GORGAS SCHOLARSHIP COMPETITION
Sci-Mix Session
Arthur J. Bond Engineering Building, Auditorium
Thursday Evening, 5:30 pm–6:45 pm
Ellen Buckner, Presiding

1. EFFECTIVENESS OF HOME REMEDIES (APPLE CIDER VINEGAR AND NATURAL YOGURT) AT CONTROLLING *CANDIDIASIS* (FUNGAL INFECTION). *Addison Allred*, Murphy High School, [Teacher-sponsor: Julie Prerost].

   Rather than going through the trouble of seeing a doctor, many people have recently been turning to different home remedies in an attempt to control their yeast infections. I have decided to design experiments to determine which home remedy, apple cider vinegar or natural yogurt, is most effective at curing yeast infections. Yeast infections are due to an overgrowth of *C. albicans* or the penetration of the fungus into deeper vaginal cell layers. Alcohol fermentation is a process in which microorganisms, such as yeast, convert simple sugars into ethanol. The higher the rate of fermentation, the more yeast is present. The alternative hypothesis is that apple cider vinegar will be most effective at decreasing the rate of alcohol fermentation. I tested this hypothesis by conducting experiments in which I measured the carbon dioxide output of fermenting yeast cells. Carbon dioxide is directly correlated to the amount of ethanol produced and is a good indicator of the rate of fermentation. I added the two home remedies to the experiments and compared their carbon dioxide production, which determines the effect they have on the rate of fermentation. My results supported the alternative hypothesis. Apple cider vinegar proved to be most effective at decreasing the rate of alcohol fermentation. Thus, I concluded that apple cider vinegar is more effective than natural yogurt at controlling yeast infections.

2. ACCESSING DIVERSITY IN GASTROENTEROLOGY AND GI SURGERY USING ARTIFICIAL INTELLIGENCE. *Tosin Badewa*, Alabama School of Fine Arts (Teacher-sponsor: Rebecca Thrash).

   The United States population is becoming more racially and ethnically diverse. Research supports that cultural diversity within organizations increases teams' performances, yet this theory has not been explored in the field of surgery. Furthermore, patients often prefer that their care providers mirror their own race and ethnicity. We hypothesize that there is a positive correlation between greater racial, ethnic, and gender diversity among gastroenterology and gastrointestinal (GI) surgery faculty and exceptional hospital outcomes. The U.S. News Best Hospitals by Specialty rankings score departments using data based on measurable outcomes like risk-adjusted mortality. We utilized these rankings to categorize gastroenterology and GI surgery departments into two groups: 1–50 and 51–100. Hospital websites of the top and bottom 50 were compared to determine if racial diversity and inclusion were highlighted in each group's core values and/or mission statements. Betaface (Betaface.com) artificial intelligence software deciphered the race, ethnicity, and gender of the physicians using facial analysis of photos taken from the hospitals' websites. We then ran the independent samples t-test to determine if there was a difference in the rankings of departments with a more non-white, underrepresented minority and female faculty. Finally, we used U.S. census data to determine if the racial and ethnic makeup of the populations served by these hospitals matched the demographics of the physicians. Hospitals with

gastroenterology and GI surgery departments in the top 50 were more likely to mention diversity on their websites compared to those that ranked from 51–100 (82% vs. 64%; $p = 0.04$). The top 50 hospitals also had a statistically higher percentage of underrepresented minority physicians (7.01% vs. 4.04%; $p < 0.001$). In the 31 states where the hospitals were located, there were more African Americans (13% vs. 3%; $p < 0.001$) and Hispanics (12% vs. 2%; $p < 0.001$) in the population compared to the faculty.

3. GRAIN STRUCTURE ANALYSIS OF ZnSe AND Cr:ZnSe POLYCRYSTALS FOR APPLICATIONS IN RANDOM QUASI-PHASE-MATCHING AND LASING IN THE MID-IR SPECTRAL REGION. *Eesha Banerjee,* Alabama School of Fine Arts (Teacher-sponsor: Rebecca Thrash).

