Prof. 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. While the main focus of the lab is vibrational communication in vertebrates, highly motivated students interested in pursuing projects in visual, chemical, or other modes of communication, or with non-vertebrate animals are also welcome.

Prof. Melanie Eshelman
Department: Biology

Pre-requisite for a Summer Position: Students who have completed both BIO211 and BIO212 would be the best fit.

Description of Research:
The Eshelman Lab is a biomedical research lab focused on the cellular and molecular biology of the cells that line the digestive tract: intestinal epithelial cells (IECs). These cells form a critical barrier that segregates the contents of the intestinal lumen from the underlying body tissue to prevent inflammation. We are interested in both endogenous and exogenous factors that influence four key IEC functions: cell barrier formation, anti-microbial compound secretion, damage repair, and immune cell modulation. For the summer of 2024, we will be focusing on two distinct projects:

Project 1: The role of RNA-binding protein, tristetraprolin (TTP), in IEC function.
Our lab has previously identified TTP as a master regulator of intestinal epithelial cell biology. To maintain healthy intestinal tissue, TTP levels must remain steady as both over- and under-expression of TTP lead to intestinal maladies. This suggests that TTP and the molecular pathways that it modulates must be tightly controlled to maintain homeostasis in the gut. To understand why such a balance in TTP levels is necessary we are interested in exploring the molecular mechanisms by which it affects the four functions of IECs. This summer our focus will be on how it modulates the intestinal barrier.

Project 2: The effect of bacterial metabolite, *p*-cresol, on IEC function.
Our lab is interested in how the intestinal microbiome influences IECs. One way they can do so is to break down dietary compounds we eat into secondary metabolites. Those secondary metabolites are recognized by IECs and alter their function. We are currently interested in the tyrosine derivative, *p*-cresol. The abundance of this compound is altered in intestinal disease, yet little is known about its effect on IECs beyond a role in modulating IEC cellular proliferation and survival. This summer our focus will be on how it influences the ability of IECs to communicate with immune cells.

In my lab, there are opportunities for students to learn many cellular, molecular, and biochemical techniques, including cell culture, organoid culture, mRNA analysis, and microscopy.

Prof. 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:
Current plan is for research to be performed on-campus and in-person.

1. One project will test the combined effects of increased seasonal temperature and pollutants such as nanoparticles on the development of wood frog tadpoles. Previous experiments have shown wood frog tadpoles 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, and simultaneous exposure to nanoparticles could exacerbate developmental timing. It is unknown how tadpole mass will be affected. The interplay between rising global temperature and chemical contamination from nanoparticles 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 reproduction of three species of freshwater snails which live in the same stream 25 miles north of Gettysburg. Two of these species are native to Pennsylvania, but one species is invasive from New Zealand. One of our native species is invasive in Europe as is the snail from New Zealand. Results from previous experiments showed that antidepressants modulate a variety of important reproductive endpoints such as egg laying in snails. We will collect snails and culture them under different temperatures and pharmaceutical concentrations, measuring the timing of egg laying, the number of embryos laid, and the hatching time of those embryos. Thus, this project will examine the impact of global climate change on reproduction in species which have invaded both North America and Europe, and which cause significant ecological damage.

Prof. Kazuo Hiraizumi
Department: Biology

Pre-requisite for a Summer Position: Completion of Biology 211 (Genetics) by the end of the Spring Semester of 2024 would be desirable. An alternative qualification would be completion of Biology 115 or Biology 212 (Cell Biology). Laboratory experience working with Drosophila would be a plus but not a requirement.

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.

Current plan is for research to be performed on-campus, in-person.

Prof. Steve James
Department: Biology

Pre-requisite for a Summer Position: Bio 211 (Genetics) and/or Bio 212 (Cell Biology)

