School of Integrative Science and Technology
GROUP SUMMER SCHOLARS RESEARCH PROGRAM

2025 Research Streams *(Tentative & Subject to Change*)*

4 week session Research Streams, July 7–July 31, 2025:

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.

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.

Forensic Chemistry Research (4-week session)
Dr. Mingjing Sun

Forensic chemistry is an exciting field that uses chemistry to solve mysteries and help with criminal investigations. In this summer program, high school students will get to experience what it's like to be a forensic chemist, learning hands-on techniques that are used to analyze evidence, especially in cases involving illegal drugs. During this program, students will take part in fun and practical activities that show what forensic chemists do every day. They will: 1. Learn how to recover fingerprints using black powder and analyze patterns. 2. Use computer tools to figure out what unknown pills and tablets are. 3. Perform simple chemical tests on everyday medicines and illegal substances, like aspirin or cannabis. 4. Use advanced tools like liquid chromatography-mass spectrometry (LC-MS) to detect drug traces in water samples. 5. Explore data from gas chromatography-mass spectrometry (GC-MS) to learn more about the structure of illegal drugs. This program is designed to teach students important skills used in forensic chemistry and help them understand why this work is so important in solving crimes and supporting justice. By combining hands-on activities with real-world science, students will discover how chemistry can make a difference in the world.

AI for Good: Create a Smart System to Support PKU Patients (4-week session)
Dr. Malihe Aliasgari
This project empowers high school students to create an AI-powered system that supports Phenylketonuria (PKU) patients by recommending low-protein recipes and foods while answering key dietary questions. Over four weeks, students will dive into Python programming, data analysis, and AI concepts as they collaboratively build a recommendation model that suggests personalized food options based on nutritional attributes. They will also design an interactive Q&A interface to provide quick, user-friendly answers to common PKU-related queries, all within a simplified and engaging framework using tools like Streamlit.

By focusing on hands-on, real-world applications of AI, the program makes advanced topics like recommendation systems and data integration accessible to young learners. With an emphasis on creativity, teamwork, and problem-solving, students will develop technical and critical thinking skills while building a meaningful tool to address real-life health challenges. The program culminates in a showcase where students demonstrate their innovative system, providing them with a sense of accomplishment and a strong foundation in AI and health tech.

Screening and Characterization of Antiviral Compounds Targeting Nipah Virus Matrix Protein Using Computational Approaches (4-week session)
Dr. Supratik Kar
The Nipah virus (NiV) is a serious global health threat, spreading from animals to humans and causing major outbreaks. NiV-M, the virus's "engine," drives its growth and spread. Blocking this engine can stop the virus from causing harm. Since no USFDA-approved drug exists for NiV, we are targeting the NiV-M protein to design and propose new drug candidates. Using advanced computer programs like docking and molecular dynamics simulations, we'll identify molecules that can attach to NiV-M and disable it. This project offers a unique opportunity for high school students to dive into cutting-edge research at the intersection of biology, chemistry, and computer science. You'll gain hands-on experience with state-of-the-art tools, learn how scientists design medicines to combat deadly viruses and contribute to global health advancements.

Molecular Microbiology of AB-Toxins and T-Even Phages (4-week session)
Dr. Pat Malkom
The **Malkòm Learning Laboratory** primarily focuses on the cell biology of AB toxins, which 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, one known for its malevolent use in bioterrorism, and it is considered a biological weapon. Understanding how these toxins carry out a successful intoxication inside their host cells is key to help improve treatment strategies against the diseases they cause. Ongoing projects in our lab screen natural compounds for anti-toxin properties, while other ones are actively exploring the use of nanoparticles as a cellular delivery system as an approach to study the catalytic subunits of several AB toxins. Moreover, our toxin delivery approach will have other potential applications, such as targeting cancer cells. Other projects in our lab investigate the basic biology of phages, viruses studied under BSL-1 environment that infect bacteria and pose no threat to mammalian cells. One of our active projects aim to elucidate the host and viral factors that dictate lysis and lysogeny decisions in T-even phages (T-2, T4, and T6). A better understanding on the factors that dictate lysis

and lysogeny decision in T-even phages, as well as how they communicate (virus with host and virus with other virus) may provide key insights into the biology of viruses that cause human diseases. Students in our lab are trained to use a list modern tools/techniques that include cell-based fluorescent assays, flow cytometry, microscopy, real-time cell analysis, molecular biology, virus production and purification, just to name a few.

Predicting Student Performance Using Machine Learning Based on Python (4-week session)
Dr. Yousef Nejatbakhsh
This research project applies machine learning techniques to predict student performance by analyzing key factors such as study hours, attendance, parental involvement, and socioeconomic status. Python will be utilized for data analysis, visualization, and machine learning implementation. The project begins with data preprocessing, including cleaning, handling missing values, and normalizing features, followed by Exploratory Data Analysis (EDA) to identify trends and correlations, such as the relationship between attendance and academic success. Machine learning models, including Linear Regression, Decision Trees, and Random Forests, will be trained and evaluated using metrics like accuracy and mean squared error (MSE), with hyperparameter tuning applied to optimize performance. Results will include feature importance analysis and visualizations highlighting key insights, culminating in a comprehensive report and presentation.

This 4-week program introduces students to practical data science and machine learning techniques, equipping them with hands-on skills while addressing real-world educational challenges. By leveraging predictive models, the project aims to support data-driven decision-making for educators and policymakers, improve academic outcomes, and inspire students to explore technology-driven problem-solving.

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 have 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.

2 week session Research Streams, July 21–July 31, 2025:

New Jersey Water Quality (2-week session)
Dr. Shuting Liu
Harmful algal blooms (HAB) are recurring problems in aquatic systems in New Jersey and change water quality both chemically and biologically over time. In addition to freshwater, HAB have

become an increasing event throughout the coastal environments. HAB produce organic toxins that are detrimental to both ecosystem organisms and human health. Using the developed liquid chromatography-mass spectrometry (LC-MS) method, new toxin domoic acid isomers that possess potentially varying toxicity have been detected in shellfish and diatom samples. Microcystin is another organic toxin with diverse isoforms produced by freshwater cyanobacteria, predominantly *Microcystis*, but also *Oscillatoria*, *Nostoc*, *Anabaena* or *Anabaenopsis*. Under the stress of urban development, high-nutrient loading runoff, and climate change, HAB events may become more frequent, algae species present in an area are subject to change, and toxin-producing strains may emerge over time in areas with no HAB present before. While most HAB studies focus on freshwaters in New Jersey or only identification of HAB species in coastal environments, comparative measurements of HAB produced organic toxins such as domoic acid and microcystin in both aquatic environments are necessary. In this research stream, students will study the distribution and concentration levels of organic toxins released by HAB species in both New Jersey freshwater and coastal environments in order to help establish water quality baselines of understudied New Jersey coastal environments, link potential connection between freshwater and coastal water in terms of HAB development, and provide scientific evidence for policy-making preventive plans and responsive strategies in the future. Students will be trained with field sampling techniques, basic lab preparation skillsets such as filtration and concentrating, and advanced instrument analysis such as LC-MS, and data analysis.

Plant Cell Biology Lab Techniques Crash Course
Dr. Laura Lorentzen (2-week session)
Students will learn the science behind the lab techniques and perform the lab exercises commonly used in cell biology laboratories. Laboratory work will entail manipulation of small liquid volumes with micropipetters, then plant tissue homogenization and differential centrifugation to separate proteins from other cellular components including DNA . The enriched protein samples will then be analyzed by the BCA Assay and with the use of the microplate reader instrument to quantify the amount of protein extracted.