Precision genome editing using prime editors in zebrafish

Darius Balciunas
darius@temple.edu
CST
Biology

One of the main drawbacks of the CRISPR/Cas9 genome editors is that they introduce double strand breaks. These breaks are repaired by error-prone repair mechanisms, leading to small insertions and deletions. Even in the presence of a template for homology directed repair, only a small fraction of CRISPR/Cas9-induced double strand breaks are repaired in precise manner, introducing the desired mutation. The recently published prime editors rely on reverse transcriptase activity to introduce a precise change into the target site with only one DNA strand broken (nicked), without a double strand break. In this project, we will test if Prime Editors can be used to introduce epitope tags into genes coding for important developmental regulators in zebrafish. Please see Burg et al., 2016 (PMID: 27892520) for a fairly recent reference.

Location: Main
Student Majors Accepted: Biochemistry and Biology
Class Preferences: Sophomores & Juniors
Important Selection Criteria: strong background - or interest in - genetics

---

Mesopredator & Small Mammal Diet Dynamics

Jocelyn Behm
jocelyn.behm@temple.edu
CST
Biology

The Integrative Ecology Lab (www.iecolab.org) is looking for a research assistant to help with a project investigating the diets of mammalian mesopredators (foxes, opossums, raccoons, etc.) and small mammals (mice, chipmunks, voles, etc.) in the greater Philadelphia area. The research assistant will aid in the processing of fur samples collected during the summer and fall of 2022 for stable isotope analysis. All work will be done in-person within the lab on Temple University’s main campus.

Location: Main
Student Majors Accepted: Biology; Environmental Science; Ecology, Evolution and Biodiversity
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: All majors and years are encouraged to apply. Ideal applicants will have an interest in ecology and the environment, strong time management skills, and exceptional attention to detail.

Arthropod Biodiversity in Philadelphia's Vacant Lots

Jocelyn Behm
jocelyn.behm@temple.edu
CST
Biology

The study and conservation of urban biodiversity is essential to ensuring our cities are healthy and vibrant places to live. Our goal is to understand the role of vacant lots (empty parcels of land scattered across Philadelphia's poorest neighborhoods) in providing habitat for arthropods (including bees, butterflies, spiders and more!). Arthropod samples were collected in 20 vacant lots in summer 2019 and are ready to be sorted and identified. The undergraduate researcher involved in this project will learn to identify insects and other arthropods using technical guides and laboratory tools. The student will also help design and implement statistical analyses to understand the impacts of habitat management (mowing, vegetation clearing, tree cutting, etc.) on arthropod diversity. This project provides a unique opportunity for a highly-motivated student to develop arthropod identification skills and contribute to a research project with important implications for urban biodiversity and conservation. They will be encouraged to present their work at scientific conferences and submit it for publication in peer-reviewed journals.

Location: Main
Student Majors Accepted: Biology; Environmental Science; Ecology, Evolution and Biodiversity
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Successful undergraduate researchers are curious, detail-oriented, and thoughtful. If that describes you, we'd love for you to join our team!

Urban Fox Niche Dynamics and Caribbean Herp Diversity

Jocelyn Behm
jocelyn.behm@temple.edu
CST
Biology

The Integrative Ecology Lab (www.iecolab.org) is looking for a research assistant to help with two projects being conducted by researchers in the lab. The first project is investigating the diets of red foxes and feral cats in the Philadelphia area. The research assistant will aid in the collection of samples from forested areas of the city and so that the diet of foxes found in Philadelphia can be determined. The second project is investigated the influence of human activity on large-scale patterns of reptile and amphibian diversity in the Caribbean. When the research assistant is not in the field collecting samples for the first project, they will be in the lab updating a species occurrence database of Caribbean reptiles and amphibians as well as collecting information of ecological trait of these species from the published literature. The option for conducting the Caribbean database work remotely is available.

Location: Main
Student Majors Accepted: Biology; Environmental Science; Ecology, Evolution and Biodiversity
Class Preferences: 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. In addition, a willingness to work both in the field and in the lab on a computer is required.

Temple Forest Observatory

Mariana Bonfim
mariana.bonfim@temple.edu
CST
Biology

The Temple Forest Observatory, a collaboration between the Temple Ambler Field Station 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 Temple Forest Observatory was substantially impacted by an EF2 tornado, a remnant from Hurricane Ida. 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 Temple Forest Observatory 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 at the Temple Forest Observatory and other nearby field sites, while developing skills in field data collection, data analysis, and more. Additional opportunities for professional development training are also provided. These positions are open to all students who have an interest in gaining field experience in forest science, ecology, and global change. 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 Temple Forest Observatory and Ambler Field Station are located on the Temple Ambler Campus, a 50-minute drive from Main Campus. Transportation will be provided.

Location: Ambler
Student Majors Accepted: All majors
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: All students are welcome to apply

Resilience of Forest Ecosystem Services to Global Change

Amy Freestone
amy.freestone@temple.edu
CST
Biology

Forests cover nearly one third of the Earth's land surface and provide food or income to 25% of the global human population. Forests are also critical assets to humanity and provide a suite of services that sustain human society, by regulating climate, purifying air and water, and providing food, energy, and medicines. Global change, however, is causing unprecedented modifications to our natural systems, including forests. Global changes, including land use change, climate change, and biological invasions, have modified forests on a massive scale, undermining ecological resilience and degrading forest capacity to provide critical services to human society. Shifts in physiological rates, pest and pathogen loads, plant composition and diversity, species interactions, and hydrological processes alter the very ecosystem functions that provide these services. The environmental and biological dynamics that underlie forest ecosystem services and their resilience to global change are complex, and substantial gaps remain in the scientific understanding of these fundamental processes. Research conducted this spring will use the Temple Forest Observatory, a forest stand that was recently hit by an EF2 tornado at the Ambler Field Station, as a model system to understand the resilience of forest ecosystem services, specifically carbon storage and sequestration, to climate-driven wind disturbance. The Ambler Field Station is located on the Temple Ambler Campus, and student transportation is provided to/from Main Campus by the intercampus bus.

