Chemoenzymatic Synthesis of Complex Bioactive Bis-Indole Alkaloids

Rodrigo Andrade
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CST
Chemistry

The study of natural products--small molecules produced by living organisms--has impacted society from chemistry to biology to medicine. We are interested in the synthesis of complex, dimeric indole alkaloids by employing combination of chemical synthesis (i.e., reactions) and enzyme-mediated transformations. With these synthetic natural product in hand, we will evaluate their biological activity in collaboration with medicinal chemists for therapeutic value (i.e., drug discovery) along with their molecular mechanism of action by collaborating with chemical biologists.

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: Chemistry/Biochemistry/CIS
Class Preferences: Juniors, Seniors
Important Selection Criteria: Have taken CHEM 2201 and 2202; Enjoy and are "good at" Organic Chemistry, including mechanism, synthesis, structure determination, and synthetic methodology; Have good time-management skills; Are innately curious and wish to engage in curiosity-driven research.

Precision genome editing in zebrafish

Darius Balciunas
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CST
Biology

Unlike humans, zebrafish possess a remarkable regenerative capacity, including the ability to regenerate their hearts after severe injury. We are working to figure out which genes control this process and precisely how. To achieve this goal, we are using the CRISPR/Cas9 system to introduce precise changes into the zebrafish genome, including integration of sequences coding for epitope tags and loxP sites (see PMID: 30427827 and PMID: 27892520). We are looking for one or two students to join this effort. Sub-projects include screening for CRISPR/Cas9-induced genome editing events and analysis of generated mutant lines.

Location: Main
Student Majors Desired: Biology, Biochemistry
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: N/A

Lyme disease ecology

Jocelyn Behm
jebehm@temple.edu
CST
Biology

Lyme disease impacts hundreds of thousands of people annually, but human risk of getting the disease is related to complex interactions between ticks, deer, mice, and their predators. As part of this project, students will process photos from motion-activated trail cameras to identify species involved in the transmission and control of Lyme disease. There is potential for involvement in future lab or field work related to this study for committed students.

Location: Main: Virtual or computational research
Student Majors Desired: Biology and Environmental Science
Class Preferences: N/A
Important Selection Criteria: No prior experience with research is needed but students should have strong attention to detail, as well as reliable access to a computer and internet. Interest in animals is a bonus.

Identifying bias in urban ecology research

Jocelyn Behm
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CST
Biology

After decades of research, ecologists have amassed a trove of information on many of the plants and animals living in cities. But what have they missed? In this project, we are working to map urban ecology research across the United States and understand how the biases of urban ecologists may impact what we know about urban ecosystems. As a student working with our group, you will learn to use computational tools like geographic information systems (GIS) and statistical programming languages (R) to analyze spatial information and critically review the urban ecology literature.

Location: Main: Virtual or computational research
Student Majors Desired: Biology, Environmental Science
Class Preferences: Freshmen, Sophomores, Juniors, Seniors
Important Selection Criteria: Students are expected to exhibit attention to detail, work well with others and independently, and demonstrate good written and oral communication skills. Prior experience with GIS or R is helpful, but not required.

Identifying bias in Urban Ecology research

Jocelyn Behm
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CST
Biology

After decades of research, ecologists have amassed a trove of information on many of the plants and animals living in cities. But what have they missed? In this project, we are working to map urban ecology research across the United States and understand how the biases of urban ecologists may impact what we know about urban ecosystems. As a student working with our group, you will learn to use computational tools like geographic information systems (GIS) and statistical programming languages (R) to analyze spatial information and critically review the urban ecology literature.