Description of Research:
Identification of *wdA*-interacting proteins by epitope tagging and co-immunoprecipitation
Background: Cells rely on a cytoskeleton to determine shape, structural integrity, movement of materials throughout the cell, and to mediate the faithful segregation of the genetic material (chromosomes) during nuclear division (mitosis) and cell division. This essential cytoskeletal framework is composed of microtubules, rodlike fibers consisting of heterodimers of alpha- and beta-tubulin proteins. We discovered a novel regulator of the microtubule cytoskeleton, which we named *wdA*. Cells lacking the *wdA* gene (*ΔwdA*) undergo lethal mitotic catastrophe, *i.e*., failure to segregate chromosomes during mitosis. In *ΔwdA* cells, mitotic failure resulted from absence or reduction of microtubules. Thus, *wdA* serves a critical function in microtubule dynamics and cell proliferation. This gene is conserved across a wide span of the fungal kingdom, but is unstudied in any other fungus, and therefore we have the opportunity to contribute new understandings about regulation of microtubule stability/dynamics.
Identification of *wdA*-interacting proteins: By identifying proteins that interact with *wdA*, we may uncover the complex in which *wdA* operates and in this way identify its function. To identify *wdA*-interacting genes, we undertook **genetic** and **proteomic** approaches, as follows:
Genetic approach: During 2019-2022, students working in the James laboratory discovered genetic interactions between *wdA* and two genes: (1) ***mcnC*$^{\mathbf{Def1}}$** – binds to ubiquitin-like domains in target proteins to facilitate their destruction by the 26S proteasome, not previously implicated in microtubule-related functions; and (2) **TBCA, Tubulin-binding cofactor A**, binds beta-tubulin to control tubulin homeostasis and facilitates dimerization with alpha-tubulin. We discovered that deletion of *wdA* rescues a near-lethal growth defect caused by loss of TBCA, suggesting, along with the interaction with *mcnC*$^{\mathrm{Def1}}$, that *wdA* plays an important role in tubulin proteostasis.
Proteomic approach: Prof. James performed Immunoprecipitation plus Mass Spectrometry (IP-MS) and generated a dataset of candidate interactors with *wdA*. Among the highest-scoring proteins from approximately 1000 candidates was beta-tubulin. Subsequent AI-based 3-D modeling of protein-protein interactions using Colabfold and ChimeraX produced high-confidence models predicting physical association of *wdA* with beta-tubulin and TBCA.

Students in summer 2024 will engineer epitope tags onto *mcnC*$^{\mathrm{Def1}}$, β-tubulin, and TBCA, respectively, followed by co-immunoprecipitation (co-IP) to test association with *wdA*. Co-IPs can identify physical association of two proteins bearing different biochemical (epitope) tags that are recognized by commercially available antibodies. If two proteins associate, then capturing one of the proteins with a tag-specific antibody will also capture the second protein, which is then identified by western blotting using a different antibody against the second protein. Using an existing *wdA* protein tagged with GFP (Green Fluorescent Protein), students will perform co-IPs after tagging their genes with HA3 or FLAG epitopes.

Prof. Steve James, continued
Department: Biology

What technical skills will students learn from this experience?: you will use fusion PCR to create an epitope-tagged gene construct, followed by DNA-mediated transformation of *Aspergillus* and molecular diagnostics to verify replacement of the wild-type gene by the tagged version. Following this, you will learn how to isolate native proteins from *Aspergillus* and perform co-IP + western blotting using anti-GFP and anti-HA or anti-FLAG antibodies to assess whether your protein physically associates with the wdA protein. You will also learn how to culture and manipulate a filamentous fungus, as well as how to design failsafe PCR primers, and you will learn how to use Colabfold and ChimeraX to model 3-D protein-protein interactions.

Prof. Ryan Kerney
Department: Biology

Pre-requisite for a Summer Position: N/A

Description of Research:
The main project goal for the summer is to live image cell-tissue interactions of a unique symbiosis. Mutualist algal cells (*Oophila amblystomatis*) enter the embryonic tissues and cells of the spotted salamander (*Ambystoma maculatum*) during development. This is the only known instance of a vertebrate endosymbiont. The alga blooms outside the blastopore in neurula-stage embryos and spreads through the intracapsular fluid. *Oophila* eventually enters the alimentary canal, tissues, and cells from all three host germ layers. The proposed research will resolve the *in vivo* algal movements within embryonic tissues and test whether macrophages are required for these processes. These experiments will answer lingering questions about the routes of algal tissue entry, the fate of intracellular algae, and *Oophila's* tissue affinity.

Critical gaps remain in our understanding of this association. *Oophila* enters opaque tissues against a steep light gradient. Older embryos have high concentrations of algae in the embryonic alimentary canal, with scattered algal cells occurring in other tissues. Establishing the dynamics of algal taxis in the tissues will give critical insights into the specific gradients these algae follow during tissue and cellular entry. The proposed work will be our first attempt at 4D *in vivo* imaging. If funded, this project will entail staying at the Janelia Research Campus in Ashburn, VA, for 3 weeks to run their SimView light sheet microscope and work with their team of microscopists and bioinformaticians. We will spend the remaining weeks on campus analyzing the data with Fiji, Mastodon, and Python. We will hear from Janelia later this fall about the status of our 2024 proposal.

Prof. Matthew Kittelberger
Department: Biology

Pre-requisite for a Summer Position: I am seeking 2 research students for the summer; ideally, the selected students will already have completed our BIO 212 (Cell Biology) course, though this is not an absolute requirement. If you enjoyed the Cell Bio lab, this could be a fun way to take that experience further.

