**Lyme disease ecology**

The Integrative Ecology Lab (www.iecolab.org) is conducting surveys of wildlife across the Philadelphia region to better understand how community interactions impact Lyme disease dynamics. Students will assist with research by processing previously collected field data. Students are primarily need to review photos from motion-activated trail cameras to identify species involved in the transmission and control of Lyme disease. There may also be opportunities to be involved in identifying animal tracks from track plates or analyzing data. This position is open to all students who are interested in gaining experience conducting research in ecology. Most of the work can be completed in-person or virtually.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** All Majors  
**Class Preferences:** Freshmen, Sophomores, Juniors & Seniors  
**Important Selection Criteria:** An interest in animals is a plus for processing photos.

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**Mapping urban field ecology: How much do we know about urban ecosystems?**

Urban birds, bats, beetles, and more all perform ecosystem services that benefit the people who live in cities. We are using computer mapping and text analysis to identify gaps in our understanding of these organisms in urban ecosystems in the United States. Urban field ecology studies have grown in number over the last few decades and our goal is to understand whether certain species, ecosystem services, or geographic areas are understudied by urban ecologists have studied. Since urban ecosystems affect millions of people, it is imperative that we understand how these systems function across socio-economic and ecological gradients. We are conducting a comprehensive review of the urban ecology literature and are analyzing and mapping each study. Through this project undergraduate researchers will become familiar with a wide range of urban ecology research and the fundamentals of computer mapping software and data management.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Biology; Environmental Science; Ecology, Evolution and Biodiversity  
**Class Preferences:** Freshmen, Sophomores, Juniors & Seniors  
**Important Selection Criteria:** All majors and years are encouraged to apply, but the ideal applicants will have an interest in ecology and the environment, good time management skills, and great attention to detail.
Development of a method of individual identification for the spotted lanternfly

The spotted lanternfly is an invasive insect that is spreading across the northeastern US and that has the potential to cause billions of dollars in damage to the wine, timber, and ornamental plant industries. The Integrative Ecology Lab (www.iecolab.org) is conducting research on the ecology and impacts of this pest. Because of their small size and high local abundances, most methods cannot be used to track their daily movements. Students will develop a computer-aided method to identify individual spotted lanternfly using wing patterns. Tasks will include processing photos in a specialized software and test the accuracy of the method.

Location: Main; Virtual or computational research
Student Majors Accepted: All majors
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Curiosity - Interest in ecology

Temple Forest Observatory

The Temple Forest Observatory (TFO), a collaboration between the Temple Ambler Field Station (TAFS) and the Smithsonian Forest Global Earth Observatory (ForestGEO; https://www.forestgeo.si.edu/), is a platform for inquiry-based education and long-term forest research. On September 1, 2021, the TFO was substantially impacted by an EF2 tornado, a remnant from Hurricane Ida, and most trees were blown down. This uncommon disturbance event is emblematic of larger changes that are occurring worldwide. Storm frequency and intensity are increasing due to climate change, causing changes to disturbance regimes in natural ecosystems. The TFO now provides an important opportunity to understand forest resilience in the face of these changes. Using detailed data collected before and after the storm, students will engage in outdoor, hands-on research to understand forest recovery, while developing skills in field data collection and more. These positions are open to all CST students who have an interest in gaining field experience in forest science and ecology. No previous research experience is required. An integral part of our mission is to promote diversity, equity, and inclusion in science, and we encourage applications from students from populations underrepresented in science. The TFO and TAFS are located on the Temple Ambler Campus, a 50-minute drive from Main Campus. Transportation from Main Campus is provided via the inter-campus bus during the academic year.
Location: Ambler; In-person essential
Student Majors Accepted: All Majors
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: A background (coursework/experience) in ecology or related field is recommended, but not required.
Building a tree of life with DNA data

This project involves working with DNA sequence data of diverse organisms, and software, to help build the tree of life and better understand evolutionary principles. It takes place in the Center for Biodiversity and mostly involves learning and using new computer tools and applications. The center is located in SERC.

Location: Main; In-person essential
Student Majors Accepted: Biology, but could be any major
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Strong academics

Conserving the biodiversity of Haiti

This project involves helping efforts in Temple’s Center for Biodiversity to learn more about the biodiversity of Haiti, and to protect it. The multi-faceted team efforts include discovery of new species, mainly through DNA sequencing of samples collected in Haiti, ecological and evolutionary studies, and educational and outreach components. The center is located in SERC.

