Sophomore Early Research Program 2022-2022
Natural Science Faculty Projects

Projects in Astronomy, Biological Sciences, Biochemistry, Chemistry, Computer Science, Geosciences, Mathematics, and Neuroscience

Astronomy

Kim McLeod
Hunting for Planets from Whitin Observatory

My SERP student would join my TeamTESS research group which is conducting observations to help vet candidate exoplanets identified by NASA's Transiting Exoplanet Survey Satellite (TESS). TeamTESS students are responsible for opening and operating our 0.7m telescope, calibrating images, and analyzing the data. They also assist new students in learning how to use the telescope. Students will have the opportunity to join in at TESS Science Meetings and hone their understanding of exoplanet transit analysis.

Wesley Watters
Environmental Sensory and Fast-tracking Telescope Development

This project is part of ongoing work at the Whitin Observatory to develop a system of instruments for comprehensively characterizing objects in the sky as well as conditions in the environment. One project involves developing a pan-tilt mount with three instruments to track and photograph objects in the night and daytime sky, as well as measure optical spectra and high-speed photometry (i.e., fast variations in light intensity). Experience with Python and with programming Arduino microcontrollers is strongly encouraged. A second project involves building a muon detector from a kit (experience with soldering preferred, if possible).

Biological Sciences, Biological Sciences/Biochemistry

Louise Darling
Investigating Membranes and Membrane Proteins in the Context of Human Health and Disease

This project will integrate students into a collaborative and inclusive research environment in the Darling lab where we investigate how biological components interact with and are brought across cell membranes, often by “gatekeeper” membrane

proteins. Students will work in a team with their lab colleagues on a project relating to cardiac ion channel protein-protein interactions, the design, and engineering of novel antimicrobial peptides (in collaboration with the Elmore lab in Chemistry), or on mechanisms of adult stem cell resistance to the chemotherapeutic methotrexate. Our interdisciplinary work draws from the fields of cell and molecular biology, biochemistry, and bio/medical engineering. Qualified students have generally completed an introductory course in Cell and Molecular Biology (BISC 110/110P/112/116) and Chemistry (CHEM 105/120/116).

Vanja Klepac-Ceraj
Microbial Processes in Lake Waban and Paint Shop Pond

The composition of microbial communities associated with the lake water and sediments can have a large effect on the cycling of elements and the ecosystem as a whole. Our lab is interested in characterizing the microbiomes associated with Lake Waban and the PaintShop pond and how they change over time. We look forward to working with a SERP student to explore these microbiomes using culture-dependent and -independent microbial methods.

Martina Koniger
Impact of the Invasive Reed Phragmites on the Local Plant and Insect Community

We are trying to understand the genetic, physiological, and ecological underpinnings of biological invasions by focusing on a recent invader right on our campus. We will survey several stands of Phragmites australis and compare their physiological traits as well as their effects on the surrounding insect and plant communities. The richness of this study is in the multi-disciplinary approach that contributes to a comprehensive picture of a species introduction. The project requires a broad interest in ecology and data analysis since students will be involved in 1) the collection and identification of insect and plant specimens, 2) the collection and analysis of physiological measurements and 3) the analysis of soil samples.

Heather Mattila
Describing the Pheromones that Giant Hornets Use During Attacks on Social Insect Prey

This project will examine the pheromones produced by glands of the southern giant hornet, Vespa soror. In collaboration with faculty from the Chemistry department, we will examine samples collected in Vietnam to determine the volatile chemicals that

hornets use to recruit nestmates to group attacks on prey. Students will learn about social insect biology, insect anatomy and microdissection, and analytical tools used by biologists and chemists to understand animal communication. Lab effort will include technical training by faculty from the Biology and Chemistry departments, as well as processing and analysis of hornet samples. Students in the Mattila Lab are expected to attend weekly meetings about lab research efforts. No prior experience is necessary.

Kaye Peterman
Exploring the Role of Lipid Signaling Genes in Plant Development

The current focus of our work is on the role of PI4Kinases in the plant genetic model organism, *Physcomitrella patens*. PI4Kinases produce a regulatory lipid that plays a critical role in all eukaryotic cells, phosphatidylinositol 4-phosphate. Using CRISPR mutagenesis we have uncovered both conserved and novel functions for PI4Kinases in Physcomitrella development. We are using molecular genetic, biochemical, and cell biological approaches to investigate the roles of these proteins in polarized cell growth during the microscopic filamentous stage and also in the transition from 2-dimensional to 3-dimensional growth patterns during the establishment of the leafy shoot. A sophomore work-study would join a team of students working on these projects. Through these projects, the student will gain experience with a variety of microscopic (fluorescence, bright-field, and confocal laser scanning) and molecular genetic (CRISPR mutagenesis, PCR, cloning, protein expression) techniques. The student will also present her work at weekly laboratory meetings.

