will the survivability of species on earth be impacted by a catastrophic event like a tornado, earthquake, asteroid strike, or global warming. At first glance you may think these events are not desirable for the species, but it opens up new opportunities for other species and lays the foundation for growth for them. For example, global warming can open new trade routes in the arctic ocean, thus developing the economy in those areas. My experiment creates the simulation to show interactions between catastrophes and ecosystems and measures the survivability and migration of species.

In this simulation an ecosystem of various species (i.e. plants, predator, prey, humans) are mimicked by programming certain environmental rules. Catastrophic events are programmed, and its impact is measured on the ecosystems. In this program a catastrophic event is characterized by intensity, frequency and location of the event. These parameters are modified and the impact of the catastrophic event (i.e. population decline/growth, migration of each of the species) and are measured.

An agent-based modeling tool called Net Logo is used to program the environmental rules and the environment. The output reports from Net Logo are used to analyze the results.

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**Category CE**

**L19** The Effects of Boron Compounds on Amyloid-beta 42 Plaque Aggregation: A New Th

**Abstract**

The purpose of this experiment is to reduce or prevent amyloid-beta (A $\beta$ ;) protein aggregation by using two boron compounds: Trans-beta-Styrylboronic acid (B1) and Trans-2-Pheynlvinyboronic acid MIDA ester (B2). Limiting the formation of A $\beta$ ; protein aggregation by the boron compounds can be potentially used to combat Alzheimer's Disease (AD), the most common type of dementia, and serve as a possible stepping-stone in the prevention of AD. It was hypothesized that both boron compounds will inhibit A $\beta$ ; aggregation and higher boron concentrations will result in decreased amount of A $\beta$ ; aggregation. In addition, trans-2-Pheynlvinyboronic acid MIDA ester (B2) will have a higher cell viability compared to the trans-beta-Styrylboronic acid (B1). This experiment was conducted in two parts. The first part was conducting a dot blot assay to see how the boron compounds would only inhibit A $\beta$ ; peptides. The second part was performed by testing the boron compounds on the A $\beta$ ; peptides within mouse neuroblastoma stem cells (N2a cells). Based on the results, both boron compounds will inhibit A $\beta$ ; aggregation in the dot blot assay. However, higher concentrations of boron did not decrease the amount of A $\beta$ ; aggregation. B2 had higher average cell viability than B1, but was not statistically significant. Compared to the A $\beta$ ; column there was only a slight inhibition in the A $\beta$ ; with either boron compound. Based on these results, it provides a stepping stone in the treatment or prevention of AD.

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**Category EV**

**L20** Calculating Nephelometric Turbidity Units of Increased Suspended Solids in

**Abstract**

Turbidity is an underestimated issue when analyzing water quality. Turbidity, the amount of sedimentation in water, is calculated in the units of NTU (Nephelometric Turbidity Units). Turbidity is harmful to aquatic ecosystems due to the amount of sunlight different depths of water receive. When higher turbid water is present, light cannot penetrate layers of water it needs to, which causes a decrease in dissolved oxygen and ultraviolet sterilization. This year's project was to create a turbidity buoy system using an attenuation light collection system with a cost-efficiency orientation. The attenuation light collection system was created using a photosensor and LED that scans 180 degrees from each other for decreasing amounts of light seeping through the water. The photosensor acts as a resistor that changes the amount of resistance based upon how much radiation from light is striking the photoconductive layer. This gives raw output of how much radiation is detected, compared to other sensors that use photo iodides to convert light to frequency. The meter also contains GPS coordinate tracking, wireless communication via SMS, Inductive Charging, motor control abilities, and a charging docking station created specifically for the buoy. The meter was 97.8% accurate with water samples 0-300NTU. The claims are supported by 10,000 total readings of the multiple solutions. The portion of the meter and the light-collection system cost's \$12 and the other features included cost \$65. Handheld meters on the market right now cost \$800-\$4,000 proving the product has a place on the

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*Category EV*

**L21** Great Lakes Initiative (Biodegradable, Sustainable, Edible Fishing Lure)

*Abstract*

Great Lakes Initiative created a 100% edible, biodegradable, and sustainable fishing lure to prevent the use of plastisol/petroleum lures in the Great Lakes. Currently, petroleum-based plastisol is used to make SPLs, which isn't environmentally sustainable. The plastisol SPLs never biodegrade in a marine environment. Weathering degradation of plastics results into surface embrittlement and microcracking, yielding microparticles/microplastics that continue on in the environment. These microplastics become increasingly smaller and absorb persistent organic pollutants, posing a dangerous threat to wildlife in the surrounding environment. In addition, the plastisol is not digestible by fish, birds, or marine mammals, which often blocks their digestive paths and suffocates many species. My mission is to transform commercial and recreational fishing into a sustainable future. First, I needed to record the rate of biodegradability of these bioplastic alternatives. I put all my different bioplastic lures in beakers filled with saltwater, brackish water, and freshwater. After a submerging the lures in water for a portion of time, I compared the new weight of the bioplastic lures to their original weight in order to determine the rate of biodegradability. In addition, I used a forced sensor to compare the strength of my bioplastic lure against the petroleum-based SPLs. I used the force sensor to test the strength on different points of the lure. My goal was to achieve similar strength as SPLs used in freshwater fishing. In the future, I hope to engineer a biodegradable fish hook as well.

