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Aresty Research Center for Undergraduates

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2017 Summer Science Student Abstracts

Listed alphabetically

Jacob Armitage
Professor Eric Lam
Exploration of Mechanisms underlying the Bacteria Community in the Duckweed Microbiome

Duckweed is an aquatic angiosperm found in lakes and ponds and its small size, simple architecture and rapid growth rate make it an ideal model organism to study plant microbiomes. Over 50 bacteria strains have recently been collected from the endosphere of different species of duckweed. As a first step to explore biological mechanisms that mediate the dynamic community structure of the duckweed microbiome, we will screen these microbes for binary, tertiary and quaternary inhibitory relationships by growing them in vitro on rich medium. These assays aim to test for growth effects on the bacteria by others in various context based off both morphological and PCR data. Once an interaction is found, these bacteria are further studied by co-cultivation with duckweed. Using a novel bacterial attachment assay that has been established in the Lam lab, we will further explore these interactions in the plant context. This project will contribute to a better understanding of how microbe-microbe interactions can impact the dynamic plant microbiome.

Sandra Ashamalla
Professor Ben Samuels
Identifying Sex Difference in Depression using Chronic Corticosterone Model

Major Depressive Disorder (MDD) is a heterogeneous and complex disease affecting nearly 300 million people each year. Previous findings suggest depression is linked to deregulation of the hypothalamic-pituitary-adrenal axis (HPA), an intricate set of reactions resulting in the release of the stress hormone corticosterone. For years, chronic administration of corticosterone in male mice's drinking water has created an effective model for inducing an anxiety/depressive like phenotype in male mice. This depressive-like state led to a decrease in the hippocampal expression of three genes related to mood disorders- β-Arrestin 1, β-Arrestin 2 and Giα2, which was completely reversed by antidepressant treatment. However, little research has been done on the effects of corticosterone administration on female mice because their estrus cycle adds another area of variability. In order to identify sex differences between male and female mice, we used the chronic corticosterone model on female mice followed by chronic administration of the antidepressant, fluoxetine, all the while tracking the female estrus cycle. We subsequently performed a series of behavioral tests and separated mice into antidepressant responders and nonresponder groups. Afterwards, we cut flash frozen brains, punched for the hypothalamus and areas of the hippocampus, and ran qPCRs to determine the gene expression. We found that female mice are less susceptible to the chronic corticosterone model and accordingly we expect to find less significant impairment of the three genes due to corticosterone. This is significant because it indicates a better model is needed to study depression in female mice.

Valerie Ballance
Professor Fuat Celik
Determining Catalytic Behavior of Lab Synthesized Titanium Dioxide via Photocatalytic Methylene Blue Degradation

Searching for renewable and sustainable ways to decrease pollution continues to be a focus for many researchers. Our research focuses on the synthesis of photocatalysts that can utilize sunlight to convert biomass into fuels and chemicals. Anatase TiO_2 is known to have high photoactivity and stability under reaction conditions, but it has a high band gap energy (BGE) of 3.2 eV and primarily absorbs light in the

UV range. A novel lab synthesized Titanium Dioxide (TiO_2) catalyst has been created via gas-phase synthesis in the lab of Stephen Tse. When testing the photoactivity of the novel TiO_2 catalyst using gas phase methanol oxidation, the preliminary conversion of methanol under UV illumination gives promising production of dimethyl ether, a precursor fuel, and methyl formate and formaldehyde, precursor chemicals. In order to further understand the photocatalytic activity of the novel catalyst compared to previously designed catalysts, we focus on the Methylene Blue degradation. Methylene Blue is commonly used as a representation for water pollution. TiO_2 catalysts of various nano-structures have been created and analyzed using UV-Visible Spectrophotometry. In UV-Visible spectrometry, the percent absorbance of light across the range of 200 nm to 1000 is measured to determine the percent degradation of Methylene Blue per milligram of the catalyst used over the reaction period. This information allows us to hypothesize which samples will make good UV-photocatalysts that will be able to assist in the degradation of water pollutants as well as give us insight into the photoactivity of TiO_2 in relation to sustainable synthesis of bio-based chemicals and fuels.

Sophie Benaroya
Professor JeanMarie Hartman
Factors Affecting Soil Infiltration Rates in the Lower Raritan Basin

Infiltration rate is a major factor in determining soil health; good rates are needed to promote plant growth, organic matter content, and to reduce surface runoff. Inadequate levels of organic matter, porosity, permeability are likely to negatively affect infiltration rates. Urbanization and the increase in impervious surface likely contribute to lower infiltration rates as compared to forestland cover. Data was downloaded from Web Soil Survey about different soil health indicators pertaining to the lower Raritan basin and the data analyzed and collated using ArcGIS software to produce informative maps describing my findings. The maps show similar patterns between low levels of organic matter and high levels of soil fragments greatly reducing infiltration rates. Urban areas were also shown to have lower infiltration rates than forests. In addition, highly fragmented forests generally had lower levels of infiltration when compared to less fragmented forests. Low organic matter and a high percentage of soil fragments also appear to be correlated with urban areas. Urban land use has a negative effect on infiltration rates, likely due to anthropogenic effects. To mitigate the low infiltration rates, conservation of current forest is pivotal, and an increase in green infrastructure in urban areas to increase the infiltration rates of soil would be beneficial.

Jeremy Berkowitz
Professor Lisa Klein
Sol-Gel Processing of Superinsulation Materials

Silica-Aerogel, a material that is mostly air by volume, has remarkable hydrophobic and thermal insulation qualities. This has allowed aerogel to be used as a coating as well as a device to capture small particles in the pores that contain the air. Compressive strain tests, which indicate compressive limits, were performed to find the aerogel's breaking point. Because of the unique structure of aerogel, less dense versions were found to withstand more stress than their heavier counterparts. Samples were measured for the skeletal densities via Helium Pycnometry, and results from axial compressive tests from an Instron determined the strengths of the various samples. Because of the nuances of the molecular structure, samples with different compositions varied in strength. The trend that arose for samples with the same composition proved that there is not a simple relationship between compressive strength and density and porosity, contrary to previous studies that have shown positive proportionalities between the two. Therefore, the lack of degradation of compressive strength with lower density allows for very light versions of aerogel to be used without a risk of failure. Ultimately, this quality provides an opportunity for higher efficiency, being that aerogel has an extremely low density and terrific thermal insulation properties that can improve the overall quality of objects without compromising the strength.

Tucker Birmingham
Professor Nick Bello
Taste Sensitivity in a Mouse Model of a Common Polymorphism of the Mu-opioid Receptor

A common single nucleotide polymorphism (SNP) of the μ-opioid receptor gene (Oprm1 A118G) is present in an estimated 10% of people globally, and up to 50% of the Asian population. This SNP has been shown to be related to addictive behavior, and is more common in obese individuals with binge-eating disorder (BED). However, the sensory-neural adaptions of this SNP have yet to be identified. In the current study, taste sensitivity was explored in female transgenic mice with the homologous SNP (A112G). An automated gustometer (the "Davis Rig") measures the number of licks the animal takes from the tastants in 5 second intervals, and therefore excludes the post-ingestive response to the tastant. Sucrose, fructose, alanine, NaCl, and Intralipid solutions of varying concentrations were run to assess sensitivity to sweet, salty, and oleogustus, a recently discovered "fatty" taste. Mice homozygous for the GG allele had significantly lower sensitivity ($p < 0.05$) to sucrose at 1.5M concentration, and fructose at 0.3 and 1 M concentrations. There were no differences in NaCl, alanine, or Intralipid sensitivity. Differences in total lick count during testing were noted, which requires further examination. This data suggests that the presence of the A112G SNP incurs an altered sensitivity to sweet tastes. Future studies will explore taste preference, to better illuminate potential neural alterations resulting from the polymorphism. Together, this research aims to identify effective treatments or dietary interventions for individuals with BED.

Mohana Biswas
Professor Ken Paradiso
Evidence for the Presence of Local Protein Synthesis at a Presynaptic Nerve Terminal

A fundamental precept in neuroscience has been that proteins are exclusively synthesized in the neuronal cell body and then transported to appropriate subcellular locations. However, in the past decade, significant evidence has shown that neurons are capable of translating proteins locally in dendrites and some axons. Recent evidence now indicates that local protein synthesis can also occur at nerve terminals in the mammalian central nervous system (CNS), but this remains controversial. To better understand local presynaptic protein synthesis, our lab has employed the use of a giant synapse located in the mouse auditory brainstem called the calyx of Held. The large size of this synapse allows specific manipulation of the presynaptic terminal. Using immunohistochemistry (IHC) we can specifically tag the presynaptic terminal and monitor newly translated proteins and the components necessary to produce proteins locally. Finally, we address the functional significance of presynaptic protein synthesis at this auditory synapse by inhibiting translation and monitoring neurotransmitter release during high frequency neuronal stimulation using electrophysiology. Our experiments indicate that there are ribosomal components in the presynaptic terminal and that the presynaptic terminal is capable of protein synthesis. Since numerous neurological disorders are due to changes in synaptic activity, it is important to investigate local translation due to its involvement in synaptic plasticity and likely role in neuropathologies such as Alzheimer's Disease and Parkinson's Disease. Understanding the machinery in regional compartments of the neuron that sustains synaptic communication is critical to our understanding of neurotransmission which is essential for normal brain function.

Gabrielle Caponigro
Professor Wilma Olson
Analyzing the 3D Structure of RNA Chemical Modifications

The chemical modification of the four traditional RNA bases (adenine, cytosine, guanine, and uracil) has implications that affect the structure and, therefore, function of the RNA strand in which they occur. Because these chemically modified bases generally do not adhere as closely to the same rules as the four traditional bases, understanding of them is vital to understanding of RNA as a whole. The presence of chemical modifications in RNA molecules has been evident for quite some time now, but there is not a significant amount of information concerning what the specific implications of a single modification are. In order to investigate the 3D structural context of these chemically modified RNA bases, data were

collected from a nonredundant set of RNA structures using software that analyzes each individual base and interaction. These data were used to identify patterns about the structural context, pairing tendencies, and the frequency of specific chemical modifications. These patterns show that chemical modifications alter the folding and pairing of RNA bases.

