Michael Caldwell
Department: Biology

Pre-requisite for a Summer Position: N/A

Description of Research:
In the Caldwell Lab, we study the ways in which animals use vibrations traveling through surfaces, such as the ground or plant stems, to assess their world. Although we know far less about how animals use vibrations, as opposed to other sensory modalities like vision or hearing, we do know that vibrational information is important in the communication, foraging, and risk assessment behavior of hundreds of thousands of species.

Methods in our lab include the recording and playback of vibration and sound signals produced by animals, video analysis of behavioral responses to these signals, and the measurement of vibrations as they propagate through body tissues and the environment.

Current lines of research include:
- Teasing apart the communication roles played by airborne sound and plant vibrations produced by red-eyed treefrogs (*Agalychnis callidryas*) when they call to attract mates.
- Determining whether toe tapping behavior exhibited by some foraging frogs serves as a vibrational signal used to manipulate the behavior of termite prey.
- Measuring the physiological sensitivity of snakes to substrate vibrations, and testing whether snakes use vibrations to locate their prey.

Students joining the lab should expect a mix of theoretical discussions, intense fieldwork, software based data analysis, and fiddling with experimental technologies.

Jenna Craig
Department: Biology

Pre-requisite for a Summer Position: N/A

Description of Research:
There are different molecular subtypes that have been identified in bladder cancer tumors that result in differences in tumor invasiveness and aggression. Bladder cancer tumors with a luminal molecular subtype are typically not invasive and have a more favorable therapeutic response. Meanwhile, tumors with a basal-squamous molecular subtype represents an aggressive, invasive and difficult to clinically treat phenotype. In addition, bladder cancer is known as a highly heterogeneous disease with both luminal and basal-squamous molecular subtypes co-occurring within the same tumor. Multiple morphological subtypes are also observed in bladder tumors. DNA methylation negatively regulates expression of an important transcription factor, *Forkhead Box A1* (*FOXA1*), in a CpG island specific manner in basal bladder cancer. However, the mechanisms that drive alterations in the DNA methylation landscape in basal bladder cancer compared to luminal bladder cancer are unknown. Finally, observations in other human cancers suggest that RB1 plays a regulatory role of DNMTs at gene promoters. Therefore, it is possible that alterations in RB1 status promote epigenetic silencing of *FOXA1* by regulating interactions of DNA methyltransferases (DNMTs). For one summer research intern, the goal of his or her project would be to explore and investigate candidate genes known to drive changes in DNA methylation in bladder cancer cells including RB1. The student would perform various cell and molecular techniques such as western botting, qRT-PCR, cell culture, and isolation of DNA, RNA, and protein from cells.

In addition, RB1 status has been use to predict clinical outcome in some bladder cancer patients. However, while some medical professions and scientists believe that RB1 status is a useful determinant in drug efficacy, others do not. Therefore, it is imperative to determine what current drug therapies would be beneficial for a patient with altered RB1 status. This project will use approved drug therapies for bladder cancer patients and determine the affects on these drugs in wild-type and RB1 knockout human bladder cancer cells. The student will perform various cell and molecular techniques such as cell culture, cell viability assays, and isolation of RNA and protein from cells for analysis via western blotting and qRT-PCR.

Betty Ferster
Department: Biology

Pre-requisite for a Summer Position: Applicants should be prepared to encounter ticks and poison ivy and raspberry thorns and to do a lot of weeding. We do field work as a team, you should be able to work well as part of a supportive group. Each student will be responsible for a part of our large data set. Applicants should be self-motivated enough to work independently with data to answer questions that help us understand the biodiversity of the ephemeral grassland around us.

Description of Research:
Grassland butterfly conservation - Insects have disappeared worldwide in the past few decades and some of the first insects to noticeably vanish from landscapes were charismatic butterflies. The Gettysburg area was once home to abundant butterflies, but many have disappeared. Butterfly surveys in the summer of 2021 in Gettysburg found no species of *Speyeria* (fritillaries) in the area. Studies of one fritillary, the regal fritillaries (*Speyeria idalia*), found that a loss of nectar plants was likely responsible for their population declines. In order to support reintroductions of regal fritillaires into the Gettysburg National Military Park (GNMP) grasslands, we may need to increase nectar plant abundance or diversity. These efforts will likely have a positive impact on other grassland butterfly species.

Our lab group investigates how butterflies use open areas in and around Gettysburg and how conservation of plant diversity can support butterfly diversity here. We do weekly butterfly and plant surveys of grasslands in GNMP that biologists hope to reintroduce rare regal fritillaries into, and of gardens on and around the Gettysburg College campus. Flowering plant surveys let us know what resources are available and may help us understand what conservation efforts will support the greatest diversity of grassland species. We use the campus greenhouse to learn about and grow important nectar plants. We are establishing a pollinator garden on campus that has become part of our long-term monitoring study and will allow us to understand how butterflies disperse and use man made habitat as a resource.

Peter Fong
Department: Biology

Pre-requisite for a Summer Position:
Students should be interested in aquatic organisms, bioactive chemicals, animal behavior, and pollution of the natural environment. Students should be comfortable being outdoors wearing waders and collecting animals in the summer heat and humidity of southern Pennsylvania.

Description of Research:
1. One project will test the combined effects of increased seasonal temperature and human pharmaceuticals (especially antidepressants) on the development of wood frog and toad tadpoles. Previous experiments have shown both species to be sensitive to environmental contamination resulting in differing body sizes and timing at metamorphosis. Effects of increasing global temperature could cause tadpoles to metamorphose sooner, but exposure to antidepressants released from wastewater could cause developmental delays. It is unknown how tadpole mass or overall activity will be affected. The interplay between rising global temperature and chemical contamination from human drugs is the focus of this project which concerns a group of animals (amphibians) with global interest among stewards of the environment.