Location: Ambler
Student Majors Accepted: All students are welcome to apply.
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: A background in ecology, plant physiology, GIS, and/or data science is recommended but not required.

Sea urchin growth under climate change conditions

Amy Freestone
amy.freestone@temple.edu
CST
Biology

Sea urchins, like other ectothermic organisms, are at risk due to increasing ocean temperatures. To understand how herbivory interactions may be impacted by climate change, urchins underwent feeding trials at four different temperature treatments relating to low, medium, and high impact climate change scenarios. In addition to food consumption, urchins were injected with tetracycline, a florescent chemical incorporated into their test which allows you to track urchin growth from the time of injection. For this project, a URP student will assist in quantifying the growth of each urchin using a fluorescent stereoscope to measure growth rings. Experience with microscopes is preferred. No independent research experience required.

Location: Main
Student Majors Accepted: Biology, EEB, Enviromental Science
Class Preferences: Freshmen, Sophomores, Juniors, Seniors
Important Selection Criteria:

Building a tree of life with DNA data

S. Blair Hedges
sbh@temple.edu
CST
Biology

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
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

S. Blair Hedges
sbh@temple.edu
CST
Biology

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
Student Majors Accepted: Biology, but could be any major
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Strong academics

Spotted Lanternfly Invasion Meltdown

Matthew Helmus
mrhelmus@temple.edu
CST
Biology

Temple University's iEcoLab (https://www.iecolab.org/) 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.

Location: Main
Student Majors Accepted: Biology, CIS, ES, Physics, Engineering, GUS
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: 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.

Universal Patterns of Biodiversity

Matthew Helmus
mrhelmus@temple.edu
CST
Biology

Temple University's iEcoLab (https://www.iecolab.org/) 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.

Location: Main
Student Majors Accepted: Biology, CIS, ES, Physics, Math, Engineering, GUS
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: 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.

Spotted Lanternfly Invasion Meltdown

Matthew Helmus
mrhelmus@temple.edu
CST
Biology

The iEcoLab (www.iecolab.org) at Temple University runs various research projects on the invasive Spotted Lanternfly. This insect pest has enormous potential for economic disruption in agricultural product and ornamental plants sectors. Projects cover a diverse range of topics, including biological control, species traits, ecology, data science, computer coding, and machine learning. There are opportunities for students from a range of academic disciplines to work on projects in any of these areas. Students will work in a diversified and dynamic group of undergraduates, graduate students, and postdocs with a unified passion for the conservation of biodiversity for future generations.

Location: Main
Student Majors Accepted: Biology, CIS, ES, Physics, Engineering, GUS
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: 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 and data science.

Spotted Lanternfly Honeydew: A Novel Resource

Matthew Helmus
mrhelmus@temple.edu
CST
Biology

Temple University's iEcoLab (https://www.iecolab.org/) has a project focusing on the use of Spotted Lanternfly honeydew as a novel resource to local arthropod communities. Students will work with field collected samples in the lab to identify arthropods within the samples. A strong attention to detail is desired as students will be trained to identify arthropods and apply those skills. Students will work within a dynamic group of undergraduates, graduate students and postdocs focusing on spotted lanternfly ecological research.

Location: Main
Student Majors Accepted: All majors.
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Successful undergraduate researchers are curious, detail-oriented, and thoughtful. If that describes you, we'd love to have you join the team!

Improved methods for the study of natural selection on genes.

Jody Hey
hey@temple.edu
CST
Biology

The proposed research develops and applies a new class of Multiple Synonymous Substitution models that include both selected and neutral synonymous changes in estimates of evolutionary change. Our hypothesis is that the current definition of what constitutes neutrally evolving sites is importantly wrong in that it biases the estimation of selective forces (by underestimating the rates of neutral changes), and that improved estimates without that bias will provide significantly better and more accurate understanding of the action of natural selection in a broad array of evolutionary contexts. We will apply and validate these methods across a broad array of taxa and develop news comparative and population genetic tests of selection.

Location: Main
Student Majors Accepted: Biology, Genomic Medicine, Ecology & Evolution, Biochemistry, CIS, Math
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: basic data science skills required, such as some experience with python and statistics

Machine Learning and Landscape Genomics

Jody Hey
hey@temple.edu
CST
Biology

This project will develop a new machine learning approach to identify local, partial selective sweeps in large population genomic data sets.

Location: Main
Student Majors Accepted: Biology, Genomic Medicine, Ecology & Evolution, Biochemistry, CIS, Math
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: data science skills, including statistics, preferably with some machine learning experience

Allele age and natural selection

Jody Hey
hey@temple.edu
CST
Biology

The research will implement a new method for identifying mutations with effects on health and fitness based on the patterns of variation that are found in large whole genome and exome sequencing studies of many individuals. Such data provide access to the age of a mutation, which in turn can reveal how likely it is that the mutation has been under natural selection. is harmful. Multiple populations will be studied from several perspectives, including genome scans of the cumulative effect of mutations and including fitting statistical models of the demographic and selective history of populations.