Amanda Chen
Professor Pal Maliga
Development of Plastid Transformation in Arabidopsis thaliana

Chloroplast transformation is routine in tobacco, but is not practical in Arabidopsis, the model plant for plant research, due to low transformation efficiency (Sikdar et al. 1998). Recently, plastid transformation frequency in Arabidopsis was 100-fold improved in the acc2 nuclear background (Qiguo et al., 2017). The preexisting vector pATV1 resulted in efficient transformation, but was not suitable for cloning due to its lack of cloning sites, and the tissue culture protocol failed to yield fertile transformed plants. The objective of my research is to construct vectors that moderately express marker genes which do not impede plant growth, and test which auxins and cytokinins enable plant regeneration to yield viable seeds. I constructed vectors pAC1 and pAC2 with the desired level of GFP gene expression, which are shown in Figure 3. A third vector, pAC5, carries an excisable aadA marker gene, which can be removed using the phiC31 phage site-specific recombinase. We also regenerated Sav-0 shoots from leaves on different combinations of cytokinins and auxins, harvested seeds, and germinated them and evaluated viability (Table 1). The vectors will be tested for transformation efficiency by bombardment of Arabidopsis leaves and showing transmission of the marker genes to seed progeny.

Jasmine Cheung
Professor Qian Cai
Cellular Mechanism of Tau Pathology in Alzheimer's Disease

Alzheimer's disease (AD) is the most common cause of late life dementia. In AD brains hyperphosphorylated tau protein aggregates, resulting in the formation of neurofibrillary tangles, one of the pathogenic hallmarks of AD. Phosphorylated tau loses its ability to bind to and stabilize microtubules, leading to synaptic dysfunction and neurodegeneration. Autophagy is the key intracellular quality control pathway that eliminates protein aggregates and damaged organelles and is essential for the maintenance of neuronal homeostasis. Defective autophagy has been implicated in AD pathogenesis. However, the underlying mechanism remains poorly understood. By purifying synapse-enriched synaptosomal preparations and western blot analysis, we demonstrated a significant increase in phosphorylated tau at synaptic terminals of AD patient brains. Moreover, Snapin-deficient mouse brains recapitulate this phenotype, displaying synaptic retention of these pathogenic tau, coupled with autophagic accumulation. Given that Snapin, a dynein motor adaptor, mediates retrograde transport of newly generated autophagosomes from distal axons to the soma for lysosomal degradation, our findings suggest that impaired retrograde transport disrupts autophagic removal of pathogenic tau from distal axons. Next, we will investigate whether such defects are attributed to impaired autophagic clearance of hyperphosphorylated tau due to impeded retrograde transport in distal axons of AD neurons. If so, the question remains whether Snapin-enhanced retrograde transport can facilitate the removal of pathogenic tau and thus rescue synaptic pathology associated with AD. We hope to provide a better understanding of such mechanisms for the long-term goal of developing therapeutic strategies to delay or even prevent the progress of AD.

Min Sung Cho
Professor Richard Ebright and Wei Lin
Determining the Dependency of Alternative Sigma Factor Function on Specific Nucleotide Placement

Current antibacterial drugs used for treatment of tuberculosis target the clamp region of RNA polymerase (RNAP) to prohibit DNA strands from interacting with RNAP and thus prohibiting transcription for essential gene function. However, such methods become inefficient, as bacteria have mutated to block drug target sites while retaining lethality. An alternative method of antibacterial treatment is suggested

via the usage of sigma factors. Sigma factors are subunits of RNAP that are conserved within a multitude of bacterial species and bind to the promoter region of DNA once it has inserted itself into the clamp of RNAP. Sigma factors are categorized into two classes: One major unit called the primary sigma factor, which controls general functions of transcription, and others that are called alternative sigma factors, which control transcription of regulatory genes for survival (i.e. oxygen deprivation, pH spikes, temperature changes, etc.). It has recently been discovered that alternative sigma factors, when undergoing transcription, create a 15-nucleotide "code" which activates the sensitive genes mentioned above. Thus, by swapping these "codes" using mutagenesis and testing for results using Cryo-Em protein imaging and testing of bacterial strains in vitro it is implied that the roles of the alternative sigma factors can be affected as well. It is hypothesized that this method would be able to change the specificity of certain sigma factors. If successful, such regulatory transcribing sigma factors may be able to inhibit bacteria from activating key genes for survival under specific conditions and thus eliminate needs for a new antibacterial drug.

Krista Collins
Professor Mehmet Uzumcu
Effects of Endocrine-Disrupting Chemicals on the Female Reproductive System

Endocrine-disrupting chemicals (EDC) are substances found in our everyday environment in plastics, fertilizers, and medical devices that mimic or oppose the actions of hormones. Phthalates are a type of plasticizer known to have properties of EDCs. One of the most common phthalates is di-ethylhexyl phthalate (DEHP) with known anti-androgenic effects. Since harmful effects of DEHP were shown in males, di-isononyl phthalate (DINP) is being proposed as a replacement. However, relatively little information is available for the effects of DEHP or DINP in females. We exposed female rats to 24 µg to 240 mg/kg DEHP or DINP infused in Nilla Wafer daily between embryonic day (E11) and postnatal day 7 to study the effects on the ovary and female reproduction. Analysis of various growth and reproductive parameters between PND1 and PND50-60 and ovarian follicular analysis between PND50 and 60 showed no statistically significant effects. To determine whether the effects were more apparent in aged animals, reproductive cyclicity and litter size were analyzed around one year of age. We observed irregularity of estrous cycles in females treated with the highest doses of DEHP or DINP. However, the litter size results were too variable even in control animals. The lack of effect at early age could be due to possible dosing inconsistencies and the route used. In future studies, oral gavage will be used to ensure full dosage of the phthalate. In addition, to ensure the observation of an effect, a higher dosage will be administered for use as a positive control.

Arielle D'Elia
Professor Stephen Garofalini
Battery Membranes: Atomistic Behavior of Organic-Inorganic Interfaces in Solution

A battery separator is a permeable membrane which allows rapid ion transport between the cathode and anode. There are various substances that can be used in membrane composition – one option being silica, often in combination with a polymer support. Using molecular dynamics computer simulations, we studied the molecular interactions associated with adding hydrocarbons, specifically methyl, at the silica surface. A key focus was to understand the effects of water and temperature on this inorganic-organic combination. We performed atomistic structural evaluation of a single united methyl molecule on both dry and hydroxylated crystalline silica surfaces at 1, 100, and 298 Kelvin. Comparisons among surfaces indicate that the water has a significant effect on the adsorption energy and the diffusion behavior of the methyl. In particular, diffusion was evident at the higher temperatures; otherwise, the methyl adsorbed onto the silica surface. We conclude that both water and temperature are important factors in the bonding relationship between methyl and silica, as well as the diffusive properties of the methyl.

Nidhi Desai
Professor Zhiping Pang
Role of μ-Opioid Receptor A112G SNP in Mesolimbic Reward Neurocircuitry

Opioids, powerful analgesic compounds, have been responsible for the recent addiction epidemic, which poses a tremendous socioeconomic burden. Opioids act on the μ-opioid receptor (MOR) to activate the mesolimbic reward circuitry, which controls reward, pain, and addiction. Previous studies indicate that natural genetic variation in humans, i.e. the A118G single nucleotide polymorphism (SNP) in OPRM1, the gene encoding MOR, has played a significant role in the regulation of pain and analgesia. To study whether the A118G SNP in MOR influences sensitivity to opioid drugs through acute and chronic administration of morphine, we used genetically engineered mice, which carry the A112G SNP (homologous to human A118G). We tested mice with different genotypes, AA (wild-type) and GG (transgenic), in a single-dose morphine administration experiment as well as a weeklong morphine-induced conditioned place preference experiment and observed the effects of morphine, an opiate, on mice behavior. In order to understand how the reward pathway is involved, we looked at the activity of dopaminergic neurons in the ventral tegmental area (VTA) projecting to the nucleus accumbens (NAc) medial shell. Overall, AA mice show higher locomotor activity compared to GG mice after morphine administration. Our results from the behavioral testing indicate that in mice, the A112G SNP in MOR may decrease sensitivity to opioids. Understanding the role of MOR with respect to its various genetic variations may provide more insight into the neurobiology of opioid dependence and addiction in humans.

Sheri Elsaker
Professor Nicole Fahrenfeld
Microplastics in Bed Sediments of the Raritan River

Plastic particles smaller than 5mm are emerging contaminants in freshwater bodies, including the Raritan River. Some believe that tons of microplastics have already and are continuing to infect our waters. The microplastics may be primary microplastic from personal care products or secondary microplastic, for example, from broken down litter. While the presence of microplastics in the Raritan River and Bay has been demonstrated, the factors controlling their fate, including settling, are poorly understood. To gain insight on the distribution of these types of microplastics in the bed sediments of the Raritan River as a function of distance from known sources (wastewater treatment plants, WWTP), bed sediments were sampled along transects upstream and downstream of two WWTPs. Samples were separated by size class (250-500,500-2000 μm). Plastics were recovered by density separation and wet peroxide oxidation prior to quantification. The chemical composition of the plastics were confirmed by FTIR. Microplastic concentrations in both size classes peaked at select locations downstream of the WWTP. Results indicate that settling may be an important control on microplastic fate in the Raritan River.

Benjamin Feng
Professor Rong Di
CRISPR-gene Editing of Arabidopsis Susceptibility Genes to Improve Powdery Mildew Disease Resistance

Powdery mildew is a widespread disease caused by different obligate fungal pathogens in many different plants. Studying the close interaction between powdery mildew fungi with their host plants has led to the identification of host susceptibility genes which can be precisely knocked out by the new CRISPR (Clustered regularly interspaced short palindromic repeats)-gene editing technology, rendering plants resistant to powdery mildew pathogen infection. Using Arabidopsis (Arabidopsis thaliana) as a model plant in this study, we have identified the following three genes related to powdery mildew susceptibility: Enhanced Disease Resistance 1 (EDR1), Mildew Resistance Locus O 2 (MLO2), and Lifeguard 1 (LFG1). We have cloned and sequenced the partial cDNAs and genomic DNAs of these three genes from A. thaliana, designed our plasmid constructs, and used the floral dip method using Agrobacterium tumefaciens to transform wild type A. thaliana to knock out these three genes. Through these methods we have potentially produced a triple gene knockout mutant plant. The next steps will involve validating the

mutations, selecting homozygous plants and testing resistance through powdery mildew inoculation and tracking parasitic penetration and plant resistance. The anticipated results suggest that a similar technique can be applied to crop plants for powdery mildew disease resistance to reduce financial loss.

