Keck Graduate Institute

Summer Undergraduate Research Experiences (SURE) Program

June 15 – July 24, 2026

Independent Research Projects

We are offering research opportunities in

A: Biology (wet lab research)

B: Computational Biology (mainly data analytics, but some projects also have a wet lab component)

C: Engineering (medical devices and bioprocessing)

D: Business / Social Sciences

For your application, please select the top three projects you are interested in, and in your essay discuss why you are interested in these projects, and what skills (lab, computational, etc.) you possess that would make you a good candidate.

A: Biology:

Project Number: A1

Project Title: Designing Therapies for Neurological Disorders

Advisor: Barbara Bailus

Description:

The Bailus Lab focuses on neurological disorders, with a specific emphasis on gene therapy and delivery mechanisms. We build custom proteins in the lab that have the ability to cross the blood brain barrier and have a therapeutic effect. Some of the diseases and disorders studied in the lab include Angelman syndrome, SETBP1 Haploinsufficiency Disorder, Huntington's disease and Alzheimer's disease. Students in the lab will have the opportunity to learn a variety of techniques that may include human and mouse cell culture, cloning, western blots, protein purification, immunostaining. The lab is open to potentially having students continue past the summer as part of their senior thesis.

Project Number: A2

Project Title: Alzheimer's Disease drug discover

Advisor: Derick Han and Gerome Garcia

Description:

Alzheimer's disease (AD) is the sixth leading cause of death in the United States, with approximately 5.8 million Americans currently living with the condition. Numerous studies have demonstrated a positive association between liver injury—resulting from factors such as heavy alcohol consumption and obesity—and the development and progression of AD. Our laboratory focuses on understanding how alterations in the liver–brain axis influence brain function and contribute to AD pathology. The goal of our SURE project is to explore and test potential therapeutic compounds in liver cell culture models (HepG2 cells) that may modulate proteins involved in the regulation of amyloid-beta relevant to AD. Students will conduct literature reviews on potential drug candidates and evaluate their effects in HepG2 cells.

Project Number: A3

Project Title: Drug discovery and signaling in Alzheimer's Disease, Epilepsy focused on Excitation Inhibition Balance in the brain

Advisor: Subhrajit Bhattacharya

Description:

The Bhattacharya laboratory is interested in neuroscience research in general believing that only a fraction of the "brain story" has been read so far. A range of scientific discoveries are needed to get a better understanding of complex neural networks specifically in the field of synaptic plasticity and how it

is affected in diseases like epilepsy, Alzheimer's Disease (AD) and others. My training in neuroscience and pharmacology allows me to investigate in-depth mechanisms of drug action in the CNS using cellular and animal models. Supported by my postdoctoral training in molecular neuroscience and electrophysiology (Emory University Medical School with Drs. Stephen Traynelis and Raymond Dingledine), this interest grew into a long-term goal to study how receptors play a major role in different diseases. Current research goals of our lab include 1) synaptic mechanisms of glutamate receptor subtype mediated activities and 2) intense electrophysiology aided drug development of NMDAR subtype-selective compounds in epilepsy and AD. We have recently developed novel biased modulator compounds for the NMDA receptors that will be tested for dementia and other disease states. 3) We are also interested in understanding AMPAR and its novel auxiliary units, signaling in different parts of the thalamus in Parkinsonian models, stroke and channelopathies.

Students interested in wet lab research involving cell culture, animal tissue and having background in neuroscience and molecular biology, animal work, tissue dissection, will have opportunities to participate in the above-mentioned research projects.

Project Number: A4

Project Title: Modulation of GPCRs for the treatment of Th17-mediated diseases

Advisor: Jeniffer Hernandez

Description:

We are investigating G protein–coupled receptors (GPCRs) expressed on Th17 cells to determine whether selective modulation of these receptors can lead to novel therapeutic strategies for Th17 cell–mediated diseases, such as multiple sclerosis (MS).

Following RNA-seq analysis of Th17 cells treated with forskolin, a CREB pathway agonist, we identified several GPCRs that are highly expressed in Th17 cells compared to other T-cell subsets. We hypothesize that modulation of these receptors may regulate Th17 cell survival and effector function, offering new avenues for immunotherapy.

This project involves the molecular and functional characterization of candidate GPCRs using techniques such as western blotting, real-time quantitative PCR, flow cytometry, metabolic assays, and primary T-cell culture. In addition, we employ CRISPR/Cas9-mediated gene editing to generate loss-of-function and gain-of-function Th17 models, enabling precise dissection of GPCR signaling pathways. Promising targets are further evaluated using small-molecule agonists and antagonists in vitro and in vivo within the experimental autoimmune encephalomyelitis (EAE) model of multiple sclerosis.

Students with a strong background in molecular biology, cell signaling, or immunology will gain comprehensive experience in both mechanistic and translational approaches to immune modulation.