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**Category EV**

**L22 Underwater Expedition**

**Abstract**

Underwater exploration is the investigation of physical, chemical, and biological conditions within an aquatic environment. There are many things in pond water, some harmful and others helpful to aquatic life. Fish play a large role in an underwater ecosystem's overall health. The vast majority of fish are bony fish and are members of Class Osteichthyes. Some researchers try to count the number of fish in a particular body of water in a harmful manner. One such method is electrically shocking the fish. This can lead to paralysis, psychological and/or physiological stress, permanent physical damage, and death even weeks after contact. A safer way to observe and count fish is through the use of remotely operated vehicles (ROVs). These are underwater robots that are tethered and can dive to great depths and stay there for extended periods of time. The purpose of the project is to build a small submersible to non-invasively explore an underwater habitat. The expectation is that once the submersible is completed, pond life will be able to be observed in its natural environment. The submersible framework will be created from PVC pipes and joints. Incased within the PVC pipes will be three motors with shafts connected to 3D printed discs which will be magnetized with neodymium magnets. This will serve to turn three 3D printed propellers which will also be magnetized and will be attracted to the magnets on the discs. The propellers will be placed so that the submersible will be able to move in all directions, controlled with two remotes. A LED light will encased behind a clear endcap in order to illuminate the areas of observation so that pictures can be transmitted to a laptop via a cable. Either pool noodles or weights may be used in order to obtain the desired initial depth for the submersible. Prior to observation in the pond, the submersible will be tested in an indoor heated pool. Calculations will be made to accommodate for the difference in water density due to temperature. Data collection will consist of observing through the web camera, counting the number of fish within a given area, and categorizing the types of fish. The observation of fish is important to this project in order to explore a safer alternative of fish counting. This project has the potential to contribute to future fish counting methods due to its small size which makes it less invasive. To minimize risk to pond inhabitants, all components will be encased within the PVC pipe. The submersible will be tethered with a rope, to prevent any risk of it being lost in the pond in the event of a malfunction. The pond being observed is a medium size pond that is occupied by many species most of which are in Class Osteichthyes, including Bluegill, Sunfish, Bass, and Pike. The submersible will be minimally invasive and after the project, the pond inhabitants will be left to resume life as normal.

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**L23** Using Nanotechnology in an Environmentally Safe Method to Remove Oil Spills

*Abstract*

The purpose of this study is to test the use of ferrofluid along with a neodymium magnet to remove oil spills that are modeled in various conditions. Ferrofluid is a colloidal suspension of iron particles in oil; when ferrofluid is exposed to a magnet, it experiences a strong attraction that enables it to trap other molecules between the iron particles and the magnet. This is a physical method of removal, meaning it is reliable in many different temperatures and chemical environments. Many ferrofluids are biocompatible, meaning they are nontoxic to living tissue and thus safe for the environment.

This study includes four phases. Phase 1 tests the ability of the ferrofluid to trap and pick up four different oils. It is expected that used motor oil will be most easily picked up with ferrofluid as it contains impurities such as iron. Phase 2 compares different ratios of ferrofluid to oil, and it is expected that as that ratio increases, the percentage of oil removed will also increase. Phase 3 will test the effect of pH of the water sample, and phase 4 will test the effect of the temperature. In these two phases, there is expected to be no significant effect of temperature or pH on the ferrofluid/magnet method. The setup of this experiment includes a petri dish containing tap water a layer of oil. About 0.1 mL ferrofluid will be dispersed into the oil, and a magnet will be swept around the petri dish to remove the ferrofluid and oil.

The first hypothesis was not supported; both mineral oil and fresh motor oil had an average 50% of the oil removed by ferrofluid while an average of only 42% of the used motor oil was removed. The second hypothesis was not supported either, as no apparent correlation existed between the ratio of ferrofluid to oil and the percentage of oil removed. The third hypothesis was not supported as the set with pH 7 water had an average of 75% of the oil removed, significantly more than water with a pH of 6 or 8. Temperature had no effect on the average percentage of oil removed; thus, the fourth hypothesis was supported.

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*Category EA*

**L24** Preventing Soil Pol. By Testing The Pol. Endurance Level Of Diff. Polypedons

*Abstract*

Day by day, we are connected to soil with almost everything we do. When you walk into school, the ground carrying the building up is filled with soil. We gain nutrients from animals that eat plants that gain their nutrients from those in soil. However, due to the fact that soil is slowly created, but easily destroyed, it is commonly polluted from gas fuels, and dumping sites. In this technical age, pollution seems to be a given. Although pollution prevention is the most ideal source to fix the problem of soil pollution, it can take up to decades to solve. But is there a way to help adjust the environment to this, even though pollution won't end. Is there a certain soil that can withstand pollution better than others? I will be testing this, two separate ways. The first is by testing which type of soil (sand, clay, topsoil, Miracle Gro), holds the most pollutants. By doing this I will be able see which type of soil absorbs the most pollutants, which is very harmful, and the type of soil that allows the pollutant to slip through. The second way I'll be testing out which soil withstands pollution best is by testing out which type of soil plants can survive in best while facing pollution (artificial acid rain formula). For my first experiment, I predicted that the topsoil will carry the least amount of pollutants, while clay will absorb the most. I tested this out by separately filling  $\frac{1}{2}$  a cup of each type of soil in a rubber sink filter, then added  $\frac{1}{2}$  cup of the pollutant (oil and anti-freeze) into the soil, waited for thirty minutes, and measured how much pollutants each type of soil carried using the following formula;  
 $125\text{ml} - \text{Amount Filtered} = \text{Amount Absorbed}$ .

For my second experiment, I predicted that the plant growing in Miracle Gro will survive the best, while the one in growing in clay will most likely die off first. I repotted four primrose plants in different types of soils. For two weeks, I watered each plant with  $\frac{1}{4}$  cup of water for one day, than  $\frac{1}{4}$  cup of an artificial acid rain formula the second day. This insured that the plants won't die off immediately, and would prolong the experiment. The results of my experiments proved  $\frac{1}{2}$  of my first hypothesis were correct, and my second hypothesis was fully proven correct. If I were to do this again, I would use a wider variety of soils, pollutants, and different types of plants.

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*Category PS*

**L25** Effect of Light on Plants

*Abstract*

The reason Of doing this project was to figure out what would happen if we had two plants put under different types of light . so doing this project is to see the difference between two plants growing under different types of light. and so far the two plants don't grow the same time if they are under different types of light.

The plant under the artificial light is taking time.

The point of this project is which plant will grow faster with the sunlight or the artificial light.