Location: Main
Student Majors Accepted: Biology, Genomic Medicine, Ecology & Evolution, Biochemistry, CIS, Math
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Basic data science skills required, such as some experience with python and statistics

Human Population Genomics and Natural Selection

Jody Hey
hey@temple.edu
CST
Biology

Large human data sets hold the potential to reveal the action of natural selection, including weak natural selection. We will adapt existing methods, and develop new approaches for identifying selection acting on coding regions and regulatory regions.

Location: Main
Student Majors Accepted: Biology, Genomic Medicine, Ecology & Evolution, Biochemistry, CIS, Math
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Basic data science skills required, such as some experience with python and statistics

Evolution of gender in language

Rob Kulathinal
robkulathinal@temple.edu
CST
Biology

The sexual identify of a gene can switch between being male-biased and female-biased in expression over evolutionary time. Such reversals in sex-biased expression are thought to be due to sex-specific adaptations. In a similar fashion, nouns from modern languages can also change gender and much could be learned about a language's culture by identifying these switches. Are certain classes of nouns prone to be more masculinized or feminized? Using a resolved phylogeny of romantic languages rooted in Latin, we will map gender changes on the tree using a set of noun orthologs. We will use open corpora (databases) of English words available at Brown and WordNet. the Natural Language Toolkit (python), and the Wordnik API.

Location: Main
Student Majors Accepted: Biology
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Interests in applying evolutionary theory to non-biological data

Mapping phenotype ontologies to genes and genetic networks in Drosophila

Rob Kulathinal
robkulathinal@temple.edu
CST
Biology

Behavioral traits are among the most diverse characters among animal species, and have been implicated in a range of important evolutionary processes, including sexual selection (Darwin 1871) and reproductive isolation (Coyne and Orr 1989). Behaviors generally are polygenic and many are sexually dimorphic. By studying the underlying genetic architecture of these characters we come closer to understanding the genetic basis of sexual selection, including such models as female choice (Darwin 1871), runaway selection (Fisher 1930; Lande 1980), and sexual conflict (Parker 1979), as well as their subsequent role in population divergence. The system of Drosophila melanogaster provides extensive data on phenotypes, associated genes and their alleles, and estimates of sex-bias gene expression, making it an ideal model organism for this study. Here, we perform a network analysis of phenotypes and their underlying genes in order to unravel the polygenic and sex-specific nature of behavior. We examine general network properties, as well as sex-biased gene and allelic expression for the genes known to cause behavioral phenotypes. We also use Drosophila's unparalleled evolutionary datasets in order to compare the evolutionary histories of these phenotypic networks.

Location: Main
Student Majors Accepted: Biology
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Interest in classical and molecular genetics

---

Genomic Music: Transforming phylogenomic diversity into digital sound to enable gene discovery and evolutionary constraint

Rob Kulathinal
robkulathinal@temple.edu
CST
Biology

While the vast majority of eukaryotic genome sequences are functional deserts, 1-3% code for proteins. Once these coding regions are aligned, they follow a distinct evolutionary pattern or "beat" that are based on the selective constraints of a triplet genetic code. The more phylogenetically distant the aligned sequences are, the greater the number of differences. In this project, we will transform the visual interface of multiple sequence alignments (MSA) typically used in comparative genomics into auditory signals in order to explore its potential use as a new medium to identify new genes and to understand the role of selection vs constraint.

Location: Main
Student Majors Accepted: Any
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: A creative coder with a knowledge of musical notation

Molecular identification of Antarctic protists (algae and protozoa)

Robert Sanders
robert.sanders@temple.edu
CST
Biology

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
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

Brent Sewall
bjsewall@temple.edu
CST
Biology

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
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

---

Spotted lanternfly studies at the Temple Ambler Field Station

Brent Sewall
bjsewall@temple.edu
CST
Biology

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
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 in Oral Medications

Gregory Smutzer
smutzerg@temple.edu
CST
Biology

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, Monk fruit, or sucrose. One novel approach is to encapsulate bitter tasting compounds in solid lipid microspheres or in solid lipid microparticles. 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 is achieved by encapsulating bitter taste stimuli in solid lipid microspheres along with masking agents, and then placing these encapsulated stimuli in rapidly dissolving edible films that also contain a variety of bitter taste masking agents. In this approach, masking agents are immediately released as edible 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 project will primarily use techniques that enhance the masking of bitter taste in the oral cavity, and will require a minimum of three hours of lab work per week per academic credit. In summary, this 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
Student Majors Accepted: Neuroscience, Biology and Biochemistry
Class Preferences: Juniors & Seniors
Important Selection Criteria: Willingness to work a minimum of three hours per week per academic credit. Engagement in the research project. Ability to solve problems associated with the research project. Ability to recruit test subjects for psychophysical studies.

Investigating ecological and evolutionary forces influencing population persistence or extinction.

Rachel Spigler
rachel.spigler@temple.edu
CST
Biology

Habitat fragmentation tends to decrease population sizes and threatens extinction for many plant and animal populations. To predict the fates of these populations in an everchanging world, we need an understanding of the ecological and evolutionary forces influencing population growth and decline. For many plants, the ability to self-fertilize on the one hand ensures reproduction when pollinators or mates are few, but then their seeds are often of poorer quality due inbreeding depression, which could lower the probability of persistence. This project will use data on germination, growth, survival, and reproduction from wild populations of a native plant to investigate the demographic consequences of selfing and inbreeding depression. The student will work closely with Dr. Claire Godineau Postdoctoral Associate in the Spigler lab to investigate the relationship between the selfing rate and vital rates (growth, fecundity and survival) and to construct demographic models of population growth that will inform on how inbreeding depression affects the persistence probability of plant populations. During this project, the student will learn about demographic models, to organize a large dataset and to practice regression models in R. The Spigler lab offers a dynamic research environment combining empirical and theoretical eco-evolution. The student can work in person, virtually, or via a combination.