Description of Research:
Students in the Kittelberger lab this summer will work with cultured melanoma cells, to identify viable tools for manipulating expression of specific cancer-related genes, and to explore the role of these genes in aspects of the cancerous phenotype. This project is intended to lead to a significant re-design of the lab curriculum in our Cell Biology (BIO 212) course. Currently, Cell Bio students engage in a month-long semi-independent project in which they treat melanoma cells with a drug of their choice, and examine effects on cell proliferation and differentiation (as measured by cellular production of melanin, or cell morphology). Our hope is to expand on these projects to a) give students more independence, with a broader array of experimental options; b) enable students to incorporate more modern molecular biology and microscopy techniques in their experiments, including timelapse imaging and quantitative microscopy methods; and c) better connect student experiments with material covered in lecture (e.g., cell signaling, cytoskeletal dynamics, the cell cycle, mitochondrial function and metabolism, etc). To this end, we seek to identify an array – perhaps ~20 – of genes, involved with different subcellular structures and functions, that future Cell Bio (or X-SIG) students can manipulate to explore aspects of cell structure and function in control and drug-treated cancer cells. Specifically, we aim to transfect melanoma cells with plasmids, containing various genes of interest fused to fluorescent proteins, which enables easy identification of transfected cells, as well as the ability to visualize and examine specific organelles.
Research students in my lab this summer will:

1) Work as part of a collaborative team to perform literature research to identify interesting potential genes to target. This work will begin this spring, so students will be expected to put in a little time towards the end of the semester helping prepare for the summer research.
2) Select 3-4 specific target genes per student, and conduct experiments to optimize the transfection of these genes into cultured melanoma cells.
3) As time permits, begin conducting experiments to test whether over-expression of the targeted genes affects the cancerous properties of melanoma cells (e.g., proliferation rate, differentiation state, vulnerability to chemotherapy, etc).

Research students will learn cell culture techniques; methods for transfection of specific genes into melanoma cells; and fluorescence microscopy, using the new EVOS 5000 and 7000 microscopes the Biology Department recently purchased, to visualize and quantify transfection rates and potentially aspects of subcellular function. Possibilities exist for interested students to continue to work on this project beyond the summer, and for potential publication (e.g., in the Journal of Cell Biology Education).

Prof. 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 other stresses on *C. elegans*.

Prof. 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 also be trained in experimental techniques, bioacoustics software, behavioral analysis software, and methods in tropical fieldwork.

Prof. Katherine Buettner
Department: Chemistry

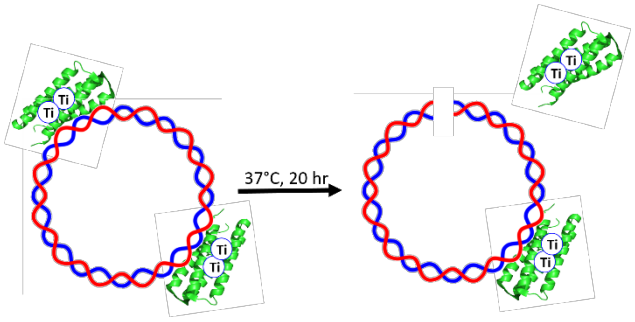
Pre-requisite for a Summer Position: Students should have completed general chemistry to work in the lab.

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 and as mimics of natural vanadium enzymes.

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.



Prof. Shelli Frey
Department: Chemistry

Pre-requisite for a Summer Position: Should have completed a year of general chemistry.

Description of Research:

Project 1: Measuring the interactions of huntingtin protein with model cell membranes

Huntington's disease is characterized by the accumulation of nanoscale protein aggregates in the brain and central nervous system. Genetic mutations which cause an expansion of polyglutamine (polyQ) amino acid stretches are responsible for the subsequent misfolding of the huntingtin's (htt) protein that contributes directly to the pathogenesis of Huntington's disease. Interestingly, the length of the polyQ region directly correlates with disease progression. Additionally, htt interacts with a variety of membraneous structures within the cell (Figure 1), and the N-terminus (Nt17) is implicated in lipid binding.

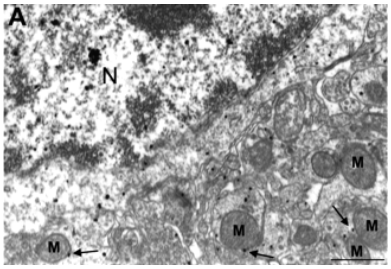


Figure 1: Huntingtin protein aggregates associated with mouse mitochondria

This project focuses on discerning the mechanism of this protein N-terminal membrane association. Since the htt N-terminus (Nt17) is random coil in aqueous solution and becomes alpha helical when bound to a membrane interface, circular dichroism (CD) will be used to monitor this secondary structural transformation as we step through protein post-translational modifications and different membrane compositions to determine how these variables affect the kinetics and equilibrium of binding. Additional experiments with isothermal titration calorimetry (ITC) will be used to measure thermodynamic parameters of these binding events and determine how this interaction changes as membrane context and protein to lipid ratio are varied.