As an example growing two plants they are the same type they are put in the same pot and they have the same amount of water and the same temperature the only difference was the first plant was put under the sunlight and the second plant was put under the artificial light.

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**Abstract**

Nitrogen fixing bacteria, such as the legume mutualist rhizobia, and lightning are the only natural processes that convert atmospheric nitrogen into a usable form for living organisms. Leguminous plants, like the model species *Medicago truncatula* (*M. truncatula*) directly benefit from this process by forming a symbiotic relationship with rhizobia. The rhizobia fix atmospheric nitrogen to a bioavailable form (NH<sub>3</sub>) for the plant and are supplied with photosynthetically fixed carbon in return. Host plants have the ability to dynamically respond to biotic factors in their respective environments. I investigated how *M. truncatula* responds to non-rhizobial bacterial partners in terms of its growth, nodulation and rhizobial fitness, and nutrient allocation to ineffective rhizobial partners. Additionally, a growth inhibition assay was performed on TY agar plates to see how the microbes interact with each other when there are no spatial limitations (i.e. not confined in plant-derived structures called nodules). The assay showed that *Burkholderia* spp. inhibits the growth of the nitrogen-fixing *Ensifer meliloti* (Rm 1021). Even though *Burkholderia* inhibits the growth of rhizobia, *M. truncatula* showed the most positive trends of growth when co-inoculated with *Burkholderia* and Rm 1021. This is the opposite of what is expected since the plant would theoretically be receiving less nitrogen since *Burkholderia* is inhibiting the growth of the nitrogen-fixing rhizobial species Rm 1021. This data suggests that there may be a tripartite interaction among *Burkholderia*, Rm 1021, and *M. truncatula*, in which *Burkholderia* inhibits the growth of Rm 1021 while simultaneously amplifying the growth of *M. truncatula*.

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**Category CH**

**P01** The Mystery of Cercospora

**Abstract**

In general there are two ways to stop microbes from infecting or deteriorating materials—disinfection and antimicrobial surfaces. The first is usually realized by disinfectants, which are a considerable environmental pollution problem. Antimicrobial and/or antifungal surfaces are usually designed by the penetration of materials with biocides that are released into the surroundings where upon microbes are killed.

Current fungicides, both systemic and contact fungicide options, have not been totally effective to control Cercospora leafspot in sugarbeets. We have been evaluating the effectiveness of a covalently bound antimicrobial/antifungal organosilane formulations against Cercospora leafspot fungus.

Spray application was performed with a hand pump in a two gallon sprayer. Leaf cutting was done periodically over two months to evaluate the performance of the antifungal coating. Samples of the soil in the test plot area were taken and labeled.

The results show a difference in the foliage of the sugar beets. Control leaves were damaged by the fungus. Examining the photographs of the leaves show that the new antifungal treatment controls the growth of fungus and is comparable to systemic pesticides now used in the field. The cultures appear to show less microbial growth on the leaves that were treated. Current agricultural fungicides are spray applied up to 5 times/year. Our testing demonstrated antifungal control with only 1 or 2 spray applications/year. This antimicrobial spray doesn't need to be applied as often as pesticides and it is a carbon based antimicrobial so it is better for the environment than other sprays or pesticides.

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**Category CH**

**P02** Painting Away the Fire

**Abstract**

I tested three different chemicals at four different quantities. The four quantities I will test will be 5mL, 10 mL, 15 mL, and 20mL of solution added to the 100 mL of paint. Each mixture was painted onto separate pieces of balsa wood. Then after they fully dry for a day, I took the wood and stood it up between two bricks. Using a kitchen blowtorch, I set it just far enough, so the flame touched the wood. Then setting a stopwatch I counted how many seconds it took for the wood to catch on fire. I ran two trials for each chemical and quantity and averaged them out. The chemical calcium sulfate dihydrate worked best at 20 mL, but only held up against the fire for 10 seconds. The lower quantities for even less time. The magnesium hydroxide worked the next best. The amount of 15 mL of magnesium hydroxide lasted 23 seconds. I believe the reason the 20 mL did not produce the best time was because of the way it was painted onto the board. The coat of paint was too thin so the concentration of the magnesium hydroxide did not change too much. The boric acid worked the best overall. It last 31 seconds with the 20 mL of solution. This probably worked the best because of the wood behind the paint, as boric acid is a good fire retardant with wood. In conclusion the amount of paint put on the board didn't not provide a sufficient amount or separation between the fire and the wood, which cause the wood to burn more quickly in all cases.

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**Abstract**

Energy sectors are looking for new renewable energy sources rather than conventional fossil fuels such as solar, wind, hydroelectric power. These energy sources are creating challenges with respect to their availability during the day. These challenges can be overcome by large-scale energy storage systems. Recently, redox flow batteries have raised much attention in this regard because of its various advantages compared to solid state batteries. Flow batteries are the liquid analogue of ordinary batteries where the redox-active material is in solution rather than in the solid state. These solutions are to be charged in an electrolyzer cell first, and the following discharge effectively produces electricity. The flow cell consists of two half-cell chambers, separated by a membrane that is able to provide a charge flow for dissolved redox active species. In a typical charge-discharge cycle, the anolyte is oxidized and the catholyte is reduced, using energy from an external source (for example solar or wind energy), and the energy is stored in the oxidized anolyte and reduced catholyte species, much like charging works for a solid state battery. For discharging, the reduced species now becomes the anolyte and releases the stored electrons, which pass through the circuit to reduce the oxidized species. We have developed several water soluble metallocene-based materials which fulfill criteria such as cost effectiveness, durability, high potential window in water as well as long cycling ratios. Starting from a cheap starting material, ferrocene can be functionalized by sulfonation to synthesize mono and di-functionalized derivatives or via the formylation reaction, some amine derivatives can be prepared. These can be quarternized for water solubility. These materials were fully characterized by different spectroscopic techniques and electrochemically tested for their electrochemical properties. Initial results showed that mono-sulphonation derivatives having redox potential ~650 mV but the di-sulphonation derivative and the quarternary ammonium derivative having redox potential is around 800-850 mV with respect to Ag/AgCl. These potentials are in good agreement in aqueous medium.