Location: Main
Student Majors Accepted: Biology, Math
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Interest in ecology and evolution, enthusiasm & tenacity. Previous experience with R or R studio appreciated but is not required if you have a strong motivation to learn!

Study Protein and RNA in Cancer Cells

Weidong Yang
weidong.yang@temple.edu
CST
Biology

We are highly motivated to develop innovative research tools to meet the needs of solving challenging biological and biomedical problems, as we have done in the past and will be doing in the future. Currently, by developing and employing high-speed super-resolution microscopytechniques, our research aims to solve two critical transport mechanisms involving three sub-cellular organelles in eukaryotic cells: nucleus, cytoplasm and primary cilium. Macromolecular trafficking among these compartments is suggested to be gated by two unique machineries. One is the nuclear pore complex (NPC) embedded in the nuclear envelope that mediates the bidirectional trafficking of proteins and RNAs between the cytoplasm and the nucleus; the other is the transition zone (TZ) located at the base of cilium that regulates the entry of membrane and cytosolic proteins into the cilium. Due to the challenges in elucidating kinetics and real-time transport routes for macromolecules through the sub[1]micrometer NPC or TZ in live cells, however, the fundamental gating mechanisms in either of these two machineries, remain obscure. Moreover, these transport mechanisms are not only the fundamental unanswered questions in cell biology, but also are loosely associated with human diseases. For example, dysfunction of the nuclear transport through the NPC are linked to numerous human diseases including leukemias, cancers, and primary biliary cirrhosis. Also, defects in ciliary structure and/or function causes a variety of diseases (called ciliopathies) such as cystic kidney disease, nephronophthisis (NPHP), and retinitis pigmentosa.

Location: Main
Student Majors Accepted: Biology, Biophysics, Physics, Computer Science
Class Preferences: N/A
Important Selection Criteria: N/A

Comparative genomics of parasites and pathogens

Ananias Escalante
Ananias.Escalante@temple.edu
CST
Biology/iGEM

The goal is to study the genetic diversity and long-term evolution of gene-encoding proteins considered essential in the host-parasite relationship. Such genes are usually targeted for vaccine development or drugs, but also they may be involved in pathogenesis.

These studies involve creating and curating genomic databases that include parasite/pathogen genetic data and its associated metadata. Students are expected to work with public data depositories and search literature. We aim to understand the drivers of these genes, parasites, or pathogens' evolution. Currently, we are working on parasites of the genus Plasmodium that cause malaria in vertebrates, including humans, and the bacteria genus Leptospira, which species drive in different environments, and some are related to human disease.

Location: Main
Student Majors Accepted: All levels and majors will be considered but preferable Biology, Biological Data Science, Genomic Medicine, and Computer Sciences
Class Preferences: Sophomores & Juniors
Important Selection Criteria: A highly motivated and independent student, preferably with interest in learning genetics and evolution to discover patterns and solve problems. Interest in learning bioinformatics and using computers for data analysis. Open to considering Freshmen if meeting these requirements.

Personalized medicine and evolutionary link between DNA and disease

Sudhir Kumar
s.kumar@temple.edu
CST
Biology/iGEM

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
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

Sudhir Kumar
s.kumar@temple.edu
CST
Biology/iGEM

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

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

Biodiversity of symbionts in wildlife

Maria Pacheco
Maria.Pacheco@temple.edu
CST
Biology/iGEM

Species assemblages of hosts and symbionts offer information on processes affecting biodiversity. Like a canary in a coal mine, symbiont extinctions, their host ranges, and host switches inform about the impact of global changes in ecosystems, including the factors driving the emergence of infectious diseases. Unfortunately, data on symbiont diversity is still limited and is usually dispersed. Dr. Escalante and I are working on Haemosporida, a diverse taxon of vector-borne protozoa symbionts found in terrestrial vertebrates in almost all world ecosystems. Although some haemosporidian species have been widely studied because of their link to malaria in birds and humans, there are critical knowledge gaps on their diversity and the processes leading to their host-symbiont assemblages. In this project, we are studying haemosporidian parasites in wildlife. Beyond studying an ignored part of biodiversity, our research aims to (1) advance symbiont species delimitation, (2) generate new knowledge on the processes driving haemosporidian species diversity, (3) enrich biodiversity sciences by developing standards for symbiont-host data integration, and (4) develop databases that support symbionts biodiversity sciences. Overall, these studies include Haemosporida in biodiversity science and, by so doing, provide new insights into regional evolutionary and ecological processes.

Location: Main
Student Majors Accepted: We are open to consider students at all levels and majors. However, Biology and Biological Data Science are encouraged to apply.
Class Preferences: Sophomores & Juniors
Important Selection Criteria: There are a variety of activities across different levels of data processing. Ideal applicants should have a strong interest in evolutionary biology and data analysis. Great attention to detail is paramount. Interest in learning basic bioinformatic tools is required. Although programming in Python is not required, students with such skills will be able to use them in particular aspects of the project.

Combining Photons, Electrons and Nanoparticles for Plasmonic Sensing and Catalysis

Eric Borguet
eborguet@temple.edu
CST
Chemistry

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
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

Eric Borguet
eborguet@temple.edu
CST
Chemistry

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
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.