Project 2: Unraveling biophysical Mechanisms of how antiviral detergents disrupt cell membranes

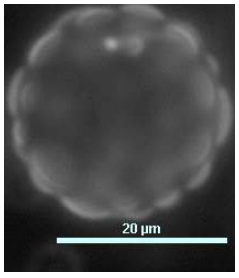


Figure 2: Fluorescence microscopy image of a giant unilamellar vesicle; obtained in Lipid

Micelle-forming Triton X-100 (TX-100) detergent is vitally important to inhibit membrane-enveloped pathogens such as viruses in cell-based manufacturing processes and in the blood supply. However, TX-100 is being phased out from industrial use due to environmental safety concerns. Intense efforts are underway to discover regulatory acceptable detergents to replace TX-100 but there is scarce mechanistic understanding about how these other detergents disrupt phospholipid membranes and hence which ones are suitable to replace TX-100 from a biophysical interaction perspective. We will use fluorescence microscopy and vesicle permeability assays to characterize the membrane-disruptive properties of a panel of TX-100 replacement candidates with varying antiviral activities. More specifically, lipid giant unilamellar vesicles (GUVs) of different compositions will be exposed to select detergents after the vesicle electroformation process and then imaged with fluorescence microscopy to measure morphology changes and vesicle size distributions.

Prof. Lucas Thompson
Department: Chemistry

Pre-requisite for a Summer Position: To join the NanoLab it is expected that students will have completed one year of chemistry (107/108) by May 2024

http://nanolab.sites.gettysburg.edu/

Many materials take on new and exciting properties when they are structured at the nanoscale. Many of the coinage metals like gold and silver exhibit new and unique optical properties that are dependent on their size and shape. The unique optical properties of gold nanoparticles are shown in Figure 1 where nanorods of differing aspect ratio (length/width) display their different colors. These optical properties have been harnessed for advanced applications in drug delivery, solar cells, disease detection (COVID tests), and catalysis. While these nanoparticles have shown great promise in diverse fields, there is still much to be learned about the synthesis, growth, and self-assembly of these particles to further enhance their impacts on our everyday lives. In order to tune the properties of gold nanoparticles for advanced applications, it is first necessary to specifically control the chemistry at the interface between the nanoparticle and its surrounding medium. At the core of our research group we are constantly thinking about how to modify and control the surface chemistry of gold nanoparticles with the goal of generating new structures or developing a better more quantitative understanding of the surface or to understand the implications of nanoparticles in the environment. The plan for the summer of 2024 and beyond is to work on two projects that address the control of surface chemistry and the environmental fate of nanoparticles.

Figure 1: Gold nanorods in aqueous solution. The pink solution on the left are spheres and as you go from left to right the length of the rods increase as the width stays roughly the same.

In the first project, we are interested in taking many little pieces (nanorods) and stacking them together into a larger structure using pH responsive polymers. The unique optical properties of gold nanoparticles can be further tuned by having particles in particular orientations to one another at close proximity. To accomplish this task we will be using gold nanorods that will have their surface modified with polyelectrolytes (highly charged polymers). We want to understand how polyelectrolyte modifications of gold nanoparticles engenders control and reversibility of the assembly of nanoparticles. In one part of this project we will be using a pH mediated structural transition (from random coil to alpha helix when the solution pH is raised above the pK_a) in an adsorbed polyelectrolyte, poly-l-lysine (PLL), to assemble rod shaped nanoparticles into higher order structures in a reversible manner. In addition to exploring pH, we will also test if the identity of the intermediate layer is important (PLL is positively charged so we need to have a negative layer between the particle (also positively charged) and the PLL). This project requires a wide array of instrumentation from UV-Vis Spectroscopy and Circular Dichroism Spectroscopy to Dynamic Light Scattering and Transmission Electron Microscopy which you will be in charge of running after appropriate training.

The discharge of pollutants such as pharmaceuticals, personal care products, heavy metals, and other toxicants into freshwater streams and oceans is a growing environmental problem. Despite their

Prof. Lucas Thompson, continued
Department: Chemistry

increasing industrial use, our knowledge of the environmental consequences of released nanoparticles in air, soil, and water, is wanting. We are particularly interested in quantifying the total quantity of gold that is taken up by the animals and to correlate that dosage and temperature to any developmental differences observed. In addition to quantifying the uptake of the gold nanoparticles we are interested in identifying the route by which the nanoparticles are brought into the body. This project will involve the synthesis and characterization of the nanoparticles prior to exposure to the animals. After exposure, it will be necessary to quantify the uptake with ICP-OES and identify the locations of uptake with electron microscopy.