Location: Main; In-person essential
Student Majors Accepted: Biology, but could be any major
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Strong academics
<table>
<thead>
<tr>
<th>Project Title</th>
<th>Contact Information</th>
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</thead>
<tbody>
<tr>
<td><strong>Spotted Lanternfly Invasion Meltdown</strong></td>
<td>Matthew Helmus</td>
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<tr>
<td>Temple University's iEcoLab (<a href="https://www.iecolab.org/">https://www.iecolab.org/</a>) has several projects on stopping the destructive spread of spotted lanternfly. Projects include biological control, species traits, ecology, data science, computer coding, machine learning. Students will work within a dynamic group of undergraduates, graduate students and postdocs focusing on spotted lanternfly ecological and computational research.</td>
<td><a href="mailto:mrhelmus@temple.edu">mrhelmus@temple.edu</a></td>
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<tr>
<td><strong>Location:</strong> Main; Virtual or computational research</td>
<td>CST Biology</td>
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<td><strong>Student Majors Accepted:</strong> Biology, CIS, ES, Physics, Engineering, GUS</td>
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<td><strong>Important Selection Criteria:</strong> We have projects available for a range of skill sets. We have projects that are focused on ecology and projects that are focused on computer coding.</td>
<td></td>
</tr>
<tr>
<td><strong>Universal Patterns of Biodiversity</strong></td>
<td>Matthew Helmus</td>
</tr>
<tr>
<td>Temple University's iEcoLab (<a href="https://www.iecolab.org/">https://www.iecolab.org/</a>) has several projects on understanding global patterns of biodiversity and how humans are causing extinctions through pollution, deforestation and climate change. Projects include species traits, ecology, data science, computer coding, machine learning. Students will work within a dynamic group of undergraduates, graduate students and postdocs focusing on biodiversity and its conservation for future generations.</td>
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</table>
Population genomics of domesticated dogs and the evolution of disease

With a relatively short time (thousands of years) since a known common ancestor (wolves), extant dog breeds provide an excellent example of rapid evolution in action. The variety of phenotypes from behavior to morphology demonstrate how artificial selection can quickly act within a population. Accordingly, dozens of breeds of dogs have been sequenced with genomes publicly available. Dogs have also become a model for human disease with several databases available that connects genotypes to specific disease.

Location: Main; In-person essential
Student Majors Accepted: Biology, Computer science, Mathematics, Chemistry, Physics
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: We will be handling large amounts of digital data. Coding, bioinformatics, and databasing will be required.

Evolution of compensatory mutations in proteins

Within a protein, secondary amino acid substitutions are able to mask deleterious mutations by preserving the protein’s overall structure and function. The deleterious mutations, found in a protein-coding exon, are known as “disease” mutations with tens of thousands annotated in humans. The secondary substitutions are known as intramolecular "compensatory" mutations and can prevent deleterious effects by masking functional changes caused by disease mutations. When a human disease mutation is found in another mammalian species (i.e., orthologous site), compensatory substitutions are assumed to have evolved prior to the fixation of the diseased mutation itself. In this project, we would like to identify these compensatory sites in order to understand their mechanism of evolutionary change. These results can be applied to genomic medicine questions such as drug targeting, molecular stability, and viral transmissibility.

Location: Main; Virtual or computational research
Student Majors Accepted: Biology, Chemistry, Biochemistry, Physics, Mathematics, Computer Science
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Highly motivated and independent student with knowledge of genetics and evolution. Coding experience will be required.
The neurogenomics of incipient speciation in Drosophila

Behavioral isolation is thought to be among the first stages in forming new species. Among known populations of Drosophila melanogaster, female fruit flies from Zimbabwe display a unique preference to mate with males of their own population and discriminate against foreigners, including those from neighboring Zambia and global populations such as those from North Carolina. This Zimbabwean population presents one of the few naturally occurring examples of incipient speciation, presenting an excellent model to study behavioral isolation at its earliest stage. By combining high-throughput genomics and available phenomics data from the lab, we hope to gain a detailed understanding of both the neurogenes and evolutionary processes involved in population divergence and early species formation. The student will be expected to develop and build behavioral assays in the laboratory with fruit flies.

Location: Main; In-person essential
Student Majors Accepted: Biology, CIS, Physics, Mathematics
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: We will be generating large amounts of digital data. Some coding will be required.