   Technologies using random quasi-phase-matching and thermal diffusion of dopants for mid-IR lasing are dependent on the grain structures of the polycrystals used, particularly the size and orientation of the grains. With the exception of expensive technology such as EBSD, these structures have been analyzed by manually using the line-intercept method to estimate the mean grain width. Existing imaging, image processing, and image analysis technologies can be utilized to provide a more affordable, in-depth grain structure analysis for lasing applications. In this research, preliminary experiments have been conducted for the development of such a process. The best combination of imaging, processing, and analysis obtained so far is: 1) using a high-resolution dissecting microscope and an external light source to image the crystal at eight different orientations of light; 2) stacking these images and using ImageJ to process the stack; and 3) obtaining distributions of the grain area and orientation angle from ImageJ to characterize the crystal and using boundary-to-boundary analysis for rQPM applications with a step size equal to the average grain width and a decreased resolution by filtering out widths less than five pixels.

4. EXAMINING THE EFFECT OF GENETIC VARIATION IN *DROSOPHILA MELANOGASTER* ON THE COST OF REPRODUCTION. *Sophie Dudeck,* Alabama School of Fine Arts (Teacher-sponsor: Rebecca Thrash).

   The cost of reproduction theory says that reproduction can negatively impact an organism's life span since it requires resources to be reallocated for the reproductive processes. Studies on this theory, particularly in the fruit fly, *Drosophila melanogaster*, largely ignore the use of genetic diversity and both sexes. This lack of information creates a gap in our understanding of the theory since many effects are sex-specific. Diverse strains of *D. melanogaster* are necessary since longevity is influenced by genetic background and varies by strain. Of the 15 genotypes used in this study, 10 were found to have significant interaction effects between sex and mating status on the risk of mortality, which have not been examined in other studies. The effects on reproduction alone were not significant across all genotypes, which could point to the theory being genetically dependent, showing a need for further experimentation. The cost of reproduction requires the diverse backgrounds of *D. melanogaster* so that we can gain a better understanding of the theory for other organisms and the evolution of life-history trade-offs.

5. LOSS OF HIPPOCAMPAL DAY-TIME INHIBITION IN ALZHEIMER'S DISEASE AND ITS CONTRIBUTION TO COGNITIVE IMPAIRMENT AND AMYLOID-β PATHOGENESIS. *Rachael George,* Alabama School of Fine Arts(Teacher-sponsor: Rebecca Thrash).

6. AN INVESTIGATION IN FRACTIONAL CALCULUS AND ITS APPLICATIONS. *Jacob Glidewell*, Alabama School of Fine Arts (Teacher-sponsor: Rebecca Thrash).

   In recent years, fractional calculus has gained a lot of attention with the discovery of its many applications. Since the days of Leibniz, many mathematicians have asked if derivatives and integrals can be extended to fractional order similar to exponents. A development of fractional calculus is shown. Additionally, a few properties and abstractions are presented that seem useful in the study of fractional derivatives. Finally, we discuss two recent applications and the interpretation of the use of fractional calculus in economic indicators and particular diffusion.

7. DEVELOPING A DECISION-MAKING MODEL TO ANALYZE AIR POLLUTION REMEDIATION WITH TREES: BIOREMEDIATION OF PM2.5, NO_2, AND CO IN BIRMINGHAM, ALABAMA. *Abhinav Gullapalli*, Hoover High School (Teacher-sponsor: Janet Ort).

   Birmingham, Alabama, has a long history of industrial pollution. The impacts of past and current transportation and industrial particle pollution on humans are exacerbated by environmental injustice and cause concern for public health. Chronic exposure to particle pollution has been shown to impact brain, respiratory, and immunological health. Trees have been shown to reduce particle pollution. This study utilized a Particle Photon IoT sensor to record and compare the concentrations of PM2.5, NO_2, and CO in Birmingham's various urban and suburban sites. The study also used iTree's MyTree v1.5 calculator to analyze the abilities of 232 trees, common to the southern United States, to reduce levels of PM2.5, NO_2, and CO. A Java program was created to aggregate the tree data from MyTree by annual reduction, in ounces, for PM2.5, NO_2, and CO. The program employs a system of weighted priorities based on corresponding Air Quality Index values determined through the EPA's AQI Calculator for recorded pollutant levels to deliver a comprehensive list of trees ranked by their overall effectiveness in reducing the studied pollutants. A Python program using the PuLP library was developed to recommend the number of each of the top eight trees to plant in order to optimize air quality while adhering to a simulated budget and space constraints. The computer programs developed in this study can be applied to any city in the world to deliver a site-specific solution for ideal, native trees to efficiently reduce targeted pollutants and promote environmental justice for all.

