Sophomore Early Research Program 2021-2022
Natural Science Faculty Projects

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

Astronomy

Wesley Waters
Measuring the Distribution of Impact Azimuths on Mars

Impact craters sometimes occur in linear clusters, which indicate the impact direction. This can also be suggested by the shapes of impact crater planforms and ejecta blankets. In this work, we will measure the distribution of these impact directions and compare with expectations based on what is known about the evolution of Mars' spin axis and the distribution of planetesimal orbits.

Biological Sciences, Biological Sciences/Biochemistry

Jackie Matthes
Ecosystem Resilience Following Disturbance

Forest ecosystems are experiencing stress from climate change and invasive insects and pathogens, yet some forests have shown remarkable resilience in maintaining their function or reliably recovering after major disturbance events. The Matthes EcoLab has a suite of projects that study how and why some forests recover from disturbance events like severe storms and insect outbreaks using existing datasets and mathematical models. This research crosses the disciplines of biology, environmental science, geosciences, computer science, and data science. Students applying to this position should have skills in working with data in spreadsheets and some familiarity with, or a strong desire to independently learn, data analysis using the R computer language, which is applicable to a broad set of disciplines.

Kaye Peterman
The Role of PI4Kinase alpha1 in the 2D to 3D Growth Transition in Physcomitrium patens

The colonization of the terrestrial environment by plants ~470 million years ago was a transformative moment in the history of life on earth. A key

innovation that ensured success in the transition to land was the evolution of three-dimensional (3D) growth. A transition from 2D to 3D growth occurs during the development of all extant land plants thus recapitulating this major step in land plant evolution and providing an opportunity to explore the cellular and molecular mechanisms that underlie this innovation. We are exploring the role of the phosphatidylinositol 4-kinase, PpPI4Ka1, in the 2D to 3D growth transition in the moss Physcomitrium patens, a well-developed molecular genetic model organism. A sophomore work study would join a team of students working on this project. Through this project 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

Exploring the Colonization of Wellesley College's Wetlands Combining Genetics, Physiology and Ecology

This collaborative project strives to connect the genetic, physiological and ecological underpinnings of biological invasions by focusing on a "local" and recent invader right on our campus. We will survey stands of Phragmites on campus and assess the genetic structure and richness of different stands using a battery of molecular tools. In parallel, we will compare physiological traits that are important to optimizing the photosynthetic performance and light stress tolerance in different communities. Finally, we will assess the contribution of the invasive stands to different ecological communities by examining the insect and plant communities surrounding Phragmites stands. The richness of this study is in the multidisciplinary approach that will contribute to a complete and connected picture of a species introduction. Students involved in this project will assist with 1) genetic data analysis, 2) collection of insect and plant specimens and 3) collection and analysis of plant physiology measurements.

Ideal student team members will be those that appreciate developing field, lab and data analysis skills and are motivated to understand biological invasions. This project is a collaboration between Prof. Martina Koniger and Prof. Andrea Sequeira, both in the Bio department.

Yui Suzuki
Effect of Temperature on Hormonal Control of Caterpillar Body Size

Climate change poses major challenges for organisms. One of the major traits impacted by temperature is body size where higher temperatures often consistently leads to smaller body sizes. Through this project, the student will learn how to conduct molecular research, including quantitative PCR, and explore how hormones in caterpillars are impacted by elevated temperatures.

Chemistry, Chemistry/Biochemistry

Chris Arumainayagam
Did Photons or Electrons Create Life?

Our overarching goal is to study the differences and similarities between condensed-phase reactions initiated by electrons and photons, each with energies below 10 eV. Radiolysis and photolysis will be investigated under conditions that simulate those responsible for the synthesis of prebiotic molecules near star-forming regions trillions of miles from earth. The student(s) will not only learn how to operate the complex instrumentation in my research laboratory, but they will also learn fundamental transferable research skills such as how to systematically troubleshoot malfunctioning equipment, design control experiments, perform challenging error propagation calculations, and carry out sophisticated data analyses.

Don Elmore
Design of 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 either chemistry, biology or other related math and science fields during their first year of Wellesley.