2. Similar to project #1, the second project will test the combined effects of increased seasonal temperature and human pharmaceuticals (especially antidepressants) on important behaviors (righting response, locomotion to the air-water interface, and foot detachment from the substrate) in marine and freshwater snails. Results from previous experiments showed that antidepressants modulate a variety of important behaviors with evidence for hormesis (low-dose stimulation, high-dose inhibition). In summer'22, my lab will investigate the modulation of behavior in snails by antidepressants combined with the possible exacerbating effect of increased water temperature. We will collect snails from local creeks and marine snails from Delaware, maintain them in the lab at different temperatures, and do a behavior experiment each day testing different concentrations of antidepressants. As pollutants and global climate change continue to be serious environmental problems in the ocean and in fresh water, it is important to test multiple stressors that may pose unforeseen health risks for aquatic organisms.

Kazuo Hiraizumi
Department: Biology

Pre-requisite for a Summer Position: Completion of Biology 211 (Genetics) by the end of the Spring Semester of 2022 would be desirable. An alternative qualification would be completion of Biology 113/114, Biology 115, or Biology 212 (Cell Biology). Laboratory experience working with Drosophila would be a plus.

Description of Research:
Dipeptidases belong to a class of digestive enzymes and are found ubiquitously among organisms in every kingdom. These enzymes hydrolyze peptide bonds to provide amino acids for various metabolic and physiological processes. The level of catalytic activity of dipeptidases is a quantitative phenotype that varies between individuals in a continuous distribution within a natural population for any species. The genetic, molecular, and biochemical basis for such variation could be differences in the number of enzyme molecules that are produced (related to transcriptional or translational efficiency) or in the structure of the enzyme molecule (related to amino acid composition or sequence). Research projects focus on the characterization of genetic variation for gene regulation using the dipeptidase genes in Drosophila melanogaster as a model system. Identification and understanding of genetic factors that affect regulation of these enzyme-coding genes has relevant medical applications, given that reduction in enzyme levels of certain dipeptidases in humans is associated with disorders such as Huntington Disease, Alzheimer Disease, Crohn's Disease, and Celiac Disease.

Three of the Drosophila dipeptidase enzymes are encoded by independent genes (Dip-A, Dip-B, Dip-C). Each gene transcribes multiple forms of mRNA. Dip-B and Dip-C each produces mRNA isoforms that contain the same coding sequence (amino acids) for the primary structure of the enzyme but differ in the number and composition of nucleotide bases in the upstream non-coding portion of the mRNA (5' Untranslated Region or 5' UTR). For Dip-A, mRNA isoforms encode polypeptides of different amino acid sequences. How these molecular differences contribute to the expression of enzyme function is one of the primary research questions. Some of the ongoing and future research projects include: 1) molecular characterization of new mRNA isoforms of dipeptidase genes and transcriptional profile between genetic strains that differ in enzyme activity; 2) characterization of tissue-specific and developmental expression of mRNA isoforms for the three dipeptidase genes; 3) quantitative analysis of dipeptidase proteins at various developmental stages using antibodies; 4) comparison of DNA sequence and amino acid composition of dipeptidase isoforms between genetic strains that differ in enzyme activity; 5) knockout and knockdown modification of dipeptidase genes using CRISPR-Cas9 approaches; and 6) bioinformatics strategies for the identification of potential mRNA isoforms in other peptidase and proteinase genes. The summer internships offer an opportunity to contribute to these areas of research.

Sarah Meiss
Department: Biology

Pre-requisite for a Summer Position: N/A

Description of Research:
Wetlands:
Wetlands are an important ecosystem not only serving as habitat for various bird, reptile, mammal and plant species, but as cyclers of nutrients, filters of pollution, and carbon storage (helping to balance climate change imbalances). The plant, animal, and microbial community diversity is believed to be the contributing factor to the success of wetland environments. Currently, in the US, wetlands are destroyed for development and urbanization, causing widespread loss of essential habitat and ecosystem health. When a wetland is slated for destruction, a constructed wetland is built in a neighboring area. These constructed wetlands have potential to provide habitat, nutrient cycling, pollution filtration, and carbon sequestration, but many do not sustain for more than 5-10 years. After that time, they dry up and change their flora and fauna, essentially not serving as a wetland habitat. Microorganisms in soil influence the success of many ecosystems, including agricultural, forest, and aquatic systems. Even with the current methodologies, many aspects of the soil microbial community is unknown. Due to the nature of the wetland ecosystem, it is expected that microorganisms also contribute to the overall health and stability of the wetland environment. This project aims to examine and qualify the soil microbial community structure changes and the microorganisms in it in order to assess their effect on the success of natural and constructed (mitigated) wetlands. It is hypothesized that the loss of diversity and change in community structure, play a major role in sucess of mitigated wetlands. Students and the researcher will use a polyphasic approach using culture methods and molecular methods (DNA isolation:16S rRNA subunit/ITS region) to examine the microbial community, bacterial and fungal composition, in wetland soils. Students will travel to and take water and soil samples on site at the beginning of the summer while also working in the lab to examine nutrient content, water potential, dissolved oxygen, and pH/temperature. Then spend the second half of the summer working in the laboratory isolating DNA and identifying the microorganisms.