Molecular identification of Antarctic protists (algae and protozoa)

The objectives of this project are to (1) confirm the taxonomy of our polar protist culture collection using molecular tools and (2) assess the genetic drift associated with the maintenance of protists under controlled conditions for many generations.

In this project, you will be responsible for identifying the species in our culture collection based on molecular analysis. You will photo-document the cultures, extract their DNA, amplify and Sanger sequence target genes (nuclear small subunit ribosomal gene, mitochondrial cytochrome oxidase I, and in some case the plastid small subunit ribosomal gene).

During this project, you will gain experience in microscopy and molecular techniques including DNA extraction, polymerase chain reaction (PCR), and electrophoresis. You will also learn about bioinformatics used in the lab to analyze DNA sequences and about building phylogenies.

Location: Main; In-person essential
Student Majors Accepted: Biology / EES
Class Preferences: Sophomores & Juniors
Important Selection Criteria: This project requires an in lab time commitment of about 10 h per week.
Bat susceptibility to white-nose syndrome

White-nose syndrome is an emerging infectious disease of hibernating bats caused by an invasive fungal pathogen. Since its first detection in 2006, it has caused extensive mortality of bats during hibernation, and has spread across much of North America. In this project, we will seek to improve understanding of factors influencing both the impacts and spread of the disease, and means to conserve bat populations in light of this ongoing threat.

**Location:** Main; In-person essential

**Student Majors Accepted:** Biology, Environmental Science, Mathematics

**Class Preferences:** Freshmen, Sophomores, Juniors & Seniors

**Important Selection Criteria:** Coursework, training, or experience in ecology, conservation biology, animal behavior, statistics, Geographic Information Systems (GIS), epidemiology, or public health, and a strong motivation for research and interest in the topic

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Spotted lanternfly studies at the Temple Ambler Field Station

The spotted lanternfly is an invasive insect that poses an emerging threat to native forest ecosystems. In this project, the student will work as part of a team, using field surveys, standardized field experiments, and laboratory work to understand the ecology of spotted lanternflies and the effects they have on tree species. Research will occur primarily at the Temple Ambler Field Station, located on the Temple Ambler Campus, with the potential for some additional work on Main Campus. Transportation from Main Campus to the Field Station is provided via the inter-campus bus during the academic year.

**Location:** Ambler; In-person essential

**Student Majors Accepted:** Biology, Environmental Science, or related field

**Class Preferences:** Freshmen, Sophomores, Juniors & Seniors

**Important Selection Criteria:** Background (coursework/experience) in ecology or related field is recommended
The Suppression of Bitter Taste

Bitter taste is aversive to humans, and many oral medications exhibit a bitter taste. Bitter taste can be suppressed by the use of inhibitors, or by masking agents such as sucralose or sucrose. Another approach is to encapsulate bitter tasting compounds in lipid microspheres or in lipid matrices. In both cases, the release of a taste stimulus from lipids is delayed as these lipid supports erode in the oral cavity. Bitter taste suppression can be achieved by encapsulating bitter taste stimuli in lipids, and then placing these encapsulated stimuli in rapidly dissolving edible films that contain a variety of bitter taste masking agents. In this approach, masking agents are immediately released as films become hydrated by saliva, but before the erosion of encapsulated stimuli. This delivery method also minimizes choking hazards in both the young and the elderly. This novel approach is useful for increasing the palatability of oral medications, for delivering micronutrients to the oral cavity, and for enhancing the flavor of food.

Location: Main; Not accepting Spring 2022 URP students
Student Majors Accepted: Biology, Neuroscience, Biochemistry, Chemistry
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Willingness to be engaged in research, and ability to think critically.

Local adaptation to serpentine soils in a native plant

Serpentine soils present a harsh environment for plants--high levels of heavy metals and low nutrient availability. Yet some plant species thrive there. This study will examine whether there is local adaptation to serpentine soils in a native wildflower species. We will examine germination and early growth of plants from serpentine and non-serpentine sites grown in growth chambers in both serpentine and non-serpentine soils.

Location: Main; In-person essential
Student Majors Accepted: BIO, EES
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Attention to detail, basic understanding of ecology, dependability, enthusiasm
Personalized medicine and evolutionary link between DNA and disease

We all have many DNA differences from others. Which of these personal differences cause disease? We use computers to study disease variation in humans and compare it to differences humans show with other species. We also build predictive methods and tools.