Project Number: A5

Project Title: Pharmacovigilance of ADHD Medications and Tachycardia Using OpenFDA

Advisor: Jungyeon Moon

Description:

Alzheimer's disease (AD) is the sixth leading cause of death in the United States, with approximately 5.8 million Americans currently living with the condition. Numerous studies have demonstrated a positive association between liver injury—resulting from factors such as heavy alcohol consumption and obesity—and the development and progression of AD. Our laboratory focuses on understanding how alterations in the liver–brain axis influence brain function and contribute to AD pathology. The goal of our SURE project is to explore and test potential therapeutic compounds in liver cell culture models (HepG2 cells) that may modulate proteins involved in the regulation of amyloid-beta relevant to AD. Students will conduct literature reviews on potential drug candidates and evaluate their effects in HepG2 cells.

Project Number: A6

Project Title: Response of cells to low dose ionizing radiation

Advisor: Animesh Ray

Description:

Cells exposed to low dose ionizing radiation, either directly or indirectly, respond by regulating its genes. We are interested in determining the program of expression of these genes. Students with a background in genetics/biochemistry/data science are encouraged to apply.

B: Computational Biology

Project Number: B1

Project Title: Computational prediction of antibodies against an antigen

Advisor: Animesh Ray

Description:

Machine learning algorithms are used to learn the language of antigen-antibody interaction from known antigen-antibody paired data, which is then used to predict novel antibodies. Validation includes molecular docking, molecular dynamics simulation, and laboratory-based experimental tests of antibody-antigen interaction using molecular techniques such as in vitro translation and immunoaffinity based detection. Students with a background in computer science and/biochemistry are encouraged to apply.

Project Number: B2

Project Title: Analysis of single cell transcriptomic data

Advisor: Animesh Ray

Description:

Immune cells become stimulated to express various genes in response to challenge by an antigen. B and T cells particularly express high quantities of immature antibody proteins from genes that have not yet been codon-optimized for expression. How does the gene expression program of these cells adapt to high protein expression even though their tRNA pools are suboptimal for using the codons for expressing these antibody proteins? We are trying to answer this question by analyzing single cell genomic and transcriptomic data, and V(D)J sequences that match these single cells. Students with a background in genetics/biochemistry/data science are encouraged to apply.

Project Number: B3

Project Title: Enzymatic lignin depolymerization in deep eutectic solvent

Advisor: Ilya Tolstorukov and Animesh Ray

Description:

This interdisciplinary project combines AI-driven protein modeling with molecular biology to design and evaluate therapeutic proteins, including human antibodies. Students will use cutting-edge computational tools to optimize protein structure, stability, and function, then express these candidates in Pichia pastoris, a robust yeast system for manufacturing recombinant proteins. Hands-on training includes cloning, expression, purification, and characterization of proteins, with key assays focused on antibody-antigen binding and enzymatic activity.

Ideal for students with basic lab skills in microbiology, molecular biology, or biochemistry, the project also welcomes those curious about computational biology and bioinformatics. Participants will gain experience at the interface of in silico design and wet-lab validation, contributing to real-world translational research.

Collaborators include Pomona College (California), BioKinetiq (Texas), United Animal Health (Indiana), and BioGrammatics (California), offering exposure to academic and industry perspectives.

Project Number: B4

Project Title: Revealing Virus-host interaction within the human microbiome through Hidden Markov Random Field Models

Advisor: Cesar Espinoza

Description:

An important component of the human microbiome is the bacteria that live in our bodies. They play central roles in maintaining our health and influence many biological processes such as digestion and immunity. Viruses that infect bacteria (phage) are an abundant component of the human microbiome, yet being able to link these to a specific host remains elusive. In this project, the student will collect data from individual microbiome samples and bin the metagenomic data into viruses and bacteria. The frequency distributions of bacteria will then be used to train a Hidden Markov Random Field Model (HMRFM), where the observed states are the phage abundance frequencies. The models will be trained and tested on different datasets. A prediction tool will then be created, where the host emission state will be used as the probability of having a particular phage as a virus.

Project Number: B5

Project Title: Modeling the distribution of CHIKV vectors using Convolutional Neural Networks

Advisor: Cesar Espinoza

Description:

Two of the most significant mosquito species posing public health threats, Aedes aegypti and Aedes albopictus, were not always cosmopolitan. Originally restricted to Africa and Southeast Asia, they have now spread globally due to human activities, particularly international trade, human movement, and climate change. Many other mosquito species have the potential to follow a similar trajectory, expanding their ecological ranges as the climate continues to warm. To address this, we propose to develop Species Distribution Models (SDMs) for known vectors of Chikungunya Virus (CHIKV). SDMs map a species' spatial distribution in relation to environmental conditions, revealing its ecological preferences (Hutchinsonian niche) and predicting where it is likely to be found under given environmental conditions. These models are especially useful in forecasting species distributions given predicted environmental conditions of future earth climate models. Most species distribution modeling efforts have focused on a single method, Maximum Entropy (MaxEnt), and machine learning has had a very limited utilization. In the proposed work, we will innovate by employing deep learning techniques, specifically Convolutional Neural Networks (CNNs). While deep learning has seen limited application in

ecological modeling, it can be a powerful approach to analyze geographic data as it is capable to decode complex patterns. Overall, our work will accurately model mosquito species distributions, producing an invaluable dataset for the scientific community while also demonstrating the novel application of CNNs for SMDs at the intersection of public health and disease ecology.