Jennifer Powell
Department: Biology

Pre-requisite for a Summer Position: Highly motivated students who love genetics and plan to continue their research project in the Powell lab during the school year. Preference given to rising sophomores and juniors.

Description of Research:
So much stress! Cells experience many different types of stress, including the stress of being attacked by pathogens, endogenous stresses such as the production of toxic metabolites or the accumulation of unfolded proteins, and environmental stresses such as changing temperature or salinity. The Powell lab focuses on how cells recognize stress, respond to stress, and integrate signals from multiple stressors. The tiny nematode *C. elegans* is an outstanding model system to answer these fundamental biological questions using powerful molecular genetic techniques.

The immune response is a special type of cellular stress response to infection by pathogenic microorganisms. Cells must detect the infection so they can respond accordingly. An exciting hypothesis is that cells do so by monitoring for signs of cellular damage that might occur as a result of an infection. One example of damage that does occur is oxidative damage – both from the Reactive Oxygen Species (ROS) produced by pathogens to attack the host cell, and by ROS produced by the host cells to fend off the pathogen. We propose that the host's immune system may also sense the resulting collateral damage as a trigger to activate or reinforce a defense response.

We also study the response to a brief extreme cold exposure. Following cold stress, we discovered that worms face a decision to allocate resources toward repairing the damage or to provide those resources to their offspring. The choice to transfer lipids to their germline is a reproductive strategy called terminal investment because it results in a survival advantage for the resulting progeny if they experience a subsequent severe cold shock, but it comes at the expense of the life of the parent. In addition to dissecting the molecular mechanisms of cold-induced terminal investment, we are studying the combined effect of cold and osmotic shock on *C. elegans*.

Angel Solis
Department: Biology

Pre-requisite for a Summer Position: N/A

Description of Research:
The Solis Lab has two open spots for the upcoming X-SIG program. Our research is aimed at better understanding how inflammation is regulated. Inflammation is a common pathological condition underlying a wide range of human diseases, including (but not limited to) cancer, Alzheimer's disease, and diabetes. By discovering new ways that inflammation can be regulated, we can unlock a whole new array of potential therapies that could significantly impact human health.

We are especially interested in macrophages. Macrophages are an immune cell that can be found in all human tissues and are often the immune cell that initiates and drives inflammation in many pathologies. In our lab, we use a macrophage cell line to measure the level, magnitude, and kinetics of the inflammatory response. We use an approach that combines genetics, cell biology, biochemistry, and molecular biology to understand the full context of our observations.

This summer, our goals are to identify novel proteins that play a role in the inflammatory response in macrophages. We have identified a handful of genes that are expressed at high levels in inflammatory macrophages, yet currently have no known regulatory function. We are working to generate genetic knockout cell lines in our macrophage cell line, induce inflammatory responses, and measure changes in phenotypes in our cells. We also hope to discover new proteins beyond our current candidate genes. More information on our lab, including previous publications, can be found on our website: thesolislab.com

Alex Trillo
Department: Biology

Pre-requisite for a Summer Position: Successful applicants will be highly motivated, be eligible for travel abroad, and be comfortable with intense tropical field-work. Preference will be given to students who have completed one semester of research in the Trillo Lab.

Description of Research: Research in the Trillo lab integrates the fields of behavior, ecology, and evolution. We do a lot of field work and collect much of our data in the tropics, in affiliation with the Smithsonian Tropical Research Institute. We are currently examining the effects of eavesdropping predators and parasites on the calling dynamics of mixed-frog choruses.

Eavesdropper effects on mixed-species choruses of frogs: Males often use conspicuous mating calls that increase attractiveness to females. These calls, however, usually come with a cost: being attractive to females also means being attractive to eavesdropping predators and parasites. This trade-off, between attractiveness to mates on one hand, and attractiveness to eavesdroppers on the other, has been shown to strongly influence mating call evolution. We are particularly interested in how the mortality risk due to eavesdropping predators, such as the bat *Trachops cirrhosus*, and eavesdropping parasites, such as the midge *Corethrella* spp. gets transferred from one prey species to another in mixed-species aggregations of frogs. We investigate whether calling near males of another species makes signalers more or less vulnerable to ‘eavesdroppers’ – do attractive neighbors bring in additional eavesdroppers (“Collateral Damage”), or do these neighbors capture most eavesdropper attention themselves, reducing a male’s risk (“Shadow of Safety”)? Ultimately, we wish to understand how these prey species interactions drive calling site choice and calling behavior in mixed choruses of tropical frogs. Student researchers that work on this project conduct playback experiments, presenting a variety of acoustic stimuli to bats in flight chambers and in the field. They will be trained in experimental techniques, bat handling and mist-netting, bioacoustics software, behavioral analysis software, and methods in tropical fieldwork.

Katherine Buettner
Department: Chemistry

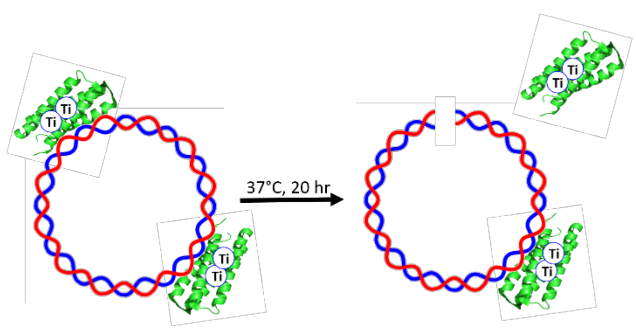
Pre-requisite for a Summer Position:
Students should have completed general chemistry to work in the lab.

Description of Research:
The design and synthesis of mini-metalloenzymes.