Steven Ferrante
Professor Sunil Somalwar
Search for Evidence of Type-III Seesaw Mechanism in Multilepton Final States at CMS

The inability of the Standard Model to explain the smallness of the neutrino mass raises an issue that can be resolved by the seesaw extension of the current theory. This study presents a search for type-III seesaw signal in events with three or more leptons. This seesaw mechanism predicts heavy fermions that could balance out the unexplained small mass of neutrinos. The multilepton final states of these fermions are simulated as signal, combined with background generation, and compared to data from CMS. Both are plotted on various histograms with variables like momentum, mass, and number of jets. A significantly large incongruence between CMS data and signal + background generation indicates that there is no presence of seesaw signal in the data. The significance of the incongruence is determined by a 95% confidence level. Candidate masses of the fermion are ruled out when this 95% confidence level is reached. This study resulted in the exclusion of the existence of the seesaw fermion below mass 860 GeV. The future of this study includes the fine-tuning of other parameters of the simulation. It is also likely that more theories will be proposed, tested, and one hopefully established as an extension that fixes the light neutrino problem.

John Fuller
Professor James Miller
Examining Elevation and Climate Change in the Yenisei River Basin

Climate change poses an imminent threat to the human species and to the many different ecological systems in the regions that it affects. Understanding the nature of climate change in high elevation regions is of great importance, as mountains are the source of much of the world's supply of surface water. This project examines the largest river system that flows into the Arctic Ocean, the Yenisei River Basin in Siberia, Russia. The data used is from CMIP5, a standardized collection of global climate models from universities and governments around the world. These models simulate the Earth's climate with mathematical equations based on the laws of physics, which are applied to the cells of a three-dimensional grid that cover the Earth's surface and atmosphere. Several studies examining this data reported finding elevation-dependent warming trends, with areas of comparatively high elevation warming at greater rates. This analysis shows that the Yenisei River Basin's latitude is the greatest predictive factor of mean annual warming during the 21st century, with higher-latitude regions undergoing greater warming.

Mariya Galochkina
Professor Kenneth Miller
North Atlantic Sea Surface Temperature Variations During the Miocene, 15-8 million years ago

The Middle Miocene Climatic Optimum (MCO) was a period of global warming spanning roughly 17 to 14.7 million years ago followed by a period of global cooling and the formation of a permanent Antarctic ice sheet. However, little data from this interval exists regarding sea surface temperatures of the North Atlantic which plays a key role in controlling ocean water circulation and global climates. An important feature in the modern ocean is the presence of a thermocline, where a sharp decrease in temperature separates the warm ocean surface from the near-freezing deep waters. The thermocline is important in the cycling of carbon, affecting both primary productivity and atmospheric CO2. This study reconstructed surface and thermocline temperatures of the North Atlantic during the MCO and the subsequent cooling period by analyzing floating oceanic microorganisms known as planktonic foraminifera for stable isotopes through a mass spectrometer. The three species of foraminifera analyzed were D. altispira and G. quadrilobatus (surface dwellers), and G. venezuelana (thermocline dweller), from Site 558 taken from the bottom of the North Atlantic Ocean. The carbonate tests of these organisms are useful in determining

paleoclimates because they calcify at the same isotopic ratios of δ13C and δ18O as the surrounding water, effectively preserving the conditions they lived in. The results show that the thermocline-dwelling foraminifera recorded a larger temperature decrease than the corresponding surface dwellers, which coincides with the final expansion of the Antarctic ice sheet at 12.8 Ma, indicating the formation of a distinct thermocline.

Rikab Gambhir
Professor Mitsunori Denda
How Can We Model Insect Flight Quickly and Accurately?

The analysis of unsteady flight through computational fluid dynamics using established methods such as the Finite Volume Method have been shown to be prohibitively expensive, motivating the development of a simpler method of analysis. Such algorithms are essential to simulations that model airplane and drone flight, and better simulations can lead to more efficient flight technology. A newer method, the Discrete Vortex method, has demonstrated success in improving computation time without sacrificing accuracy. Instead of considering the entire fluid domain, as in the Finite Volume Method, the Discrete Vortex Method only considers relevant localized air vortices within the domain. Previous implementations of the Discrete Vortex Method, using software such as MATLAB, while still faster than the Finite Volume Method, have the potential to become much faster. By carefully modifying existing implementations of the Discrete Vortex Method from MATLAB into the C++ language, we were able to generate force data that qualitatively agrees with both measurements and other simulations. Additional optimizations, including the use of an object-oriented programming approach rather than a matrix approach were employed. The end result was a simulation capable of modeling the flight of insects magnitudes more quickly than existing implementations. This suggests that the Discrete Vortex Method is the optimal tool for unsteady flight analysis, and has enormous potential to facilitate the development of flight technology.

Niranjana Ganesh
Professor Chirag Shah
Advancing Crowdsourced Social Media Data Analytics with SOCRATES

The amount of social media content on the web is growing exponentially. However, the sea of potentially useful data remains largely untouched by the common researcher. InfoSeeking's tool, the SOcial and CRowdsoured AcTivities Extraction System (SOCRATES) can make online data more accessible. By restructuring SOCRATES, a platform for social media data collection, analysis, and evaluation, to be more user-friendly, the tool can better serve its purpose as a framework for data-mining and discovery. SOCRATES was developed using Python for the back-end of the application and JavaScript, HTML, and CSS for the front end. The main new functionalities include the ability to export data as a CSV file, save the user's workflow to a database, and share the workflow with others so that experiments can be easily reproduced. As a result of these enhancements and bug-fixes, SOCRATES is more intuitive and applicable to real-world projects. The changes move SOCRATES closer to our goal of creating a space for everyday researchers to gather, analyze, and represent social media data collaboratively.

Roselyn Giordano
Professor Changlu Wang
Effects of Color Contrast on Bed Bug Locomotion Behavior

Bed bugs, Cimex lectularius L., tend to move towards sources of carbon dioxide, as they feed on human blood to survive. While it is known that bed bugs have an affinity towards specific colors, black and red, our understanding of how bed bugs perceive contrast in color is not known. The bed bug's preference to color contrast was measured using the trap catch of different colored devices, including completely black traps, completely white traps, black traps with white tape, and white traps with black tape in the laboratory. A few hundred bed bugs were released in each black or white arena. We set lures in the center of each trap to encourage the bed bugs to climb into the traps. Pairs of different colored traps were placed into each arena and the trap catch was recorded after six to seven hours. There were significantly more bed bugs in the black traps than in the white traps. In white arenas, the black traps with black tape

caught significantly more bed bugs than black traps with white tape; this difference disappeared in black arenas. These results suggest that when there is a color contrast, bed bugs were strongly oriented towards darker areas. Findings from this study suggest that when monitoring bed bugs in the field, black traps would be more likely to detect the presence of bed bugs than white traps.

Samantha Gong
Professor Janne Lindqvist
Usability Evaluation of Continuous Mobile Authentication

User security on mobile devices is an important issue in today's society as these devices are increasingly used for privacy sensitive applications such as mobile payments and emails. Traditional techniques such as fingerprint scanners, pattern unlock, and PINs only authenticate a user once when unlocking the phone. This allows unfettered access after the lock screen is passed. To address this issue, continuous authentication has been proposed as a method to repeatedly perform authentication checks on a person as they interact with their phone. These systems use a variety of method ranging from behavioral biometrics to context-aware applications. However, the usability of these methods has not been fully evaluated. Analyzing the data provided from previous work, we can see that many continuous authentication methods do not address how well the proposals function in practice. We worked on comparing continuous authentication methods to assess how usable the different methods are by evaluating false rejection and acceptance rates. Comparing the various active authentication methods, we learned that many of the methods have similar accuracy and error rates when participant feature sets are used against each other. Many of these systems do not directly test a user's interaction on their phone with another person's model. This makes it difficult to make conclusions on usability among different authentication methods. This creates uncertainty about the efficiency of continuous authentication whether it is user-friendly.

Krishna Gotur
Professor Jonathan Singer
Application of Electrospray Deposition in Patterning Nanoparticles

Electrospray deposition is a method for building thin films and selective nanostructures by means of electrically charging droplets. In electrospray deposition, nanoparticles are dissolved into a solution, which is sprayed from a nozzle held at a very high electric potential. The resulting aerosol droplets repel one another as they travel down to the substrate, allowing for the production of uniform structures. Electrospray deposition is a cheap, effective, and versatile process, making it the object of much study. Of particular interest is the possibility of using electrospray deposition to pattern nanomaterials; in other words, using it to deposit nanoparticles in selected arrangements. Micro-arrangements of various nanoparticles were prepared via electrospray deposition. The first nanoparticle solution was sprayed onto a conductive substrate coated with a dielectric polymer. The charges were allowed to dissipate before the sample was sprayed with a second nanoparticle solution. The structures were observed using scanning electron microscopy. The objective of these experiments was to have the primary particles pattern electrically due to their charges, then have the secondary particles pattern topographically due to the pre-existing nanoparticles. Electrical patterning was observed from the first sprays, but topographical patterning was difficult to produce. In order to ensure proper patterning, an understanding of droplet behavior was necessary. To this effect, an investigation into the evaporation of electrosprayed droplets was also conducted. Fluids with high boiling points were sprayed and allowed to evaporate. The droplets were observed using optical microscopy and were seen to divide uniformly as they evaporated, unlike uncharged droplets.