Treasure from trash: using discarded plastics to clean up pollutants in waterways

Graham Dobereiner
tuf71642@temple.edu
CST
Chemistry

The project will leverage the intrinsic chemical properties of waste plastics to collect persistent organic pollutants for the environmental remediation of waterways, through an interdisciplinary program that aligns with the research and geographical strengths of Temple University. To achieve this objective, the project team will physically and chemically modify waste plastics, explore how micronized/porous plastic waste adsorbs organic contaminants, like PCBs and PFAS, demonstrate adsorption of contaminants from waterways, and divert disposal of plastics/contaminants in landfills by exploring gasification alternatives.

Location: Main
Student Majors Accepted: Chemistry, Biochemistry, Materials Science
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: At least general chemistry and associated laboratory. Preference given to those who have completed organic chemistry and associated laboratory.

Chemical Education - Design of teaching tools for organic chemistry

Steven A. Fleming
sfleming@temple.edu
CST
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
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.

Modeling photophysical and photochemical properties of molecules

Spiridoula Matsika
smatsika@temple.edu
CST
Chemistry

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 photo physics 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
Student Majors Accepted: Chemistry, Biochemistry, Physics, CIS
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Interest in physical chemistry, math, computational science

---

Microfluidic synthesis of graphene-supported quantum dots for photocatalysis

Yugang Mon
ygsun@temple.edu
CST
Chemistry

This project seeks to use the home-built microfluidic reactor for synthesizing graphene-supported semiconductor quantum dots, which can adsorb solar energy to drive useful chemical reactions (i.e.,photocatalysis). The student will use the method recently veloped in my groupto synthesize graphene-supported semiconductor quantum dots including CdSe and CdS.

Location: Main
Student Majors Accepted: Chemistry
Class Preferences: Seniors
Important Selection Criteria: Wet chemistry experience

Approximate Molecular Orbital Theory

George Petersson
gpetersson@temple.edu
CST
Chemistry

Solving the equations of molecular quantum mechanics from first-principles, called ab initio theory, gives very accurate predictions of molecular properties. However, the complexity of these calculations limits the size of the chemical systems that can be treated. Semiempirical methods reduce the computer time by ignoring most of the integrals required for ab initio theory. The traditional approach to developing semiempirical molecular orbital theory has been to introduce adjustable parameters that maintain the matrix form of the ab initio equations, and proceed directly to fit these parameters to the energies of a large training set of polyatomic molecules. These methods can include more than a dozen adjustable parameters for each element. The simultaneous optimization of the entire set of parameters is necessary to achieve useful accuracy, but results in strongly coupled parameters that have individually lost any physical meaning. We are developing “approximate molecular orbital theory” in which each parameter we introduce will be adjusted to emulate a specific feature of ab initio calculations that is inaccessible to the semiempirical model. This will prevent the coupling between large numbers of parameters that can obscure their physical meaning. This also provides a clear path to improve the accuracy of our method. Recent Publications: “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). “Synthesis and characterization of fluorescent amino acid dimethylaminoacridonylalanine (PJ-11498VP)” Chloe M. Jones, George A. Petersson, and E. James Petersson, Arkivoc 2021,97 (2021). “A Bond-Energy/Bond-Order and Populations Relationship” Zulueta, Barbaro; Tulyani, Sonia; Westmoreland, Phillip; Frisch, Michael; Petersson, E. James; Petersson, George; Keith, John Journal of Chemical Theory and Computation 18, 4774-4794 (2022). “Improved Geometries and Frequencies with the PFD-3B DFT Method” Jason M. Breslin, Michael J. Frisch, and George A. Petersson, J. Phys. Chem. A, 126, 5814-5820 (2022).

Location: Main
Student Majors Accepted: Chemistry, Physics, Mathematics
Class Preferences: Sophomores
Important Selection Criteria: Interest in Mathematical Physics

Machine Learning Optimized Molecular Energy Surfaces

Jonathan Smith
jonathan.m.smith@temple.edu
CST
Chemistry

Accurate molecular properties can now be computed using quantum mechanical computations for moderate sized molecular systems. In the case of reactive systems of astrophysical and atmospheric significance and their spectroscopy, molecular dynamics can extend these studies but requires many computationally expensive steps. These steps can be sped up by >10,000 fold by trained machine learning molecular potential energy surface models.

Location: Main
Student Majors Accepted: Chemistry
Class Preferences: Juniors & Seniors
Important Selection Criteria: An aptitude in coding (or interest in learning) to automate and analyze computations.

Optimization of Extremophilic Photolyase Protein Folding

Robert Stanley
rstanley@temple.edu
CST
Chemistry

Enzymes found in extremophilic organisms that thrive in high and low temperature face challenges to stability that mesophilic proteins (like ours) don't face. Mimicing 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
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.

Understanding transformation of colloidal nanoparticles

Yugang Sun
ygsun@temple.edu
CST
Chemistry

The behavior of colloidal nanoparticles in liquid solution is very complex and the accurate description of their behavior is still absent. This project will target this ground[1]challenging problem by working with senior graduate researchers. This research will rely on the group's unique ability to use the in situ high-energy synchrotron x-ray techniques to probe the nanoparticle evolution processes in real time and even under real reaction conditions. This capability enables the collection of the unprecedented data, which are impossibly achieved with traditional methods, from colloidal nanoparticles. We will process the in-situ data to develop appropriate models to understand the complex behavior of colloidal nanoparticles. The understanding will be helpful to design the synthesis protocol for producing the best nanomaterials.