The aqueous chemistry of hydrolysis-prone metals is often avoided due to their reactivity with water. Avoiding hydrolysis through careful ligand choice opens new uses for these metals. Two such metals, titanium and vanadium, have many uses as catalysts and materials under non-natural conditions. Harnessing their reactivity with water using biological ligands will lead to novel applications of these metals. While titanium and vanadium are not commonly native to enzymes, their reactivity with water can be controlled in the binding sites of many natural proteins. We design novel enzyme active sites to bind hydrolysis-prone metals and utilize their reactivity to generate new enzymatic activities.

Many *de novo* designed proteins bind metals, however none have been reported to bind hydrolysis-prone metals, such as titanium and vanadium. These metals are relatively abundant, but underused in catalysis compared to precious metals. We have recently shown the ability of our enzymes to stabilize and functionalize titanium, providing the first report of a titanium enzyme, as well as the ability of our model system to mimic natural binuclear zinc hydrolases. Both our titanium and zinc enzymes are able to cleave DNA, showing their potential to act as therapeutics. We are now working to understand structure function relationships of these enzymes, and their ability to function against a variety of substrates.

Projects in the Buettner lab include: the design and development of new active sites in our current protein scaffolds to optimize metal binding as well as enzymatic activity; characterization of metal binding using a suite of biophysical techniques; and the optimization of enzymatic activity studies.

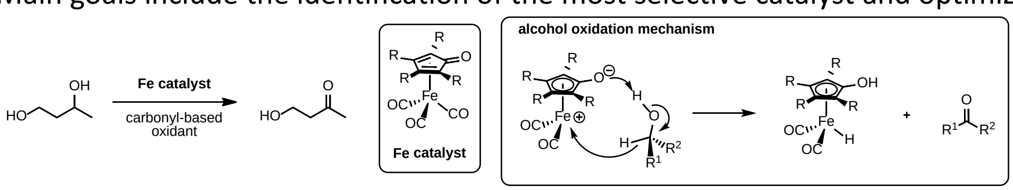


Tim Funk
Department: Chemistry

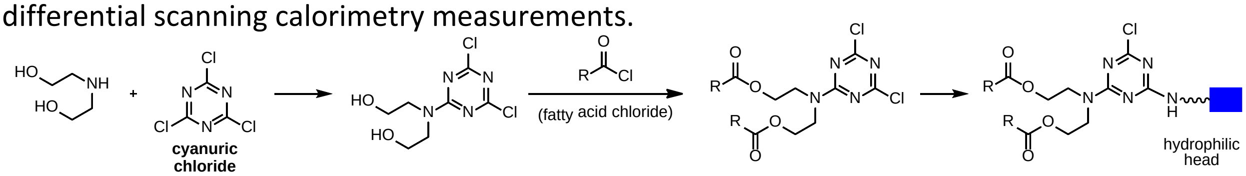
Pre-requisite for a Summer Position: Completion of Chem 107 and 108; at least one semester of organic chemistry would be helpful, but it is not required.

Description of Research:
Project 1: Selective, Sustainable Diol Oxidations. Synthetic chemistry drives many modern technologies, ranging from the development of new pharmaceuticals to the creation of innovative materials. One focus of 21st-century synthetic chemistry is improving the sustainability of chemical processes by using catalysts derived from earth-abundant metals, and research in the Funk lab is directed toward the development of (cyclopentadienone)iron carbonyl catalysts and applying them to redox transformations. Not only are these catalysts based on the second-most abundant metal in the earth's crust, but they also allow relatively benign, plant-derived organic compounds to act as terminal oxidants or reductants. Overall the goal is to develop more environmentally sustainable carbonyl reductions and alcohol oxidation reactions, both of which are fundamentally important transformations in the synthesis of pharmaceuticals and fine chemicals.

During the summer of 2022 we will focus on the selective oxidation of diols containing both primary and secondary alcohols. Selective oxidations remove the need for protecting groups and lead to more efficient syntheses. We will be synthesizing diols—some of which are natural products and/or have biological importance—and using a subset of our iron catalysts to selectively oxidize the secondary alcohol of each. Main goals include the identification of the most selective catalyst and optimizing the process.



Project 2: Functionalizable Lipid Synthesis. Through a collaboration with Prof. Vince Venditto at the University of Kentucky's College of Pharmacy, we are designing and synthesizing lipids based on readily functionalizable cyanuric chloride. Prof. Venditto is studying vaccine development and has shown that mRNA packaged in cyanuric chloride-based lipids can be delivered to and translated by HeLa cells. He and his students studied the structure-function relationships of various hydrophilic heads, and the next goal is to understand how the hydrophobic tails affect lipid transition temperature, nanoparticle formation, and gene transfection. To that end, we will couple cyanuric chloride with diethanolamine, introduce a variety of fatty esters as the hydrophobic lipid tails, and cap it with a hydrophilic head. The resulting library of compounds with C_8 – C_{18} hydrocarbon tails will be sent to Prof. Venditto for liposome formation and differential scanning calorimetry measurements.



Suvrajit Sengupta
Department: Chemistry

Pre-requisite for a Summer Position: N/A

Description of Research:
Hydrophobic interactions play an important role in protein folding, and formation of lipid micelles and bilayers. Current opinion regarding the arrangement of water around small hydrophobic molecules is that it is akin to those found in clathrate hydrates of natural gases.