Liam Hiester
Professor Bonnie Firestein
Effects of Overexpression of Cytoplasmic PSD-95 Interactor on Distribution of the Beta-7 Subunit of the Proteasome

In this study, we examine the functional consequence of the interaction between the beta-7 subunit of the proteasome and cytoplasmic postsynaptic density-95 (PSD-95) interactor (cypin), a protein involved in dendritic branching. Cypin increases dendritic branching by promoting microtubule assembly and it decreases PSD-95 localization at the synapse. Additionally, preliminary co-immunoprecipitation data suggest that cypin interacts with the beta-7 subunit of the proteasome. To understand the significance of this interaction, we assessed the effect of cypin overexpression on proteasome distribution in cultured hippocampal neurons. On day in vitro (DIV) 7, we transfected hippocampal neurons with cDNA encoding pEGFP-N2-B7 and pDsRed2-C1 or pDsRed2-C1-cypin and imaged the neurons post-fixation with fluorescence microscopy. Utilizing a custom ImageJ macro, we measured the density of beta-7 subunit fluorescence from the soma of the neuron outward using area measurements inside of incremented concentric circles in control neurons expressing DsRed2 or neurons overexpressing DsRed2-cypin to examine changes to proteasome distribution. In addition, we investigated the co-localization of beta-7 and PSD-95 using a custom ImageJ macro. Analysis of preliminary data shows no significant difference in the distribution of the proteasome in response to an overexpression of cypin. Thus, cypin may act to regulate proteasome activity in a manner that is distinct from proteasome localization. Current studies will address cypin action on the proteasome.

Jay Joshi
Professor Kim McKim
Understanding the Role of the Chromosomal Passenger Complex in Meiotic Spindle Assembly in Drosophila Oocytes

Meiosis is crucial for sexual reproduction, mistakes in which can result in aneuploidies, leading to miscarriages, infertility and developmental disorders. The chromosomal passenger complex (CPC) is important in female meiotic spindle assembly, which in turn is pivotal for proper meiotic function. By targeting the CPC to different sites, we aim to study the function of the CPC in meiotic spindle assembly. In Drosophila melanogaster oocytes, the wild-type CPC localizes at the central spindle, centromere and chromosome. Pervious experiments reveal that the central spindle does not form when the CPC is targeted to the central spindle and the centromere; however, the effect of targeting the CPC at the chromosome is yet to be tested. Therefore, we created two transgenes, HP1-Incenp and Borealin-Incenp to test the hypothesis that HP1 and Borealin mediate the CPC's interaction with the chromosome to result in the formation of the central spindle. The transgenes were injected separately in Drosophila embryos and we conducted genomic mapping to identify the chromosome on which the genes were inserted. In addition, we tested five HP1 RNAi lines to ascertain each line's RNAi efficiency and its effect on X-chromosome nondisjunction. We also carried out a yeast-2-hybrid experiment to test if INCENP interacts with Subito, a kinesin 6 homolog thought to help the CPC localize to the central spindle. Future projects will look to perform cytological analysis of HP1-Incenp and Borealin-Incenp oocytes, as well as analysis of HP1 RNAi lines with low fertility and high nondisjunction percentages.

Diljeet Kaur
Professor Eddy Arnold
Optimization of T7 RNA Polymerase Purification for in Vitro RNA Production

The initiation of human immunodeficiency virus-1 (HIV-1) reverse transcription requires the formation of the Reverse Transcription Initiation Complex (RTIC), which consists of HIV-1 reverse transcriptase, viral RNA, and the primer tRNA-Lys3. The molecular structure of the RTIC may be a good drug target but has not yet been determined. Solving it requires the ability to efficiently purify T7 RNA Polymerase (T7 RNAP), which can be used to transcribe RNA in vitro. The M15 cell line, which has traditionally been used for the purification of T7 RNAP, contains various proteases, which may affect T7 RNAP production. The BL21 cell line, however, is deficient in ompT, an outer membrane protease that cleaves T7 RNA polymerase during purification. Therefore, this study was conducted to investigate whether the BL21 cell line could produce a higher yield of more active T7 RNAP than the M15 cell line. To do so, T7 RNAP was concurrently purified from both BL21 and M15 cells. The samples were run on a SDS-PAGE gel and were further purified with size exclusion chromatography. To test activity, T7 RNAP purified from both cell lines was used to transcribe tRNA Lys3 in vitro, and the products were compared on a Urea-PAGE gel. The results

indicated that BL21 cells produced a 188% higher yield of T7 RNAP than M15 cells. Further, the M15 cells also produced a nicked T7 RNAP, although this did not affect its activity. It was concluded that the BL21 cell line is more optimal for the purification of T7 RNAP.

Grant Kenny
Professor Laura Fabris
Synthesis of Au Nanoparticles for the Catalytic Enhancement of MoS_2 Nanosheet Coated Electrodes

Thin nanosheets of Molybdenum Sulfide (MoS_2) on electrodes provide an extensive increase in the catalytic activity for the hydrogen evolution reaction (HER). Gold nanoparticles, especially nanostars, have been studied for their localized surface plasmon resonance, which have been observed to generate strong localized electric fields. By depositing gold nanoparticles onto MoS_2 nanosheet coated electrodes, it is suggested that even greater catalytic activity for the HER can be achieved while decreasing the applied potential. Gold nanoparticles of different morphology were synthesized, deposited onto MoS_2 coated electrodes and then tested for the minimum potential required for the HER to occur as well as the reaction's rate. Preliminary results show that both the morphology of the particles as well as the surface chemistry affect the catalytic activity of the MoS_2 nanosheet coated electrodes. Nanoparticles with pronounced endpoints or tips, such as the nanostar, provide a measurable decrease in the overpotential needed for the HER to occur, whereas particles such as nanospheres with no tips or endpoints provided less of an effect. However, nanorods, which are formed with the addition of a surfactant, CTAB, actually decrease the catalytic activity of the system and increase the potential required for the HER, suggesting that the CTAB coating of the nanorods screens the MoS_2 layer beneath. These results suggest that MoS_2 nanosheets with integrated gold nanoparticles could play an important role in improving catalytic activity for the HER, potentially improving the viability of hydrogen generation for use as an alternative fuel source for existing fossil fuel based methods.

Laura Kershaw
Professor E. Koray Akdogan
Tricritical Phenomena in Ferroelectrics for Solid State Nanoelectronics: Nonlinear Elastic Coupling of Polarization-strain

Ferroelectrics are ultrahigh permittivity nonlinear dielectrics in which polarization can be controlled by an applied electric field. These materials are used in nanoelectronic device applications such as random access memories (RAM), multiferroic memory devices, electro-optic devices, to name but a few where are least one dimension of the system is well below 100 nm. In such devices, the ferroelectric of interest suffers ultrahigh elastic strains for which the linear theory of elasticity does not hold. Here, we introduced a new fundamental correlation between nonlinear elasticity and tricritical phenomena in ferroelectrics with which we formulated a self-consistent theory that is based on the Landau-Ginzburg-Devonshire formalism. Specifically, we implemented a 1D model and have successfully shown that tricritical phenomena can only be explained by considering at least third order nonlinear elastic coupling of primary (polarization) and secondary (strain) order parameters in the context of Landau theory. We developed comprehensive MatLab codes from which temperature and higher order strain dependence of second and fourth order Landau coefficients were computed. Furthermore, we define a new critical strain which shows that the paraelectric-ferroelectric transition temperature and tricritical temperature can indeed merge by virtue of nonlinear elastic coupling between polarization and elastic strain at which point one expects ultrahigh dielectric and piezoelectric properties.

Maha Khan
Professors Nilgun Tumer and John McLaughlin
Growth Inhibition of Fusarium graminearum in Wheat Plants Exposed to Volatiles

The pathogen Fusarium graminearum can cause Fusarium Head Blight (FHB) in wheat plants, a staple plant, through the contamination of the roots, leaves, and flowering parts of the plant, leading to a lower crop yield. Specifically, FHB introduces mycotoxins to the grain of the wheat plant, the part humans and animals ingest in food products. This study aims to use Green Leaf Volatiles (GLVs), which are naturally

occurring aldehydes from plants, to reduce or inhibit the growth of the fungus fusarium graminearum. GLVs are produced by plants as a defense mechanism when they are wounded or attacked by other organisms. The GLV's antibacterial properties and ability to activate plant defenses suggest that they can help inhibit fusarium growth on wheat plants. To investigate this, an assay was set up where wheat plants with fusarium graminearum spores were exposed to different concentrations of the volatile. Results show, at a concentration of 10 ppm of the volatile, the fusarium growth was decreased by 75% when compared to the control. These results show that the presence of the volatile at high concentration significantly decreased fungal growth. With further experiments we hope to find a way to completely inhibit fungal growth by experimenting with the amount of time and number of volatile exposures. Overall, the work being done can help increase crop yields, sustain agriculture for years to come, and boost economic exports.

Amanda Lee
Professor Lena Brattsten
The Practicality of Eating Insects Indirectly as a Sustainable Protein Source

Massive livestock production for meat consumption is an unsustainable practice due to greenhouse emissions and diminishing land space. A possible alternative is producing protein powders from common insects such as adult field crickets and earwigs (Dermaptera) to incorporate in various foods. Though not usual in the United States, several other cultures are already familiar with insects in their diet. The process of developing such powders requires the comparison of the protein content of insects of interest and conventional animal protein sources such as chicken. Dry masses of insect tissue are obtained by freezing and dehydrating insect specimens. Each is made into a solution using chemical detergent which lyses cells to release their protein. Chemical indicators for protein are used in the solutions and a spectrophotometer measures the absorbance, which is relative to protein content. The results suggest that insects in the Dermaptera order have the highest percentage of protein content, potentially more so than beef and chicken breast. Further research may reveal specific characteristics in insects, such as feeding habits, correlating to high protein content which leads to maximizing protein in the powder. The implications for business are huge. Once people overcome their prejudice of insects as food, a currently underutilized source of protein will enter the Western market. Insect production demands less land space and less food supply, suggesting that the powder is an appropriate and sustainable source of protein.