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**Category EA**

**P04 Reducing Carbon Emissions from a Coal Burning**

**Abstract**

The purpose of this experiment is to test the ability of different chemical solutions to capture Carbon Dioxide while also giving off a helpful byproduct to society. The only ways to capture Carbon Dioxide are either inefficient or not viable long term solutions. The way this will be tested is by simulating a coal burning plant by burning bituminous coal in a wood stove. The gases emitted will then be piped through an air compressor to put pressure behind it. These gases will be filtered through buckets containing sodium hydroxide solution, calcium hydroxide solution, potassium hydroxide solution, magnesium hydroxide solution, or lithium hydroxide solution, all at 1 molar. The chemicals are expected to create sodium carbonate, calcium carbonate, potassium carbonate, magnesium carbonate, and lithium carbonate all in aqueous solution, respectively. The carbon dioxide was measured using a Vernier LabQuest 2 with CO<sub>2</sub> meter with three trials per chemical solution. All the solutions worked with calcium hydroxide performing the best by dropping the ppm of CO<sub>2</sub> by 65%. The next best performing one was magnesium hydroxide by dropping the ppm of CO<sub>2</sub> by 59%, followed by potassium hydroxide by dropping the ppm of CO<sub>2</sub> by 45%. The second worst one was sodium hydroxide by dropping the ppm of CO<sub>2</sub> by 28% and the worst performing one was lithium hydroxide by dropping the ppm of CO<sub>2</sub> by 19%. It is believed that the chemical solution did happen but the solution needs to evaporate to get the byproduct out to use.

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*Category EA*

**P05** The Effect of Flow Rate on Timed-Release Formic-Acid Polymer

*Abstract*

Formic acid is a miticide that can potentially be used in honey bee hives to eliminate Varroa destructor, which are the main cause of the significant European honey bee colony deaths around the world. This project studied the effect of flow rate on the release of formic acid from a formic-acid-containing polymer in a lab setup. This setup included a nitrogen flow, a relative humidity bubbler, a chamber housing the formic acid, and a sparging bottle to collect the formic acid when released from the polymer. There were three reactor setups with identical relative humidities, temperature, and polymer concentration. Three different nitrogen flow rates through the reactors were tested: 30mL/minute, 60 mL/minute, and 90 mL/minute. The hypothesis was that a slower flow rate would result in a slower rate of formic-acid release, and a faster flow rate would result in a faster rate of release. When comparing the amounts of formic acid released with different flow rates from the same reactor, it was found that the hypothesis was supported. These findings on the release rate of formic acid can be used to create a product to treat mite-infested hives.

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**Category EA**      **P06** Alternative Filtration Methods and Free Radicals in Hurricane Wastewater

**Abstract** Many communities in the southeastern United States, Central America, and the Caribbean islands were devastated by the hurricanes in the summer of 2017.

Chlorine is one of the most common water-purifying agents; however, it can have harmful side effects. Chlorine reacts with organic compounds and can produce trihalomethanes, compounds linked to cancer, and trichloramines, a free radical.

Which type of filtration is the most effective in purifying free radicals from wastewater?

This project used an EPR spectrometer to identify type and size of the free radical. Water, salt, motor oil, dirt, sand, and organic waste (eggshells and fruit peels) were mixed and left to sit for a week; they were then scanned with the EPR, and TEMPOL was added to the solution to track the change in radical size over time. The mixture was then separated into three parts and filtered using ion-exchange filtration, membrane filtration, and slow sand filtration.

The most effective method was purification through sand, followed by the mesh filter. The ion-exchange filter increased the radical intensity. Therefore, sand filter technologies must be developed and distributed in areas affected by hurricanes; further research can be done on sand's ability to filter out other harmful particles, like lead or fertilizers.

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**Category EA**      **P07** Effectiveness of Homemade Activated Carbon Water Filter in Removing Pollutants

**Abstract**      Activated Carbon Water Filtration Using Household Articles and Study of its Effectiveness in Removing Pollutants

#### ABSTRACT

Water is a vital element for life. Although two-thirds of the earth's surface is covered with water, only 3% of it is freshwater. Furthermore, only 0.3% of this freshwater is available for human consumption. Thus, over 99% of water on earth is unavailable for human consumption. Pollution from industrial waste, sewage, fertilizers, and the burning of fossil fuels are contaminating this already limited supply. Many people -especially those who live in rural areas- have difficulties in obtaining clean drinking water, which results in severe health consequences. Since water is a universal solvent, the removal of harmful particles is a difficult task.

In this experiment, a water filter was made using activated carbon. The purpose of this experiment was to determine the type of activation solution needed to create the most effective filter. Even though activated carbon is already used for water filtration, it is expensive for people living in poor countries (where filtration is most needed) to use these filters. In this method, the activated carbon filter was made using cheap, household items.

Charcoal made from coconut shells was used in this experiment. The shells were burned in a metal can to allow for the charcoal to be formed in the absence of oxygen, through the process of pyrolysis. A solution was added to the charcoal to create minuscule pores and increase the surface area of the particles. The effectiveness of the filter was analyzed by comparing the concentration of pollutants in the initial prepared water solution to the molecules left in the water after it was filtered. Additionally, the homemade filter was compared with a commercially purchased activated carbon filter.

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*Category EA*

**P08** Effect of Varying Solid Fuels on Indoor Air Pollution and Thermal Efficiency

*Abstract*

Billions of people worldwide use solid fuels—crop residue, charcoal or woody material—as a fuel source. However, the gases produced by the incomplete combustion of solid fuels causes significant harm to individuals, particularly those who are overexposed: the impoverished, women, and children. Liquid fuels and improved stoves help this problem, but they are expensive and inaccessible to many in rural regions. Therefore, this project attempts to determine the best solid fuel to ameliorate health conditions.

