

**Research Abstracts from the Top 10 Winners of the
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An Efficient and Environmentally Friendly Synthetic Method for Aromatic Amino Acids

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BACKGROUND: Aromatic α -amino acids are important structural units in natural products, pharmaceuticals, agrochemicals, materials, and dyes. Over the course of the past century, considerable efforts have been made to develop methods to synthesize these molecules. Unfortunately, current approaches suffer from the need to use expensive metal species, toxic reagents, surplus and expensive starting materials, or a multi-step synthesis. Consequently, they are not industrially practical processes.

METHODS: My research goal was to develop an efficient, economically and ecologically beneficial process to access aromatic α -amino acids. The cross-coupling reaction of an aryl iodide and glycine ester was performed. **RESULTS:** In this study, the α -arylation of an inexpensive, commercially available glycine ester was achieved with aryl iodides under transition metal-free conditions in the presence of potassium *tert*-butoxide. This reaction features a broad substrate scope and good functional group compatibility, and thus provides a straightforward synthesis for a wide range of aromatic amino acids. **CONCLUSIONS:** The experimental results support that this process begins with the formation of an aryl radical — generated from the treatment of an aryl iodide with potassium *tert*-butoxide — and yields an aromatic amino acid product — formed from the addition of the aryl radical to a glycine derivative.

Because of the importance of aromatic α -amino acids in natural products, medicine, and materials, this newly developed process has broad applications in organic, pharmaceutical, and material chemistry research.

Using Novel Soil Microbes as a Neonicotinoid Alternative on *Popillia japonica* Newman Infestations as a Method of Pollinator Protection

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Neonicotinoids are a family of insecticides that have gained worldwide popularity. By 2009, the global Neonicotinoid market was worth \$2.63 billion. Recently, their usage has come under question as studies have shown a correlation between Neonicotinoids and a degradation of behaviors necessary for honeybee survival. This is alarming as one third of total crop production is dependent upon insect pollination. This research is focused on determining if novel soil microbes could be a viable alternative to Neonicotinoids. The effectiveness of Imidacloprid (a type of Neonicotinoid), GrubGone G (commercial microbe) and 2 experimental microbes were tested using the model organism *Popillia japonica*. 40 beetles were sectioned off for each trial and caged in cylinders, where they then either remained untreated or underwent treatment from the respective product tested. 4 trials were replicated for each product. The number of larvae present in each plot was recorded on September 19th, 2019. The Imidacloprid was the most effective of the products, with a mean of .3 larvae. The first Experimental Microbe was more effective than the second Experimental Microbe in the July 18th trials, but less effective in the August 15th. Overall, the two microbes appear to supply similar levels of control. While not as effective as the Imidacloprid, the experimental microbes did prove to be effective in reducing the number of larvae present in comparison to the control and GrubGone G.

Insucool : Affordable Insulin Cooling

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Background: Insulin is the life-essential treatment for Type 1 diabetes mellitus, and it is also increasingly important with time for many patients with Type 2 diabetes mellitus. A reported 33% of families with children with diabetes lack a necessary home refrigerator in 30 of 37 low and lower-middle income countries. **Aim:** Produce a simple, cost-efficient wallet for insulin storage and transportation, and then compare designs used in resourced-challenged settings.

Methods: An insulin wallet was modeled, manufactured, and then tested versus traditional methods (clay pots, the EADSG recommended device, and a Frio insulin cooling case). A controlled chamber was constructed to mimic realistic ambient environments, and electronic loggers were used to measure the temperature every 2 minutes for more than 3 hours. Cooling efficacy was assessed with average absolute temperature differences (internal vs. ambient) and mean kinetic temperature differences.

Results: A prototype was produced within an affordable budget for resourced challenged populations (\$1.50 per 10-year life span of product). The mean ambient temperature was controlled. The average temperature was $16.2 \pm 1.0^{\circ}\text{C}$, with an average cooling temperature of 15.9°C . The average temperature achieved by the prototype was statistically significant compared to the clay pot ($p=0.0009$), EADSG recommended device ($p=0.01333$), and the Frio insulin cooling case ($p=0.0025$). Similar statistical significance was seen among the mean kinetic temperatures.

Conclusions: The insulin wallet prototype is affordable and more efficacious in reducing storage temperatures compared to other insulin storage and transportation devices.