Shunyao Lei
Professor Li Cai
Spinal Cord Injury Induces Endogenous Neural Stem Cell Activation in Transgenic Mouse Model

Cell transplantation is a promising therapy for spinal cord injury (SCI), but there are multiple obstacles (e.g., immune rejection and functional integration) to translating these techniques to the clinic. Neural stem cells (NSCs) persist in the adult spinal cord and represent a potential source of neural cells for tissue regeneration and wound healing after injury. However, due to the lack of complete understanding of the molecular mechanism underlying injury-induced NSC activation and neurogenesis, the potential of NSCs for neuroregeneration cannot be fully harnessed. In this study, I determine the rate of NSC activation using a SCI model on Notch1CR2-GFP transgenic mouse. In this animal, the activity of Notch1 enhancer CR2 is exclusively in NSCs during central nervous system development. I found that there is a significant increase in the number of GFP+ cells at the site of injury from 1 day post-injury (dpi) to 14 dpi as compared to the sham animals. This finding indicates that SCI induces NSC activation and neurogenesis in the transgenic mice, and further validates the usefulness of the animal model for SCI study. Our future research will determine the cellular identities of injury-induced GFP+ cells and molecular mechanism underlying NSC activation.
1. Zhang et al., Science (2010) 328: 240-243

Saleha Minhas
Professor Richard Ludescher
The Use of Luminescent Flavanols to Measure Water Activity

Flavanols are common luminescent chemical compounds that occur in high concentrations in fruits and vegetables. Photoluminescence occurs when a molecule emits light after it has absorbed photons. This can be a useful tool to measure changes in the local environment. Previous research has indicated that the fluorescence of flavanol solutions should be sensitive to the amount of water. The amount of water can be quantified in terms of the water activity, which varies from 0 meaning no water to 1 meaning pure water. We hypothesize that the fluorescence properties of flavanol solutions are sensitive to water activity. We tested this by changing water activity using salt solutions of various concentrations. We utilized 4 molal solutions of ammonium sulfate and potassium acetate, and diluted these with water by increments of .5, to create concentrations of 3.5, 3, 2.5 down to 0 molal. We then placed the flavanols which were in an ethanol solution at a low concentration into the salt solutions. We used two different flavanols: 3-hydroxyflavone and fisetin. We then collected luminescent spectra using a fluorometer and collected absorbance data using an absorbance spectrometer. Analysis of the luminescent spectra shows that there is no repeatability within the data. The same experiment repeated different days would yield different results, which demonstrates that these flavanols cannot be used as indicators of water activity in the current solvent system. The next step is to determine why this occurs. It is possible to repeat this experiment with different salt solutions and different flavanols.

Bharath Nagaraj
Professor Barth Grant
Using Genetic Cloning with GFP and TagRFP to Visualize the Hypodermis of C. elegans

Endocytic recycling, or the ability to return macromolecules to return macromolecules to the cell surface from endosomes, is a very important cell process that can be used in the field of biomedicine. In this project, molecular cloning, or the process by which recombinant DNA is created, was used in order to create recombinant C. elegans, a model organism. These C. elegans can then be used to visualize the hypodermis and study endocytic recycling that occurs in that region of the organism. In this experiment, I used GFP (Green Fluorescent Protein) and TagRFP (Red Fluorescent Protein) and inserted two hypodermis specific promoters—lin-26 and hyp-7—in order to visualize C. elegans at the hypodermis. The insertion of the two promoters was done using Gibson Assembly and the products were then verified to have the correct inserts through gel electrophoresis and sequencing. These constructs were then injected into worms and were visualized through a microscope. The genetically engineered organisms can then be used to study the endocytic recycling pathway in the hypodermis of C. elegans. This study will provide new insights into how endocytic recycling works and may hold an answer to diseases that are related to problems in the endocytic pathway such as cancer and diabetes, which affect millions of people worldwide. Further studies may consider using different promoters to see expression in different parts of the organism as well as study the change in expression over different stages of C. elegans development.

Vallab Nayak
Professor Kang Li
Development of an Efficient Humanoid Robot using Machine Learning

Inside a closed system, developing robots is straightforward and can be incredibly cost-effective. However, our world is designed for humans, where we have steps instead of linear lifts, and streets instead of conveyor belts. For robotic automation to succeed, there must be a transition where robots are designed to navigate and operate efficiently in a human environment. And it is efficiency, both in terms of performance as well as cost, that is critical to the sustainability and commercial and consumer adoption of advanced robots. Our goal is to develop a bi-pedal humanoid robot that uses machine learning to navigate, balance, and perform other human-like functions. Unlike existing humanoid robots, we use two-stage machine learning to enable the robot to naturally make its algorithms incredibly efficient. A side effect of this is no technicians will be required to adjust the humanoid for different

payload configurations. The humanoid will understand balance much better and will eventually be able to quickly adapt to any configuration. Currently, we are implementing the navigational algorithms we plan to use on the humanoid, on a test bot. This robot will be able to autonomously navigate point to point on Busch campus and will become more efficient after every run. Essentially, we are utilizing the same natural phenomenon that enables human learning in the humanoid and our test bot. We hope this makes advanced human-like robots more efficient and less dependent on traditional robotic hardware like sensors and more dependent on cameras, just like their human counterparts.

Tiago Neto
Professor X.F. Steven Zheng
Knockout of Rab1A in Relation to mTOR Activity and the Growth of Colorectal Cancer and Melanoma Using Mice as Model Organisms

Mammalian Target of Rapamycin (mTOR) is a kinase in the PI3K/AKT cellular pathway that is essential to the control of cell growth and metabolism. mTOR stimulation has been linked to high oncogenic activity in a variety of cancers. Rab1A is a signaling protein that has been identified to use amino acids to interact with mTOR in the Golgi Apparatus and whose overexpression is reported to be directly correlated with mTOR overactivity and oncogenic potential. This study has two stages, the first of which uses a conditional tamoxifen-inducible knockout system with which we will determine the appropriate amount of tamoxifen to inject into a mouse subject so that mTOR activity is diminished without significantly reducing the subject's lifespan. During this stage, we will identify phenotypes in Rab1A knockout mice that are not present in wild type mice and measure the knockout efficacy. The second stage involves data collection of Rab1A knockout mice that are inoculated with colorectal cancer (CRC) and highly metastatic melanoma. We will determine the effectiveness of the knockout by measuring the growth and metastasis of cancer tissues. If our results match our expectations, the data would suggest that localized gene suppression may be a potential treatment option for intestinal and other types of cancers.

Daniel Nonna
Professor Ashutosh Goel
Understanding Composition, Structure, and Chemical Durability Relationships in Mixed Network Former Glasses

Our understanding of the chemical durability of glasses has advanced from simple composition dependent (analytical or geochemical) models to those based on composition-structure-property relationships. This evolution has been driven by the idea that the understanding of relationships between chemical composition of glasses and their structure at atomistic level will help us in unearthing the fundamental mechanisms of glass corrosion. However, despite the ongoing strenuous effort in this direction, we are still not in a position to develop scientifically robust and statistically accurate models to predict the chemical dissolution behavior of glasses based on their structure-property relationships. We aim to combine the strengths of experimental studies and molecular dynamic (MD) simulations to understand the connection between composition, molecular structure, and dissolution behavior of mixed network former glass systems. In this pursuit, glasses in the system Na_2O-Al_2O_3-B_2O_3-SiO_2 have been synthesized and studied for their structure using various spectroscopic techniques while their chemical dissolution behavior has been studied in aqueous solutions as a function of pH in the neutral to alkaline regime. An attempt has been made to correlate the molecular structure of these glasses with their corrosion behavior. Further work will include the Na_2O-P_2O_5-B_2O_3-SiO_2 glass system; we aim to combine our efforts in multiple mixed network forming glass systems to further understanding of their corrosion behavior for fields such as nuclear waste management and bioactive materials.

Kenza Oualim
Professor Kimberlee Thamatrakoln
Study of the Correlation Between Oxidative Stress and Infection Dynamics

Phytoplankton deliver about half of the oxygen present worldwide, and within the phytoplankton population the diatom produces an astounding 20% of the oxygen we breathe. This project focuses on

the interaction between diatoms and viruses, specifically the link between oxidative stress and infection dynamics. Oxidative stress occurs when there are high levels of reactive oxygen species (ROS), which are molecules that contain oxygen and are extremely harmful to cells by incurring damage through oxidation. In response to ROS, diatoms possess antioxidative enzymes which quench ROS levels. Based on other phytoplankton-virus systems we hypothesize that oxidative stress plays an important role in diatom-virus dynamics, whereby the antioxidative system may be reducing viral infection. To observe this we manipulated the level of oxidative stress by using iron limitation and hydrogen peroxide, and tested this with CtenDNAV Type I (chaetoceros tenuissimus). We first induced iron limitation by controlling the bioavailability of Iron EDTA. Second we ran an infection under iron limitation and found that infection was prolonged. Lastly we added hydrogen peroxide, a type of ROS, to upregulate the antioxidant system prior to infection. Cell density, Photosystem II fluorescence, ROS production and chlorophyll level data was collected. Ultimately, the data collected suggests that there is indeed a correlation between oxidative stress and diatom-virus dynamics.

Elizabeth Park
Professor Spencer Knapp
Synthesis of Novel Anti-malarials involving Tetrahydrobenzonaphthyridines

Nearly half of the world's population is at risk of malaria with 91 countries and territories suffering from endemics in 2016. Currently, artemisinin-combination therapies are the standard treatment against Plasmodium falciparum, the most common protozoan parasite responsible for malaria. However, due to resistances developed by the parasite, treatments are becoming increasingly less effective which necessitates the development of novel drug candidates. Previous hit-to-lead studies yielded a tetrahydrobenzonaphthyridine scaffold with antimalarial activity. These antimalarial compounds must be water soluble, metabolically stable, exhibit no cytotoxicity to human cells, and inhibit the parasite through protein binding. In order to test structure-activity relationships that optimize the lead compound for inhibition of the Plasmodium parasite, a series of modifications to the amine functional group were introduced, varying from benzyl and butyl derivatives to various heterocycles. A four-step synthesis process was used, starting with isatin and N-Boc-piperidone to yield the tetrahydrobenzonaphthyridine core structure that was further reacted with anilines to form the bioactive carboxamides. After deprotecting to expose the secondary amine, a series of reductive alkylations using a variety of aldehydes were done to create a series of N-substituted analogs. These N-substitutions were chosen to increase activity and water solubility for oral availability while keeping the molecular weight below 450g/mol. Biological testing with the compounds will reveal effectiveness of the compounds as well as structural patterns that can be further investigated. By characterizing and observing a series of potential antimalarial agents, development of more candidate drugs can continue and hopefully lead to an effective cure.

