SMC Summer Research Program, 2021

Faculty Research Projects

Descriptions of the research projects are hyperlinked in the document below

Biology

James Berleman
Keywords: Socio-microbiology and genetics

Kai Blaisdell
Title: Virus Interactions during vector-borne transmission and host establishment
Keywords: Plant Community Ecology, Plant Pathology, Invasion Biology

Vidya Chandrasekaran
Titles: 1) Signaling pathways and proteins involved in dendritic growth regulation,
2) Toxicological assessment in zebrafish
Keywords: Developmental Neurobiology, cell biology, toxicology

Michael Marchetti
Title: California Newt trophic ecology
Keywords: Salamander food webs

Chemistry

Joel Burley
Keywords: air pollution, atmospheric science, ozone, PM2.5

Zuli Kurji
Titles: 1) Synthesis and Analysis of Light-Responsive Materials,
2) Investigating the Mechanism of Light Responsiveness
3) New one-pot synthesis for Liquid Crystal Elastomers
Keywords: Chemistry, Polymers, Materials, Material Property Testing, Organic Synthesis, Characterization, Microscopy

Mark Lingwood
Titles: 1) NMR and Electrochemistry of Surfactants
2) Immobilized Radicals for Enhanced Magnetic Resonance
Keywords: Nuclear Magnetic Resonance, Surfactants, Immobilization Chemistry

Karen Ruff
Title: Analyzing how bacteria use riboswitches to respond to changing nutrient levels
Keywords: Biochemistry, RNA, bacterial gene control

Jeff Sigman
Title: Structure-function analysis of mammalian peptidases by isothermal titration calorimetry and fluorescence
Keywords: Biochemistry, protein chemistry, thermodynamics, enzyme kinetics

Elizabeth Valentin

Titles: 1) Microwave-assisted hydrogenation with frustrated Lewis Pairs
2) Greener methods for alkene bromination

Keywords: Green Chemistry, organic chemistry, synthesis

Environmental and Earth Science

Alice Baldridge

Title: Spectral Analysis of Altered Volcanic Materials

Keywords: Geology, Planetary Science, Environmental Science

Nekesha Williams

Titles: 1) Carbon Sequestration in natural systems;
2) Application of spatial methods in environmental management;
3) Evaluating Ecosystem Goods and Services of natural ecosystems.

Keywords: Hydrology, Marine Science, GIS, Sustainability, Environmental Science

Mathematics

Michael Nathanson

Title: Vector Representations of Graphs with connections to Quantum Information

Keywords: Linear algebra, graph theory, probability

Ellen Veomett

Title: A new metric to detect gerrymandering

Keywords: Using math to detect gerrymandering. Coding, metrics, data, maps, Markov Chains

Physics and Astronomy

Aaron Lee

Title: Analyzing the birth of stars and planets

Keywords: Computational Physics, Astrophysics

Psychology

Mark Barajas

Titles: COVID's effects on mental health

Keywords: Mental health, race & culture

In addition, the following professors may be available to mentor students who propose their own research projects.

Emily Hause

Social Psychology, Organizational Psychology

Makenzie O'Neil

Emotions, Stereotyping & Prejudice, Intergroup Relations, Personality, Social Psychology

Hoang Vu

Cognitive psychology; language processing; cognitive neuroscience; experimental psychology

Project Descriptions

Biology Department

Faculty Mentor	James Berleman
Department	Biology
Title	
Keywords	Socio-microbiology and genetics
Description	
Day-to-Day Activities	Lab-based research

Faculty Mentor	Kai Blaisdell
Department	Biology
Title	Virus Interactions during vector-borne transmission and host establishment
Keywords	Plant Community Ecology, Plant Pathology, Invasion Biology
Description	My research focuses on the ecology of the economically damaging Grapevine leafroll-associated viruses (GLRaVs) and their mealybug vectors, some of which are recently introduced and invasive in California. I also explore the potential role of multiple insect species as vectors of GLRaVs and other viruses of grapes.
Day-to-Day Activities	A student will analyze medium-sized data sets of related field and lab-based virus transmission studies. There may be some field data collection and lab sample processing.
Prerequisites	Desirable: Biology, Ecology, Chemistry, some Statistics