Project Number: B6

Project Title: Teaching Large Language Models to Classify Metagenomic Sequences

Advisor: Cesar Espinoza

Description:

Microbial communities, such as those found in the gut, soil, or oceans, play essential roles in global ecosystems and human health. Yet, many of the microbes and viruses within these communities remain uncharacterized because they cannot be grown in the lab, a challenge known as cultivation bias. Metagenomics, the sequencing of all genetic material in an environment, overcomes this barrier, but it introduces a new challenge: how do we efficiently and accurately identify which sequences come from viruses and which come from bacteria?

In this project, students will explore how transformer-based large language models (LLMs), the same type of models behind tools like ChatGPT, can “read” protein sequences and learn their hidden patterns. By converting protein sequences into high-dimensional embeddings, we can capture taxonomic signals that separate viral from bacterial proteins. Students will then use these embeddings as features to train machine learning classifiers (e.g., logistic regression, random forest, support vector machines) capable of distinguishing viral from bacterial genome fragments with high accuracy.

Our preliminary work shows that this approach achieves >95% accuracy on fragments containing 20 proteins and remains robust even with shorter fragments. Students will also learn to apply dimensionality reduction and visualization tools (like t-SNE) to explore how these models encode biological meaning. Ultimately, this project combines cutting-edge AI with genomics, offering opportunities to discover novel viral sequences and push the boundaries of metagenomic classification.

C: Engineering

Project Number: C1

Project Title: Left ventricle assist device development

Advisor: Anna Hickerson

Description:

Left side heart failure occurs when the left ventricle is unable to pump enough blood to sustain necessary flow for life. In advanced stages, a patient may receive a left ventricle assist device implant. These devices have many shortcomings and have limited results. Students with a background in bioengineering, mechanical engineering, or electrical engineering will have the opportunity to participate in the development and testing of a new design concept intended to overcome several of those challenges.

Project Number: C2

Project Title: Implementation of PAT tools in CHO cell culture and mAb production

Advisor: Shiva Abdolrahimi

Description:

We are developing methods to transform biopharmaceutical manufacturing by integrating Design of Experiments with hybrid modeling, including artificial neural networks (ANNs), to optimize CHO cell growth and monoclonal antibody (mAb) production. The project involves reducing experimental burden by varying critical process parameters and using real-time in-line Raman spectroscopy for dynamic glucose control. A digital twin will simulate real-time bioprocess conditions for better decision-making and scalability. Students with backgrounds in chemical engineering, upstream processing or data modeling will contribute to developing Raman Spectroscopy into Bioreactor.

Project Number: C3

Project Title: Multi Angle Light Scattering Detector for Real-time Process Monitoring

Advisor: Vijay Maranholkar

Description:

The biopharmaceutical industry is shifting toward continuous manufacturing to improve efficiency and product consistency. One challenge in this approach is the need for real-time monitoring of product quality. Traditionally, Size Exclusion Chromatography (SEC) is used to detect size variants in monoclonal antibodies, but it’s an offline method and not ideal for continuous processes. In this six-week project, students will learn key lab techniques including cell culture and protein purification and explore the use of Multi-Angle Light Scattering (MALS) as a potential inline monitoring tool. By applying MALS to characterize molecular size variants, students will gain hands-on experience with advanced analytical

instrumentation and data interpretation, while contributing to a broader research effort aimed at improving process control in next generation biomanufacturing.

D: Business / Social Sciences

Project Number: D1

Project Title: Non-Profit Drug Discovery

Advisor: Steve Casper

Description:

Most drug development within the United States and other advanced industrial economies relies on a market logic. Major pharmaceutical companies spend billions of dollars on drug discovery and development, but only for indications for which commensurate markets exist. Market logics don't work, however, for vast regions of the world in which markets for common, often deadly diseases do not exist. Over the past thirty years an alternative system of non-market drug development has developed to create new cures for neglected diseases such as tuberculosis and malaria. The goal of this project will be to examine the effectiveness of non-market drug development research coordinated through public-private partnerships and financed by philanthropies and donor-governments. While good data on the organization and success of clinical trials exists, much less data exists for earlier discovery and pre-clinical research. For this project, a team of students examine efforts by several organizations that coordinate non-profit drug development programs. Examples include Medicines for Malaria Venture, the Multiple Myeoloma Foundation, and the Michael J. Fox Parkinson's Disease Foundation. The project will focus on gathering data on drug discovery projects coordinated by these organizations over the past 25 years. The data will be used to examine the success rates of projects that move to the preclinical trial stage of development. We will also map networks of collaborations that have been developed to support these projects. Students working on this project will learn about drug discovery, gain experience conducting bibliometric research, and develop skills in social network analysis. More broadly, students will also gain experience in teamwork, project management, and presentation skills.

