School of Integrative Science and Technology

GROUP SUMMER SCHOLARS RESEARCH PROGRAM

2024 Research Streams *(Tentative & Subject to Change*)*

4 week session Research Streams, July 8–August 1, 2024:

Developmental Biology and Alcohol Studies (4 week session)
Dr. Maria Agapito
GSSRP summer students will analyze the effect of chronic alcohol exposure on the developing embryo. We will monitor the overall health of the animals using established assays (Body length, brood size, egg hatching & laying) and develop new assays specific to neurons using an existing neuronal actin reporter.

C. elegans is a good model system for studying human disease. C. elegans has over 100 genes that are associated with human disease genes, making it a potential model system for investigating the conserved cellular roles of these genes. The genome of these animals has been fully sequenced and the nervous system wiring is fully mapped. In the last decade, C. elegans has been used to study alcohol addiction and alcohol dependency.
Studies have shown that chronic drug use can lead to compulsive drug-seeking habits and drug addiction (Everitt & Robbins 2005). Continuous alcohol intoxication results in increased alcohol consumption, tolerance and sometimes alcohol dependency in mammals (Koob 1998; Roberts et al. 2000; Koob 2003; Rimondini et al. 2003, Rimondini et al. 2007). However there is limited information about the mechanism of action of alcohol during neuronal development.

Molecular & Cellular Biology: Exploring Cancer Malignancy (4 week session)
Dr. Salvatore Coniglio
Participants in this research stream will learn the basics in molecular biology and host discussions surrounding how cells acquire and integrate information from the extracellular environment with a focus on cancer biology. Activities that focus on signal transduction, gene expression and protein expression in cancers will be the primary focus. Using a hands-on approach with image analysis software, students will learn how scientists quantify changes in gene and protein expressions in tumors.

Acoustics and Digital Signal Processing (4 week session)

Dr. Edward Farnum

Physically, all sound is produced by periodic vibrations in air pressure. At first glance,the frequency of vibration determines the pitch of a particular musical note. In fact, most sounds are a much more complicated combination of sine waves, each with a different frequency and amplitude. Mathematically, these can be described by something called a Fourier Series. Using a short-time Fourier Transform, we can analyze audio signals to better understand the production of sound waves, and also modify those signals to create new sounds. We will focus on the motion induced from nearby vibrating bodies – this is called sympathetic resonance in coupled oscillators. Students in this group will explore how the sounds of neighboring guitar strings can be encouraged to interact and generate a drone sound. This will aid in the design and construction of new and strange musical instruments, which we will build. This project can move in many directions, including theoretical, experimental, or computational. This research stream is appropriate for students with interests in **applied math, physics, computational science, engineering,** and especially music. Any familiarity with any of the above fields, as well as interests in math, physics, computation, or music, will be beneficial.

***In silico* Modeling of Prenatal Exposure to Environmental Chemicals through the Placenta: A toxicity and risk assessment Study (4 week session)**

Dr. Supratik Kar

Dr. Supratik Kar's research interests are computer-aided drug design (CADD), application of Cheminformatics and chemometric modeling, Quantitative Structure-Activity Relationship (QSAR), and machine learning to model drug toxicity to humans, chemical toxicity to the environment, followed by environmental risk assessment and management protocols. He is currently working on three different projects. Project 1: "Protein Binding Affinity as the Driver for Studying PFAS Mixture Toxicity"; Project 2: "In silico Modeling of Aquatic Toxicity of Organic Chemical to Popular and Rare Fish Species: Mechanistic Study and Ecotoxicity Gap Filling"; Project 3: "Computer-aided drug design followed by drug discovery of Nipah virus".

The previous projects and more information can be found at: https://supratikkar.wixsite.com/website/research. The complete list of his publications can be found at: https://scholar.google.com/citations?user=kzGUHjYAAAAJ&hl=en.

Biology of AB-Toxin (4 week session)

Dr. Pat Malkom

AB toxins are virulence factors produced by a variety of bacterial pathogens and some plants. They include cholera toxin (the causative agent of cholera), heat-labile toxin, Shiga toxin, exotoxin A, diphtheria toxin, and ricin. These toxins all share the same basic structural characteristic: a catalytically active A subunit and a cell-binding B subunit. At the exception of cholera and heat-labile toxins, these other toxins affect their host cells by inhibiting protein synthesis, which eventually leads to apoptosis, programmed cell death. Understanding how

these toxins carry out a successful intoxication inside their host cells is key to help improve treatment strategies against them. One of the ongoing projects in our lab uses a cell-based fluorescent assay to screen natural compounds for anti-toxin properties, while another is exploring the use of nanoparticles as a cellular delivery system, an approach that can potentially be used to deliver anti-toxins more efficiently into intoxicated cells.

Evolution and Developmental Biology (4 week session)
Dr. Matthew Niepielko
During animal development, a handful of highly conserved cell signaling pathways regulate when and where genes are expressed within a developing tissue. This process, called tissue patterning, is an essential step to ensure that animals' organs develop in the correct location and at the right time. A growing body of evidence suggests that changes in gene regulation during tissue patterning drive the evolution of new animal structures and morphologies. In our lab, we use Drosophila, the common fruit fly, as a model system to investigate the underlying mechanisms that tightly regulate gene expression during development. Additionally, we explore how these mechanisms evolve and give rise to new morphologies using a combination of computational and molecular techniques.