In my experiment, I explore the effect of solid fuel types and size in two stages of combustion, pre-heating and distillation. Solid fuels are burned according to composition and size for 15 and 10 minutes, respectively, in a simple camp stove. Three trials are conducted for composition and 1 trial for size. The average of the data collected is evaluated to create a better solid fuel source. This analysis is important for areas where indoor pollution largely occurs during cooking periods. The solid fuels tested include residential and experimental fuel:charcoal, solid fuel tablet (hexamine base), experimental solid fuel tablet (refined paraffin wax and cotton balls), lignin based shrubbery (pine tree, Pteroccephalus depressus), and light crop residue (straw, desert moss, Leptinella potentillina, Pratia pedunculata,etc).

Accordingly, there are two criteria for determining the best solid fuel: thermal efficiency and volatile matter content. Volatile matter, especially small particles like PM 2.5 and PM 10, harm one's respiratory health, accounting to millions of deaths worldwide. The particulate matter is detected in real time with an air quality sensor. Furthermore, a hotter flame leads to more complete combustion, so the thermal efficiency of each solid fuel is calculated (by recording the change in temperature).

The varying amount of the different solid fuels in a matched paired experiment show the effect on smaller (.5) versus larger quantities (x2) of solid fuel as they deviate from the control. The various solid fuels show the effect of each fuel type on pollutant emission. The kj/g of solid fuel is used to show the relation between fuel pollutant emission and thermal efficiency.

From this data the best solid fuel is postulated, and final solid fuel combinations are tested to create the most efficient, salutary solid fuel.

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**Category EB**

**P09** Home Water Detection System

**Abstract**

Home Water Detection Alarm System is a solution to the problem of water leakage in the basement. The potential use for this system is to detect an overflowing sump pump and alert homeowners if there is an emergency situation with basement flooding. This project explores the feasibility of designing a system to alert homeowners if there is water leakage.

A simple device for water detection was developed using an Arduino Uno microcontroller, a water level sensor, three LEDs and a buzzer. The water sensor is placed directly into the water source. As the water reaches different levels on the sensor, the output from the sensor changes. Based on the sensor output, an audible alarm can be triggered for higher water levels. A green, yellow, or red LED will also turn on depending on the water level.

In addition to the audible alarm that would be triggered at high sensor values, a text message will also be sent to the homeowner through a GSM (Global System for Mobile Communications) module.

An experiment was conducted to test how the quality of water changes the output. Salt water, filtered water, and tap water were tested. The salt water had the highest sensor output, followed by the tap water, and then the filtered water. This was because the varying resistivity of the water had a major effect on the sensor values.

This device can serve as a first alert to homeowners in case of water leakage and prevent large repair costs.

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**Category** *EM*      **P10** Traffic Management of Autonomous Vehicles at Uncontrolled Intersections

**Abstract** A large foreseen issue with autonomous cars is how they will communicate with one another to safely cross a uncontrolled 4-way intersection. Currently, drivers will communicate by slowly nudging their car forward or by using hand signals. However, by using car to car communication along with computer vision, I will demonstrate a logical and efficient method for managing such a situation. It will be modeled with autonomous Raspberry Pi cars that uses TCP for peer to peer communication and the open sourced library OpenCV for vision capabilities.

**Bibliography** <http://www.cs.utexas.edu/~aim/papers/ATT08-vanmiddlesworth.pdf><https://docs.opencv.org>

**Abstract**

The purpose of this experiment was to create a computer program that would be able to calculate the thrust on the platform of a linear induction motor (LIM), a technology used in automatic sliding doors, cranes, and maglev trains. The program would do this by solving an equation for the force which involves a summation and a double integration.

Before writing the program, a C++ integrated development environment was setup on a computer. Next, a method for computing integrals using Riemann sums was written, based on the endpoints a and b, and the number of rectangles under the curve n. A for-loop served the purpose of repeated summation. After this, a method for computing double integrals was written using the same concept. In the main program, after the constants in the equation were initialized, the current was calculated using a sinusoidal equation of the form  $A \sin(\omega t + B)$ , A and B being constants. Then, the current was used in the equation for the force. Following this, a for-loop was written to first calculate the force for successive time values within an interval, and then write that data to a file so that a plotting software, such as Gnuplot, could graph it.

The program was able to output accurate values for the thrust when compared to values produced from solving the same equation with more sophisticated software such as Wolfram Alpha. The accuracy could be increased if needed by increasing the number of intervals that were summed over. Thus, the engineering goal was met: a program that calculates values of the thrust on a LIM platform over a time interval was successfully created.

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*Category EP*

**P12** Maximizing Modern Solar System Production using MPPT and Algorithmic Diversion

*Abstract*

Solar energy usage has grown almost 68% over the last 10 years, and although research to attempt to improve the intrinsic production capabilities of modern solar cells has been conducted in earnest over this time frame; storage of harvested solar power is an issue that still requires a viable solution. Currently, maximum solar energy production occurs during the midday, and energy demand is maximal in the mornings and evenings. The mismatch between production and demand, requires consumers to repurchase energy at higher costs, thus limiting the off-grid capabilities of modern solar systems. This project attempts to partially resolve this problem by developing a small-scale algorithmic power diversion system, controlled by two 8-bit microcontrollers, in order to safely distribute power produced by the solar panel to a standard Lithium-Polymer battery for later usage. Additionally the system utilizes an MPPT (Maximum Power Point Tracking) subsystem, to keep produced power from the solar cell at a relative maximum, by continually adjusting the circuit resistance and comparing to previous values. The algorithm utilized analyzes current energy demand and the charge level of the battery to determine the amount of power to be diverted to the battery. Battery charge/discharge rate is regulated to preserve battery capacity and overall battery life. The effectiveness/efficiency of the system is evaluated by comparing power availability of a standard, unmodified solar panel to the power availability of the modified solar system over a one-week period. It is hypothesized that the modified system will provide at least a 20% increase in total power availability, which is proposed based on the analysis of existing power production data of commercial solar cells. Confirmation of this hypothesis could indicate that the developed system could be a plausible solution to the energy storage problem, therefore also allowing for the possibility of an effective off-grid solar system.

