Sophomore Early Research Program 2017-2018
Natural Science Faculty Projects

Natural Sciences: Projects in Astronomy, Biological Sciences, Chemistry/Biochemistry, Computer Science, Engineering & Mathematics, Geosciences, Neuroscience, Physics, and Psychology

Astronomy

Kim McLeod
*Planet Hunting*

A SERP student working with my research team would make nighttime observations with our 24" telescope in support of the KELT search for extrasolar planets. The student would also learn to reduce and analyze the KELT data. An introductory course in astronomy with telescope experience (ASTR 102 or telescope certification) is required.

Biological Sciences

John Goss
*Developing an optogenetic approach to manipulating protein localization in S. pombe*

Where a protein localizes within the cell directly affects its ability to carry out a particular function. The general approach in cellular and molecular biology to studying how a particular protein of interest is involved in a cellular process is to delete the gene that encodes that protein and monitor how the process is altered. However, in the case of essential genes, such an approach kills the cell before any observations can be made. Optogenetics is a newly developed in vivo tool that allows for rapid and reversible light-mediated protein dimerization, which can be used to create an in vivo system for controlling or disrupting protein function by manipulating their cellular localization. In this project, students will develop a novel optogenetic system for fission yeast through molecular cloning and yeast genome manipulation, and utilize fluorescence microscopy and growth assays to validate and implement this system. Previous experience with some of these approaches and techniques is strongly recommended.

Jackie Matthes
*Nitrogen and carbon transport through soil microbial communities at the terrestrial-aquatic boundary*
Precipitation events play a major role in the lateral transport of nitrogen and carbon through terrestrial soils and into aquatic ecosystems. High levels of nitrogen and carbon in aquatic environments are indicators of poor water quality, so the processes that add/remove nitrogen and carbon along this pathway are important metrics of ecosystem health. This project will measure rates of microbial respiration (carbon dioxide and methane flux) in addition to rates of nitrogen transformations to understand the impact of precipitation, flooding, and nitrogen transport on ecosystem carbon metabolism.

Kaye Peterman  
*The role of plant Sec14-related proteins in cell polarity*

The current focus of our work is on Sec14-related proteins in two plant genetic model organisms, the moss Physcomitrella patens and the flowering plant Arabidopsis thaliana. Sec14-like phosphatidylinositol lipid transfer proteins are ubiquitous eukaryotic proteins that function at the interface between phosphoinositide signaling and metabolism. We are using molecular genetic, biochemical and cell biological approaches to investigate the roles of these proteins in the establishment and maintenance of cell polarity during growth in Physcomitrella and during development of the vascular system in Arabidopsis. 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 (PCR, cloning, protein expression) techniques. The student will also present her work at weekly laboratory meetings.

Andrea Sequeira  
*The epigenetic basis of the success of introduced species*

Natural selection can act on populations of phytophagous insects through their host plants and the defenses that they deploy to deter herbivores. Through contrasts of transcriptomes from introduced and native populations we seek to uncover the identity of genes and functions that could be involved in host-mediated selection and could allow introduced weevils to succeed in an introduction situation. Students involved in this project will assist in RNA extractions and data analysis. This would be an opportunity for students interested in evolution and the molecular basis of ecological interactions.

**Chemistry, Chemistry/Biochemistry**

Chris Arumainayagam  
*Chemistry of the Heavens*

We plan to study the dynamics of low-energy (< 10 eV) electron- and photon-induced reactions in condensed matter relevant to astrophysical phenomena. Our major goal is to critically test
the hypotheses that (1) low-energy electron-induced reactions lead to the production of unique molecular species and that (2) electrons are more effective than photons in initiating condensed-phase chemical reactions. Our experimental approach will provide a more detailed understanding of how prebiotic molecules are synthesized in cosmic ices surrounding interstellar dust grains found near star-forming regions of the universe. Such studies may help us better understand the initial stages of the genesis of life.

**Don Elmore**  
*Characterization and Design of Antimicrobial Peptides*

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

**Nolan Flynn**  
*Probing the interaction of nanoparticles for cancer treatment with biological fluid*

Researchers around the world, including our lab, are exploring the use of inorganic nanoparticles for myriad biomedical applications, including cancer therapy. Despite all this work locally and globally, there is much we don't understand about the potential use of nanomaterials for in vivo applications. With this project, we investigate the interaction of nanoparticles with biological media such as human serum. Specifically, SERP student researchers will use techniques that investigate the size, charge, and stability of the particles after exposure to these fluids.

**Megan Núñez**  
*Exploring Bacterial Adhesion using Atomic Force Microscopy*

We are interested in understanding how bacteria stick to surfaces and to other bacteria. How do they recognize what kind of surface they are attached to? How strongly do they stick? What molecules do they use to help them to stick? To answer some of these questions we use Atomic Force Microscopy (AFM) in tandem with fluorescence microscopy, allowing us to see bacteria as well as measure forces of interaction.
**Computer Science**

*Eni Mustafaraj*

*Advancing Web Literacy through data-driven tools*

Join the members of the Data, Analytics, and Visualization Lab in their quest to research, design, and develop a collaborative, web-based system for learning and practicing web literacy. Though everyone uses the Web, few know its "secrets": how web domains come into life, what's in a link, where cookies are stored and how they are used to show ads that follow someone everywhere, how to evaluate genuine websites, and many more. Our system aims to help with all these issues. If you have taken CS 230 and have a passion for all things Web please apply. You'll be learning a lot with us and advancing our research goals.