Faculty Mentor	Vidya Chandrasekaran
Department	Biology
Title	1) Signaling pathways and proteins involved in dendritic growth regulation, 2) Toxicological assessment in zebrafish
Keywords	Developmental Neurobiology, cell biology, toxicology
Description	1) This research project is focused on understanding the mechanisms underlying dendritic growth in cell cultures of sympathetic neurons. 2) This research project involves the use of zebrafish embryos to study the effects of food additives, cosmetics additives and environmental pollutants on embryonic and neuronal development in zebrafish embryos.
Day-to-Day Activities	The research will involve culturing cells and cell culture maintenance or monitoring embryonic development on a daily basis. Once cells/embryos are ready for assessment, they will be either immunostained, or lysed for molecular and biochemical analyses. Then, cells will be analyzed using microscopy or imaging.
Prerequisites	Bio 1

Faculty Mentor	Michael Marchetti
Department	Biology
Title	California Newt trophic ecology

Keywords	Salamander food webs
Description	We are studying the feeding ecology of the California newt (*Taricha torosa*)
Day-to-Day Activities	Lots of lab time and some limited field work. Mostly in a lab setting preparing samples for stable isotope analysis and identifying aquatic insects.
Prerequisites	Bio 125 Ecology

Chemistry Department

Faculty Mentor	Joel Burley
Department	Chemistry
Title	
Keywords	air pollution, atmospheric science, ozone, PM2.5
Description	Anything that involves air quality data, either collected by us, or available from online sources. See 3rd floor BROH posters for many examples.
Day-to-Day Activities	Most days involve computer-based research, analyzing air quality data from databases. Depending on Covid restrictions, there might also be fieldwork occasionally.
Prerequisites	Chem 8/9/10/11

Faculty Mentor	Zuli Kurji
Department	Chemistry
Title	1) Synthesis and Analysis of Light-Responsive Materials, 2) Investigating the Mechanism of Light Responsiveness 3) Organic Synthesis - coming up with a new one-pot chemistry for Liquid Crystal Elastomers
Keywords	Chemistry, Polymers, Materials, Material Property Testing, Organic Synthesis, Characterization, Microscopy
Description	We make materials that bend in response to light by chemically attaching a light responsive small molecule to a known material in the literature. The project our lab will be working on this summer will include: (1) varying the concentration of the small molecule and measuring the light-response of the resulting materials (measuring the bend angle via image analysis, measuring force of the bend etc.); (2) coming up with experiments to isolate whether the bending we see is due to the light of the laser or the heat that also comes with the laser spot, (3) investigating catalysts to catalyze the polymerization reaction to make these materials using more safe, readily-available starting materials.
Day-to-Day Activities	Material Synthesis: measuring starting materials, mix, heat, transfer to molds, evaporate solvent, de-mold samples. Measuring Light-Responsiveness: shine a laser pointer on the sample and get video images of the bending angle, use image analysis software to analyze bend angle. Catalysis Experiments: mixing model starting materials and potential catalysts together under a variety of conditions.
Prerequisites	General Chemistry (Chem 008/010 + Lab)

Faculty Mentor	Mark Lingwood
Department	Chemistry
Title	1) NMR and Electrochemistry of Surfactants 2) Immobilized Radicals for Enhanced Magnetic Resonance
Keywords	Nuclear Magnetic Resonance, Surfactants, Immobilization Chemistry
Description	1) NMR and Electrochemistry of Surfactants: We are trying to compare two methods for determining the size of surfactant micelles: NMR diffusion and cyclic voltammetry (electrochemistry). We are working with 'probe' molecules that incorporate into the micelle, and these are actually what we measure - the diffusion of the probe molecule reflects the diffusion of the micelle, which can then be related to micelle size. This project is suitable for a Chem, Biochem, or Biology major. 2) Immobilized Radicals for Enhanced Magnetic Resonance: We have been working to develop an oddball method for enhancing the signal available in Magnetic Resonance Imaging (MRI), based on something called Dynamic Nuclear Polarization (DNP). The key component for this technique is a stable radical, which needs to be immobilized onto the surface of a solid support. We then test the DNP performance using a homebuilt NMR spectrometer, and finally apply the technique to flow-MRI. This project is suitable for a Chem/Biochem or a Physics major.
Day-to-Day Activities	1) Surfactants: Potentially synthesize probe molecule using organic synthesis techniques. Prepare sample solutions. Conduct many NMR and cyclic voltammetry measurements. Process data to extract diffusion coefficients. 2) Immobilized Radicals: Use simple synthesis techniques to attach radicals to solid supports. Test DNP performance and other NMR parameters using a (potentially tricky) homebuilt DNP-NMR spectrometer. Troubleshoot the homebuilt spectrometer when it gives us problems. Try the flow-DNP MRI experiments with a collaborator's low-field MRI system. I had to be brief here, but I encourage potentially interested students to contact me!
Prerequisites	Surfactants: Chem 104/L Immobilized Radicals: either Chem 104/L or Physics 181