Location: Main; Virtual or computational research
Student Majors Accepted: All Majors
Class Preferences: Freshmen & Sophomores
Important Selection Criteria: Interest in the field and interest in discovering patterns and solving problems.

Software development and Bioinformatics

We develop software (including smartphone apps) for analyzing biological data in the fields of Genomics, Evolution, and Medicine.

Location: Main; Virtual or computational research
Student Majors Accepted: All Majors
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Knowledge of computer programming and/or app development.

Combining Photons, Electrons and Nanoparticles for Plasmonic Sensing and Catalysis

Students will develop and use nanoscale plasmonic materials for rapid, high sensitivity detection of biological and chemical agents, as well as catalytic conversion. They will learn to use a variety of analytical techniques such as spectroscopy, Atomic Force Microscopy.

Location: Main; Virtual or computational research
Student Majors Accepted: Chemistry, Physics
Class Preferences: Sophomore & Junior
Important Selection Criteria: Curiosity and persistence - Interest in research - Aptitude for careful laboratory research - Undergraduate researchers in my group typically present at local, regional and even national conferences. Many have been co-authors on publications.
Laser Vibrational Spectroscopy and Dynamics of Molecular Species at Bio and Geochemical Interfaces

Research involves learning to use ultrafast lasers (we make some of the shortest infrared pulses in the world) to perform vibrational Sum Frequency Generation (SFG) a technique that provides sensitivity to single molecular layers. Students will investigate water, arguably the most important molecule on the planet at interfaces of biological and geochemical relevance. Students will learn about surface chemistry, biointerfaces, geochemistry and laser spectroscopy.

Location: Main; Virtual or computational research  
Student Majors Accepted: Chemistry, Physics  
Class Preferences: Sophomore & Junior  
Important Selection Criteria: Curiosity and persistence - Interest in research - Aptitude for careful laboratory research - Undergraduate researchers in my group typically present at local, regional and even national conferences. Many have been co-authors on publications.

Chemical Education - Design of teaching tools for organic chemistry

Dr. Fleming (professor of instruction) does research in chemical education. In particular, he is developing a teaching tool for organic chemistry called “Interactive Organic Reaction Animations” (iORA). This tool will assist student learning by providing a 3D perspective of organic reactions. The animations that are included in the program are based calculated data so that the representations are as accurate as possible. The iORA software will run on a smartphone as an app and it will be free for any user. We are also have a project that involves converting PDB files into UnityMol (or a similar system) and then exploring the 3D image using Oculus Rift. The ultimate goal would be to generate a virtual reality teaching tool for organic chemistry.

Location: Main; In-person essential  
Student Majors Accepted: Chemistry, Biochemistry, CIS  
Class Preferences: Sophomores, Juniors & Seniors  
Important Selection Criteria: Students working on this project would need to have a basic knowledge of computer languages and an interest in learning virtual reality. A good foundation in organic chemistry would be helpful.
Novel nucleases in nucleic acid metabolism and genetic engineering

Our lab is interested in understanding the mechanisms of enzymes involved in DNA and RNA quality control and how they may be exploited for genetic engineering approaches. We are searching for new enzymes and enzymes that can be modified and used for these purposes.

Location: Main; In-person essential
Student Majors Accepted: Biochemistry
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: N/A

Modeling photophysical and photochemical properties of molecules

Computational chemistry is applied to study the fate of molecules after absorption of light. Theoretical methods based on both quantum mechanics and classical mechanics are used to model the excited states of molecules and their reactivity, leading to our understanding of photophysics and photochemistry of chemical and biologically relevant systems. We focus on a variety of applications: (i) photostability of DNA subject to radiation, (ii) development of fluorescent probes used in biomolecular detection; (iii) absorption and fluorescent spectra of organic chromophores; (iv) formation and stability of prebiotic molecules; (v) modeling and interpreting pump probe spectroscopies of gas phase molecules. Motivated undergraduate students can make contributions to any of these topics.