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*Abstract*

The Brachistochrone Problem ponders the shape of the curve down which a bead sliding from rest and accelerated by gravity will slip, without friction, from one point to another in the shortest amount of time. The Brachistochrone curve has many applications in sports engineering, including downhill skiing, surfing, skateboarding, and rollercoasters. After exploring the solution of the Brachistochrone problem, a cycloid, I would like to see how I could apply the Brachistochrone curve to hydropower systems, namely pumped storage systems. Instead of the water pipes that lead to the turbines being straight lines or L-shaped curves, I think replacing the pipes with Brachistochrone curves (cycloids or parts of cycloids) would lead to more efficient resource use and higher power generation from the hydropower plants. In addition, different types of drainage systems like those in our homes and process plants can be changed from straight line and L-shaped curves to cycloids to increase efficiency. The mathematics behind the Brachistochrone Problem is typically done using beads or some type of a single point mass and frictionless surface. However, in my project I have to deal with viscosity, friction, and fluid in motion when dealing with water.

To demonstrate the power increase of using the cycloid in the hydropower systems, I used three pipes: straight line, L-shape, and half of a cycloid. After attaching each pipe to 2 feet by 3 feet boards, with one end of each pipe at the top left corner and the other end at the bottom right, I poured 1 gallon of water through a funnel at the top of each pipe and timed how long it took for the water to fill up a bottle at the end of the pipe to .8 gallons. In addition, to compare how the distance covered affects the time differences for water to travel between two points, I created different ratios of heights to lengths of the points. So, I had 2 feet by 4 feet boards and 3 feet by 4 feet boards as well. After visually observing a few of the trials, I observed that the force of the water coming out of the Brachistochrone curve was much higher than that of the straight line and L-shaped curves, especially the straight line. In order to calculate the force of the water coming out of the pipes, I measured the horizontal distance the water coming out of the pipe reached and used basic physics equations for projectile motion to determine the corresponding forces of the water.

Substituting the forces and times that I calculated and measured into the equation for power:  $\text{work/time} = (\text{force} \times \text{distance})/\text{time}$  gave me the rate at which the water coming out of the pipes would do work on the water turbine. Comparing the times taken for water to come out of each pipe configuration allowed me to understand whether changing the shape of pipes in homes or processing plants would benefit from being changed to cycloids.

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*Abstract*

Rationale: For two years now, I have been working in designing and lab-testing a Marine Hydrokinetic (MHK) energy Converter, which utilizes oscillators with cylinders in alternating-lift, like fish do. In contrast, turbines/windmills use rotating blades pushed by steady-lift.

In each oscillator, a circular cylinder is driven by steady flow in transverse Flow Induced Vibrations (FIV); primarily vortex-induced vibrations or galloping. Thus, the vast resource of horizontal MHK energy (ocean currents, rivers, tides) can be harnessed to produce clean, renewable, electrical energy without using dams or turbines.

Brake-force (damping) applied to an oscillator harnesses energy. Too much damping suppresses oscillations. Applying velocity-dependent damping, may maximize the harnessed energy. Fish in self-propulsion use more force to overcome higher damping at higher speeds.

New concept: Instead of a constant damping coefficient in linear viscous damping, as vibration textbooks show, I used a velocity-proportional damping coefficient. It imposes more damping at higher oscillator velocities to harness more energy; at lower velocities, it harnesses less letting the cylinder move. When properly designed, two cylinders in proximity respond in synergistic FIV, generating more power than two cylinders in hydrodynamic isolation. The downstream cylinder though, operates under capacity shielded in the wake of the upstream cylinder. This is an ideal application for adaptive damping to improve performance of both cylinders.

The Converter I am designing and testing has immense potential. It can harness a renewable energy resource and it is harmless to the environment, since it mimics fish-school kinematics. Most important, it can harness power even from slow currents, where water turbines cannot function efficiently.

Hypotheses: An adaptive, velocity-proportional, damping coefficient will improve the hydrokinetic power harnessed: (a) by a single cylinder in FIV; (b) by two-cylinders in synergistic FIV.

Objective: Find the adaptive damping that will maximize the harnessed power in a one or two oscillator Converter.

Testing: I tested the Converter in the recirculating water channel of the Marine Renewable Energy Laboratory at the University of Michigan.

Models: One and two oscillators consisting of a cylinder suspended by springs in steady flow. Constants: Cylinder diameter, length, mass, spring stiffness, cylinder spacing. Variable: Flow speed  $\approx 1.35\text{m/s}$ . Parameter: Harnessing damping. Testing time: 25 hours.

Data analysis: The displacement history of each cylinder was post-processed to calculate amplitude, frequency, and harnessed power. Laser flow-visualization with high-speed camera helped understand cylinder-wake interactions.

Results: Both hypotheses were confirmed. (a) The energy harnessed by one cylinder with adaptive damping increased 51%-95%. (b) In a two-cylinder Converter with adaptive damping in both cylinders, harnessed power increased by up to 50%.

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*Category MA*      **P15** An Analysis of Weakly Nonlinear Systems

*Abstract* In this investigation, I will be examining systems of differential equations that contain small nonlinear terms. First, I will examine a simple ordinary differential equation to establish a basis upon which to build. I will then examine linear systems of two equations to find equilibrium solutions. In order to slightly change the nature of the solutions, I will add a weak cross term. The solutions that are periodic in nature are of the most interest, since they most accurately represent natural phenomena such as predator-prey relations. Looking at various base ODEs can help in modeling different phenomena.