In addition to the projects listed above, the NanoLab has on ongoing collaboration with Prof. Fong's group where we explore the toxicity of gold nanoparticles on aquatic organisms.

Prof. Rebecca Eckert
Department: Environmental Studies

Pre-requisite for a Summer Position:

- Interest in aquatic ecology and/or taxonomy
- Ability to work with live insects/arthropods
- Ability to use a microscope for long hours
- Conduct organized and precise work
- Good communicator

Description:

My lab explores the connections between living organism in streams, how they interact with their environment, and how changes in the surrounding terrestrial environment can impact them. These organisms, though often overlooked when walking near a stream, help regulate water quality and provide other important ecosystem services including leaf decomposition. The process of leaf decomposition ties the terrestrial and aquatic worlds together and recycles nutrients, as leaves from outside the stream enter and are broken down by physical, chemical, and biological mechanisms. The biological interactions that occur during this process are complex and not yet fully understood, and I specifically examine how interactions between leaves, microbes, and macroinvertebrates in streams vary with changes in the environment. My lab's grand challenge is to untangle these relationships and investigate how they are altered by continued human impacts on the environment like the cutting of streamside vegetation, nutrient inputs, salinization of freshwater, and global climate change. Having a better understanding of these impacts will allow us to protect water quality and biodiversity within streams. To answer these questions, students in my lab utilize a variety of techniques both within the field in streams and in the laboratory.

A recent project examined temporal changes in nitrogen and carbon associated with leaves (leaf plus microbial nutrient content) throughout the decomposition process. In this, we were interested in how carbon and nitrogen vary when macroinvertebrate shredders are present to aid in the decomposition process versus microbial contributions to nutrient content without macroinvertebrate shredders. Currently, we are examining leaf decomposition dynamics under varying salt concentrations to better understand what changes may occur with the input of road salt into streams after winter road applications. We have been examining how algal and bacterial communities change in response to salt additions, how salt may alter macroinvertebrate growth, and the impact on overall leaf decomposition, using an amphipod shredder in the lab and a range of salt concentrations. This summer we will be continuing to examine road salt impacts on leaf decomposition.

Prof. 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. Note that there is phone service and limited internet access on the island. We generally have solar power, but this isn't a given, and shower once every 7-10 days. We have access to a kitchen with a propane refrigerator and stove, and food drop-offs occur weekly. 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 (6:00am), field living conditions, limited internet access, and for spending all of June and July on this remote island.

Dates: Expected dates of May 30th – July 30th, most of which will be spent on Petit Manan Island. We will also need to find time in May for 3-4 days of (paid) training.

Description: Research in the Gownaris lab focuses on how seabirds change their foraging behavior and diet in response to rapid environmental change. Our current research site is 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 farther 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. Our research focuses on how seabirds are adjusting their breeding and foraging behavior to handle climate-driven changes in food availability and in how these behavioral adjustments influence their fitness.

This summer, we will spend eight weeks on Petit Manan Island collecting data on four species of seabird (Atlantic puffins, black guillemots, Arctic terns, and common terns) that breed there. Each day on the island is slightly different, but 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, tagging adult birds and monitoring their nests, entering data. In the evenings and on rainy days, we will have time to cook meals and play games together or to take some solo downtime (reading, exercising, etc.). The student hired through XSIG would be joining Dr. Gownaris, two other students from Gettysburg College (both of whom spent the summer of 2023 on the island), and two field technicians hired by US Fish and Wildlife. The two returning Gettysburg College students are focusing on the foraging ecology of terns and to the breeding phenology of black guillemots for their senior honors theses. In addition to contributing to these projects and daily data collection tasks, the XSIG-funded student would focus their time on a new research project examining the foraging ecology of alcids (Atlantic puffins and black guillemots).

Interested students can learn more about this research from students' perspectives in this article and about life on Petit Manan Island in this slideshow.

Prof. Sarah Principato
Department: Environmental Studies

Pre-requisite for a Summer Position: N/A

Description of Research: Required courses: ES223 (required); ES230 or ES318 (recommended).
Must be prepared to start working immediately after final exams and maintain a positive attitude while conducting fieldwork in cold, rainy conditions.

Striation project:
One student will focus on striations and grooves, which are created by the abrasion process of glacial erosion. This student will create a GIS database of striations documented in the literature in order to test hypotheses related to formation of striations. We will examine rock lithology, age of bedrock, ice sheet history, topography, and other variables as they relate to glacial erosion and formation of striations and grooves. We will conduct fieldwork in Iceland and the USA to measure striations and grooves—length, width, depth, and orientation. We will specifically examine sites with crossing striations, as the formation of crossing striations is not well understood. The fieldwork data will be incorporated into the GIS analysis as well. Collaboration with ES alum (and XSIG summer of 2017), Dr. Marion McKenzie, is part of this glacial erosion project.