Location: Main; Virtual or computational research
Student Majors Accepted: Chemistry, Biochemistry, Physics, CIS
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Interest in physical chemistry, math, computational science
Making high accuracy affordable through DFT

The coupled-cluster singles and doubles with perturbative triples complete basis set limit, CCSD(T)/CBS limit [J. Chem. Phys., 138, 144104 (2013), J. Chem. Phys. 143, 214110 (2015)] offers very high accuracy for much of thermochemistry, but these calculations are very expensive. If we limit the CCSD(T) calculations to the valence electron correlation energy, the remaining small corrections can be treated by DFT with little loss of accuracy at dramatically reduced cost. For example, we recently published [J. Chem. Phys. 143, 214111 (2015)] a core-valence density functional that requires less time than a single SCF iteration, but reproduces the CCSD(T)/CBS core-valence correlation energy to within ±0.27 kcal/mol rms error. We are now developing density functional methods covering the elements H through Kr for the geometry (±0.011 Å which corresponds to ±0.065 kcal/mol rms error in the energy) [“Three Body Dispersion Corrections to the Spherical Atom Model: the PFD-3B Density Functional” George A. Petersson, Michael J. Frisch, Frank Dobek, and Barbaro Zulueta*, J. Phys. Chem. 124, 10296 (2020)]. These errors compare favorably with the inherent error in CCSD(T) energies (±0.56 kcal/mol rms error) with respect to Full CI energies for these species. This work will include extending core-valence density functional to the third-row including the transition metals, and improving on the generalized Douglas-Kroll-Hess relativistic DFT calculations of the spin-orbit coupling interactions.

* Temple B.S. 2019, currently Ph.D. student, University of Pittsburgh.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Chemistry, Physics, Math, Computer Science  
**Class Preferences:** Sophomores & Juniors  
**Important Selection Criteria:** The undergraduate research participant’s background in Chemistry is not important, but some knowledge of quantum mechanics and an aptitude for writing computer code are essential. The departmental major or class year are unimportant.
**Interface between Gaussian16 & WindNMR**

Ab initio calculated nmr spectra are useful for the interpretation of experimental spectra and molecular structural assignments. However, it is very tedious to paste calculated chemical shifts and spin-spin coupling constants into a program that simulates a high resolution nmr spectrum. This project involves writing computer code to read a Gaussian16 output file and create a data file for the program WindNMR. This work is a collaboration with colleagues at the Kitasato Institute in Tokyo.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Chemistry, Computer Science  
**Class Preferences:** Sophomores & Juniors  
**Important Selection Criteria:** The undergraduate research participant’s background in Chemistry and Spectroscopy is far less important than an aptitude for writing computer code. The departmental major or class year are unimportant.

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**Optimization of Extremophilic Photolyase Protein Folding**

Enzymes found in extremophilic organisms that thrive in high and low temperature face challenges to stability that mesophilic proteins (like ours) don't face. Mimicking the cytosolic contents of extremophiles to stabilize their intracellular constituents is a formidable but necessary task. You will explore a wide range of solvent additive conditions to find regions of protein-folding stability for the DAN repair enzyme, DNA photolyase.

**Location:** Main; In-person essential  
**Student Majors Accepted:** All majors  
**Class Preferences:** Sophomores & Juniors  
**Important Selection Criteria:** Biochemistry, Organic, analytical skills all are important. Evidence of discipline and enthusiasm are important.
## Bioinorganic Titanium Chemistry

The Valentine Lab is interested in hydrolysis-prone metal ions of biological relevance. The student will investigate possible ligand systems for stabilization of titanium(IV) in a water environment, will make and characterize new inorganic coordination compounds, and will evaluate their interactions with biomolecules.

**Location:** Main; In-person essential  
**Student Majors Accepted:** Chemistry, Biochemistry  
**Class Preferences:** Sophomores & Juniors  
**Important Selection Criteria:** intelligence enthusiasm conscientiousness - will teach skills necessary

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## Research at the Interface of Chemistry, Materials, and Energy

The Zdilla lab conducts research in inorganic chemistry, materials, crystallography, and energy science. Our projects include 1) efforts to design molecules and materials inspired by nature that split water into hydrogen and oxygen, 2) synthesis of novel energy-rich molecules with new realms of energy density, 3) design of electrolytes for safer batteries, and 4) development of new methods in X-ray diffraction and crystallography. Depending on project assignment, students may have the opportunity to learn chemical synthesis, air-sensitive handling (glove box and schlenk line techniques) spectroscopy, magnetometry, electrochemistry, and crystallography. Motivated and productive students will earn (co)authorships on published papers and attend local and/or national meetings to present their work.