*Bibliography* Lecture Notes UC Irvine - Nonlinear MathG.C. Layek - An Introduction to Dynamical Systems and Chaos

*Category MA*      **P16** One For You And Two For Me

*Abstract*

This report discusses how to recognize Gerrymandering. The goal is to educate the general public about the characteristics of a Gerrymandered district. Real life mathematical models of congressional districts take into account many variables and arguments. The approach used in this project measures the compactness of a district in conjunction, with its bizarre shape. The methods that are used in this project are simple and fundamental, however, they illustrate that Gerrymandering does in fact exist. Interestingly, the redistricting process can give credibility to the Gerrymandering argument.

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**Category MS**

**P17** Biodegradable and Cost-Effective Sanitary Napkins

**Abstract**

My project involves the development of a drying agent for sanitary napkins in the form of Agar. My project was inspired by a personal phone call that highlighted the inaccessibility of sanitary napkins because it is expensive. I used different concentrations of Agar to test its absorpivity of a blood like substance (V8) and realized it was not an absorptive agent but a drying agent. It could be used as a drying mechanism in sanitary napkins and because agar is cheap, it could make sanitary napkins cheaper by up to 3 dollars. The experiment was conducted in a 32 degree incubator to mimic the external conditions of the body. Further experimentation could involve the use of Agar to revitalize the vaginal area for women through prevention of infection.

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*Abstract*

Rare noble gases can either be extremely detrimental to environment and the health of individuals or be economically valuable for its high number of applications. Due to their lack of reactivity, these gases traditionally require energy-consuming processes to separate. Recently, a class of porous materials known as metal organic frameworks have shown to be useful and effective in selectively separating these rare gases. Experimentation with these MOF's can be expensive and time consuming, and molecular simulations offer a strong alternative. Unfortunately, most molecular force fields are inaccurate at predicting the nonbonded potentials of atoms, and thus produce results greatly varying from experimental data. By using a combination of the TraPPE force field for MOF atoms and MIE-potential force field for adsorbate molecules, which are not commonly used in this area, I have managed to produce results much closer to experimental adsorption data in four MOF's of different classes. Using these parameters with Monte Carlo simulations in the Grand canonical ensemble, I simulated the adsorption of radon with each of these four MOFs and produced isotherms, henry's constants, and heats of adsorption for comparison with experimental data. Furthermore, I simulated the adsorption of each MOF with a mixture of Rn and air to show the practical applications of these MOFs and molecular simulations.

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**Category MS**

**P19** LightScribe Graphene Supercapacitor

**Abstract**

Improvements in energy storage devices can help facilitate the implementation of renewable energy resources in collecting energy, energy storage, and using the energy efficiently. Most energy storage devices today face similar problems: slow charging time, low power and energy density, safety, and cost. These issues can all be addressed by graphene supercapacitors.

Graphene supercapacitors have fast charging and discharging rates, which not only reduce EVs charging time but also enable higher performance. The improvements in the electrolytes and the pattern design can further increase graphene supercapacitors' power and energy density. Inexpensive graphene supercapacitors can lower the cost of energy storage in solar and wind farms. There are also many more applications for RGOs (reduced graphite oxide) such as on a smaller scale, graphene's flexibility and transparency give graphene supercapacitors many potential applications for electronic devices like phones and wearables. Driving down the cost of LSG (laser scribed graphene) and scaling up the production will help make graphene supercapacitors more commercially available.

Although some lithium-ion batteries can achieve fast charging rates, graphene supercapacitors have many more benefits: they can be completely organic and metal free, which makes them more environmentally friendly, thanks to graphene's physical properties. A gelled electrolyte allows more flexibility and does not have the safety hazard of leakage. A solid electrolyte with sufficient electric conductivity in batteries is yet to be invented. Despite Sodium-based batteries' low cost, the performance of graphene supercapacitors can still be superior.

This research focuses on scalable inexpensive graphene supercapacitors from graphite oxide exfoliated with LightScribe DVD burners. The experiment examines different capacitor patterns, especially the Hilbert curve, to find the one with the highest specific surface area. It also tests how different electrolytes can help the supercapacitor retain charge longer. This research demonstrates the feasibility of an inexpensive scalable high energy density graphene supercapacitor.

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**Category PH**

**P20** Investigating How Cost of Instruments Affect Their Sound in Terms of Physics

**Abstract**

The idea is to investigate the specific affect a higher cost of an instrument has on its sound, specifically overtones and undertones in frequencies and such. Data will be obtained by using a FFT microphone to record sounds produced by specific strings on instruments (like cello). A variety of strings will be classified and recorded (for example, A, D, G, and C strings on the cello), and distance from microphone should stay constant in all situations. Each recording session will yield multiple FFT graphs that are to be interpreted in terms of what kind of graph and what kind of sound appeals to human ears and is associated with specific costs. Research in this case is interpreting and understanding what the FFT graphs show and using them to figure out the true difference in sound, cost of instrument, and what appeals to human ears. Practical application includes helping both veterans and beginners to string instruments decide which instruments to buy as well as which instruments are truly worth their price, according to the FFT readings. Extension may be applied in which other instruments, such as violins, flutes, oboes, and maybe even brass instruments can be recorded and repeated in the same situation, although brass and woodwind instruments are extra difficult considering how hard it is for them to produce the same sound every time for trials.

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**Category PH**

**P21** Factors Influencing Muon Flux and Lifetime

**Abstract**

Muons, one of the fundamental elementary particles, originate from the collision of cosmic rays with atmospheric particles and are also generated in particle accelerator collisions. Muon flux and lifetime are usually analyzed to obtain important insights regarding time dilation and ascertain the characteristics of the particles and processes that occur during collision.

In this study, we analyzed the factors that influence muon flux and lifetime using cosmic ray muon detectors (CRMDs). Cosmic ray detectors were used to conduct this study because these detectors enable the collection of data, specifically muon flux, that provides insight into the existence of muons and the processes that are related to their presence and decay. All experiments were performed in a research laboratory at the physics department of a university, over a period of four weeks.

The results of liquid shielding flux experiment and scintillator positioning lifetime experiment indicated that muon flux is inversely proportional to the depth of water that it passes through, and that detection rates of muon decay increase with the vertical height of scintillator plate orientation. Unlike previous studies, the effects of the shielding were noticeable at much smaller scales. Overall, this study suggests that water can be used to decrease muon flux and that height of the scintillator orientation is a potential determinant of the volume of data collected in muon decay studies.