Location: Main: Virtual or computational research
Student Majors Desired: Biology, Environmental Science
Class Preferences: Freshmen, Sophomores, Juniors, Seniors
Important Selection Criteria: We are seeking students with great attention to detail, work well independently, and also enjoy collaborating with others. Prior experience with R or GIS tools is helpful, but not necessary.

pygo2 regulation of WNT/ β-Catenin pathway in zebrafish

Gianfranco Bellipanni
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CST
Biology

β-catenin plays essential roles in cellular physiology being the pivotal player for Ca+-dependent cell-cell adhesion and for transduction of Wnt signaling. In the cytoplasm β-catenin interacts with α-catenin and type I cadherins mediating cell-cell adherence junctions adhesion, but, in response to Wnt signaling, it is also transduced into the nucleus where binds to DNA binding factors of the lef/tcf family and activates transcription of a battery of Wnt target genes. Aberrant activity of this factor has been linked with congenital birth defects and cancer. In our lab we are interested to study the molecular and cellular mechanisms leading to the induction and specification of D/V patterning in the zebrafish embryo via Wnt/ β-catenin activity.

One of the aspects of our research is to understand at molecular and biochemical level how β-cat ability to act as transcription factor is regulated by different splicing variants of the nuclear factor Pygo2.

The goal of this project is to search in-silico in RNA-seq databases if the sequences of different isoforms of pygo2 gene are identifiable. When and if we will identify these isoforms we may need to clone the cDNAs and –or make ad-hoc CRISPRs/Cas9 to target these isoforms.

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: Biology; Computer science
Class Preferences: Sophomores, Juniors
Important Selection Criteria: Cell structure and function BIOL3096.

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 Desired: 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
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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 Desired: 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.

Animal-Landscape Interaction

Ilya Buynevich
coast@temple.edu
CST
EES

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 Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: 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

Alexandra Davatzes
alix@temple.edu
CST
EES

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 Desired: 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

Vasily Dolgushev
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CST
Mathematics

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 to start, but could shift to in-person if the University approves
Student Majors Desired: 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!

News Mining

Eduard Dragut
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CST
CIS

The goal of this project is to create methods to automatically crawl user comments from news outlets and mine them. Project Details: https://cis.temple.edu/~edragut/Projects/MVSC/MVSC.html

Location: Main: Virtual or computational research
Student Majors Desired: N/A
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Programming skills (java and/or python)
; Data structures and algorithms
; Intro to probability and statistics

Virtual Job Assistants to Prepare Individuals with Neurodevelopmental Disabilities for Entry Level IT Jobs

Eduard Dragut
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CST
CIS

This project will integrate scientific knowledge from applied behavior analysis and best practices in job micro-tasking to guide the development of an AI-enabled software platform that implements effective strategies for job customization, job training, and on-job support.

Project Details:
https://www.nsf.gov/awardsearch/showAward?AWD_ID=2026513&HistoricalAwards=false

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: N/A
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Programming skills (java, python, and web); Data structures and algorithms

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Internet of Things (IoT) Security and Privacy

Xiaojiang Du
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CST
CIS

Internet of Things (IoT) is ubiquitous because of its broad applications and the advance in communication technologies. IoT devices interact with the environment directly and provide us with information for many aspects of our daily lives. IoT security and privacy become the most critical issue. In our research, we will study various security and privacy issues of IoT. Below is an example: Semantics-enabled Anomaly Detection in Smart Home Environments. With the large-scale deployment of the Internet of Things, smart home has become a reality to enable pervasive interactions among home electronic devices. However, anomalies (e.g., attacks, device failures or malfunction, human mistakes) occur in smart homes. Without timely detection, they may lead to severe consequences. Past researches mainly apply data mining to anomaly detection, but they suffer from a high false alarm rate in an appified home automation system. We thus propose semantics-aware data mining for anomaly detection to greatly mitigate the limitation and design a system that can comprehensively cover varieties of anomalies to help the user keep an eye on their home IoT systems.

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: N/A
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Good computer programming skills.

Developing Animations for Learning Chemistry

Steve Fleming
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CST
Chemistry

The teaching tool Bio-Organic Reaction Animations (BioORA) has been developed to assist student learning. BioORA is available online and it covers topics that include enzyme chemistry, lipids, nucleic acids, and carbohydrates. The animations that are included in the program are based on 3D data from crystal structures found in the Protein Data Bank (PDB). This research project involves developing a conversion from PDB files or Maya files to 3D visualization using Unity3D and Oculus Rift Virtual Reality hardware. The ultimate goal would be to generate a new VR-based teaching tool for bio-organic chemistry. VR work would be in collaboration with Gillian Queisser.