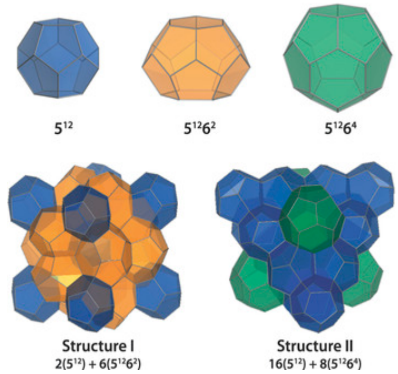
Clathrate hydrates are non-stoichiometric compounds (*i.e.*, they don't have a fixed composition) composed of a host water "cage" and a "guest" molecule. They occur naturally in the seafloor and permafrost as "gas hydrates" with methane and ethane being the most common guests. They could serve as potential energy reserves, but also pose a danger to the environment because they can form spontaneously in pipelines and thus lead to blockages. On the other hand, they could prove to be efficient means of storage and transportation of a variety of gases.

Antifreeze proteins are naturally occurring proteins that prevent the growth of ice crystals in a variety of organisms – most notably the Antarctic toothfish. They are believed to prevent the growth of ice crystals by changing the surface of the growing ice crystal into a morphology similar to those found in clathrate hydrate crystals.

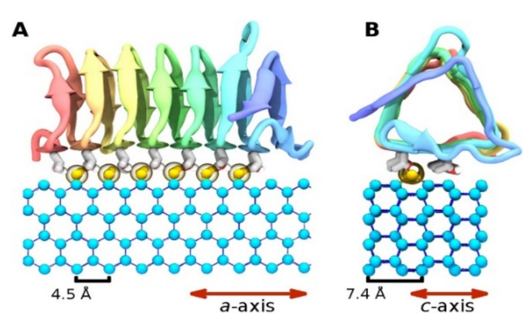
Project #1: It is suspected that hydrates are formed more easily from melts of previously formed hydrates than from the combination of freshly prepared reaction mixtures. This phenomenon is known as the "memory effect". We will use home-built equipment to monitor the melting and reformation of tetrahydrofuran (THF) or cyclopentane (CP) hydrates under the microscope. The effect of different surfaces on the memory effect will be examined.

Project #2: Using home-built equipment we will monitor the kinetics of the gas hydrate formation from ice particles in the presence of trace impurities. Effects of various hydrate formation catalysts and inhibitors such as, amino acids, surfactants, and salts will be investigated.

Project #3: We will work on expressing in *E. coli* and purifying antifreeze proteins which have been shown to influence ice growth and hydrate formation kinetics. Thereafter the project will characterize the interaction of these proteins with ice particles and monitor the effects these proteins have on ice and hydrate growth.



Cages and crystal structures of gas hydrate cages. Each vertex of a polyhedron is occupied by a water molecule. Guests are trapped within the polyhedral.



Insect antifreeze proteins bind to growing ice surfaces to halt the growth of ice crystals.

Todd Neller
Department: Computer Science

Pre-requisite for a Summer Position: N/A

Description of Research:
This X-SIG project will be for participation in the upcoming Mentored Undergraduate Research Challenge "Human-Aware AI in Sound and Music" (https://www.yetanotherfreedman.com/resources/challenge_haaisam.html). "Human-aware" refers to an AI algorithm taking input direction from the actions, perceived states, etc., of humans. Human-aware AI in Sound and Music (HAAISAM) is a broad category of research work, examples of which are automated musical accompaniment, a game soundtrack that alters according to the user's play state (e.g. winning/losing, intense interaction/lull), or a computer DJing a person's workout, matching tempo to observed motion.

There are many opportunities for creative research here, but too many choices can lead to a paralysis of decision. I have therefore reached out to contacts within Roblox to learn of ways that X-SIG students might perform an 8-week project that would be of benefit to users of their platform. Ultimately, engagement with Roblox researchers and the final choice of projects will be finalized with input from selected students.

Beyond research artifacts, our goal will be to publish on the work in the Mentored Undergraduate Research Challenge track of the 2023 Educational Advances in Artificial Intelligence Symposium, collocated with AAAI-2023, the largest general AI conference of our hemisphere.

Clifton Presser
Department: Computer Science

Pre-requisite for a Summer Position:
Students will need to have some programming experience, at minimum an introductory programming course like CS111 or CS107.

Description of Research:
My current project in procedural content generation involves generating rules for a simple peg puzzle game. The game mechanic of interacting with a pair of pegs remains constant however the conditions, interactions and outcomes for rules as well as winning conditions are generated separately. This process employs evolutionary algorithms, simulating natural selection, for finding good sets of rules. I recently taught a Selected Topics course about Procedural Content Generation which inspired the graph grammar work proposed for summer 2022.

Natasha Gownaris
Department: Environmental Studies

Pre-requisite for a Summer Position: To be a good fit, students should have completed ES 211 and should be comfortable analyzing data in the statistical program R. Additionally, students should be comfortable with the idea of handling birds and working with blood samples for stable isotope analysis and should be ready for very early mornings (4:30am), field living conditions, limited internet access, and for spending June and July on this remote island.

Description:
My research focuses on how seabirds change their foraging behavior and diet in response to rapid environmental change. Specifically, I am interested in how individuals within a species vary in how they respond to this change and in how their response influences their fitness.

My current research site is on Petit Manan Island, a small island off the coast of Maine that is home to seven species of breeding seabirds. The Gulf of Maine is warming faster than nearly anywhere else in the ocean and, in recent years, warm water moves into the Gulf in July, just as seabirds are raising their chicks. When waters warm, preferred diet items of seabirds in the Gulf of Maine (fishes like hake and herring), move deeper and more offshore. Seabirds can respond in two ways: 1) they can change their foraging behavior, or 2) they can prey switch to less preferred diet items. I am interested in which option they choose and in how this impacts the survival and growth rate of their chicks.