Till project:
A second student is needed to assist with the fieldwork component of the striation project, but will focus on the sediments creating the striations and grooves. We will collect samples of till in both Iceland and the USA to examine clast size associated with till present in close proximity to striations and grooves. In addition to grain size analyses, this student will conduct sedimentological analyses of the tills in my lab and measure properties such as water content, magnetic susceptibility, and carbon content measured using loss-on-ignition. We will spend approximately one week in Iceland conducting fieldwork, and fieldwork in the USA will be to drivable locations that contain striations and outcrops of till mostly in NE and NW Pennsylvania. If time permits, we will investigate the exceptional grooves on Kelleys Island in Lake Erie and crossing striations in Wisconsin.

Lake Project
The third XSIG project follows the work of Halley Mastro, (XSIG, 2021) and this project also continues with the theme of examining glacial erosion. This student will examine lake orientation and elongation in glaciated regions outside of Iceland. Mastro et al. (2023) found that lakes in regions that contained paleo-ice streams were more elongate than lakes without ice streams in regions of Iceland. We want to examine if this results hold for other glaciated regions that contained paleo-ice streams. This third student would also assist with fieldwork in the USA and Iceland.

Prof. Megan Benka-Coker
Department: Health Sciences

Pre-requisite for a Summer Position: Students should have some background with data and statistics and be interested in learning about data management and analysis. Previous experience in a programming language (Python or R) is preferred.

Description of Research:
The Benka-Coker lab focused on addressing the human health impacts of air pollution (primarily air pollution from cooking). Air pollution (a mix of hazardous substances from human-made and natural sources) is a major contributor to global warming and had extensive human health impacts. The US EPA monitors and regulates outdoor air pollution; however, there are currently no national regulatory standards for indoor air pollution even though people spend about 80% of their time indoors. The use of low-cost air pollution monitors allows researchers to study personal exposure to air pollutants (especially indoors) and better estimate the dose of air pollution inhaled by a participant. The proposed summer research will explore two main facets of using low-cost personal monitors for air pollution data related to indoor exposure.

1. Participate in a collaboration with Dickinson College
    a. Professor Benka-Coker will partner with Dickinson College to conduct a before-after study in homes cooking with different fuel types (liquid petroleum gas, biogas, electricity). This study will measure personal exposure to particles and gases from cooking using several low-cost personal and indoor air pollution monitors. We will also conduct an extensive survey on household characteristics, i.e. ventilation, and cooking practices.
2. Test a low-cost air quality monitor and analyze data
    a. Using a low-cost air quality monitor, students in the Benka-Coker lab may develop and test their own research hypothesis on indoor air quality.
    b. The Benka-Coker lab will work with several sets of data (including the data from the Dickinson collaboration, the individual research study, and previously collected data from a study in Ghana).

Students will travel (may travel jointly with the faculty member) and collaborate with Dickinson College faculty and students around Carlisle, PA for the indoor air quality study on cooking. The students will be involved in the initial study design, participant recruitment, setup of instrumentation, survey development and administration, data management and analysis. Each student will also have the opportunity to develop their own research question on indoor air quality and use the low-cost monitors to collect data around campus or in another specified location.

Prof. Victoria Wolf
Department: Health Science

Pre-requisite for a Summer Position: No previous research laboratory experience is required, but students should have successfully completed two semesters of human anatomy & physiology in order to be considered.

Description of Research:
Post-stroke cognitive impairment (PSCI) is a major long-term complication of ischemic stroke and a leading cause of vascular cognitive impairment and dementia (VCID). Although significant strides have been made in stroke recovery and rehabilitation research, our understanding of how interventions affect VCID development and other complications of ischemic stroke is limited. The inadequate incorporation of hypertension, the leading cardiovascular risk factor for VCID and stroke, in preclinical stroke recovery research has expanded this gap in knowledge. Enriched rehabilitation strategies have been shown to enhance brain plasticity and improve behavior in preclinical studies using relatively young, healthy, adult male animals after stroke. This translational research project was designed to determine if an enriched rehabilitation intervention prevents PSCI in male spontaneously hypertensive rats. Acute kidney injury is also a common complication following ischemic stroke. The goal of this summer project is to characterize the extent of kidney injury in hypertensive animals following experimental stroke and to test the hypothesis that enriched rehabilitation has systemic, anti-inflammatory affects post-stroke.