Location: Main: Virtual or computational research
Student Majors Desired: Chemistry, Biochemistry, CIS
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Organic chemistry and coding skills would both be helpful.

Smithsonian Forest Global Earth Observatory

Amy Freestone
amy.freestone@temple.edu
CST
Biology

The Temple Ambler Field Station is collaborating with the Smithsonian Forest Global Earth Observatory (ForestGEO; https://www.forestgeo.si.edu/) to establish a forest research site at the Field Station, located on the Ambler Campus. Student researchers are needed to assist with field work associated with the establishment of this research site. These positions are open to all CST students who have an interest in gaining experience with forest science, ecology, and georeferenced surveying. This project will continue into the summer, and while we will consider all applicants, we encourage applicants who are interested in joining the team for both spring and summer. Students need to be willing to travel to the Ambler Campus (personal vehicle, inter-campus bus, or SEPTA) to complete this field research.

Location: Main
Student Majors Desired: 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.

Spotted Lanternfly Invasion Meltdown

Matthew Helmus
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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: Virtual or computational research
Student Majors Desired: 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: Virtual or computational research
Student Majors Desired: 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.

Evolution and the Human Genome

Jody Hey
tuf29449@temple.edu
CST
Biology

Student's will work on questions about human evolutionary history using data from the human genome, as well as data from great ape and archaic humans (e.g. Neanderthal).

Location: Main: Virtual or computational research
Student Majors Desired: All majors
Class Preferences: Freshmen, Sophomores and Juniors
Important Selection Criteria: Some knowledge of genetics and of evolution. Some coding experience.

Evolutionary Genomics

Jody Hey
tuf29449@temple.edu
CST
Biology

Students will work with the genomes of multiple species to address questions about natural selection and adaptation.

Location: Main: Virtual or computational research
Student Majors Desired: All majors
Class Preferences: Freshmen, Sophomores and Juniors
Important Selection Criteria: Some knowledge of genetics and of evolution. Some coding experience.

Population Genetics

Jody Hey
tuf29449@temple.edu
CST
Biology

Students will help develop mathematical and statistical models of evolutionary processes and apply them to population genomic data sets.

Location: Main: Virtual or computational research
Student Majors Desired: All majors
Class Preferences: Freshmen, Sophomores and Juniors
Important Selection Criteria: Some knowledge of genetics and of evolution. Some coding experience.

Data freshness optimization

Bo Ji
boji@temple.edu
CST
CIS

Students will investigate the problem of optimizing data freshness/timeliness in information-updating systems and design efficient algorithms for the problem.

Location: Main: Virtual or computational research
Student Majors Desired: CS or Math
Class Preferences: Juniors, Seniors
Important Selection Criteria: Basic programming experience in Python or Java or C++.

Systems genomics of sex-biased networks

Rob Kulathinal
robkulathinal@temple.edu
CST
Biology

Among the most conspicuous differences within a species is the dichotomy of sex between males and females. Underlying this often spectacular dichotomy in phenotype are differences in gene expression: genes that are sex-limited in their expression represent a significant fraction of the adult transcriptome. With the recent availability of a large standardized transcriptome set across multiple species, between sexes, and across tissues (e.g., Yang et al. 2018), we now can compare the differences between transcript levels between males and females both genome-wide and phylogeny-wide. Using this unique and powerful dataset, we will be able to identify: i) the genes and gene classes that exhibit the most rapid change in sex-bias along external branches, ii) functional subnetworks that are co-evolving in expression levels within specific species lineages, and iii) potential targets of local selection that will provide us with candidates for sequence divergence analysis.

Location: Main: Virtual or computational research
Student Majors Desired: Biology, Math, CIS, Physics, Chem
Class Preferences: Freshmen, Sophomores
Important Selection Criteria: The Kulathinal lab is looking for hard-working, dedicated students to work on fun and exciting projects that intersect evolution, genetics, and genomics. We expect our students to either possess basic computational skills (e.g., python, R) or quickly acquire them before/after joining the lab.