This summer, we will spend eight weeks on Petit Manan Island collecting chick growth data, chick provisioning data, and stable isotope samples for four species of seabird on Petit Manan (Atlantic puffins, Black guillemots, Arctic terns, and Common terns). We will look at how diet and foraging change across the season, as sea surface temperature increase and preferred prey items become harder to obtain. A day’s work is likely to include a mixture of these activities: measuring chicks, counting seabirds, observing what food items seabirds bring back to their chicks, collecting and processing blood samples, entering data. As a student researcher, you will have ownership over a specific aspect of this project, but will also help with general daily data collection. Note that there is phone service and limited internet access on the island, limited showering using a Sun Shower, and a kitchen (food drop-offs occur weekly). If you are interested, you should plan to spend the full eight weeks on Petit Manan Island.

Sarah Principato
Department: Environmental Studies

Pre-requisite for a Summer Position:
Required course: ES223; strongly recommended courses: ES230 and ES318; also must be prepared to start working immediately after finals end.

Description of Research:
My summer XSIG students will study the retreat of part of the Iceland Ice Sheet and Holocene climate change in Iceland. We will examine glacial landforms and sediments from Iceland to reconstruct the glacial history of part of Northern Iceland. In particular, we will investigate the Saudaðalur region, south of Húnaflói, and the Skessugarður region, north of Vatnajokull. These two regions have several undated landforms and minimal to no previous work. We will use GIS analyses and remote sensing to study the landforms and conduct fieldwork to date moraines and collect glacial sediments. One student project will focus on dating moraine boulders using the Schmidt Hammer technique and lichenometry. The second student project will focus on sedimentological and geochemical analyses of sediments. If time permits (or if covid-19 prevents travel to Iceland), we will also conduct a pilot study using the Schmidt Hammer to date periglacial boulders in PA and MD.

Josef Brandauer
Department: Health Sciences

Pre-requisite for a Summer Position: While previous lab experience is generally helpful, it is not completely required.

Description of Research:

Research and Projects

The current focus of my research lies on understanding how mammals regulate mitochondrial content and activity in various tissues. A particular focus is the investigation of how cellular concentrations of nicotinamide adenine dinucleotide (NAD) contribute to this regulation.

This summer, we will continue ongoing work on determining mitochondrial biology in skeletal muscle of a mouse model of Down Syndrome. The student(s) working on this project will primarily assess mitochondrial protein expression, activity, and NAD concentrations in skeletal muscle tissue. (We receive these tissues from a collaborator at another institution, so you will most likely only work with frozen tissues, not with live animals.)

Student Expectations

For all of my research projects, I look for curious and motivated students. With focused practice, students working in my lab routinely become quite skilled at the specific techniques we use. While previous lab experience is generally helpful, it is not completely required. Rather, I look for motivated and hardworking individuals who are excited about scientific discovery, problem solving, and passionate about working collaboratively within a small team. I look forward to meeting you!

Sheakha Aldaihan
Department: Physics

Pre-requisite for a Summer Position: N/A

Description of Research:
The possible existence of new forces of Nature with ranges of macroscopic scale (millimeters to a few meters) is attracting a lot of scientific attention. Such forces play an increasingly important role in many theories attempting to solve fundamental problems in physics but are poorly constrained by existing experiments. While most research efforts are focused on improving the experimental techniques, this work will be focused on increasing the sensitivity to a subset of new forces by improving the theoretical formalism. Our group has already generated a number of formals and presented the first example of the successful use in ref. [*]. The goal of the student's project is to fit the rest of the mathematical formulas to current experimental data and investigate the possibility of uncovering new information on such forces.

We will examine the literature and walk through the physical motivation of the research, the parameterization of the forces, and the different types of existing experiments undergoing the search. The experiments we will examine are designed to detect deviations from the gravitational forces between two macroscopic masses. The functional forms we derived were calculated between two “point-like” particles. The goal of the project is, therefore, to integrate the functional forms over the volumes of the laboratory masses to come up with a formula for the force measured in the experiment. By comparing the force calculated with the measurement, the student will be able to place limits on the strength and range of the forces. This process can be repeated for two to three main experiments. At the end of the program, the student would have developed a comprehensive understanding of core problems in fundamental physics and the experiments used in the search and have gained skills such as performing complex integrals analytically and numerically, fitting functions to data, and displaying data in graphs.

[*] S. Aldaihan, D. E. Krause, J. C. Long, and W. M. Snow. “*Calculations of the Dominant Long Range, Spin-Independent Contributions to the Interaction Energy between Two Nonrelativistic Dirac Fermions from Double-Boson Exchange of Spin-0 and Spin-1 Bosons with Spin-Dependent Couplings*”. Phys. Rev. D, 95, 096005 (2017). [arXiv: 1611.01580].

Kurt Andresen
Department: Physics

Pre-requisite for a Summer Position: N/A

Description of Research:

1. Measuring the Kinetics of the Disassembly of Mononucleosomes

There is two meters of DNA packed into the nuclei of every one of our cells (a container that is approximately one micrometer in diameter). One of the major steps in compacting this DNA is the wrapping of the DNA into hockey-puck shaped spools called nucleosomes. In this project, we will be using a few different biophysical and biochemical techniques to try to understand the physics that drive these processes. In particular, using our in-house Circular Dichroism Spectrometer to measure the timed unfolding of nucleosomes. This will give some idea as to the energies involved in unwrapping the DNA form the nucleosome in important biological processes like transcription. Furthermore, using ICP-AES (fancy machine that measures the concentration of elements in a sample) we will try to measure the type and number of ions that surround nucleosomes, information that is vital to the physical understanding of nucleosome interactions. Students will learn wet lab techniques (pipetting, equilibrium dialysis), basic Python analysis, and some interesting biology all while exploring the underlying physics that drives these processes.