Adrian Huang
The Properties of Pyrazole Derivatives

The students in my lab develop synthetic methodologies and apply them to synthesize novel molecules, such as catalysts, drugs, and supramolecules. Recently, my lab has focused on studies of pyrazole derivatives. Pyrazole derivatives play important roles in catalysis and pharmaceuticals. For example, FDA-approved drugs celecoxib and ruxolitinib are pyrazole derivatives. The students in my lab will gain hands-on laboratory experience and skills.

Megan Nunez
Understanding the Role of the Spiroiminodihydantoin Base Lesion in DNA Packaging and Repair

A student researcher working on this project will learn how to generate the Sp lesion on DNA, purify it, characterize it, and bind it with proteins. This is a very hands-on project, so applicants should enjoy lab courses and be willing to try new things (and fail along the way, as that is the nature of science) as they learn a range of biochemical techniques.

Mala Radhakrishnan
Computational Models for Molecular Matchmaking

We develop and use computational models to predict and understand how molecules "recognize" or bind to each other in the complex, dynamic cellular environment. Our systems include drug/target, protein/protein interactions, and protein/DNA. We are also interested in clearly communicating and exciting others about the field of computational science and developing activities for high school students to engage with molecular modeling as well. Students doing this work get an interdisciplinary experience, learning about chemistry, physics, biology, math, and computer science.

Rachel Stanley
Oxygen and Noble Gas Tracers for Probing the Marine Carbon Cycle

The ocean sequesters approximately ¼ of CO2 produced by anthropogenic carbon, mostly through two processes: (1) air-sea gas exchange into cold waters because of solubility and (2) biological uptake through photosynthesis. Noble gases are ideal tracers for studying air-sea gas exchange and oxygen, in conjunction with Ar, can be used to quantify photosynthesis and respiration in the upper ocean. In this project, students

will either use O2/Ar data collected on coastal oceanographic research cruises to examine factors controlling photosynthesis in coastal waters and how photosynthetic fluxes are responding to climate change or will develop methods for using small semi-portable mass spectrometers to measure noble gases. The first project consists of using Matlab to analyze large data sets. The second one involves working in the lab and learning how to think like a mass spectrometer. Both projects are highly interdisciplinary, combining chemistry, physics, geosciences and biology. In both projects, students will enhance their critical thinking skills, have the delight of figuring out how a natural system works, and be contributing to research aimed at elucidating the effects of climate change.

Mathew Tantama
Protein Engineering Optical Tools to Study the Brain

We are broadly interested in how cellular signaling and metabolism is altered when the brain is injured, aging, or diseased. To study these processes, we create new fluorescent and bioluminescent sensors made of proteins, and we use these to measure physiological changes in redox potential, ATP, pH, etc. Students have the chance to 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

Eni Mustafaraj
Visualizing and Characterizing Black Lives Matter Social Media Conversations

Social media has become one of the most important tools for engagement and grass-root activism on pressing social justice issues such as anti-racism, climate change, and more. Given that millions of people participate in social media, generating as a consequence large amounts of data, it is necessary to use computational tools and skills to make sense of such data. A group of computer science students under the supervision of Prof. Maneesh Arora (Political Science) has collected millions of tweets with hashtags related to the Black Lives Matter (BLM) movement, covering the time period 2013-2020. What stories do these tweets tell about the engagement of Twitter users in BLM activism? Did these social media conversations spur legislative actions in the various US states? What can we learn about the growth of the movement by studying the growth of the communication networks? These are just a few of the questions that we can try to answer by analyzing data from different sources and guided by political science

theories. The SERP student in this project will have the opportunity to work with Prof. Mustafaraj and collaborate with Prof. Arora in the pursuit of such questions. Students who fulfill the SERP eligibility criteria and have completed CS 111 are strongly encouraged to apply.