Population genomics of domesticated dogs and the evolution of disease

Rob Kulathinal
robkulathinal@temple.edu
CST
Biology

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: Virtual or computational research
Student Majors Desired: Biology, Math, CIS, Chemistry, Physics
Class Preferences: Freshmen, Sophomores
Important Selection Criteria: The Kulathinal lab is looking for hard-working, dedicated students to work on fun and exciting projects that intersect evolution, genetics, and genomics. We expect our students to either possess basic computational skills (e.g., python, R) or quickly acquire them before/after joining the lab.

Evolution of compensatory mutations in proteins

Rob Kulathinal
robkulathinal@temple.edu
CST
Biology

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 compensation.

Location: Main: Virtual or computational research
Student Majors Desired: Biology, Chemistry, Math, CIS, Physics
Class Preferences: Freshmen, Sophomores
Important Selection Criteria: The Kulathinal lab is looking for hard-working, dedicated students to work on fun and exciting projects that intersect evolution, genetics, and genomics. We expect our students to either possess basic computational skills (e.g., python, R) or quickly acquire them before/after joining the lab.

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: Virtual or computational research
Student Majors Desired: 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: Virtual or computational research
Student Majors Desired: All Majors
Class Preferences: Freshmen, Sophomores, Junior
Important Selection Criteria: Knowledge of computer programming and/or app development.

Deep Neural Networks and Their Applications in Computer Vision

Longin Jan Latecki
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CST
CIS

One of the most innovative and transformative technologies of our time is deep learning, a form of machine learning that uses neural networks containing many hidden layers, which are called deep neural networks (DNNs). Recent success has led to breakthroughs in applications in particular in computer vision. In this project, we will focus in applying DNNs to various computer vision tasks.

Location: Main: Virtual or computational research
Student Majors Desired: Computer Science, Math, Chem, Bio
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Linear Algebra; Programming skills in Python; Knowledge of PyTorch and Matlab are a big plus.

Comparative Genomics to Characterize Lineage-Specific Biology

David Liberles
tuf77157@temple.edu
CST
Biology

Computational pipelines to analyze genomic data from different species towards an understanding of the changes in gene content that correspond to changes in organismal phenotype will be generated and run. Species groups we are currently analyzing include spiders, fish, and plants.

Location: Main: Virtual or computational research
Student Majors Desired: Biology, Chemistry, Physics, Mathematics, Computer Science
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Students with experience in programming, strength in mathematics, and an understanding of and interest in phylogenetics and evolutionary biology are desired.

Quantum control of molecules using dressed states created by laser

A. Marjatta Lyyra
Lyyra@temple.edu
CST
Physics

High resolution molecular spectroscopy based quantum optics research. Students can participate in data collection, analysis and design of experiments including calculation of lifetimes, molecular constants after they have calibrated the data etc. Our research is both experimental and computational in support of experiments as well as analysis of data after results become available.

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: Physics, Chemistry
Class Preferences: Juniors, Seniors
Important Selection Criteria: Students need to have taken the Optics course, Physics 4302 first. In addition they should take the Atomic, Molecular and Optical Physics course when offered. The course has been taught as Physics 4000 for a couple of years and is now pending approval as an elective cross listed course (4000 level/5000 level) for undergraduates as well as beginning graduate students.

Novel nucleases in nucleic acid metabolism and genetic engineering

Carol Manhart
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CST
Chemistry

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: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: Biochemistry
Class Preferences: Freshmen, Sophomores, Juniors, Seniors
Important Selection Criteria: N/A

Current theories on the mechanisms of Insulin Resistance in Diabetes Type II.