Location: Main
Student Majors Accepted: Chemistry
Class Preferences: Juniors & Seniors
Important Selection Criteria:

Bioinorganic Titanium Chemistry

Ann Valentine
ann.valentine@temple.edu
CST
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
Student Majors Accepted: Chemistry, Biochemistry
Class Preferences: Sophomores & Juniors
Important Selection Criteria: intelligence enthusiasm conscientiousness - will teach skills necessary

---

Development of novel imaging agents for image-guided cancer therapy

Ross Wang
rosswang@temple.edu
CST
Chemistry

Chemical biology approaches to the mechanism study, diagnosis, and treatment of human diseases

Location: Main
Student Majors Accepted: Chemistry, Biology, Biochemistry, Pharmaceutical
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Having completed General Chemistry, Organic Chemistry I with a grade of B or higher. Preferably with prior laboratory experience in Chemistry and Biochemistry

---

Design and synthesis of antibody mimics

Ross Wang
rosswang@temple.edu
CST
Chemistry

Chemical biology approaches to the mechanism study, diagnosis, and treatment of human diseases.

Location: Main
Student Majors Accepted: Chemistry, Biology, Biochemistry, Pharmaceutical
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Having completed General Chemistry, Organic Chemistry I with a grade of B or higher. Preferably with prior laboratory experience in Chemistry and Biochemistry

Metal Free Conversion of Aryl C–H to C–N Bonds

Sarah Wengryniuk
sarahw@temple.edu
CST
Chemistry

The conversion of aryl C–H to C–N bonds, or C–H amination, is a highly sought after transformation in the pharmaceutical industry. Unfortunately, current methods often require expensive or toxic metals or functionalized substrates, adding additional synthetic steps and generating excess waste. Our goal is to effect direct conversion of C–H bonds on phenols to C–N bonds in the form of pyridinium salts. These compounds then allow access to many different amine derivatives from a single intermediate, facilitating rapid small molecular library synthesis. This will be achieved using a class of reagents known as hypervalent iodine compounds, which are mild, inexpensive, non-toxic, and green alternatives to traditional metal catalysts.

Location: Main
Student Majors Accepted: chemistry, biochemistry
Class Preferences: Sophomores & Juniors
Important Selection Criteria: passed Organic I with a B or higher

Research at the Interface of Chemistry, Materials, and Energy

Mike Zdilla
mzdilla@temple.edu
CST
Chemistry

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
Student Majors Accepted: Chemistry and 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, and students should apply with the intent to meet these expectations.

Extracting and Linking AI Artifacts

Eduard Dragut
edragut@temple.edu
CST
CIS

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
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

Eduard Dragut
edragut@temple.edu
CST
CIS

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
Student Majors Accepted: CIS, Communication, Journalism
Class Preferences: Juniors & Seniors
Important Selection Criteria: diligent; communication and/or programming skills

Expert Goggles: Teaching Data Literacy with an AI Tutoring System

Stephen MacNeil
stephen.macneil@temple.edu
CST
CIS

People form opinions (e.g.: is climate change real?) and make decisions (e.g.: should I get vaccinated?) based on data visualizations. However, research shows that people frequently misunderstand visualizations.
Our project, Expert Goggles, helps people with limited data literacy skills see visualizations through the eyes of an expert by automatically annotating visualizations with key insights and scaffolding for interpretation.

Location: Main
Student Majors Accepted: Computer Science, Psychology, or Design Fields
Class Preferences: Freshmen & Sophomores
Important Selection Criteria: Students should be excited to work in a multi-disciplinary team

---

Creating tools for civic designathons and hackathons

Stephen MacNeil
stephen.macneil@temple.edu
CST
CIS

Our research team has hosted a few hackathons and designathons---such as Design for San Diego (D4SD), ScaleSD, and San Diego Design Week (SDDW). For these events, our research team has developed a technology platform that collects the ideas that emerge across teams to summarize activities, provide cross-team inspiration, and facilitate real-time feedback exchange.

Location: Main
Student Majors Accepted: Computer Science, Management, Psychology, Design
Class Preferences: Freshmen, Sophomores & Juniors
Important Selection Criteria: Candidates should be excited to design, develop, and deploy technology in the real-world

Feedback Buffet: A NLP System for Generating Feedback

Stephen MacNeil
stephen.macneil@temple.edu
CST
CIS

Good feedback is a rare resource and students do not always have access to high quality mentors to guide them. We developed Feedback Buffet an AI-powered feedback system that gives students feedback on their statements of purpose, essays, and emails. We investigate how students can fine tune the feedback they receive from Feedback Buffet.

Location: Main
Student Majors Accepted: Computer Science
Class Preferences: Juniors & Seniors
Important Selection Criteria: Candidates should have ReactJS development experience and should be excited about large language models

Human-AI Interaction: How do Individuals develop Mental Models of AI Systems?

Stephen MacNeil Richard Souvenir
stephen.macneil@temple.edu
CST
CIS

People will increasingly interact with AI systems to commute to work, recommend music and news, and help them to perform their work. This raises important new questions about how people understand AI systems and how they adapt when these systems break down.
We are designing and conducting experiments to better understand how people develop an understanding of the AI systems that they use.

Location: Main
Student Majors Accepted: Computer Science, Psychology
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Interest in explainable AI systems (XAI)

Security of Smart Speakers

Chiu Tan
cctan@temple.edu
CST
CIS

Smart Speakers, such as Amazon's Alexa, allow users to purchase items just by speaking to them, e.g. order pizza. The current security protections include (limited) speaker recognition as well as verbal PIN. The objective of this project is to investigate the security vulnerabilities of Smart Speaker apps and design possible solutions to mitigate these threats.

Location: Main
Student Majors Accepted: CS, IST, Data Science, Criminal Justice
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Interest in cybersecurity.