Feeding modality and saturation response in the jaws of New Zealand white rabbits

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Bone adapts to mechanical loading during life to maintain the structural integrity of the skeleton. Large loads and/or repetitive loads result in the greater bony response. Robling et al. (2002) loaded ulnae of two groups of rats: one group experienced 360 loads during a single bout and the other experienced 90 loads divided into 4 bouts, each separated by a 4 hour rest period. The 90x4 groups had a greater bony response. This is because bone cells become desensitized with repeated loading (saturation response) and a rest period followed by renewed loading initiates new bone growth. The questions posed here are does saturation response occur in other parts of the skeleton, is a rest period necessary, and is this occur in other mammals? I measured the cross sectional area and the cortical thickness of the mandibular corpus at the first premolar in 13 male rabbits. The rabbits were split into two groups; six unimodal, having access to food all day and seven bimodal, having a rest period for five hours in between feeding cycles. Rabbits were raised on this feeding schedule for 48 weeks, beginning at weaning. Results show that one cortical thickness measurement (inferior lingual region) was statistically significantly greater in the bimodal than unimodal group ($P=0.034$). The lack of statistically significant differences in other measures is likely the results of higher caloric intake in the unimodal group. This is the first evidence of a saturation response in a non-rodent and non-limb part of the skeleton.

Testing the Effectiveness of Mosquito Traps

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The purpose of this experiment was to test the effectiveness of commonly used mosquito traps in a local setting. A mosquito trap with a greater number of attractants and trapping mechanisms is more likely to yield a greater number of mosquitoes in one night than a more simplified trap. The type of trap will have no effect on mosquito density in a given region. Each trap variation was run at least three times, in three separate locations, and with a constant factor being a CDC light trap. Once mosquito collection was concluded, the species of the collected samples were identified using PCR and an online database. The most effective of the tested traps was found to be the most complex and life-like one, which included both a heat and CO₂ source. A total of 171 samples were collected. Of these 171 samples, the majority of them were identified to be a species called *Aedes japonicus* and the rest were either unidentifiable or of another mosquito species. The results of this project support the hypothesis and null hypothesis. Furthermore, the findings from this project could have potential use in both the consumer market, as a way to limit mosquito population in a certain region, and for research purposes, as a way for researchers to be able to gather samples in order to study local mosquito species and the diseases they might carry.

The Effects of Cisplatin Versus Docetaxel on Gene Expression in Triple Negative Breast Cancer

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Triple Negative Breast Cancer (TNBC) is extremely aggressive and acquires an early drug resistance which results in poor prognosis. Its three main hormone receptors are not expressed, making nontargeted chemotherapy the viable treatment option. Since nontargeted chemotherapy disperses through most rapidly dividing cells, it is imperative to provide the best outcome for treatment by knowing how it affects the genes. Four specific genes treated with docetaxel from a previous experiment were compared to the researcher's investigation where they were treated with cisplatin. The hypothesis is that two genes (SNHG18, LGALS12) will have the same effect with cisplatin and docetaxel, and two genes (UCA1, COX7B2) will have opposite effects. These two chemotherapeutic drugs induce apoptosis in different manners. Docetaxel prevents cell division by clumping the microtubules whereas cisplatin inserts itself into DNA's structure to prevent transcription and replication. The comparison of the treatments and their potential effects will aid in determining the most effective treatment for TNBC. A cisplatin treated cDNA solution was compared to a media treated solution and both were combined with a primer-MasterMix solution into a DNA plate using micropipettes. The plate was put into the thermocycler which measured the amount of copies being produced by the treatment. The data were analyzed and compared to docetaxel's results. It supported the hypothesis. All four genes were downregulated in some sense except for UCA1 at twelve hours. The downregulation of COX7B2, UCA1, and SNHG18 suggests a positive effect on the cancer treatment whereas the downregulation of LGALS12 could suggest metastasis.

A Novel Tool for the Accurate and Affordable Early Diagnosis of Pancreatic Cancer via Machine Learning and Bioinformatics

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Pancreatic cancer (PC) is the fourth leading cause of cancer death in the United States due to its five-year survival rate of 8.9%. Late diagnosis, affiliated with the asymptomatic nature in early stages and the location of the cancer with respect to the pancreas, makes current widely-accepted screening methods unavailable. Prior studies have achieved low (70-75%) diagnostic accuracy, possibly because 80.1% of PC cases are associated with diabetes, leading to misdiagnosis. To address the problems of frequent late diagnosis and misdiagnosis, an accessible, accurate, and affordable diagnostic tool was developed by analyzing the expression of nineteen genes in PC and diabetes. First, machine learning algorithms were trained on four groups of subjects, depending on the occurrence of PC and Diabetes. The models were analyzed with 400 PC subjects at varying stages to ensure validity. Naive Bayes, Neural Network, and K-Nearest Neighbors models achieved the highest testing accuracy of around 92.6%. Second, a novel user interface, PanCan Diagnosis, was designed to test an individual's occurrence of PC where the average likelihood of PC was displayed. Third, the biological implication of the nineteen genes was investigated using bioinformatics tools. It was found that these genes were significantly involved in regulating the cytoplasm, cytoskeleton and nuclear receptor activity in the pancreas, specifically in acinar and ductal cells. This novel tool is the first in the literature that achieves a PC diagnostic accuracy of above 90%, potentially increasing the five-year survival rate to 36%.