Health Effects of Coffee By-Products and Compounds in an Organism Model called Caenorhabditis Elegans (worms) (4 week session)

Dr. Renalison Farias Pereira

Students will evaluate the health effects of coffee by-products and compounds in an organism model called Caenorhabditis elegans (worms). This animal model serves as a genetic tool to investigate the mechanisms of action and behavioral changes induced by food bioactives, with the goal of translating their uses to humans.

These microscopic worms will be fed coffee extracts and compounds before undergoing behavioral, biochemical, and molecular biology assays. Students will observe these worms under a microscope to create survival curves. Colorimetric and molecular biology assays will be employed to determine changes in metabolites and gene expression in C. elegans fed with coffee compounds. Once we determine the concentration of coffee extracts that have beneficial effects on worms (e.g., increased lifespan) and observe changes in metabolites, we will further investigate the molecular pathways using gene expression assays. Students will be actively involved in worm culture and the performance of biochemical and molecular biology assays. The proposed research aims to establish a development path for new coffee-related products.

Earthworm Chemoreception and Feeding Behavior (4 week session)
Dr. Cecil J. Saunders
Earthworms fulfill critical ecological roles in soil and agricultural maintenance. Several studies have shown that earthworms are attracted to complex mixtures of chemicals in soil, but few studies have attempted to determine what individual molecules stimulate earthworm feeding systematically. Most animals detect the presence of glutamic acid and other free amino acids –

an indication of a source of protein – and respond with appetitive behaviors. We have developed a novel feeding assay for earthworms by exploiting the universal phenomenon that hungry animals will typically consume more of better-tasting (appetitive) food substrates than substrates with neutral or aversive hedonic valances. For this assay, earthworms are food restricted for 2-3 days in containers containing 1- 2 cm of 5% agar to provide moisture. Subsequently, dry soil and amino acid solution are combined, and an earthworm allow to feed on this soil for 1 hour. Earthworms are then placed on a light table to enable visualization of their GI tract and the soil eaten during the trial; the amount of soil each earthworm consumes is calculated as a fraction of its body length. Under control conductions (water only added to the soil), earthworms typically eat until 40% of their GI tract is full of soil; when 50 µM L- Glutamic acid is added to the soil, earthworms eat until 60% of their GI tract is full. We propose having GSSRP summer students test the other biologically relevant biomolecules, including other amino acids, in this assay. Participation in these experiments will expose students to basic animal behavior research, experimental design, solution preparation, and provide many opportunities to practice collecting, recording, and analyzing scientific data. As time permits, students will observe the molecular and cellular assays used to determine the identity of the receptor proteins and sensory cells that the earthworms use to detect chemicals in their environment.

2 week session Research Streams, July 22–August 1, 2024:

Thermoelectric Energy for Sustainable Usage (2 week session)
Dr. Paul Belony
We introduce a thermoelectric system as an alternative source of sustainable energy. We measure the energy generated by temperature gradients from various sources. This system shows promising application as a human wearable to produce useful energy for everyday usage. This research measures and shows the relationship between temperature gradients and voltage output using a network of Thermo-couple devices.

Conventional energy devices require sources that, oftentimes, are not easily accessible when we need them the most. In developing countries, there is often a lack of resources to access these conventional sources. However, there exist several sources of energy that could be made accessible in these regions. In fact, they are already using some of them but for other daily purposes. In this research, we will explore the waste energy from several everyday items and use them in conjunction with a Thermoelectric system. The temperature gradient generated will be characterized and controlled and ideal voltage output conditions will be studied.

Molecular Ecology (2 week session)
Dr. Brenna Levine
Ecology, or the study of organisms and their relationships to each other and their environments, has traditionally been studied by directly observing plants and animals in their habitats.

However, field observations alone often fail to fully capture an organism's interactions with their environment. When analyzed in the context of field observations, DNA can provide critical information about an organisms' ecology that would otherwise be unknown. This is the field of molecular ecology. Molecular ecology applies genetic data to the study of ecological questions. In this research stream, group summer scholars will learn field ecology and molecular genetic techniques to study the invasive spotted lanternfly.

Analysis of illicit drugs (2 week session)
Dr. Mingjing Sun

Illicit drugs are substances that are prohibited by law for manufacturing, possessing, selling, or using. These drugs have a detrimental impact on individuals and society due to their addictive nature and potential for harmful effects on physical and mental health. Illicit drugs represent the largest volume of criminal cases that are examined by forensic science laboratories. Illicit drugs can be classified into four main types based on their primary effects: stimulants (such as amphetamines and cocaine), depressants (like barbiturates), narcotics (including heroin and morphine), and hallucinogens (such as cannabinoids and LSD). Analyzing illicit drugs is a crucial function of forensic science laboratories, which primarily cater to the needs of the judicial system. The main objective of this analysis is to examine unidentified samples, which can include powders, crystals, liquids, tablets, capsules, and plant material.

This project aims to educate students on the practical application of computer-aided skills in identifying unidentified pills and tablets. Additionally, students will gain hands-on experience in conducting various chemical tests to perform presumptive tests for amphetamines, cocaine, heroin, morphine, and cannabinoids. Furthermore, the project will provide students with knowledge on advanced analytical techniques like gas chromatography-mass spectrometry and liquid chromatography-mass spectrometry. This will enable them to effectively determine the presence of illicit substances in unknown samples.

**Note that proposed research streams are tentative and subject to change. While we will try to accommodate preferences, we cannot guarantee placements. Research streams are capped for safety reasons and to guarantee the best learning experience for all participants. Students will be notified of their research stream placement at the time of acceptance and switching streams is not permitted. Research streams and program format are subject to change and are dependent on ongoing Covid-19 emergency circumstances.*