Kidney tissues harvested from hypertensive animals that were randomized to either experimental stroke or sham procedure will be processed and studied for markers of inflammation and kidney injury. Furthermore, we will test to see if enriched housing conditions was protective against acute kidney injury compared to standard housing conditions following stroke. As part of this research project, the student would be expected to help characterize the extent of renal injury using frozen and formalin-fixed kidney tissue samples that were collected at the Medical University of South Carolina. Under my mentorship, the student will learn about the experimental design, data collection, and data analysis involved with preclinical, integrative physiology research. I will also teach them how to perform western blots and how to process, stain, and analyze kidney sections for signs of glomerular or tubular injury. No previous research laboratory experience is required, but students should have successfully completed two semesters of human anatomy & physiology in order to be considered.

Prof. Kurt Andresen
Department: Physics

Pre-requisite for a Summer Position: Students do not need any biology or chemistry background, but should have interest in learning about biophysics, be self-motivated, and enjoy spending lots of time in the lab!

Description of Research:

1. Measuring Ions around 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 electrostatics that drive these processes. In particular, using our in-house 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) and some interesting biology all while exploring the underlying physics that drives these processes. Students do not need any biology or chemistry background, but should have interest in learning about biophysics, be self-motivated, and enjoy spending lots of time in the lab!

2. Measuring the Kinetics of the Disassembly of Mononucleosomes

Building on the first project (above), we will be 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. 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. Students do not need any biology or chemistry background, but should have interest in learning about biophysics, be self-motivated, and enjoy spending lots of time in the lab!

3. 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. In this project, we will subject DNA systems to measurements utilizing our in-house isothermal calorimeter. We will explore how different ions and osmotic pressure affect the binding of DNA. 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.

Prof. Bret Crawford
Department: Physics

Pre-requisite for a Summer Position: N/A

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 visible light transmission through evaporated films and/or an 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.

The two summer students will learn about energy loss mechanisms, learn to run the accelerator, evaporate thin films, use the AFM and UV-Vis, run the simulation software, collect proton energy data, develop and run Python scripts to analyze spectra, etc. This summer I am interested in improving the energy resolution of the detection process – LN2 cooling the detector, tracking down noise in the electronics – and comparing these spectra with simulations. The simulations will need to be broadened by convoluting the simulated spectrum with an instrumental response function. I am also interested in reducing the amount of ionized H2 ions that present a low-energy background in our spectra.

Prof. Ryan Johnson
Department: Physics

Pre-requisite for a Summer Position: See project descriptions

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 examining the effect of the 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. Currently, computationally expensive algorithms are run at the time of simulation in order to produce data that has been corrected for this time shift. This project involves the ongoing development and testing of a projection algorithm that is used on recorded simulation data in order to produce the same results with much better flexibility. The project will use the outputs from either the GADGET or FLASH hydrodynamic codes along with Python to interpret and visualize the data. This project is best suited for a Physics major interested in theoretical astrophysics.

Projects II and III: Geospatial data analysis using COVID data. Since spring of 2020, copious amounts of data have been collected on the spread of the COVID-19 virus throughout the world's population. In each of these proposed data science projects, we will be using python's geospatial visualization libraries to numerically analyze relationships between COVID-19 infection rates, hospitalizations, and deaths, and other regional demographic data. The first project is a continuation of previous work looking into the regional correlations between the peaks in COVID infections, hospitalizations, and deaths. The second project is an extension of the tools used in the first, but with an eye towards identifying geospatial demographic data that also correlates with COVID statistics. The goal of both of these projects will be to create analytical tools for the community to use in understanding how public health statistics are spatially correlated. These projects 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. These projects will heavily utilize the Python computing language, and are best suited for students with an interest in data science or computer science. Interested students should have at least an introductory facility with some computer language.

Prof. Jena Meinecke
Department: Physics

Pre-requisite for a Summer Position: N/A

Description of Research:
The universe abounds with shock waves, from those arising during structure formation, to those driving supernova explosions that create the elements of which life is made and can even trigger star formation. Furthermore, radio synchrotron emission and Faraday rotation measurements have all revealed that the universe is magnetized—from clusters to filaments to voids—implying that magnetic fields are essential players in the dynamics of luminous matter.

At present, the origin and distribution of magnetic fields are far from understood, but the standard model suggests that galactic and intergalactic magnetic fields can be generated by shock waves (e.g., via the Biermann Battery mechanism) and then amplified by dynamo or turbulent processes to a level consistent with current observations. Due to the advent of high-powered lasers, scaled astrophysical phenomena can be created in the laboratory – a supernova several parsecs in diameter can be scaled down to the size of a baseball.

Prof. Meinecke is currently conducting high-powered laser experiments at both the Laboratory for Laser Energetic (LLE) in New York and the National Ignition Facility (NIF) in California to study the origins of magnetic fields in the universe. Meinecke would like to request two or three students for the summer of 2024 to help with these laser experiments, the analysis of the data, and the development of her laser lab (to support this work) at Gettysburg College.