2. The Entropy and Enthalpy of DNA systems

One of the major questions in biophysics is what energies and entropies drive complex systems to behave in the way they do. One of the systems I have been studying throughout my career is the self-attraction of DNA when in a solution of +3 ions. Recently, my collaborator and I have been studying the role of osmotic pressure (i.e. pushing the DNA together using force) in the physics of self-attracted DNA bundles. In this project, we will subject DNA systems to measurements utilizing our in-house isothermal calorimeter. We will explore how different ions affect the binding of DNA. Building on the work of past students, we will use home-built Python scripts to fit this complex data. Students will learn how to use the isothermal calorimeter, wet lab techniques, some basic thermodynamics, data analysis using the Python programming language, and some interesting biology.

3. Measuring Zn^{2+} binding to DNA (in collaboration with Professor Kate Buettner

One of the fundamental questions in DNA electrostatics is whether or not certain ions bind strongly to specific parts of the DNA or whether they just bind through general electrostatic interactions. Building on previous work, we will be measuring the binding of Zn^{2+} to DNA utilizing a combination of circular dichroism and ICP-AES (a technique used to measure the concentration of ions around the DNA). We will investigate whether there is specific binding of the Zn^{2+} to the DNA, and if so how much. These measurements will be useful in understanding how the small amounts of Zn^{2+} in our body affect DNA and the binding of other biomolecules (e.g. proteins) in the cell. Students will learn wet lab techniques (pipetting, equilibrium dialysis), basic Python analysis, and some interesting biology and physics.

Bret Crawford
Department: Physics

Pre-requisite for a Summer Position: Phy211 or Phy110 is preferred but not required.

Description of Research:
Proton Energy Loss through Thin Films

The Student Proton Accelerator at Gettysburg College (SPAGetty) creates beams of protons up to several microAmps with energies between 50 and 200 keV, which I would like to use to study proton energy loss through thin films. While this phenomenon has been well studied, accurate modeling gets more challenging at low energies. Energy loss is important for solid-state ion detectors which have thin "dead" layers of material through which the ion must pass before the entering the detector's active region. This dead layer significantly affects the detected energy spectrum for low-energy ions. In high-precision measurements that use these detectors, correct modeling of the detected energy spectrum can be quite important, e.g., the on-going neutron-lifetime measurement at NIST. To study this, we will deposit thin films (10s of nm) of gold or possibly other metals onto the bare silicon surface of our proton detectors, Passivated Implanted Planar Silicon (PIPS) detectors. The proton beam will then be adjusted so that it is detected after first going through the silicon dead layer of the PIPS or after the gold (or other material) and silicon dead layers. Comparing these spectra will allow us to extract the effect of the gold film. Using the college's Atomic Force Microscope (AFM), we can measure the film thickness and thus study energy loss and energy spectrum shape as a function of film thickness and incident proton energy. These results can be compared with simulation software to assess the accuracy of the models being used in the software.

Summer research students will learn about energy loss mechanisms, learn to run the accelerator, evaporate thin films, participate at some level with the AFM, run the simulation software, collect proton energy data, develop and run Python scripts to analyze spectra, etc.

Tim Good
Department: Physics

Pre-requisite for a Summer Position: N/A

Description of Research:
I will employ two students to conduct experiments in the Charged Plasma Device (PCPD). The overarching goal of the plasma research is to excite and study antenna-launched ion acoustic waves (IAW). Students will employ an electrostatic Langmuir probe to study the electron and plasma potential response to the IAW and also will use an optical diagnostic system in order to study the ion response via laser induced fluorescence (LIF) spectroscopy. The two students will be employed for an eight week research campaign beginning June 6 and ending August 5, with one week holiday break in July. A trip to the plasma physics lab of Professor Earl Scime of West Virginia University is planned in order to participate in and gain experience from spectroscopic studies of argon ions in a helicon plasma device.

The research project is collaborative in essence with a common goal of studying the IAW. Students will be provided with common hands-on training on the maintenance of the vacuum system and gas flow system, the maintenance and operation of the plasma source, and the collection and interpretation of measurements. Working together concurrently is necessitated by appropriate safety protocol regarding the inherent electrical dangers associated with the circuitry of the filament discharge plasma source. Students will be provided laboratory safety training as well.

Each student will take a principal role in running one of the diagnostic systems and each student will contribute an upgrade to that system. The probe person will assemble and install a computer-controlled stepper motor scanning apparatus for spatial scanning in order to study wave dispersion and damping via measurements of wave interferograms. The laser person will construct and install a new photomultiplier tube housing for improved LIF detection for the measurement of the ion velocity distribution function.

Goals:

1. Install new fiber optics and related optics hardware to replace open air transport of the laser beam from the optics table to adjoining experiments in PCPD and the magnetized sodium gas cell. Particular emphasis will be placed on the efficient coupling of the laser at the fiber port to allow high power transmission from the optics table to the PCPD.
   This will enhance student eye safety and provide better beam pointing stability.
2. Carefully align the injected laser beam on axis of PCPD to the fluorescence collecting telescope that views through new window ports in the aluminum plate flanges. Adjusting two sets of lens optics to find the intersection of the laser beam and viewing volume of the telescope may sound trivial, but it is the most critical step for obtaining LIF measurements and requires painstaking effort with clever methods of observation.
3. Returning to an unattained goal from 2018, we will construct new PMT housing for LIF detection with machined parts obtained from Dr. Scime at WVU.
4. Having constructed a new Langmuir electrostatic probe diagnostic with an extended shaft, we will install a probe shaft driver mechanism to allow spatial scanning of density and potential structures.