**Location:** Main; In-person essential  
**Student Majors Accepted:** chemistry, biochemistry  
**Class Preferences:** Freshmen & Sophomores  
**Important Selection Criteria:** We are looking for students with a passion for chemistry who intend to commit significant time. Research cannot be done as a side hustle. A significant fraction of weekly hours over multiple years is needed for undergraduate researchers to be successful,
Extracting and Linking AI Artifacts

The goal of this project is to create a framework for extracting from scientific literature all salient aspects of an artificial intelligence (AI) workflow, including data, AI models, AI tools, tasks, and training methodology.

Location: Main; In-person essential
Student Majors Accepted: computer science and related
Class Preferences: Juniors & Seniors
Important Selection Criteria: diligent, programming experience

A System for Mapping the (Local) Journalism Life Cycle

Develop techniques to track the life cycle of local journalistic content and observe its uses and misuses across time and across digital platforms.

Location: Main; In-person essential
Student Majors Accepted: CIS, Communication, Journalism
Class Preferences: Juniors & Seniors
Important Selection Criteria: diligent; communication and/or programming skills
Scene Analysis for Large Image Collections

The student will apply and adapt recent techniques from computer vision and machine learning to identify attributes from images of indoor scenes. This work is part of an ongoing project to (http://traffickcam.org/about) to combat human trafficking by identifying hotel room features from images.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Computer Science  
**Class Preferences:** Sophomores & Juniors  
**Important Selection Criteria:** Strong programming skills (preferably Python), interest or experience in image processing, data science, or machine learning.

Managing Telehealth Videos

Medical consultations over the video conferencing software increased in popularity during the COVID pandemic. While these video sessions can be recorded for archival purposes, they are typically too long for patients and doctors to review video recordings to extract useful information. The objective of this project is to design software tools to improve the management of such videos.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Computer Science, Computer Engineering  
**Class Preferences:** Juniors & Seniors  
**Important Selection Criteria:** Familiarity with programming (Java or Python)
Networking through Unconventional Data Management

Computer networking today are hard to manage. This is in sharp contrast to relational data structured in a database that allows easy access and rapid innovation. In this project, we ask why cannot (or how can) we turn network management into a data problem that can be automated in modern databases. We will also study how unique network challenges can be addressed with unconventional database techniques.

Location: Main; Virtual or computational research
Student Majors Accepted: Math, computer science, physics
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Good math skills, analysis and critical thinking, programming, database

Artificial General Intelligence

NARS is a model of Artificial General Intelligence (AGI) developed in the framework of a reasoning system. The model has been implemented into computer systems, and is under testing in various domains. Undergraduate students can join our existing projects, as well as explore novel ways to test the system.

Location: Main; Virtual or computational research
Student Majors Accepted: Computer and Information Sciences, Mathematics
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Strong interest in science, especially in human and machine intelligence and cognition; solid background in discrete mathematics and computer science; basic programming skills.
Animal-Landscape Interaction

Zoogeomorphology - field observations of animal-landscape interactions (e.g., geological impact of reserving beaver populations in Philadelphia suburbs). Some aspects may involve analysis of georadar (GPR) images of biogenic structures (large burrows).

Location: Main; In-person essential
Student Majors Accepted: Geology, ES
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Geology or Environmental Science major, but other CST majors will be considered.

Auto-detection of geologic features through citizen science

I am looking for a student to work with me and a few graduate students on a project where we are developing a citizen science activity to annotate images for the purposes of machine learning.

Location: Main; Virtual or computational research
Student Majors Accepted: EES, CIS
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Students must have some geologic background, preferably completion of physical geology and Sedimentary Environments.
GT-shadows and their action on child's drawings

GT-shadows are tantalizing objects which may be thought of as approximations to elements of the mysterious Grothendieck-Teichmueller group. GT-shadows are connected to many interesting areas of mathematics. Exploration of GT-shadow and their action on Grothendieck's child's drawings will shed light on very hard questions related to the absolute Galois group of rational numbers.

Students who choose this project will work with presentations of group, covering spaces, learn some advanced mathematics and will get some programming experience with the computer algebra system "Magma".

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Mathematics and/or computer science  
**Class Preferences:** Juniors & Seniors  
**Important Selection Criteria:** Math 2111 and Math 3098 are prerequisites for working on this project. Most of all, I expect a student to be passionate about mathematics!