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**Category PH**

**P22** Mars Exploration Zone Map Design for the Manned Mission to Mars

**Abstract**

Abstract: The goal of this abstract is to propose a road/resource map for the Mawrth Vallis exploration zone to guide the exploration of the manned missions to Mars. Mawrth Vallis is a 636 km ancient water outflow channel which terminates at the border of the southern highlands and northern lowlands. Just south of the terminus of Mawrth Vallis, is the exploration zone. There is a high bio-signature preservation potential, meaning that most evidence of the past environment would have been likely to be preserved. The exploration zone contains the largest amount of phyllosilicates on Mars, which would yield information about past environments, and also water can be extracted and other elements such as Iron, Aluminum, and Silicon can also be collected from the clay. Mawrth Vallis also has the most abundant hydrated mineral resource on Mars. All the craters, water features, labels, and the routes were all drawn with the Science ROIs layer. The landing sites were drawn with the Landing Zone layer, and the ellipses were made with the Landing Site Ellipse layer, which I renamed to Science and Resource ROIs + Outcrop B. This map of Mawrth Vallis should be used during the manned mission to Mars because this map shows many of the natural features of the exploration zone, the routes are at a low incline, which would reduce difficulty traveling through the Mawrth Vallis. Most of the distances between the landing sites and ROIs as well as between the ROIs are short, which reduces time for traveling and increase time for exploration.

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*Category RO*

**P23** Using Deep CNNs and Feature Matching Algorithms for Smarter Autonomous Cars

*Abstract*

With Tesla and various other car companies jumping on the autonomous car bandwagon, various methods and algorithms have been developed in order to improve these systems. This project seeks to develop fully functional autonomous car software that, theoretically, can be ran on a real car. To replicate this project, only a sufficiently powerful computer, the code, and the data set is necessary. This project consists of two parts, steering and braking/collision avoidance.

Steering control is based on a paper released by Nvidia titled "End-to-End Deep Learning for Self-Driving Cars". The software uses a deep neural network consisting of 5 convolutional layers and 5 fully connected layers. The neural network was trained through the use of back propagation. This consists of thousands of images being passed through the neural network then comparing the output to the actual data. The trained neural network can then be used predict to steering when given dash cam footage.

The second part allows for the car to control braking and avoid collisions. The algorithm uses feature matching algorithms to match the already found features of backs of cars to those of the dash cam footage to locate any cars that are in view. The algorithm outputs a bounding box of the located cars. We can then use this data to find the size of the car in front, how close it is, and thus decide when to start braking.

This software was written in Python and uses the libraries "Keras" and "OpenCV". The result of this project was a piece of software that ran sufficiently well considering the time frame and the data set used, but is still unsuitable for actual use on the road. With more time and further research, perhaps, a more powerful piece of software can be developed that solves many of the problems encountered such as steering and handling intersections.

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**Category RO**

**P24** Econometric Model of USGDP through Artificial Neural Networks

**Abstract**

Forecasting economic strength from several economic indicators is the primary concern of the area of econometrics. Gross domestic product measures the current price of all goods within a country and is one of the most prominent economic parameters used to judge economic development. With the understanding of how economic indicators affect the economy, planners can choose to allocate resources in certain industries to boost economic growth. This study builds an econometric model of US GDP with back-propagation artificial neural network architecture. Taking data from further than the past 70 years, this model will use machine learning to understand the behavior of three economic sectors of the United States. By analyzing the interconnecting behavior of the three sectors, it can form a mathematical relationship between them and produce an output of US GDP. This model accounts for nonlinearity and can be easily adapted to include more economic indicators than just the three sectors selected, sharpening the results. After the machine learning process is complete, economists can adjust the input values to examine its effect on the resulting GDP from the derived mathematical relationship. The model's current implementation is found to be very satisfactory and can be useful for the future planning of economic activity.

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**Category SO**      **P25** Thinking Cap

**Abstract** I plan to use a Mark IV OpenBCI headset to read brain waves in order to assess mental condition during work. I plan to send this data to an Android app of my own making in order to process it and determine the effectiveness of the brain at any time and provide suggestions at times when a break is needed. I hope to create this to make studying more effective for people who have more work on their hands than they have time for and have trouble with time management.

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**Category SO**

**P26** Protocol Identification Methodologies: A Comparative Study

**Abstract**

Protocol classification is a concept that involves identification of the types of protocols present in a given trace. Protocol classification is an essential piece of protocol traffic analysis which has many applications in security and networks such as intrusion detection systems, network management systems among others. There are many algorithms for protocol classification which identify protocol trace from mixed Internet traffic. Since the advent of the use of machine learning and the surge in the use of Bayesian probability techniques, many of these algorithms have begun utilizing machine learning methods such as Support Vector Machines and Decision Trees as well as Bayesian methods such as Markov Chain Monte Carlo algorithms such as Gibbs Sampling to make much more precise and accurate decisions.

In my project, I identified three algorithms that make use of machine learning and bayesian statistics: ProHacker, ProParser, Este et al.'s SVM based classifier. In this project, I implemented these algorithms in Python in order to perform tests on these algorithms. I preprocessed data from various SMTP, FTP and etc. traces. From these traces, I divided them into training and testing data based on Jaccard's similarity. In each of these algorithms, I identified their advantages and identified specific test cases for comparison.

I trained each of these algorithms using the training data that I gathered from protocol traces. I collected data on experiments that I ran on a 1.6 GHz, i5 intel core, and 8 GB RAM computer by running the test cases through the trained algorithm. I collected data for each of these including the metrics: precision, recall, F-measure, and runtime. In addition to experimental evaluation, I also performed a theoretical evaluation based on asymptotic analysis, perplexity and efficiency of each algorithm. I identified the best suited algorithm under both experimental and theoretical evaluation.

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