Sophia Pastore
Professor Xiang Liu
Risk Mitigation Strategies of Flying Ballast on High-Speed Rail

Ballast flight is one of the most commonly observed phenomena in rail safety, especially given the increased development of high speed rail (HSR) lines. Flying ballast is a safety concern that can cause damage to train cars and wheels, or even injure workers near tracks. There are several methods to quantitatively assess the probability of ballast flight. The objectives of this paper are to discuss the potential risk mitigation strategies, as well as to apply a risk analysis on HSR lines to propose the best methods to mitigate the risk. The strategies include setting reasonable speed limits, ballast bagging, lowering ballast profile, and increasing the number of ties per mile. Generating probability distributions for each mitigation technique allows for the comparison between each method and its corresponding location. From these comparisons, it becomes evident that ballast bagging is the most efficient method, followed by decreasing the distance between ties. This can be explained by the influence each method has on the risk factors. Ballast bagging totally prevents flight, and decreasing the distance between ties reduces the pressure areas formed beneath the train.

Mykhalo Petrovskyy
Professor Torgny Gustafsson
Investigation of Thin Film Stress by a Novel Stress Measurement Method

Physical stress in semiconductors significantly affects the performance of the device. The purpose of this investigation is to measure the physical stress at the interface of SiO2/SiC structures using a novel stress measurement method. This is significant for not only understanding defect formation but in also understanding its structural reliability. We used a novel laser measurement device to accurately measure the curvature of the substance at various stages of production to an accuracy of 4*10^-6 m (a task that was very difficult to do beforehand). The novel laser device works by combining the effects of laser diffraction and interference to carry out the measurement of sample curvature. Stress levels were then successfully calculated in the thin film using Stoney's equation. The results show stress of the magnitude of 108Pa is induced in SiO2 film during its growth. The findings are important because they give researchers a better understanding of the stress properties in SiO2/SiC samples. Such properties are significant for commercial and scientific purpose due to its critical role in material and mechanical science and technologies. Quantifying such stress enables us to control the quality of film and hence the quality of film-based devices.

Archana Raghunath
Professor Gleb Shumyatsky
Assessment of Stathmin-Dependent Microtubule Stability in Depressive-Like Phenotype of Postpartum Mice

Stathmin, a phosphoprotein crucial to microtubule stability, is related to anxiety and social behavior. Previous research has shown that Stat4A, a constitutively active, mutated form of stathmin, is expressed primarily in the dentate gyrus, basolateral amygdala, medial prefrontal cortex, and anterior cingulate cortex, and is linked to a depressive-like phenotype in postpartum mice. Our research aimed to understand which of these areas is responsible for characteristics of postpartum depression, such as depressive-like behavior and deficits in maternal behavior. Because Stat4A is highly expressed in the dentate gyrus, it is likely this area is responsible for postpartum behavioral deficits observed in Stat4A mice. To understand the neuroanatomy of postpartum depression, we used a strategy that involved adeno-associated virus mediated gene transfer primarily in the dentate gyrus to assess depressive-like behavior in postpartum mice. Female C57BL/6J mice were injected with virus AAV-DJ-Camk2a-HA-Stat4A, which induces expression of Stat4A, or virus AAV-DJ-Camk2a-eGFP, a control. After delivery, we subjected the mice to a set of behavioral tests, including those of maternal behavior, such as pup retrieval and nest building, and of depressive behavior, such as the sucrose preference test. Upon comparison of Stat4A mice and control GFP mice, we expect Stat4A postpartum mice to show depressive-like behavior, and to perform poorly in tests of maternal competency, suggesting the dentate gyrus is involved in postpartum depression. In the future, we expect to research the other three areas of the brain in which Stat4A is expressed, and further learn about the neural mechanisms of postpartum depression.

Varun Raghuraman
Professor Shishir Chundawat
Tuning the Affinity of CBMs to Cellulose by Modulating the Surface Charge Density

Carbohydrate bonding modules (CBM'S) are known to increase the concentration of cellulases near cellulose surface, thus enhancing the rate at which they deconstruct into soluble sugars. Adsorption of CBMs to cellulose is driven by hydrophobic and electrostatic forces. Previous work has identified the role of protein surface potential in CBM adsorption to cellulose. Our goal is to better understand the role of cellulose surface potential and its relation with pH in this phenomenon by TEMPO-mediated oxidation of cellulose. Oxidized avicel (cellulose) has a lower rate of binding possibly due to electrostatic repulsion between the protein and cellulose surface Utilizing multiple assays performed at different pH levels and protein concentrations, the effects of charging the substrate can be shown. The first few assays demonstrated that while the highly charged and uncharged cellulose substrate should show the least

amount of bonding, while the substrate with lesser charge showed a greater incidence of bonding, varying the pH changes this dynamic. Further examination of the exact point when binding is maximized is pending. The results suggest that a higher level of charge does repel proteins—however, the pH may play a role by restricting binding sites. Potentially, these effects could be harnessed to more efficiently produce biofuels.

Rohan Shah
Professor Kenneth Irvine
Investigating the Cellular Mechanisms for Organ Shape Control in Drosophila through Spindle Orientation and Wing Growth

Organ shape depends on the interaction between cell proliferation and cell arrangement during tissue development and can be further controlled by the orientation of cell divisions. This tendency is observed in the developing Drosophila imaginal disc, which is collected at the 3rd larval stage. Currently, more is known about the mechanisms regulating cell proliferation than about the processes responsible for cell distribution. However, we know that that the orientation of cell divisions in the wing are impacted by the Dachsous-Fat Pathway, a series of protein interactions leading to expression levels of transcription regulators and planar-cell polarity (PCP). It has been proposed that the wing shape is established by a bias in the mitotic spindle orientation, leading to growth along the Proximal-Distal axis. We used the strategy of knocking down various genes in the Dachsous-Fat Pathway by RNA interference (RNAi) in the developing wing and clones, and then comparing their shape at varying temperatures. Our results show that not only do Fat and Rhok genes promote normal wing shape while the Jub protein promotes roundness, but also that Dachs has non-autonomous effects on clone shape. This indicates that the orientation of cell divisions and specific protein interactions within the Dachsous-Fat Pathway play a key role in the imaginal discs and adult organs of Drosophila. With these results, we will begin testing whether cytoskeletal tension is responsible for the non-autonomous effects of Dachs and the roles of other proteins within the pathway.

Soham Shah
Professor Amrik Sahota
Crystal and Stone Formation in a Mouse Model for Cystinuria

Cystinuria is a genetic disorder that causes defective reabsorption of the amino acid cystine in the kidneys and high concentrations of cystine in the urine, leading to chronic cystine crystal formation in the urine of patients. While cystinuria can be managed, non-medical treatments such as drinking more water can be tedious and ineffective for some, and pre-existing medical treatments may bring about numerous unwanted side effects. Using a mouse SLC3A1 knockout model for cystinuria, we examined the concentrations of particular analytes in mouse blood and, using a microscope, counted the number of cystine crystals in the urine samples of the mice to check for differences between the knockout cystinuria mice and wild type “normal” mice. We also ran a CT scan to study if female mice form stones, and administered the drug LH708 to wild type mice to see if it causes renal damage. Firstly, we hypothesize that the concentration of analytes in the blood for both groups of mice will not be significantly different. Secondly, we hypothesize that knockout mice will have significantly more crystals in their urine compared to wild type mice. Thirdly, we hypothesize that the drug LH708 will not be toxic to the mice. Following the toxicity check, our next steps will include testing the drug for its effectiveness on reducing the number of crystals. As cystinuria is the most common inherited stone disease in children, finding a safe and effective drug would be a huge milestone in helping those suffering from the disorder.

Yunjung Shin
Professor George Carman
Structural Requirements of Yeast Pah1 Phosphatidate Phosphatase Function

Phosphatidate (PA) phosphatase, encoded by the PAH1 gene in yeast, catalyzes the penultimate step in the synthesis of triacylglycerol (TAG). The enzyme converts PA to diacylglycerol (DAG), which is then

converted to TAG. The DAG produced in the reaction can also be converted to membrane phospholipids. The Pah1 protein contains conserved (e.g., N-LIP and HAD-like motifs required for PA phosphatase activity) and non-conserved regions. In this work, we examined the physiological function of the non-conserved region at the C-terminal end of the protein. A series of Pah1 mutant proteins that lack amino acid residues at the C-terminus were constructed and expressed in a pah1Δ mutant lacking the wild type Pah1 protein. The function of the mutant protein was assessed by the ability to complement the temperature-sensitivity of the pah1Δ mutant at 16 and 37 oC, and ability to synthesize TAG. The analysis of various mutant proteins indicated that a region at the C-terminal end between amino acids 637 and 646 were required for Pah1 function in vivo.

Alexander Shu
Professor Debashish Bhattacharya
Linking Trends in Algal Adaptation of Physical Characteristics due to Environmental Changes to Gene Expression

The Imaging Flow Cytobot (IFCB) is an automated flow cytometer that takes images of cells from samples of liquid. I am in the process of manipulating the images generated by the IFCB using Matrix Laboratory (MATLAB) libraries custom made by Dr. Heidi Sosik at Woods Hole Oceanographic Institution, in order to form a neural network that will automate the classification of algae images taken by the IFCB using many different factors such as size, shape, and volume of the object. I have run several preliminary tests that indicate that in order to create a classifier that is able to correctly identify algae on a genus level at least 90% of the time one needs to create a training set of at least 200 images. In the future I hope to use the data of the physical attributes of specific model algae such as those of the genus Asterionella in conjunction with data from gene expression assays in order to map out what genes cause a change in the model organism's physical characteristics in response to the organism adapting to environmental pressures over time.

Christina Signore
Professor Tracy Anthony
Regulation of Mechanistic Target of Rapamycin Complex 1 (mTORC1) Signaling Following Asparaginase Exposure

The anti-leukemic agent asparaginase rapidly depletes circulating levels of asparagine and glutamine, activating hepatic phosphorylation of the translation factor eukaryotic initiation factor 2 (eIF2). Genetic deletion of the eIF2 kinase GCN2 prevents phosphorylation of eIF2 and allows for the inappropriate activation of the mechanistic target of rapamycin complex 1 (mTORC1) signaling pathway following asparaginase exposure. The objective of this study was twofold: to assess acute activation of another eIF2 kinase called PERK by asparaginase and to evaluate regulation of mTORC1 signaling following asparaginase exposure. In a series of time course experiments, wild type mice and GCN2 knockout mice were injected with asparaginase or saline excipient. A second cohort of mice were injected with tunicamycin, an inducer of ER stress, to activate PERK and then injected with asparaginase 30 minutes later. In both study cohorts, liver samples were collected at 15, 30, and 60 minutes after injection of asparaginase or excipient. Western immunoblotting showed that asparaginase alone did not acutely activate PERK in wild type or GCN2 knockout mice. However, activation of PERK by tunicamycin before asparaginase increased phosphorylation of eIF2 and rescued the hyperactivation of mTORC1 in the liver of GCN2 knockouts. These data suggest that auxiliary phosphorylation of eIF2 by PERK returns normal mTORC1 inhibition following asparaginase exposure.