Automobile voice systems and driver distraction

Chiu Tan
cctan@temple.edu
CST
CIS

Modern automobiles allow drivers to use natural language commands to accomplish certain tasks, e.g. find me a restaurant, play jazz music, etc.. The objective of the project is to attempt to understand whether the design of these applications pose a distraction to the driver, as well as develop new user interactions to reduce the cognitive load on drivers.

Location: Main
Student Majors Accepted: CS, IST, Psychology, Cognitive Science
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: An interest in usability is helpful

Security of mobile payment apps

Chiu Tan
cctan@temple.edu
CST
CIS

Mobile payments have become increasingly popular, and with that popularity, has led to a rise in frauds. The objective of this project is to collect and analyze mobile apps to determine the causes and design new solutions to defend against these new attacks.

Location: Main
Student Majors Accepted: CIS, criminal justice, psychology
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Background in UX or criminal justice or psychology, will be helpful.

Climate modelling in a box: containerizing a climate model and optimizing workflow for running experiments on a laptop

Rebecca L. Beadling
rebecca.beadling@temple.edu
CST
EES

The Manabe Climate Model (MCM) is a climate model which began its development with Nobel Laureate Suki Manabe and collaborators at NOAA's Geophysical Fluid Dynamic's Laboratory (GFDL) in the 1980s (known then as the R30 model). This model was used extensively through the early 2000s as a powerful tool to research global warming and how the climate system works. Under the leadership of retired GFDL scientist and original model developer, Ronald Stouffer, the MCM has recently been brought back to life and has been used to perform climate change experiments, participating in the sixth phase of the World Climate Research Programme's Coupled Model Intercomparison Project (CMIP6). Owing to its relative simplicity, the computational costs of running the MCM is relatively low and up to 20 model years per day can be simulated on a modern personal computer. The Ocean Climate Connections Lab (sites.temple.edu/oceanclimateconnections/), under the guidance of Dr. Becki Beadling and in collaboration with Ronald Stouffer, is aiming to "containerize" the MCM using Docker (www.docker.com/resources/what-container/) so that the model can be run quickly and reliably from one computing environment to the next. This process would greatly reduce the barrier to entry to running a model simulation and would enable the MCM to be used as a teaching resource, allowing students to have hands-on experience with running climate model experiments. We are seeking a highly motivated student with experience in computer programming and computer architecture to work on the containerization of the MCM and optimizing the workflow from model simulations to data storage.
Location: Main
Student Majors Accepted: Computer Science, Data Science, Applied Mathematics, Environmental Science
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Highly motivated student with experience in computer programming (Python, Fortran - willingness to work with Fortran 77!), csh, command line, Unix/Linux, and computer architecture

Structural mapping of the Nili Fossae, Mars

Alexandra Davatzes
alix@temple.edu
CST
EES

In this project, students will utilize remote sensing data of the Martian surface to map the structural and potential hydrothermal features in the Nili Fossae region. Students will complete a geologic map, with possible stratigraphic analysis where high resolution outcrop images are available.

Location: Main
Student Majors Accepted: Earth and Environmental Science
Class Preferences: Seniors
Important Selection Criteria: Students should have a strong background in structural geology as well as geologic mapping.

Investigating antiviral drug targets

Michael L. Klein, FRS
Michele.Young@Temple.edu
CST
ICMS

Investigating antiviral drug targets via computation.

Location: Main
Student Majors Accepted: Biophysics, Bioinfomatics & Chemistry
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Working in a team environment with Faculty, Post Doc and Staff. Preferred students who can commit to multiple semesters of research.

Exploration of GT-shadows for the gentle version of the Grothendieck-Teichmueller group

Vasily Dolgushev
vald@temple.edu
CST
Mathematics

Grothendieck-Teichmueller (GT) shadows are morphisms in the groupoid whose objects are certain finite index normal subgroups of the pure braid group on 3 strands. This groupoid acts on Grothendieck's child's drawings and, in some situations, connected components of this groupoid can be described explicitly. More information about the topic can be found in the block "Exploration of Grothendieck-Teichmueller(GT)-shadows and their action on Grothendieck's child's drawings" on my webpage https://math.temple.edu/~vald/research.html

Location: Main
Student Majors Accepted: Mathematics or Compute Science
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Math 3098 (Modern Algebra) is definitely a prerequisite. Math 4063 (Topology) and Math 4051 (Complex Analysis) may be helpful. Some programming skills or desire to master these skills fast is helpful. A student interested in a graduate program in Math or related topics would benefit from this project.

Impedance spectrum reconstruction from experimental data

Yury Grabovsky
yury@temple.edu
CST
Mathematics

The goal of the project is to develop an algorithm that reconstructs the impedance spectrum of an electrical circuit from a finite set of measurements. The main objective is to be able to deal with circuits exhibiting sharp resonances. The existing algorithm either captures the sharp resonances, but produces very spiky spectra everywhere, or misses the resonances. The idea is to adapt the existing algorithm to handle the sharp resonances by capturing individual resonances in the "spiky" mode and then reconstructing everything else in the smooth mode. The original algorithm implementation is in Fortran, but work in Matlab is also an option. This work has a much wider applicability than to electrical circuits. Complex electromagnetic permittivity functions and scattering amplitudes in particle collisions also fit the same model.

Location: Main
Student Majors Accepted: No preference
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Knowledge of either Matlab or Fortran is required. Knowledge of both is a big plus.