8. THE EFFECT OF NITROGEN ON *TRIGOLIUM REPENS*. *Elizabeth Hill* and Jenifer Jaynes, Fairhope High School (Teacher-sponsor: Mary Stuart).

   The experiment conducted tests to determine if giving a white clover plant more nitrogen would affect its growth rate and the number of root nodules present. Nitrogen is an essential element for life on Earth. For plants to be able to access this element, it must be converted into a usable form through nitrogen fixation. *Trifolium Repens*, or the white clover, has a symbiotic relationship with rhizobia, a nitrogen-fixing bacteria in the soil. Rhizobia forms root nodules in the plant, which give the white clover nitrogen and the bacteria a place to live. When the white clover has more nitrogen available through the minerals in the soil, it should theoretically develop fewer nodules and have an increased growth rate. The results are somewhat inconclusive, as the clover did not grow as well as planned.

9. CLEAR-CUT CLEAR-CUTTING. *Sydney Reeves*, Wetumpka High School (Teacher-sponsor: Virginia Vilardi).

Studies have shown that clear-cutting has negative effects, e.g., stormwater runoff and erosion contaminating underground water streams. But, what effect does clear-cutting have on lakes? Many streams, rivers, and groundwater sources feed into lakes, which can cause a buildup of sediment. How does this affect aquatic life? If clear-cutting has occurred by a stream leading to a lake, then the water quality will be greatly diminished in the surrounding area and where the stream feeds into the lake. The dissolved oxygen level is acceptable between 7–8 mg/L and is optimal at a reading of 9 mg/L or above; the optimal pH levels are between seven and eight. The temperature and turbidity readings for all sites are in the optimal ranges for aquatic life. The pH levels for all sites also stay in the optimal range while the dissolved oxygen readings stay in the acceptable range. In times of non-precipitation and wind, the water quality is not affected by the clear-cutting that has occurred upstream from the test sites. There is still visual evidence of clear-cutting, however, and sediment has been pushed down streams, filling in areas of the lake that were once deeper.

10. THE ROLE OF CONVERSATION AND HEALTH LITERACY IN THE PATIENT-SURGEON ENCOUNTER. *Isabel Silwal,* Alabama School of Fine Arts (Teacher-sponsor: Rebecca Thrash).

    Patients with low health literacy experience difficulty understanding health information, which may lead to poor surgical outcomes. In surgery clinics, health information is often presented through conversation. It is unclear, however, if variations exist in patient-surgeon conversations. We hypothesized that variations exist in conversational characteristics between surgeons but that opportunities exist to make improvements. New surgical patients in the UAB Colorectal Clinic were recruited for and consented to the experiment. Health literacy was measured using the Brief Health Literacy Screening Tool (BRIEF). Patient-surgeon encounters were audio-recorded. The patients' understanding was evaluated using a three-item survey. The patients rated their understanding on a scale of one to five, five for complete understanding and one for no understanding. Recordings were transcribed and analyzed for the surgeon's rate of speech, length of visit (LOV), and understandability of words according to the Flesch-Kincaid Ease Score (FKES) and Simple Measure of Gobbledygook (SMOG). Fifty patients were enrolled. The mean age was 49 years (+/- 17.2) and 56% were female. Health literacy levels were adequate (70%), marginal (26%), and low (4%). Significant variations existed in the rate of speech and understandability of words between surgeons ($p < 0.05$). Additional variations existed in LOV by health literacy. Low health literacy patients had the shortest LOV and reported the lowest understandability. Faster rates of speech were associated with less understandability by the FKES and SMOG ($p < 0.05$), shorter LOV, and poor patient understanding. Significant variations exist in the speech rates and understandability of words used at patient-surgeon encounters. Faster rates of speech are significantly associated with less understandable words, and patients with limited health literacy are at-risk for shorter LOV and decreased understanding. Actions can be taken to mitigate the effects of health literacy in the interaction.