Andrea Sequeira
Stepping over the Species Line: Interspecies Hybridization and a Genomic Tug-of-war between Introduced and Endemic Weevil Species in the Galápagos Archipelago

This project aims to test the hypothesis that hybridization with close relatives is a source of adaptive genetic variation facilitating adaptation to novel environments. An ideally self-contained system to answer this question is a trio of closely related broad-nosed weevils in the Galápagos Archipelago. We will conduct an integrative behavioral-genomics study of the patterns of mating and gene flow between these species. By assisting in analyzing video footage and constructing genomic libraries for the three focal species, students will gain experience in a diverse array of behavioral ecology and molecular genetics methods. These investigations have the potential to transform our understanding of the definition of invasive-endemic species boundaries.

Yui Suzuki
The Molecular Mechanism of Genetic Accommodation

In this project, we will explore the molecular mechanisms underlying developmental plasticity, and the ability of organisms to develop differently depending on the environment. We will examine how gene expression changes and methylation states change to accommodate new phenotypes in changing environments. The student will learn how to perform standard molecular techniques and will also explore ways to study epigenetic changes in development.

Chemistry, Chemistry/Biochemistry

Chris Arumainayagam
Photochemistry vs. Radiation Chemistry of Interstellar Ices

The overarching goal of my research is to understand the extraterrestrial synthesis of prebiotic molecules. My research students run experiments using sophisticated instruments (e.g., electron guns, a laser-driven photon source, a mass spectrometer capable of detecting neutrals, positive ions, and negative ions in a single experiment), analyze and interpret data, perform helium leak checks, build electronic circuits, spot-weld difficult junctions, draw CAD diagrams using SolidWorks, disassemble and reassemble equipment, and perform computer modeling — hands-on work — especially important for prospective scientists.

Don Elmore
Design of Histone-Derived Antimicrobial Peptides

A SERP Project in the Elmore Lab would involve studies of antimicrobial peptides, which are small proteins that kill bacteria and other microorganisms and represent a potential alternative to conventional antibiotics. Projects will aim to determine how peptides kill bacteria and how peptides and conventional antibiotics can work together synergistically. Students joining the lab as part of the SERP program would participate in this project by learning experimental methods, such as bacterial culturing, fluorescence and circular dichroism spectroscopy, lipid vesicle preparation or confocal microscopy, or computational methods, such as molecular dynamics simulations. Qualified students will generally have completed at least two courses in chemistry, biology, and/or other related math and science fields during their first year of Wellesley.

Nolan Flynn
Metallic Nanoparticles From Synthesis to Application

Researchers around the world, including our lab, are exploring the use of nanoparticles for myriad applications. Despite all this work locally and globally, there is much we don't understand about the potential use of nanomaterials—from the most efficient means of synthesis to their ultimate fate in different settings. We will work to expand our understanding along an avenue of most interest to the SERP researcher. Position requirements are: (1) an interest in studying chemical systems and (2) a comfort with the laboratory environment.

Mala Radhakrishnan
Computational Modeling of Biomolecular Interactions

In our group, SERP students get introduced to the exciting world of computational biomolecular modeling and learn fundamental techniques to predict and analyze biomolecular interactions computationally. These include learning about and running molecular dynamics simulations, quantifying electrostatic interactions using various models, and predicting ways to optimize drug/target interactions. Students will learn about specific projects in our lab during this experience so that they can ultimately take ownership of their own project at the interface of chemistry, physics, biology, math, and computer science. Students will also learn valuable computer programming skills.

Mathew Tantama
Protein Engineering Fluorescent Sensors

How do cellular signaling and metabolism change in response to a brain injury or disease? We develop molecular tools that can be used with optical techniques to answer this question. Specifically, our tools are fluorescent sensors made of proteins, and they sense different indicators of cell health such as ATP concentration, pH, and redox potential. Students can learn about recombinant DNA technology, protein biochemistry, and spectroscopy. Students from all backgrounds are welcome, and at least one introductory science course with a lab is useful.

Computer Science

Peter Mawhorter
Mapping Metroidvanias

We will be building and improving an open-source Python library for creating & managing maps of video-game spaces, with a focus on 2D Metroidvania games. Ideally, you should be prepared to program in Python (e.g., you took CS 111), but the work can focus more or less on programming aspects. Other parts of the research include playing games & mapping their spaces using the tool we're developing, reasoning about what aspects of the games are and are not captured in the mapping format, and of course some reading of academic papers in related areas of research including computer science, cognitive science, and psychology, and game studies.