Orit Shaer (2 projects)
The Mobile Office: The Future of Work and Wellbeing in Automated Cars

In the near future automated vehicles will allow drivers to engage in non-driving activities related to work and well-being. This SERP research project will explore a number of questions related to human-computer interaction in vehicles with the ultimate goal of allowing drivers to be safe and productive in automated vehicles, as well as to engage in activities that successfully increase their well-being. Working on this project, students will learn to work with state-of-the-art driving simulators and voice user interfaces. Students will design and implement an experiment that examines the use of voice interfaces in automated vehicles. This is an interdisciplinary project - students with a background in one or more of these areas are invited to apply: computer science, data science, statistics, design, or psychology. This work is part of a large NSF project with multiple collaborating academic institutions. For more information check the project website: http://cs.wellesley.edu/~mobileoffice/

DISCOVRE: Distributed Immersive Scientific Collaboration Over Virtual Reef Environments

This project focuses on the design, development and evaluation of a new kind of distributed immersive (VR) data analytics system for use by coral reef researchers to collaboratively explore, analyze and annotate heterogeneous coral data. Students will design and develop VR scenes, visualizations, and interaction techniques with Unity, and work with state-of-the-art VR collaboration tools. This is a collaborative project with Tufts University. Students will work in collaboration with researchers from Tufts. Students with a background in VR and AR, media arts and sciences, computer science, and data science are encouraged to apply.

Geosciences

Adrian Castro
Constraining the Metamorphic and Tectonic History of the Bronx Zoo Schist

The boroughs of Manhattan and the Bronx in New York City are an excellent location to explore how urban geology can be used to infer the tectonic history of North America. The Bronx Zoo in particular hosts excellent

outcrops of the Bronx Zoo schist, a unit of rock thought to record the dynamics of mountain building approximately 440 million years ago. Despite this excellent exposure, these rocks have gone long understudied and are ripe for exploration! As a SERP researcher you will be responsible for preparing rock samples for thin section and XRF work, conducting XRF analyses, and interpreting thin sections. You will get the opportunity to work with a collaborative team of researchers at Wellesley College, the American Museum of Natural History, and local high schools in NYC. Interested students should have completed GEOS 101 or 102.

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). In our team we value 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
Estrogens and Metabolism

Steroid hormones act throughout the body to regulate development, growth and reproduction. Our lab is interested in how the ovarian steroid hormone, estradiol, regulates energy homeostasis. Estrogens elicit profound effects on metabolism by acting as an anorectic in humans and rodents. In support, postmenopausal women gain fat weight, which increases their risk of heart disease, cancers and type 2 diabetes. Recent work from our lab and others reveals that estradiol treatment protects against high fat diet-induced obesity in female mice. However, the mechanism by which estradiol prevents weight gain and obesity is not well understood. Within the gastrointestinal tract there is an exclusive combination of different communities of organisms, including bacteria, viruses, protozoa and fungi, which are collectively referred to as the gut microbiota. The collection of

these microorganisms, their genomes and the factors they produce are all part of the gut microbiome. Studies of the human and rodent gut microbiome reveal that microbial communities present in the intestines are a key player in obesity. Increasing evidence suggests that these microorganisms actively participate in shaping and maintaining physiology in humans. Our lab is investigating how estrogens and diet affect the gut microbiome in female mice. Students will be involved in animal handling, sample collection and data analysis.

Sara Wasserman
Does Sleep Deprivation Alter Visual Perception in Fruit Flies?

The Wasserman Lab is interested in understanding how an organism generates flexible behavior in varied internal and external environments. This project will focus on understanding how changes in sleep state modulate visual behaviors in the fruit fly. During the fall semester, the SERP fellow will learn to set-up our custom-built virtual reality flight simulators and begin to familiarize themselves with the experimental approaches and analyses used in the lab. In the spring semester, they will begin to run behavioral experiments and analyze data using Matlab. In addition they will be responsible for helping to feed and maintain lab fly stocks. Please see www.wassermanlab.com for more information on the lab.

Mike Wiest
Neural Correlates of Perception and Attention in the Rat Brain

In the Wiest Lab, we use surgically implanted arrays of tiny electrodes to record the electrical activities of neurons in rats' brains while they engage in sensory detection tasks, to try to understand how the brain creates perceptions and regulates attention. A SERP student would be responsible for helping to set up the lab again, and then for regular training of a group of rats, and if interested could also help with neural recordings and data analysis, implantation surgeries, and other lab activities. Potential educational benefits of this position include learning about animal behavior, behavioral neurophysiology, the technical computing language Matlab, histological techniques, surgical techniques, and modern approaches to the scientific study of mental functions like attention and consciousness.

Paulson Ecology of Place Initiative

Suzanne Langridge
Please contact Dr. Suzanne Langridge at slangrid@wellesley.edu for more information regarding her project.