Understanding antibiotic resistance: Computational study of biofilm architectures

Antibiotic resistance is one of the most relevant research topics in the health research sector. In this project biofilms, which are ubiquitous in the human body, will be studied computationally to understand the impact of the structural organization of biofilms on potential antibiotic resistance. This is a joint project with Dr. Buttaro (Department of Microbiology and Immunology, Temple University) who will provide microscopy data. This data will be used to develop computational workflows for spatio-temporal analysis. The proposed research lays the ground work for simulation-based studies of antibiotic flow through heterogeneous biofilms in order to quantify potential antibiotic resistance.

**Location:** Main; Virtual or computational research  
**Student Majors Accepted:** Math, CIS  
**Class Preferences:** Sophomores, Juniors & Seniors  
**Important Selection Criteria:** Java programming skills are a clear asset.
Virtual Reality-based Computation of Signaling in Neurons

Gillian Queisser
queisser@temple.edu
CST
Mathematics

Neuroscience has become a highly interdisciplinary research area. Combining expertise in mathematics, physics, computer science, and biology the function of brain cells can be studied in a highly systematic way.

In this project Virtual Reality (VR) is integrated into a computational workflow that allows scientists from all areas to study the spatio-temporal activity of neurons and interact with and drive simulations in real time in VR.

Undergraduate researchers will be part of an active team that develops visualization and interaction tools for VR using Unity3D. Another component of the project is the development and implementation of mathematical and computational methods. This allows researchers to identify their personal research interests within the project and take control of their subprojects.

Location: Main; Virtual or computational research
Student Majors Accepted: All majors
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Familiarity with programing languages (e.g. C#, C++, Java, ...) and/or Unity3D is a clear asset.

Understanding the Impact of Vehicle Automation on Traffic Flow

Benjamin Seibold
seibold@temple.edu
CST
Mathematics

The broader goal of this research is a better understanding the impact of vehicle automation on traffic flow and its impacts on health and safety. This specific project focuses on developing mathematical models, simulations, and small-scale virtual experimentation that can provide new insights into heterogeneous traffic flow in which a few vehicles are automated and the rest are human-driven. Two particularly important research directions are: (a) the development of better models for traffic waves, smart vehicle controllers that smooth traffic waves, and models that quality the energy impact and accident risk; and (b) the incorporation of models for traffic waves into 3D virtual reality simulators that can then be used for studies on human reactions to automated vehicles. No specific course or technical background is required; but the projects require a keen interest in mathematical models, simulations, data, programming, and hardware (all or some of the above). Students will work virtually or in the Center for Computational Mathematics and Modeling.

Location: Main; Virtual or computational research
Student Majors Accepted: Mathematics, Computer Science, Physics
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Experience in numerical methods, data processing, and/or programming (particularly Unity) is very welcome.
Solutions of an SQG front equation

The surface quasi-geostrophic (SQG) equation describes the dynamics of atmospheric temperature, and is broadly used in weather forecast. From a mathematical point of view, the inviscid SQG equation has some structural similarities with the 3-D incompressible Euler equation. The study of the SQG equation may shed lights on the long-standing mathematical open problems on the 3-D Euler equation. In this project, we will study a special type of solution to the SQG equation, called the front solution. The students are encouraged to read some background literatures (graduate level text books and research papers) and give a proof for the local well-posedness of solutions to a parametrized SQG front equation.

Location: Main; In-person essential
Student Majors Accepted: Mathematics
Class Preferences: Juniors, Seniors
Important Selection Criteria: The student should have completed the real analysis/advanced calculus course and have interests in analysis and its applications.

X-ray Spectroscopy of Emergent Quantum Phenomena at Oxide Interfaces

Laboratory and synchrotron-based investigations of emergent electronic and magnetic phenomena at interfaces between strongly-correlated oxides.

Location: Main; In-person essential
Student Majors Accepted: Physics, Chemistry
Class Preferences: Juniors & Seniors
Important Selection Criteria: Interest in experimental condensed matter physics and/or materials science, familiarity with Matlab programming
Research in Nuclear Physics

Double-electron capture studies with high resolution, ultra low background Germanium gamma ray detector in SERC basement. Computational and hands-on support for the HUNTER Experiment (https://phys.cst.temple.edu/hunter/). Computational and hands-on support for directional dark matter detector based on LAr in a 6 Tesla magnetic field (in SERC).

Location: Main; In-person essential
Student Majors Accepted: preference based on interest, not major
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: must be able to do useful work with one or more of the following: Mathematica, C++, Web of Science, chemistry lab equipment, or hand tools.