Neuro-VISOR: VR-based neuroscience modeling and simulation

Gillian Queisser
queisser@temple.edu
CST
Mathematics

The student's research project will advance the tool Neuro-VISOR, which immerses the user in a virtual lab world where brain cells can be visualized, interacted with, and stimulated. Real-time simulations of neuronal activity can be analyzed and interacted with, making Neuro-VISOR a unique tool in the area of computational neuroscience, used in an instructional and scientific context. The project revolves around the development of novel virtual reality-based computational tools, applied to neuroscientific modeling and simulation, and is co-advised by Dr. Seibold and Dr. Queisser. Students will have the opportunity to work in a team that covers a broad range of research, from mathematical modeling, numerical and visualization methods, to optimizing computational scalability for large problems.

Location: Main
Student Majors Accepted: Mathematics, Computer Science, Physics
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Knowledge of programming languages (e.g., C#, C++, Java) are critical. Experience with Unity3D is a plus, but not a must.

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
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.

Math Aspects of Voting Theory

Jeromy Sivek
sivek@temple.edu
CST
Mathematics

Ranked preference voting is becoming increasingly popular. The most common method for counting votes, called Instant Runoff in most places, is simple but has known shortcomings. In fact, we know (via Arrow's famous theorem and similar results) that there is no "perfect way" to count ranked preference ballots. This continuing project uses simulation (current code in python) and theory to explore and classify the cases where reasonable counting methods disagree. We are also analyzing historical elections as that data becomes available.

Location: Main
Student Majors Accepted: Math, Computing, Economics, Political Science
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Some comfort with coding in python is helpful. One can engage this project on a purely mathematical level, but in this case should have passed Basic Concepts (Math 2111) and have some comfort with combinatorics. Those with economics or political science backgrounds would be welcomed too.

Fixed Point Theory and Applications

Jeromy Sivek
sivek@temple.edu
CST
Mathematics

Fixed point theory refers to a collection of mathematical results guaranteeing that T(x)=x must have a solution. In most applications, T is an operator consisting of many terms and reflects the specifics of the application. Students will explore the rich foundation of this area and be shown a few applications. Students will then be encouraged to take a deep dive into any one application and possibly pursue more abstract and open problems about fixed points and minimal invariant sets that have already proven somewhat accessible at the undergraduate level.

Location: Main
Student Majors Accepted: Mathematics, Physics, Computing
Class Preferences: Sophomores, Juniors & Seniors
Important Selection Criteria: Students should have some background in proof-based mathematics. A course like Math 3137 or 3141 would be an appropriate pre-req or co-req for starting the project.

X-ray Spectroscopy of Emergent Quantum Phenomena at Oxide Interfaces

Gray Alexander
axgray@temple.edu
CST
Physics

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

Location: Main
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

---

Density Functional Theory of Electron Systemsic

John P. Perdew
perdew@temple.edu
CST
Physics

Density Functional Theory is the standard quantum mechanical way to predict on the computer what atoms, molecules, and solids can exist and with what properties. It defines an exact density functional (formula) for the exchange-correlation energy, which must be approximated in practice. The most predictive approximations are designed to satisfy the known mathematical properties of the exact functional. One of those is a lower bound on the exchange energy. There is a conjectured lower bound that is tighter than any bound so far proved. Computer calculations of exact and local density approximation exchange energies of spin-unpolarized atoms can test the conjectured bound.

Location: Main
Student Majors Accepted: Physics, Chemistry
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Some knowledge of quantum mechanics, including Schroedinger's equation for the wavefunction of one electron. Some knowledge of computing and coding. The student can learn more by working with the PI and his research-group members.

Computational discovery of density functional theory for low-dimensional quantum materials

Adrienn Ruzsinszky
aruzsinszky@temple.edu
CST
Physics

Density functional theory (DFT) is the most widely used method in materials science. The term "quantum materials" refers to materials that exhibit extraordinary effects of quantum mechanics leading to exotic and often incredible properties. Sometimes the term "quantum material" is misleading because all materials obey the laws of quantum mechanics at some level, but beyond standard quantum mechanical properties "quantum materials" exhibit unique properties such as strong correlation, superconductivity, magnetic order, quantum coherence, and topological behavior. Quantum materials contain unusual magnetic and electrical properties that with a methodological framework could allow us to harness energy in new ways, creating breakthroughs toward more efficient technology. Within this project we aim to explore how far DFT can be pushed for materials with quantum features such as charge density waves, spin anisotropy or topological properties. Many-body methods will additionally be used for benchmarking of excitonic effects and related phenomena.

Location: Main
Student Majors Accepted: Physics, Chemistry
Class Preferences: Juniors & Seniors
Important Selection Criteria: reliability, willingness to hard work, basic background with linux and possibly with some programming languages

---

Design of advanced materials for strategic applications including body armor.

Michael L. Klein, FRS
Michele.Young@Temple.edu
CST
TMI/ICMS

The project involves the computational design of advanced materials for strategic applications including body armor. The materials currently under investigation are aromatic polyamides such as Kevlar® and ultra-high molecular weight polyethylene. Researchers at Temple Material Institute (TMI) are using computational methods to explore the molecular structure and properties of these materials with main objective of enhancing their performance. The student's research primary focus will be on use of computational methods (modeling, simulation, machine learning) for improving predicting capabilities in designing new polymeric structures for strategic applications. Secondarily, as appropriate, the student's activity will involve sssessing some properties of polymer samples in the form of powders, fibers, or films, using thermal analysis (Differential Scanning Calorimetry), and nanoindentation.

Location: Main
Student Majors Accepted: Physics, Chemistry
Class Preferences: Freshmen, Sophomores, Juniors & Seniors
Important Selection Criteria: Working in a team environment with Faculty, Post Doc and Staff. Preferred students who can commit to multiple semesters of research.