Gary Simmons
Professor Aaron Mazzeo
Additive Manufacturing of Thermosetting Resins and Composites

This project aims to understand the spreading and curing kinetics of thermosetting polymers for applications including in-space additive manufacturing, additive manufacturing of soft robotics, and centrifugal coating. Although work exists modelling thermosetting polymers, the knowledge on dynamic

spreading and curing behavior of these types of materials is limited. In this work, we obtained rheological data on the complex viscosity and shear moduli of Ecoflex-0050 (Smooth-On) and G/flex 650 (West System) filled with 0%, 5%, 10%, 15%, 20%, and 25% carbon fiber by weight in order to verify the models. By using a 3-D printer built at Rutgers University, we also verified results obtained from numerical simulations, as well as produced test samples of the thermosets to perform characterizations including tensile strength and electrical conductivity. As the thermosets tested were very sensitive to change of temperature, we devised a temperature controlling system for the extrusion head to ensure the thermosets are in a thermally controlled environment; this system will attempt to keep the temperature of the printing materials at 25 +/- 1.0˚ C. After successfully verifying the models, we will be able to predict more accurately how thermosetting materials will spread and cure as functions of time and temperature, leading to improvement of additive manufacturing technology.

Sneha Sivaram
Professor Paul Falkowski
A Method of Photoacclimation in Phaeodactylum tricornutum

Diatoms are marine photoautotrophic eukaryotes. They are primary producers in the ocean and account for about a quarter of the earth's oxygen. While their physiology and molecular mechanisms has been studied extensively in the past ca. 70 years, their photophysiology and photoacclimation strategies are still not completely understood. Diatoms are known for their ability to quickly, and reversibly, adapt to changes in light intensity. Two known strategies of photoacclimation in phytoplankton are either changing the cross section of the photosynthetic unit or changing the number of photosynthetic units. This research attempts to look at the different effects of light regimes and intensity on the basic photophysiology of the model pennate diatom Phaeodactylum tricornutum. This is done by growth curves to determine growth rate, calculating chlorophyll per cell and protein per cell, and quantifying the number of major photosynthetic subunits and reaction centers by western blots. The results indicate that the different light regimes and intensities have some effect on the physiology and photoacclimation of this specific diatom.

Christopher Stephen
Professor Michael Verzi
Role of BRAF-V600E in Serrated Tumorigenesis

A variety of driver mutations are known to cause the onset of colorectal cancer. The serrated tumor pathway, unlike the conventional pathway of colorectal cancer progression, commonly involves mutations in the BRAF gene. The molecular oncogenic progression of serrated polyps is poorly characterized despite it occurring in around 10-30% of colorectal cancer cases. In addition to the lack of characterization, the prognosis of a patient with a progression of serrated polyps is distinctly worse due to the fact that current forms of chemotherapy are not effective at treating this form of the cancer. Activation of the mutated BRAF oncogene, BRAFV600E, not only inefficiently induces tumor formation in the intestinal epithelium, but also induces the loss of stem cells in the intestine of the available mouse models. Due to the constant renewal of epithelial tissue in the intestine, any mutation not existent in stem cells would be lost, thereby making stem cells the perfect vector for oncogenic mutations. This phenomenon is seemingly counter intuitive given that a tumor driver dependent on stem cells would cause the loss of stem cells, indicating that an unknown process must be responsible for allowing such a mutation to survive. Using the in vitro organoid system, the characteristics of the BRAFV600E mechanism can be studied without the many variables present in the in vivo models. With an established organoid system, the mutated gene can be expressed, and the effects of certain drugs can be tested against the BRAFV600E mechanism in order to better understand its physiology.

Aastha Suvarnakar
Professor David Margolis
Optogenetic Nerve and Muscle Stimulation in Awake Mice

Optogenetics is a technique in neuroscience in which channelrhodopsin-2 (ChR2), a light sensitive protein, is introduced to muscle and nerve cells and optically excited to incite motor functions and sensory responses. The mouse whisker system is a classic model system for investigating neural and behavioral aspects of sensory processing and motor responses. The whisker pad moves whiskers by protractions and retractions produced by intrinsic and extrinsic muscles. If mice will react to an evoked protraction with retraction and more whisking, then, with repeated trials, they may adapt and become less responsive because pulsed stimulation could modulate reactive whisking. We used head-fixed mice to study the whisker amplitude of protraction using a single 50ms light pulse followed by a phasic 10Hz or 100Hz light pulse for 1s. These movements were recorded using a high-speed video camera and analyzed using a whisker tracking software. Movements evoked during the quiet whisking period, when the mouse was not spontaneously whisking, paralleled the previously obtained anesthetized baseline data. During the active whisking period, when the mouse was already whisking, optogenetic stimulation was less effective as the mouse responded with either some degree of retraction or enhanced protraction. Both categories showed no significant adaptation to the stimulations. These results will help design future behavioral experiments using the differences between responsiveness within active and quiet whisking. The future use of non-invasive optogenetic stimulation could aid in recovery from motor neurodegeneration and nerve damage in clinical studies with respect to appropriate patterns of nerve and/or muscle stimulation.

Xiaofan Tian
Professor Judith Storch
Therapeutic Effects of Cyclodextrin Polymers in NPC Disease, a Lysosomal Lipid Storage Disorder

Niemann-Pick C (NPC) disease is a rare neurodegenerative disorder characterized by the abnormal accumulation of cholesterol in the endosome-lysosome compartment. It is caused by the malfunction or absence of NPC proteins (NPC1 or NPC2) which are thought to be the transporters of cholesterol out of the compartment. Previously, researchers found that a compound cyclodextrin (CYCLO) can effectively extract trapped cholesterol in diseased cells. However, CYCLO is tiny so that it is filtered out by kidneys rapidly. To improve CYCLO's poor bioavailability, we thread these ring-shaped CYCLOs on a long polymer to create big necklace-like compounds, which will stay longer in the circulation. We hypothesize that these compounds will be as effective as CYCLO monomers, and should have longer circulation times. To test their effects, I treated fibroblasts from a patient with NPC1-/- disease with these compounds. 24 hours later, a sterol-binding fluorescent dyes filipin and a cholesterol-binding cytolysin perfringolysin O* (PFO*) were used to stain and indicate the cholesterol accumulation in cells. The intensity of the stains were quantified by two methods in parallel: microscopy and flow cytometry. With both methods, the experimental groups showed a 60~50% cholesterol reduction, which is comparable to the effect of the same concentration of CYCLO monomers. Moreover, it was found that the efficacy of compounds is directly proportional to the number of CYCLO's in each polymer. In the future, by studying NPC disease, we will try to optimize the treatment for NPC patients, and explore the intracellular pathways of cholesterol trafficking in mammalian cells.

April Tong
Professor Mark West
Nucleus Accumbens Tone-Evoked Neuronal Activity During Relapse in Cocaine Addiction

Drug addicts worldwide suffer from dependency on cocaine, an addictive psychomotor stimulant that increases levels of extracellular dopamine in the mesocorticolimbic dopaminergic system. Dopamine neurons project via the Medial Forebrain Bundle, connecting the Ventral Tegmental Area (VTA) to the Nucleus Accumbens (NAc). Afferent signals from the VTA to the NAc have been understood to associate extrinsic stimuli with rewarding or aversive behavior. The Nac's crucial role in this process involves its key position as a gateway from the limbic system to the motor system. The interaction of increased NAc

dopamine with limbic signals from the amygdala regarding drug cues appears to induce neuroplasticity in the Nac. Therefore, it is essential to elucidate how relapse-inducing cues are processed by the NAc and then projected to premotor regions to execute drug-relapse behavior. Additionally, the roles that NAc core and shell subregions play in drug-paired reward association remain unclear. Thus, by utilizing a relapse centered self-administration paradigm, the present study aims to understand cue-induced neuronal activity in the NAc core and shell. Neurons were recorded via single-unit microwire-arrays in Long-Evans rats trained to self-administer intravenous cocaine. Firing Rate (FR) results demonstrate differences between cue processing in the core versus shell during cue-induced relapse to drug taking. Further differences in cue-induced NAc neuron FRs were observed between males and females. Ultimately, due to the powerful ability of drug cues to trigger craving and relapse in addicts, understanding Basal Ganglia processing of relapse-inducing cues may hold clinical value for prevention.

Dhruti Trivedi
Professor Mimi Phan
Effects of Statins on Auditory Memory and Imitative Learning

The increase in childhood obesity has led to increased incidence of hypercholesterolemia (high cholesterol) and other risk factors in children normally associated with adult cardiovascular diseases. HMG-COA reductase inhibitors (statins) have been recommended for the management of high cholesterol in children. However, oral statins may affect cholesterol synthesis in the central nervous system (CNS), disrupting brain growth and maturation. We have developed the zebra finch (ZF) as a model system to examine potential cognitive and neural effects of statins in juveniles and adults by assessing song learning, memory and performance on a Go/NoGo operant paradigm. The results of the study suggest that oral simvastatin treatment, given in therapeutic dosages chronically across development and into adulthood, produces deficits in learning and memory in adults. However, it is still uncertain whether these deficits are a result of chronic exposure to the statins or the fact that the ZFs were in the adult phase of life. To address this concern, we are now dosing 16 adult ZFs (8 vehicle/8 drug) for 120 days. If the ZFs in this experiment present with the same learning and memory impairments, we can conclude that these deficits were a result of adulthood, rather than a result of chronic exposure. If the ZFs do not prove to have the same deficits, we can conclude that chronic exposure to statins produces learning and memory deficits.