Effects of Functionalizing Activated Carbon Surfaces on Carbon-based Supercapacitors

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Portable energy storage devices are vital in modern society, when anything from a laptop to a military vehicle needs quick and convenient energy. Among energy storage devices, supercapacitors are a common electrochemical device that excels at producing energy quickly, but lack the superior energy capacities that batteries hold. This study examined if depositing redox-active functional groups onto supercapacitor electrode surfaces boosts capacitance through increasing ion adsorption and redox activity. Activated carbon was functionalized with either carboxylic or alcohol groups, and the functionalized activated carbon was used to fabricate carbon electrodes. Then, the electrodes were used to “sandwich” an electrolytic membrane to make supercapacitors. Next, the supercapacitors were examined using cyclic voltammetry tests and galvanostatic tests. The results showed that carboxylic and alcohol functional groups improved the specific capacitance of non-functionalized supercapacitors by 3-fold and 4-fold, respectively. However, the gained capacitance was not as significant at high charge-discharge rates. This may be because redox reactions of the functional groups are not fast enough to keep up with very fast charge-discharge cycles. The chemical process of functionalization may also partially damage the nanoporous carbon structure, contributing to the sub-optimal capacitance under extreme conditions. In conclusion, while functionalization of carbon electrodes with carboxyl or alcohol groups can increase the energy capacities of supercapacitors, the benefit in energy storage is not as pronounced at high charge-discharge rates. Future studies should optimize the dosages of the functional groups so that the performance is more consistent across all charge-discharge rates.

Mapping the Lethality of Wallenda in Drosophila Mushroom Bodies

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Wallenda (WND) is a gene that is responsible for neuron regeneration and premature cell death. The purpose of this experiment is to find out at what point of the life cycle does lethality occur so that this gene can be looked at as a possible and viable treatment for patients with Alzheimer's and Parkinson's disease. For this experiment, two strains were crossed:

cnbw TA _____; _____: 854 ⊗ _____; _____; _____
cnbw TM6B,Sb Sm1 TM6B,Sb +

These two strains of genetically modified flies were used to map the lethality period of Wallenda in the mushroom body of the brain. My hypothesis was that the lethality period occurs at the pupa stage. By looking at the life cycle of a fruit fly, it is possible to see when the specimen stops its development and no longer continues its life processes. This experiment took place in a 25 degrees celsius incubator since Wallenda is activated at this temperature. These results were compared to 18 degrees celsius when Wallenda is not activated. To ensure the crosses happened the way they were supposed to, data was listed and compared by each phenotype and its survival rates. The results showed that the crosses did indeed happen the way they were supposed to, and that the lethality period occurred at the pupa stage. Now that the lethality period is determined, the possibility to bypass this period is now plausible. By bypassing the lethality period, one can further study the effect of Wallenda on different model types.

LifeRemind

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Over the last 20 years, nearly 1,000 children died needlessly due to being left in a hot car, with the highest number of fatalities within the last two years. That averages out to one child dying every nine days. More than 93% of those children were under the age of five. LifeRemind is a device that manufacturers can build directly into the child safety seat and connects to an app on your phone using Bluetooth. It will lock the phone screen and sound an alarm from the cellphone when it detects that a person has left their vehicle with a child safety seat still buckled. A few companies have attempted to produce devices that alert individuals that a child was left behind in a vehicle, however, they are a separate device needed to purchase and are expensive, often ranging between \$60 to \$150. Unfortunately, most of these products don't truly work in all situations and are not widely known about. In conjunction with these issues, the "It'll never happen to me!" attitude further prevents any action from some people. Since state laws require that all infants and small children be in a safety seat, LifeRemind can easily be implemented across the US so that children are protected. The app will be offered for free and will require minimal interaction from the user. LifeRemind can be used to drastically reduce child heatstroke fatalities in a vehicle and save the lives of innocent children.