Faculty Mentor	Karen Ruff
Department	Chemistry (Biochemistry)
Title	Analyzing how bacteria use riboswitches to respond to changing nutrient levels
Keywords	Biochemistry, RNA, bacterial gene control
Description	Bacteria can react to changes in nutrients, environmental conditions, and even the presence of other bacteria. One system by which they can respond involves structured RNA molecules called riboswitches. These RNA

	sequences 'switch' genes on and off in response to changes in the bacterial environment. Because these systems are only found in bacteria, they are potential novel antibacterial targets. In addition, they are fascinating molecules, because they're relatively 'simple' repeating polymers of RNA, but they fold to have complex structures and functions. Researchers working in my laboratory will gain valuable experience in biochemistry, molecular biology, and biophysics.
Day-to-Day Activities	Most days involve lab work. Researchers will culture bacteria and study how they respond to different nutrients. Depending on the project, students might also gain experience with cloning/gene mutation or HPLC analysis.
Prerequisites	Bio1 and Chem104

Faculty Mentor	Jeff Sigman
Department	Chemistry (Biochemistry)
Title	Structure-function analysis of mammalian peptidases by isothermal titration calorimetry and fluorescence
Keywords	Biochemistry, protein chemistry, thermodynamics, enzyme kinetics
Description	1) The student will continue in the design, expression, and purification of a series of mutants of the enzyme neurolsyin with the aim of developing a model system to study the role of conformational changes in catalysis and substrate selectivity. The student will chemically modify the expressed neurloysin mutants with a fluorescent tag and evaluate the sensitivity of the tag to conformational changes using fluorscence spectroscopy. The steady state and pre-steady state kinetics of the successfully modified enzymes will be further analyzed using fluorescence spectroscopy. 2) Design and evaluation of conditions to stabilize neurolysin for study by isothermal titration calorimetry. Isothermal titration calorimetry (ITC) used to determine the affinity between two molecules interacting in aqueous solution. The primary application of ITC is for the determination of protein-ligand interactions - for instance in drug design. Past efforts to perform ITC analysis of the mammalian peptidases, neurolysin and thimet oligopeptidase, have proved difficult due to denaturation of the proteins over the time course of the experiments. The goal of this project is to evaluate conditions under which the proteins can be stabilized for ITC analysis. Both proteins are known to be associated with cell membrane so the project will investigate options for stabilization of the proteins using ionic surfactants and/or generic engineering of the protein surface.
Day-to-Day Activities	Lab-based research. Students will learn: PCR, protein expression and purification, gel electrophoresis, enzyme kinetics, fluorescence spectroscopy, isothermal titration calorimetry.
Prerequisites	Biochem-101

Faculty Mentor	Elizabeth Valentin
Department	Chemistry
Title	1) Microwave-assisted hydrogenation with frustrated Lewis Pairs 2) Greener methods for alkene bromination

