New Jersey Center for Science, Technology & Mathematics

# GROUP SUMMER SCHOLARS RESEARCH PROGRAM

## 2018 Research Streams

### Analytical Chemistry & Chromatography:
### Isolation, Identification and Characterization of Drug-Like Chemical Compounds in Medicinal Plants Using Biological Assays, Chromatography, and Mass Spectrometry Techniques

*Faculty Leader: Dr. Dil Ramanathan*

Students in this research stream learn bioanalytical methods, including chromatography, mass spectrometry, and solid phase extraction, while studying plants that show anticancer, antibacterial, and antimicrobial activity. Students will isolate, identify, and quantitate drug-like chemical compounds in medicinal plants using biological assays and analytical instruments such as liquid and gas chromatography coupled to mass spectrometry.

### Medicinal Chemistry & Modern Drug Discovery:
### Synthesis of Chemokine Receptor Antagonists

*Faculty Leader: Dr. James Merritt*

Students in this research stream learn basic principles of medicinal chemistry and pharmaceutical research by synthesizing and testing novel receptor antagonists. Students work as part of a multidisciplinary drug discovery team to optimize compounds that can block chemokine receptor signaling. Using real drug discovery screening assays, students test the newly created compounds in collaboration with the Cancer Biology Team to determine effects on the growth and activation of cultured glioblastoma cells.

### World of Data:
### Virtual Reality & Scientific Visualization

*Faculty Leader: Dr. David Joiner*

Immersive environments, such as 3D games and virtual reality headsets allow for the rich exploration and modeling of multi-dimensional scientific data. There has been a growing variety of options for developing and viewing virtual reality, and students in this stream will be part of a team building a virtual reality application for scientific visualization, developed across multiple platforms including the Oculus Rift, Kean's 7'x10'x10' 3D CAVE, and the Gear VR. The tool will enable students, teachers, scientists, and enthusiasts to view, build, and share a variety of scientific data and simulations in virtual reality. Prior programming experience is helpful but not required, and instruction in programming in the Unity3D environment will be part of the stream. In addition to being part of the World of Data design team, students will also search

for, curate, and visualize data across a variety of disciplines including biology, mathematics, chemistry, physics, and computer science.

## Microbes, Microbiomes & Bioinformatics: Exploring the Structure and Function of the Microbial World

*Faculty Leader: Dr. Marshall Hayes*

In this research stream, you will take a hands-on approach to exploring the vast microbial diversity that lies hidden in, on and around us. You will gain a working knowledge of concepts that are relevant to microbiology from the fields of ecology, evolution, molecular biology, genetics, computer science and statistics. You will hone your laboratory skills in classical and molecular microbiology, including isolating, cultivating and characterizing samples using biochemical, genetic and genomic techniques. We will also devote half of our time to examining algorithms and tools used to make sense of data from large-scale high-performance DNA sequence analysis projects, particularly those that rely on state-of-the-art Next Generation Sequencing. In collaboration with the American Type Culture Collection's Center for Translational Microbiology, we will also highlight the use of culture collections in the search for new targets of therapeutic chemicals, the design of diagnostic tools based on the human microbiome, the identification of novel enzymes for producing next-generation biofuels, and ways to produce highly valued materials from waste streams and other environmentally sustainable sources.

## Molecular & Cellular Biology: Exploring Cancer Malignancy

*Faculty Leader: Dr. Salvatore Coniglio*

This research stream provides opportunities for inquiry-based learning of cell and molecular biology, with a focus on cancer. Students search for novel interactions between cancer cells and macrophages, specialized cells of the immune system found in the cancer microenvironment. Changes in gene expression are measured in these cells, giving students the opportunity to learn methods to quantitate mRNAs and proteins of interest using real-time PCR, SDS PAGE based immunoblotting (western blotting), immunofluorescence microscopy and cell culture. Ultimately, students test their findings in a cell invasion assays to determine their functional significance.

## Computational Mathematics: Pattern Formation and Wave Propagation

*Faculty Leader: Dr. Edward Farnum*

Students in this research stream study the mathematical properties underlying wave propagation, and learn computational tools to analyze these waves. Broadly speaking, we are interested in the conditions under which coherent patterns form in a system, and in describing the stability of these patterns. Applications range broadly from tsunami formation to sun-spots to laser dynamics. Students will learn about standard mathematical models to describe the formation of ultra-short pulses of light in fiber-optic communications systems. They will help develop computer programs to determine ideal systems parameters which lead to robust pulse-formation. They will also study and analyze a new mathematical model for an application called a frequency comb, a technique which allows engineers to generate lasers at multiple frequencies simultaneously. They will use computational methods to determine ranges of parameters which successfully give rise to stable frequency combs, and those which do not. They will learn about the Fourier Transform and spectral analysis of signals. Students should have an interest in applied mathematics, computer programming, and physics.