More specifically, her next LLE shot day is scheduled for May 21st, 2024, and Meinecke would like to train students to help with a vital diagnostic. The training would involve learning a brand-new technique for passively determining the electron temperature of a plasma using a gated x-ray detector (GXD); a skill that is in high demand at national labs. The students would then use the GXD diagnostic on the LLE shot day to procure data, quickly analyze it in real-time to inform decisions, and perform a more thorough set of analysis to support one or more high-impact papers. The students will be able to tour the laser facility and meet colleagues from various universities and national labs to important career contacts.

Furthermore, these students will spend a day or two at LLE with my colleague, Petros Tzeferacos, training at the FLASH Center for Computational Science to use their powerful hydrodynamic code. Back at Gettysburg College, they will run simulations to inform and help develop a laser lab at the college. As a new faculty member, Meinecke aspires to develop a laser lab in Masters Hall that can deliver several joules of pulsed light onto target in a gas-filled vacuum chamber to study minimagnetospheres above the lunar surface. The students will additionally help to physically set up this lab, which may include learning about vacuum systems, laser operations, safety protocols, optical alignment, and so forth.

All three of the students would ideally work together on many of the following tasks, but they can be split up if it's easier.

Prof. Jena Meinecke, continued
Department: Physics

(1) Learn how to use a gated x-ray detector to measure the electron temperature of a plasma. Write and execute codes to analyze diagnostic data
(2) Participate on the laser shot day at LLE to generate turbulent shock waves relevant to supernovas
(3) Learn how to use the FLASH code to predict plasma conditions for laser experiments
(4) Use the FLASH code to help develop a laser lab at Gettysburg College
(5) Help, physically, develop a laser lab in Masters Hall by assessing preexisting equipment, determining equipment that is needed, and preparing the space for new projects

Prof. Mitch Powers
Department: Physics

Pre-requisite for a Summer Position: Experience with C++ or Fortran is strongly preferred.

Description of Research:
Liquid crystals are materials that have long range order, like a crystal, but are squishy and disordered, like a liquid. Liquid crystal behavior is closely related to molecular structure, with most liquid crystals featuring long floppy tails that help to give them their liquid-like properties. This project focuses on a group of molecules that don't have these tails, but are still liquid crystals. We will explore the relationship between their molecular structure and phase behavior using molecular dynamics simulations to study how these molecules spin, wiggle and align themselves. For this project, there are two general roles: Running code and developing code. Students are welcome to choose either based on their skills and interests.

Running simulations and analyzing data: Run molecular dynamics simulations on some of the most powerful computers in the country and analyze the results. In this role you will learn the basics of high performance computing, run jobs on a super computer, and carry out preliminary data analysis. Previous experience with scientific computing, shell scripts or python are welcome but not required.

Developing simulation code: This is your chance to "work under the hood." Learn how molecular dynamics simulations work, and help improve simulation code to make them work better. In this role, you will help develop, test and benchmark new code and make contributions to a larger community of users and developers. This is a great opportunity for students interested in computational physics or computer science.

Prof. Sara Keefer
Department: Psychology

Pre-requisite for a Summer Position: Psych 236 and/or 237 or strong interest in neuroscience, behavior, and rodent research.

Description of Research:
The field of behavioral neuroscience first examines behavior in rodents that directly reflects behavior in humans. My overarching behavioral research goal is to examine motivated behaviors when they occur adaptively but also when they occur maladaptively in rats. Motivated behaviors that are adaptive include food seeking and using environmental cues to learn about and find rewards (e.g. Pavlovian conditioning). Motivated behaviors that are maladaptive include persistently attending to and seeking out food and food cues despite not being hungry or when there are negative consequences, such as during risk-taking behaviors. My research examines the innate differences between these behaviors and identifies ways to change them, behaviorally or neurobiologically.

As a neuroscientist, I am interested in studying the neurobiological mechanisms of adaptive and maladaptive behaviors by using psychopharmacological drugs and brain manipulation techniques to observe resulting changes in behavior. The behaviors described above can be combined with neuroscience manipulation techniques, such as lesions and pharmacology, to investigate the necessity and involvement of different brain regions (e.g. the amygdala, hypothalamus, nucleus accumbens, ventral tegmental area, and prefrontal cortex) and/or neurochemicals of interest (e.g. dopamine, orexin, serotonin, just to name a few!).

In the lab, students can expect to search for, read, and comprehend primary research articles relevant to the research question. From these readings, students will be involved in the planning of the project including minimal coding that is involved in equipment setup. Students will run the rats through the behavioral paradigms and be involved in data collection and analysis. If desired, students can be trained in rat brain surgery with heavy guidance from myself and at the end of the projects, be involved in brain collection, histology, and microscopy.