Karen Palter
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CST
Biology

Treatments for Diabetes Type II do not address the major issue which is resistance to insulin that is produced by the body. Our laboratory studies a fly model for Diabetes in which due to a deletion in the sialic acid pathway which affected a voltage gated potassium channel, the flies become hyperinsulinemic which leads to insulin resistance. We believe this is similar to the root cause of insulin resistance in humans. How hyperinsulinemia leads to insulin resistance is not known. Our laboratory was using three genetic strains of flies, wild type, the mutant flies, and a rescued fly line that had the sialic acid synthase gene expressed only in the insulin producing cells (IPCs) to monitor the changes in the insulin signaling pathway from eclosion to three weeks during which time the flies became diabetic. Since we will not be in the laboratory Rini will read the literature to find the theories that have been put forth about the mechanism of insulin resistance.

Goals: To evaluate which theories of insulin resistance are testable or seem plausible.

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: Biochem, Bio or Neuroscience
Class Preferences: Freshmen
Important Selection Criteria: Having a GPA higher than 3.2, interest in the subject.

Research Opportunities in Quantum Chemistry #1

George Petersson
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CST
ICMS

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. 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.

Location: Main: Virtual or computational research
Student Majors Desired: Chem. Physics, Computer Science
Class Preferences: Freshmen, Sophomores, Juniors
Important Selection Criteria: Background in Chemistry and Spectroscopy is far less important than an aptitude for writing computer code.

Research Opportunities in Quantum Chemistry #2: Making high accuracy affordable through DFT

George Petersson
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CST
ICMS

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), zero-point-energy (±0.063 kcal/mol rms error), scalar relativistic corrections (±0.18 kcal/mol rms error), and spin-orbit coupling (±0.21 kcal/mol rms error). These errors all 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.

Location: Main: Virtual or computational research
Student Majors Desired: N/A
Class Preferences: N/A
Important Selection Criteria: A course in quantum mechanics is vital.

Virtual Reality-based Computation of Signaling in Neurons

Gillian Queisser
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CST
Math

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 to start, but could shift to in-person if the University approves
Student Majors Desired: N/A
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Familiarity with programing languages (e.g. C#, C++, Java, ...) and/or Unity3D is a clear asset.

Bat susceptibility to white-nose syndrome

Brent Sewall
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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: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: 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

Stateless Mission Critical Computing

Justin Shi
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CST
CIS

The fundamental flaw in the mainstream program-to-program communication paradigms is the unrealistic reliability assumption in physical devices, such as processors, storage and networks. The resulting systems are vulnerable to arbitrary device failures. Thus the systems suffer scaling difficulties. Although the checkpoint/restart and backup/restore algorithms can postpone the inevitable, they cannot eliminate the arbitrary data and service losses. The stateless computing is a paradigm shift from legacy systems by eliminating the unrealistic assumptions. Thus program, data and all physical devices are completely decoupled in software and statistic multiplexed in hardware.

Location: Main: Virtual or computational research
Student Majors Desired: CIS, Math, Physics
Class Preferences: Juniors, Seniors
Important Selection Criteria: U.S. citizenship or U.S. permanent residency required.

The Suppression of Bitter Taste

Greg Smutzer
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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 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
Student Majors Desired: Biology, Neuroscience, Biochemistry, Chemistry
Class Preferences: N/A
Important Selection Criteria: Willingness to be engaged in research, and ability to think critically.

Scene Analysis for Large Image Collections

Richard Souvenir
souvenir@temple.edu
CST
CIS

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 Desired: CS
Class Preferences: Sophomores, Juniors
Important Selection Criteria: Strong programming skills (preferably Python), interest or experience in image processing, data science, or machine learning.

The negative impacts of self-fertilization in a native plant

Rachel Spigler
tuf10949@temple.edu
CST
Biology

Many plant species are hermpahrodites and therefore capable of self-pollination. But this is the most extreme form of inbreeding and can results in reduced survival and growth of selfed offspring. The student will assist in a series of experiments investigating inbreeding depression in a native wildflower. While we are virtual, the student will measure plants using digital imaging tools. Upon return, the student will assist in setting up new plant experiments and monitoring survival and growth of selfed and outcrossed plants.

Location: Main: Virtual to start, but could shift to in-person if the University approves
Student Majors Desired: N/A
Class Preferences: Freshmen, Sophomores, Juniors, Seniors
Important Selection Criteria: Attention to detail. Comfortable learning new software. Organized. Responsive.