Franklyn Turbak
Labeling Programming Misconceptions in MIT App Inventor

This research project involves the development of machine learning models to automatically identify misconceptions in programs for MIT App Inventor (http://appinventor.mit.edu/), an online blocks-based visual programming environment for creating mobile apps that have been used by millions of people, many with little or no previous programming experience. The SERP student will be trained in the use of App Inventor, will be introduced to some common misconceptions encountered by App Inventor users (and encouraged to identify new misconceptions), and will work with other students to identify and label misconceptions in a dataset of user projects. The resulting labeled dataset will be used to train machine learning models to automatically discover bugs in App Inventor projects and help App Inventor users develop more robust mobile apps. In this research project, the SERP student will strengthen their code understanding and debugging skills, will learn about applications of program analysis to educational computing, and will be introduced to the basics of machine learning. Since this project is a collaboration with faculty and students at MIT and Ben-Gurion University in Israel, the SERP student will also get experience in doing research in an international setting.

The ideal SERP candidate will have already taken both CS111 Computer Programming and Problem Solving and CS230 Data Structures, though students who have only taken CS111 Computer Programming and Problem Solving (or have other substantial programming experience) will also be considered.

Geosciences

Dan Brabander
GeoHealth: Legacy Metals, Public Health, and Environmental Justice

Research in the DJB-GeoHealth Lab focuses on understanding the fate, transport, and exposure pathways of legacy metals (e.g. lead and arsenic). Current projects include extensive collaboration with activist and community partners in Oklahoma and Boston. We are examining mine waste transport enhanced by climate change and the challenges of sourcing urban compost that has "safe" levels of lead. Students must have an introductory STEM course in GEOS or ES to apply.

Adrian Castro
Unraveling the Tectonic History of New England: Perspectives from Central MA, and NYC

Despite its importance in the tectonic history of North America, the dynamics of Paleozoic mountain building and metamorphism in Central MA and NYC are poorly constrained. To address this issue, a SERP student will explore 1-2 samples from our field areas. They will be responsible for sample prep for XRF and thin section analysis, and the acquisition of preliminary monazite ages at the electron microprobe at either UMass-Amherst, Syracuse University, or Rensselaer Polytechnic Institute.

Mathematics

Ann Trenk
Using Graph Theory to Determine Group Assignments

Graph theory can be used to model real-world problems. For example, professors may want to divide their students into groups and rearrange the groups multiple times throughout the semester to meet certain objectives. This situation can be modeled using a graph that consists of a vertex for each student in the class and an edge between two vertices if those two students can be assigned to work together in a group. In this project, we will consider various questions in this group assignment problem and use edge coloring in graphs and other tools to help find solutions.

A SERP student in this position would work with Professor Trenk and her honors thesis student, and potentially share ideas with a larger group of math research students.

Neuroscience

Sharon Gobes
Neural Mechanisms Underlying Song Learning in Birds

In the Gobes lab, birds (zebra finches) are used to investigate the neural mechanisms underlying learning and memory. Research assistants will get exposure to one or more of the following techniques: working with animals, behavioral tests, analysis of behavioral data, histological processing of brains, confocal microscopy, image analysis, and wet-lab procedures (immunohistochemistry). Our team values a high degree of responsibility and participation during lab meetings & Journal Clubs. Through these meetings, we aim to collectively further our understanding of the scientific questions that we are pursuing, and thus the SERP student will get ample opportunity to practice critical reading skills in addition to learning more about neuroethology research.

Marc Tetel
The Wellesley-Mayo Gut and Vaginal Microbiome Study

While there are well-established, bidirectional communication pathways involving the gut microbiome (e.g. oral-gut microbiome axis), specific communication pathways have not yet been defined for the vaginal microbiome. In collaboration with colleagues at the Mayo Clinic, we will study the possible interaction between the vaginal and gut microbiomes. To investigate this crosstalk between these two microbiomes, time-longitudinal vaginal swabs and stool samples will be collected from participants. In addition, we will collect lifestyle data (e.g. diet, exercise, mood in collaboration with Christen Deveney) using the app developed by our IT group. Our goal is to 1) identify species that cooccur between the two microbial sites, 2) determine whether the overall gut community profile can predict vaginal community state types, and 3) determine if these distinct microbiomes are influenced, in concert, by lifestyle factors.