11. GENIUSES: BORN OR MADE? *Anna Lei Singleton,* Wetumpka High School (Teacher-sponsor: Virginia Vilardi).

    Last year, I researched the qualities of a "genius" by comparing how genetic factors and environmental factors influence overall cognitive development. My hypothesis supported that implementing scholastic activities at an early age would enhance a person's cognition and academic success. Continuing this research, I tested whether the conclusions I made off this

phenomenon could be applied to the multiple intelligences theory. The purpose behind this project is to prove that people are not limited in their opportunities because they do not fit typical intelligence expectations. This experiment shows the importance of different outlets for learning and how vital it is to engage with children at a young age. I predict that if a person puts extensive hours into a particular talent, or intelligence category, then they will perform exceptionally well in it. Moreover, if a child is instilled with education at a young age, they can almost guarantee academic success. Procedures for this experiment were divided into three sections. Part one consisted of making a survey with questions concerning parental academics, early childhood education, current grades, test scores, and study habits and testing people in Math, English, and Reading Comprehension using previous ACT testing material. Part two involved making a survey that questioned the relationship between an individual's behavior and their parents'. And part three included conducting a simple robotic game simulation in which participants were monitored on how their scores improved over an extended period. The data recorded correlations between natural inclinations and extensive practice in intelligence types, influences in early development, personal choice, levels of motivation, and inheritance. My hypothesis was proved under conditional circumstances. The results lead me to wonder whether certain intelligences are more easily inherited than others. Nonetheless, the concepts that I tested could only be accurate if I had full access to people's lives.

12. PHARMACOKINETIC MODELING OF INVITRO DIFFUSION RATES FOR THE ANTIVIRAL ACYCLOVIR. *Nikitha Sridhar*, Auburn High School; Sridhar Krishnamurti, Auburn University; and Babu Ramapuram, Auburn University (Teacher-sponsor: Mark Jones).

    Acyclovir is an antiviral drug used in the treatment of *Herpes labialis*, a difficult-to-treat viral infection affecting over 140 million people worldwide. Traditionally, the administration of acyclovir has been by oral or intravenous route. These formulations are effective but face difficulty in clearance from the kidneys in humans with poor renal or immunological function. Topical transdermal (via skin) delivery of acyclovir by cream or gel formulations can provide direct delivery to the site of infection, thereby alleviating nerve pain, reducing viral multiplication, and facilitating clearance. Topical application of acyclovir, an antiviral drug designed to treat herpes infections, was evaluated by using gel formulations with plasma concentrations similar to generic Zovirax formulations. In vitro diffusion rates for a 5% acyclovir solution were collected via vertically-mounted Franz diffusion cells with a dialysis membrane mounted between the donor and receptor compartments. To create an in vivo predictive model of clearance, the in vitro diffusion data above were modified by applying human clearance data for acyclovir from published NIH studies. The obtained data were used to simulate the drug clearance rates in patients with normal renal function and impaired renal function. The in vitro diffusion rates and in vivo clearance rates calculated above were used to model output concentration and clearance variables. Neural networks modeling of data provided statistical algorithms to pair input variables (initial concentrations, release rates, and plasma concentrations) with predicted output variables (output concentration and clearance rate). The results showed a dose-dependent relationship of acyclovir that can be complicated by diffusion and renal clearance mechanisms.

13. CAN BATTERIES BEAT OUT THE KING OF ENERGY STORAGE: HYDRO PUMPING? *Jon Tessier*, Wetumpka High School (Teacher-sponsor: Virginia Vilardi).

This experiment was done to determine if there is a better way to store energy than the most common way, which is hydro pumping. I believed that storing energy in a battery would release a higher percentage of the input energy than hydro pumping, and therefore, storing energy would be more effective in a battery and a better way to store energy. To test this theory, I recorded the power and time required to pump five gallons of water up a distance, and the power and time produced by releasing the five gallons back through a waterwheel. I also tested a battery by lowering the voltage to zero and then recorded both the time and voltage required to charge the battery as well as the time and voltage produced by the battery to return the voltage to zero. Since I was running energy both forwards and backwards through the same circuit, I assumed that the resistance was the same both ways and compared joule ohms instead of joules. The battery ended up being 55% effective and hydro pumping was only 3% effective, which supported my hypothesis by demonstrating that less energy was lost when being stored in a battery.