Keywords	Green Chemistry, organic chemistry, synthesis
Description	1) Frustrated Lewis Pairs are a combination of acid and base that cannot form a traditional bond. The frustration energy is so high that it can break the molecular hydrogen bond and deliver a hydride and proton to an unsaturated compound. This project uses microwave irradiation to accelerate FLP hydrogenations into a timeframe suitable for undergraduate research. 2) A second project would be the development of an undergraduate laboratory experience where the student would use sodium perborate and sodium bromide to perform a bromination reaction on an alkene. This reaction would be compared against other bromination reaction conditions in terms of yield, reactivity, and compliance to green chemistry principles.
Day-to-Day Activities	A student would read some background literature on their project. They would prepare a laboratory notebook to perform 1-2 reactions, depending on the time constraints. They would monitor their reaction(s) to assess completion, then isolate and characterize their product(s) by spectroscopic methods. Finally, the student would meet with me at least once a week to evaluate the progress of the project and plan a proper course of action. The student would submit a report at the end of the research experience.
Prerequisites	CHEM104/106

Environmental and Earth Science

Faculty Mentor	Alice Baldridge
Department	Environmental and Earth Science
Title	Spectral Analysis of Altered Volcanic Materials
Keywords	Geology, Planetary Science, Environmental Science
Description	If we are able to complete our field work in spring, I will have altered volcanic samples that need to be analyzed for mineralogy. Potential students would use a portable spectrometer to measure Visible and Near Infrared spectra of the samples and then compare measurements to a library of mineral spectra using the spectral analysis program ENVI.
Day-to-Day Activities	Students would prepare and measure samples in the lab. Once samples were measured, students would learn to use the software and compare lab measured data to that collected in the field and to a library of mineral spectra.
Prerequisites	EES 40 or Physics 90

Faculty Mentor	Nekesha Williams
Department	Environmental and Earth Science
Title	1) Carbon Sequestration in natural systems; 2) Application of spatial methods in environmental management; 3) Evaluating Ecosystem Goods and Services of natural ecosystems.
Keywords	Hydrology, Marine Science, GIS, Sustainability, Environmental Science
Description	Research projects can be interdisciplinary in nature with emphasis on developing a desired skill set or deepening ones knowledge in a particular

	area of study. These projects can include (1)Determination of carbon sequestration potential of natural systems using field methods, geospatial tools and geochemical analysis; (2) Application of geospatial technology to address complex environmental issues at the land-sea interface or in the urban context; (3) Cataloguing and quantifying ecosystem goods and services in natural areas in San Francisco and (4) Characterizing sediments in wetlands and/or other aquatic systems.
Day-to-Day Activities	In the first week, students and I will work towards planning fieldwork and analysis. Students will be assigned peer-review journals to read/critique in an attempt to develop their foundational knowledge. Based on the project, students should expect to conduct some field work, followed by desktop and/or laboratory analyses.
Prerequisites	One or more lower or upper division EES course.

Mathematics

Faculty Mentor	Michael Nathanson
Department	Mathematics
Title	Vector Representations of Graphs with connections to Quantum Information
Keywords	Linear algebra, graph theory, probability
Description	This project is at the intersection of graph theory and linear algebra. A graph is a collection of points (vertices) and edges that connect some pairs of vertices. One view of graphs is as encoding a communication setting: each vertex represents a possible message that might be sent, and two vertices are connected by an edge if the corresponding messages might be confused for each other. We study vector representations of graphs, where each vertex of a graph is labeled with a vector, such that two vertices are connected by an edge whenever the corresponding vectors are not orthogonal. My project is interpreting such representations when the vectors represent states of quantum physical systems. There are several open questions in this area that students can work on depending on their interest.
Day-to-Day Activities	Students will begin the summer by studying the relevant materials. The bulk of the summer will be spent developing good questions to ask; trying to answer those questions; and then using the answers to ask new questions. Students will work together to figure out how best to approach a problem; and then meet with me regularly to explain and get feedback on their ideas. I will be a collaborative member of the team, but students will be determine the direction of the work.
Prerequisites	Math 120 or Math 103

Faculty Mentor	Ellen Veomett
Department	Mathematics and Computer Science
Title	A new metric to detect gerrymandering
Keywords	Using math to detect gerrymandering. Coding, metrics, data, maps, Markov Chains