**Engineering/Mathematics**

*Amy Banzaert/Ann Trenk*

*Digital Fabrication of Mathematical Educational Models*

As digital fabrication tools (such as laser cutters and 3D printers) become more and more accessible, affordable and, usable, the opportunity to innovate with them expands. In this interdisciplinary project, the SERP student will work with Professor Amy Banzaert (Engineering) and Professor Ann Trenk (Mathematics) in designing and creating models for hands-on activities in math (e.g. demonstrating the Pythagorean theorem using tangram-like pieces). The student will also participate in related outreach activities at Wellesley College and in the community, in maintaining the We-Lab, and assist in preparing an article about this work for a journal in engineering education. We seek a student who is responsible, detail-oriented, and would enjoy participating in math outreach activities. Students applying will be most competitive if they have experience making 3-dimensional objects with digital and/or traditional fabrication tools, have taken a course with Prof. Banzaert or had similar hands-on engineering coursework, and plan to enroll in math courses during their sophomore year.

**Geosciences**

*Daniel Brabander*

*Urban agriculture geochemistry challenge: Increasing food sovereignty minimizing lead exposure*

Designing sustainable urban agricultural best practices in food deserts presents many challenges. How can produce be safely grow in urban soil that is often contaminated with lead? What cost effective amendments can be added to the soil to lower lead uptake in plants and
reduce lead bioaccessibility in soils? The Brabander lab group has been fingerprinting municipal compost source streams to determine how to reduce total trace metal inventories while providing a growth matrix that reduces lead geomobility in soils. Urban foraging is also on the rise in major US cities and our lab has begun to examine both the nutrient and trace element profiles of fruit (typically, cherries, pears, peaches, and apples) that is harvested from trees found in urban backyards, parkland, and along roadways. Is this fruit as safe as organic/conventional produce? Can adding this to the palette of urban agriculture lengthen season to late fall-early winter thereby increasing sovereignty throughout a longer period of the year?

Preference for those considering ES/GEOS majors and having taken one of the following courses GEOS101, GEOS102, GEOS 120, ASTR 120, ES101, or ES103.

Neuroscience

Deborah Bauer
*How do glutamate transporters influence glutamate receptors in C. elegans?*

Glutamate is the major excitatory neurotransmitter in the mammalian brain and its synaptic levels are tightly regulated by glutamate transporters, located primarily on glia. In the nematode, C. elegans, the major excitatory neurotransmitter is acetylcholine, but glutamate neurotransmission remains critical for a number of functions. This project will involve worm-mating, PCR, and fluorescence microscopy experiments to determine whether glutamate transporter expression influences receptor localization before and after learning paradigms. Through these experiences, you will also learn to keep a lab notebook, sterile technique, solution making, worm maintenance, experimental design, use of a dissecting microscope, worm behavioral testing, statistics, data analysis, and literature review pertinent to the field.

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 trained on one or more of the following techniques: behavioral tests and analysis of behavioral data, histological processing of brains, light microscopy and image analysis, wet-lab procedures (immunocytochemistry and other chemical procedures to highlight structures in the brain), or fMRIImaging. After training, and once the student is proficient in the technique, the SERP student will become responsible for running one aspect of a larger study independently. This includes time planning of experimental procedures, purchasing and maintaining the required materials, running experiments, collecting and analyzing the data, and co-authoring an abstract / preparing a poster to present the results of the study. The fellow will work closely together with the lab-manager, which will require a high degree of responsibility and general tasks.
Physics

James Battat

Projects in experimental physics

I am an experimental astroparticle physicist. For my main research, I test gravity with lunar laser ranging, and develop technologies to search for dark matter particles. But I have broad interests in experimental physics. Rather than me calling out a specific project here, I invite you to collaborate with me to define a project built around specific skills and interests that you have, and, more importantly, that would support your intellectual and technical growth into an area where you do not yet have expertise. Students that have worked with me in the past have learned to: program (python, C++), sense the environment and control hardware (Raspberry Pi and Arduino microcontroller), build basic electronic circuits (e.g. op-amps, CPLDs), operate vacuum systems, use high-voltage and gas systems and radioactive sources safely, sense single photons with photomultiplier tubes, and use particle physics instrumentation to detect otherwise invisible particles. I look forward to hearing from you.

Psychology

Maggie Keane

Understanding Human Memory

The aim of our research is to understand the functional and neural architecture of human memory and related cognitive processes. A SERP student will assist in the design, implementation, and analysis of experiments with undergraduate research participants at Wellesley. The experience will also include close reading of the empirical literature on human memory.