Cara Trulli
Professor Tony Kong
Potential Chemopreventative Properties of Phytochemicals Cyanidin, Malvidin, and Delphindin through Induction of the Nrf-2 Pathway

Anthocyanins, a class of flavonoids, are known to possess a variety of health benefits. Among the most prevalent are cyanidin, malvidin, and delphinidin, commonly found in cherries and berries. As antioxidants, these compounds have numerous potential applications in the prevention of diseases caused by oxidative stress, such as cancer and cardiovascular diseases. At this time, there is still limited knowledge on the precise mechanisms of anthocyanins; however, it is hypothesized that these compounds ameliorate cellular damage through the activation of the Nrf2-antioxidant response (ARE) signaling pathway, the master regulator of anti-oxidative stress and anti-inflammatory responses. MTS assay for cell viability was performed to establish a safe, non-toxic dose of each anthocyanin to be tested in Nrf2-mediated ARE-luciferase assay and qPCR. Based on MTS assay, malvidin was found to be largely non-toxic. Cyanidin and especially delphinidin were found to be more toxic to HepG2-C8 cells. Delphinidin and cyanidin showed a general increase in ARE luciferase activity while malvidin did not display as strong an increase. Sulforaphane (SFN), a known Nrf2 activator and positive control, reliably displayed a stronger increase in ARE activity at 5 μM and 10 μM. The qPCR performed to evaluate gene expression showed that SFN increased Nrf2 and NQO1 genes. However, the anthocyanins malvidin and cyanidin did not display a strong induction of Nrf2 or its downstream genes. In short, this experiment demonstrated that anthocyanins, found in a variety of berries, can carry potential health benefits as antioxidants in preventing disease through its actions on the Nrf-2 pathway.

Antoine Washington
Professor Stephen Schnetzer
Searching for Vector-like Quarks in the CMS Detector at the LHC

Vector-like quarks (VLQ) are theorized particles which behave unlike the known quarks. Whereas normal quarks behave differently depending on whether they have left- or right-handed chirality, a VLQ's left- and right-handed components would interact equally. If VLQs exist, they may not have been found because they're too massive to have been generated by previous collider experiments. With new data coming from the Compact Muon Solenoid (CMS) detector at the Large Hadron Collider (LHC), we look for evidence of VLQs with mass of at least 1000 GeV/c2. Assuming the VLQ decays predominantly to a b-quark and a Higgs boson, we expect to see 6 "jets" of particles in the detector. Sometimes, however, one of these jets is an "extra" jet, a result of initial or final state radiation of a gluon. This analysis involves identifying this extra jet and removing it from the search for the VLQ mass. We remove this extra jet and continue the search for the VLQ. We find no evidence of the VLQ in the end. This suggests that if the VLQ exists, it is more massive than 1000 GeV/c2, and we'll need more accumulated luminosity to find it.

Mingyao Xiao
Professor Seongshik Oh
Installing a Molecular Beam Epitaxial System for the Precise Growth of Topological Insulator Structures

Topological Insulators (TI) are a relatively new class of insulating solids characterized by the unnatural property of having metallic surfaces of near zero resistivity. Even with the limited knowledge we have of TIs, they promise substantial breakthroughs in super compact and heat suppressing processors, spintronics, and quantum computational devices. To study TIs, our lab (along with most labs) focuses on Bismuth Selenide (BS), the best material we can feasibly obtain that reflects the properties of the theoretically ideal TI. However, BS is a delicate material that loses its unique quantum properties quickly in poorly made crystals. This, along with the fact that even a pure crystal of BS suffers from intrinsic problems that must be remedied through precisely made molecular accoutrements, necessitates a crystal growth system that can control the crystal at the atomic level, growing by adding one layer of atoms at each stage. I will discuss the many components of such a system and my role in installing them. These parts include the three stage vacuum pump system, the computer assisted shutter controller, the central growth chamber motor, the in site RHEED crystal analyzer, and the PAPP system that accomplishes the analysis of the crystal's electric transport properties. I will then describe how they combat the enemies of BS, such as lattice mismatch, "metallization" due to high carrier density, and oxygen degradation. Finally, I will discuss the potential (far off) applications of topological insulators, going into detail how the Quantum Hall effect removes resistance, how the Spin Orbit Coupling introduces new pathways for spintronics, and how the production of Majorana fermions furthers the practicality of quantum computers.

Marila Xie
Professor Gal Hochman
Economic Benefits of Lemna and Piaractus Brachypomus in Aquaculture Operations

The world population is expected to reach 8 billion by 2020, yet current agriculture operations are straining to feed them. In the hopes of improving efficiency, research into aquaponics integration with commercial fisheries is under investigation. Duckweed (genus Lemna) has potential in aquaponics as a water purifier and reliable source of fish food by growing on waste water. Duckweed may also potentially spur faster growth in fish. Two tanks of 5 red-bellied Pacu fish (Piaractus brachypomus) were placed in separate tanks and measured for length and mass over a period of two months. Fish were fed twice daily with four hours between feedings, with one tank receiving commercial fish flakes and one tank receiving duckweed and commercial flakes. The latter tank also circulated waste water to a separate duckweed tank for waste water exchange daily for approximately 15 minutes to observe the water quality. Each week tanks were tested for pH, ammonia, nitrate, and nitrite levels. Two fish from each tank were measured and massed weekly, and the collected data when plotted indicated growth curves over time of the two tanks. Water temperature was also recorded daily, as higher temperatures caused stress and fish

subsequently ate less duckweed. Results suggest fish fed duckweed do grow faster than fish fed commercial feed, though the short experimentation period may inflate results and a longer experimental period is needed for conclusive results.

Kyra Yap
Professor Charles Dismukes
Iron and Nickel Phosphide Catalysts for the Electrochemical Reduction of Carbon Dioxide

Nickel phosphide and iron phosphide catalytic electrodes were synthesized for the electrochemical reduction of CO2 into 2,3-furandiol, formic acid, and 2,4-dihydroxy-2,5-dimethyl-3(2H)-furan-3-one. These catalysts operate at room temperature and ambient pressure for efficient hydrogen evolution, but also effectively reduce CO2 at low overpotentials. By bypassing the reduction of CO2 into CO, the catalysts promote the direct reduction of CO2 into carbon complexes with longer carbon chains. The catalysts were chosen because of their stronger binding energy to the CO bond than previously documented catalysts. In addition to this, the crystalline structure of the phosphides allows for the binding of multiple CO bonds to each active site, resulting in conditions under which the formation of longer carbon chains is possible. Under higher overpotentials (-0.7V), the products form a polymer chain, a novel result in CO2 reduction. The formation of 2, 3-furandiol, 2, 4-dihydroxy-2, 5-dimethyl-3(2H)-furan-3-one and polymer are the first products of their kind to have been produced via CO2 reduction. CO2 reduction utilizing iron and nickel phosphides presents an unexplored pathway to producing reaction intermediates for larger glycosides, which are key structures found in drugs, cleaning products and foods.

Caleb Yu
Professor Mubbasir Kapadia
Artificial Intelligence Approaches for Embodied Conversational Agents

Virtual personal assistants are making a massive impact in both commercial and personal markets. Almost every new smartphone or device is equipped with a built-in virtual personal assistant. However, none of these are capable of doing a very simple human task: interpreting and responding to emotional changes. We are developing a new personal assistant technology that is revolutionary in two aspects: having the human ability to understand emotions and having the capability of responding to this emotion with a high quality animated conversational character. We have given life to this character using cutting edge emotion reading technologies, Affectiva and Nemesysco, an advanced natural language processing (NLP) implementation, and behavior trees. By combining emotional interpretation and a Pixar-level quality character, our personal assistant AI will be setting the standard for future conversational agents.

Jungeun Yun
Professor Joachim Kohn and Mariana Reis Nogueira de Lima
Optimization of Tyrosphere for Delivery of Curcumin

With over 5 million patients in the U.S only, Alzheimer's disease has been raised as one of the major problems in aging society. Its cause includes the death of neuron cells and accumulation of peptides in brain tissue that results in inflammation. In order to address neurodegenerative disease like Alzheimer's, this study focuses on a medicinal substance called Curcumin, which has been proved to have several pharmaceutical applications that can promote the growth of neuron cells and reduce the amount of accumulated peptides. However, because of its poor bioavailability and low water solubility, previous attempts to utilize Curcumin as a medicine were not very effective in terms of the amount of Curcumin taken in and amount successfully absorbed into the circulation system. Therefore, we suggest delivering Curcumin via Tyrosphere, a biocompatible and biodegradable polymeric nanoparticle with core-shell structure that can protect Curcumin from degrading and improve drug solubility. We prepared Curcumin loaded Tyrospheres and empty Tyrospheres via precipitation then used dynamic light scattering (DLS) in identifying the hydrodynamic diameter of spheres and high-performance liquid chromatography (HPLC) in determining loading properties. The size of the Tyrosphere prepared was found to be consistent with every attempt and stable over one month. Moreover, different attempts in loading were tested in order to

achieve optimal results for desired application. Further optimization and release studies are still required. Results so far suggest that Tyrosphere is a suitable drug delivery method for Curcumin.

Chenzhen Zhang
Professor Sam Gu
Epigenetic Regulation H3K9 Trimethylation of LTR Retrotransposon in C. elegans

Gene regulation mechanism that involves methylation has been a long standing topic in the biology field. Some cancers arise from misregulation of methylation, leading to consequences such as reactivation of retrotransposons. Originally came from retrovirus, retrotransposons are often methylated in the genome so that they are prevented from inserting randomly in the genome. In C.elegans, LTR (Long Terminal Repeats) retrotransposons are silenced by trimethylation of histone protein H3 at the lysine 9 residue (or H3K9me3). Even though previous data show an abundance of H3K9me3 at cer3, the genomic sequences at cer3 locus that trigger H3K9me3 have not been determined. We hypothesized that the long terminal repeats at the 5' and 3' end of cer3 and an internal promoter are unique features that might have played a role in H3K9me regulation. We generated strains that contain 5'-LTR, 3'-LTR, or internal promoter deletion, various combinations of double deletions and one triple deletion. We will combine biochemical approach with computational analysis to perform chromatin immunoprecipitation (ChIP) with antibody specifically against H3K9me3 to pull down DNA fragments associated with H3K9me3, sequence those DNA fragments via Illumina sequencing, and finally align the reads to cer3 locus. If we detect a change, as compared to the wild type control sample, in the H3K9me3 profile due to a particular deletion of cer3 genomic region, then it suggests the significance of that region in triggering H3K9me3. If we determine the triggers of H3K9me3 at cer3 locus, we will also examine other targets of H3K9me3, such as retrotransposon cer8.