Description	Gerrymandering is the drawing of district lines to unfairly disadvantage a group of voters. It is understood to have occurred when a map drawer packs her opponents into a small number of districts, which are won with an overwhelming majority, and then cracks the remaining opponents among many districts in which they cannot obtain a majority. Many states have recently been accused of partisan gerrymandering, resulting in an explosion of techniques to use mathematics to detect gerrymandering. Early metrics to detect gerrymandering have focused on the shape of a suspect district. But modern technology has allowed nefarious mapmakers to create tens of thousands of districting maps satisfying any given shape requirements, and then select the most partisan among those maps. Thus, the desire for a metric to detect gerrymandering which does not rely on geometry has arisen. A few such metrics have been created, but they all rely on only election outcomes, and do not use the districting maps at all. Thus, they are unable to show whether packing or cracking actually occurred. Two collaborators and I designed two different metrics which use both the districting map and election data to determine whether a map gerrymandered. We have very drafty python code to calculate the value of one of these metrics on either real data or created test data. We would like to create python code for the second metric and test each of these metrics on real data and created test data. We'd also like to mathematically analyze exactly how the metrics function.
Day-to-Day Activities	You would spend some hours writing code, some hours finding and cleaning data, some hours trying to prove how the metrics function. An hour talking with your student collaborator, and maybe 2-3 times a week an hour talking with me about how things are going and next steps.
Prerequisites	CS 21, Math 103

Physics and Astronomy

Faculty Mentor	Aaron Lee
Department	Physics and Astronomy
Title	Analyzing the birth of stars and planets
Keywords	computational physics, astrophysics
Description	Stars and planets in the universe form when light-year-sized clouds of gas collapse from their own self-gravity. The densest parts of these clouds form a few stellar objects. Possible projects will have students use computational physics to analyze recently-completed simulations of star-forming clouds. Through computational analysis and data visualization, students will analyze terabytes of data to better quantify the natal conditions of these stars. Other projects can have students run radiative transfer calculations on these datasets, creating synthetic observations that give us an impression of how this simulation data would have looked through a telescope, allowing for direct comparisons with published data. Additional possible projects can

	have students run N-body simulations of the resulting planetary systems that develop in the accretion disks around these stars, with the aim of better understanding and being able to statistically quantify the avenues for how observed planetary systems came to develop.
Day-to-Day Activities	Research is done entirely on a computer. You will do a lot of coding/debugging. Some programs will be professional packages you must familiarize yourself with; some programs you will write from scratch. Collaboration occurs through day-to-day interactions over Slack, one-on-one weekly meetings, and weekly group meetings.
Prerequisites	Physics 1,2,3,4 + Physics 102 or have computer programming experience (ideally Python or MATLAB)

Psychology Department

Faculty Mentor	Mark Barajas
Department	Psychology
Title	COVID's effects on mental health
Keywords	mental health, race & culture
Description	This is a longitudinal qualitative study exploring mental health among three among specific populations -- Latinx individuals, students and faculty, and grocery store workers -- during the ongoing COVID-19 pandemic. Three semi-structured are conducted with interested participants exploring their overall mental health, coping strategies, social connections, and challenges and successes in responding to the pandemic. Interviews are recorded and transcribed, and then analyzed following a Grounded Theory research protocol. Data collection, transcription, and analysis is ongoing. As of January 2021, over 100 interviews have been conducted and over 50 have been transcribed.
Day-to-Day Activities	Depending on the exact timing of the project, students will have opportunities to recruit and interview participants, transcribe interviews, design interview questions, analyze qualitative data, and interpret themes related to mental health during the pandemic. Students are also expected to complete research ethics training and contribute to the IRB application.
Prerequisites	Psych 1, 3, 103 (desired), Spanish language ability (desired)

In addition, the following professors may be available to mentor students who propose their own research projects.

Faculty Mentor	Emily Hause
Department	Psychology
Title	
Keywords	Social Psychology, Organizational Psychology
Description	
Day-to-Day Activities	

Prerequisites	Psych 1, 3, 103

Faculty Mentor	Makenzie O'Neil
Department	Psychology
Title	
Keywords	Emotions, Stereotyping & Prejudice, Intergroup Relations, Personality, Social Psychology,
Description	
Day-to-Day Activities	
Prerequisites	Psych 103

Faculty Mentor	Hoang Vu
Department	Psychology
Title	
Keywords	cognitive psychology; language processing; cognitive neuroscience; experimental psychology
Description	
Day-to-Day Activities	
Prerequisites	Psych 1, 3, 103