Ryan Johnson
Department: Physics

Pre-requisite for a Summer Position: See descriptions below.

Description of Research:

Project I: Quantifying the Effect of Light's Travel Time on Projected Galaxy Cluster Data

This project is a continuation of a study I began several years ago into the phenomenon of the effect of finite travel speed of light on astronomical observations of galaxy clusters. When we use simulations to predict where and how these clusters should evolve, we must project the data onto a 2D observational plane, in order to mimic the projection of that data onto our sky. Specifically, we will be examining the observational effect of projecting 3D astronomical data onto a 2D observational plane when the object we are projecting is so large that light takes millions of years to get from one side to the other. Because of this, all currently used data projection methods are not taking into account that different parts of the object are also being projected to different times. Our goal is to develop and test several different numerical projection methods which will both project the data onto the same plane, and correct it so that it will all be projected to the same time as well. This project is best suited for Physics majors interested in theoretical astrophysics.

Project II: War! What is it Good For? Probability Analyses.

The is a continuing project to explore the effect of chaos in deterministic systems by doing statistical and probability analyses of the card game "WAR." The essential question I want to answer is, given any current game state (the number, position, and identity of cards in each player's hand), what is the statistical probability of winning the game? Since, in the traditional format, the order of all of the cards is preserved between rounds (no shuffling), the system is completely deterministic (the exact same game and outcome will result given the same initial conditions). When one inserts random shuffling between rounds (chaos), the outcome is no longer certain as has been noted by several authors in the literature (Haqq-Misra, 2009, and Lakshtanov & Roshchina, 2011). I am proposing to follow these previous studies in order to quantify the effect of shuffling, or reordering, cards, on the victory probability. No background knowledge in programming is required, but this project is best suited for a student with computer science or data science experience.

Project III: Over the past 18 months, copious amounts of data have been collected on the spread of the COVID-19 virus throughout the world's population. In this data science project, we will be using python to numerically analyze the temporal relationship between COVID-19 infection rates, hospitalizations, and deaths for several regions around the United States. The goal of this analysis will be to create a predictive model for the temporal difference between increasing rates, or peaks, of infections, hospitalizations, and deaths. For those regions with the most extreme differences, I am also interested in including more granular demographic data, and attempt to ascertain the effect of local, state, and national health and safety advice on these temporal differences. This project will use publicly available data from sources such as usafacts.org, which is the central repository for all COVID data in the US, and the Coronavirus COVID-19 Global Cases by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. This project is best suited for a student with a data science or computer science background.

Jackie Milingo
Department: Physics

Pre-requisite for a Summer Position:
There are no prerequisites for these projects only the expectation that the students will be physics majors with a professional interest in STEM.

Description of Research:

I have a number of projects that students can participate in, all of them are basically observational astronomy projects that include time-series photometry (measuring how the light changes over time) of variable stars (acquisition, reduction, and analysis of that data), as well as work that needs to be done at our College observatory. The Gettysburg College Observatory houses a 16" telescope with a CCD camera and filter wheel. While highly uncertain, if in-person work and travel is safe and allowed then I would include an observing run at the National Undergraduate Research Observatory (NURO) in Flagstaff, AZ. NURO also currently has remote and robotic observing options. Time-series analysis photometry projects would likely be further participation in the Our Solar Siblings project specifically continuing the RR Lyrae work (variable stars used as distance indicators) I've been doing for the past few years. Ideally though, I would like to focus on work required at the College observatory to streamline the observing process and make the observatory more “user-friendly”.

Preference will be given to those students specifically interested in astronomy/astrophysics related fields.

Yoshihiro Sato
Department: Physics

Pre-requisite for a Summer Position: Completion of one of the following courses: PHY310, CHEM203, CHEM204, CHEM305, or CHEM306. Knowledge about Python programming language is desirable but not required.

Description of Research:
Molecular Excitation Energy and Charge Transfer Mechanisms in Photosynthesis.

Plants, algae, and many kinds of bacteria capture natural light to sustain their life by photosynthesis. These organisms are using specific proteins to convert the light energy into molecular excitation of pigments, and they eventually create electricity for subsequent chemical reactions of photosynthesis. These proteins are called reaction centers. A remarkable aspect of the reaction center is that efficiency of energy conversion is nearly 100%, much higher than the best commercially available photocells. How did they successfully develop such a mechanism in their course of evolution? Recent experimental and theoretical studies indicate that the quantum mechanics is playing a key role in keeping the efficiency.

In this project, we devise computer simulations to investigate how quantum mechanics is working in the photosynthetic reaction centers. We particularly focus on building a physical model of photo-induced charge transfer dynamics in photosystem II reaction centers, which are commonly found in oxigenic photosynthetic organisms such as plants and cyanobacteria. The simulations will be performed using a GPU-accelerated high-performance computing cluster located in Masters 202.

There are two subprojects available for students:

1) Running simulations and analyzing the results to extract properties of charge transfer dynamics in reaction center.
2) Developing a method for molecular dynamics and quantum chemical simulations on energetic properties of biomolecules including chlorophylls and carotenoid.

In both of the projects, the students will be much involved in data analysis using their knowledge about quantum physics and/or chemistry.