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Student Majors Desired: N/A
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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 Desired: N/A
Class Preferences: Sophomores, Juniors
Important Selection Criteria: Biochemistry, Organic, analytical skills all are important. Evidence of discipline and enthusiasm are important.

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 Desired: chem/biochem
Class Preferences: Sophomores, Juniors
Important Selection Criteria: intelligence enthusiasm conscientiousness - will teach skills necessary

Virtual Job Assistant to Prepare Individuals with Neurodevelopmental Disabilities for Entry Level IT Jobs

Slobodan Vucetic
vucetic@temple.edu
CST
CIS

This is an NSF-funded project https://www.nsf.gov/awardsearch/showAward?AWD_ID=2026513. The goal of this interdisciplinary project is to develop an AI-supported software platform to improve participation of neurodiverse young adults in a future workforce.

Location: Main: Virtual to start then transition to in-person if University permits
Student Majors Desired: CS, Data Science, IST
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Programming experience, willingness to learn about AI-supported technology and to work in a multidisciplinary team.

A Knowledge Driven Policy System for the Internet

Anduo Wang
adw@temple.edu
CST
CIS

Internet routing has evolved greatly from its original incarnation --- computing paths on a graph --- as policy considerations became a fundamental part of the routing infrastructure, underlying the routing requests and constraints of almost all stakeholders (domains, or autonomous systems, and end sites). Yet, policy was incorporated into the routing infrastructure rather late. Border Gateway Protocol (BGP) introduced policy by incremental patches and was intended only as a temporary solution with severe limitations. Many more alternative schemes were proposed to address various BGP deficiencies, often as a policy component carefully wired into some clean slate routing protocol driven by a specific need of a particular party, none was widely deployed, with BGP remaining today's one single de facto inter-domain routing protocol. And it is still not clear what policy considerations we should support at the expense of whom, how to balance different policies, how to constrain the impact of policies, and more. Indeed, in the distributed global Internet absent a central authority, rich policy management remains a black art.

The goal of this proposal is to bring to the Internet policy infrastructure the ability to define, model, and analyze it, precisely. Our work will place policy routing for Internet on a strong intellectual foundation, solving pressing problems and smoothly adapting to future needs. To accomplish this, we develop a knowledge management system for policies: Rather than carefully stitching together policy considerations and routing into a single solution that works best for all requests, we propose to split the policy routing infrastructure into the connectivity maintenance system and a separate policy system, two sub-systems that are easier to manage and are independent to evolve, each with superior properties which in turn produces more powerful policy routing.

Location: Main: Virtual or computational research
Student Majors Desired: N/A
Class Preferences: Sophomores, Juniors, Seniors
Important Selection Criteria: Passion with real world problem with rigorous methods. Willing to dive deep in theory and work with practical computer system. Knowledge of computer networking, relational database is a plus. Strong skills in mathematics is highly helpful.

Artificial General Intelligence

Pei Wang
pei.wang@temple.edu
CST
CIS

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 Desired: 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.

Machine learning for solid-state materials

Qimin Yan
qiminyan@temple.edu
CST
Physics

The student will be involved in the development of novel machine learning frameworks that incorporate physical principles (such as symmetries) and beyond-atom material information (such as atomic orbitals) to achieve supreme performance. The machine learning models will be tested for solid-state inorganic crystals to make reliable and efficient predictions of material properties for materials discovery and design.

Location: Main: Virtual or computational research
Student Majors Desired: CS, Physics, Chemistry
Class Preferences: Juniors, Seniors
Important Selection Criteria: Experience in Python and knowledge in machine learning.

Defects for quantum computing

Qimin Yan
qiminyan@temple.edu
CST
Physics

The student will be involved in the development of theoretical approaches to achieve a deeper understanding of the collective behavior of defects in two-dimensional materials as qubits for quantum computing.

Location: Main: Virtual or computational research
Student Majors Desired: Physics, Chemistry
Class Preferences: Juniors, Seniors
Important Selection Criteria: Python, solid-state physics, or inorganic chemistry.