Project Number: D2

Project Title: Drug Repurposing

Advisor: Steve Casper

Description:

Drug repurposing involves testing a molecule that has been approved for use in one disease for possible use in a second, unrelated indication. Over the past two decades drug repurposing has been a popular and widely promoted strategy of drug development. Because much is known about the safety, tolerability, and dosing of a repurposed drug for its original indication, clinical trials for new indications can often skip the first phase of clinical trials. This saves money, speeds up the drug development process, and increases the probability of success. Despite these advantages, evidence gathered on drug repurposing projects in infectious disease suggests that the failure rate for drug repurposing trials is significantly higher than that for novel molecules. For this project, students will gather information comparing the organization of preclinical and clinical research for drug repurposing projects in two area of infectious disease that have extremely high failure rates, HIV/AIDS and malaria, and compare it with

the organization successful drug repurposing projects in other indications. Students working in this project will learn about the drug discovery and development process, gain experience in using research publications and clinical trial databases to gather information, and develop skills in organizing data. More broadly, students will also gain experience in teamwork, project management, and presentation skills.

Project Number: D3

Project Title: Sponsor Company Characteristics and Clinical Trial Diversity

Advisor: Yun Liu

Description:

This research project will investigate the relationship between characteristics of companies sponsoring clinical trials for new drugs or medical devices and the diversity of participants in clinical trials. By analyzing factors such as company size, ownership structure, financial constraints, and board characteristics, the study will assess how these attributes influence participant demographics. Using data from clinical trial registries and company profiles, the project aims to identify trends in participant diversity linked to different sponsor characteristics. Students with backgrounds in health sciences, corporate finance, and data analytics will have the opportunity to analyze data from multiple sources and examine how company characteristics impact strategic behaviors with social implications.

Project Number: D4

Project Title: The Business Drivers Behind Clinical Trial Locations and Patient Access

Advisor: Yun Liu

Description:

This research project examines how a company's finances, mergers, and leadership influence where clinical trials take place in the United States. Using data from ClinicalTrials.gov along with local community and company information, students will conduct research on how business decisions affect which patients can participate in trials. The project highlights health equity and shows how corporate strategies shape access to new therapies. Students will gain hands-on experience conducting real-world research and see how biomedical research, healthcare policy, and economics come together to impact patient care.

Project Number: D5

Project Title: Analyzing Popular Culture Representations of Medications for Opioid Use Disorder (MOUDs)

Advisor: Maxim Polonsky

Description:

Opioid agonist treatment (OAT) is an evidence-based therapy for opioid use disorder that also supports HIV prevention. OAT reduces HIV transmission by 58% among people who inject drugs and lowers rates of relapse, overdose, and mortality. Yet negative attitudes, misconceptions, and stigma remain major barriers to adoption, with many patients viewing OAT as addictive or inconsistent with recovery—perceptions often reinforced by peers and media. This project examines how OAT and other MOUDs are portrayed on platforms such as TikTok and YouTube, and how these portrayals may influence public attitudes and treatment perceptions. Using systematic content and sentiment analysis, the study will identify common themes, emotional tones, and misinformation patterns. Students interested in clinical, behavioral, or social research will gain hands-on experience coding video content and conducting quantitative analysis, with opportunities for continued involvement and potential co-authorship on conference or journal publications.

Project Number: D6

Project Title: Sentiment analysis around the online discourse of two controversial drugs

Advisor: Cesar Espinoza and Maxim Polonsky

Description:

In this project the student will access the Twitter API to complete a project involving monitoring, tracking, benchmarking, and understanding public perception and online discourse around opioid agonist treatments (Methadone) and pre-exposure prophylaxis (PreP). A significant barrier to the adoption of treatment in these two cases is the existence of negative perceptions and/or misinformation on social media.

Initially, we aim to analyze online discourse to identify the main 'myths' or themes of misinformation and negative perceptions. The question we intend to answer is: What are the main negative opinions on these drugs? What are the main myths? We expect to suggest policy changes that can directly address these perceptions and myths, which in practice represent a barrier.

As a second aim, we want to answer the question: Have these opinions evolved over time? This question has two initial points. On one hand, we are interested in seeing if these myths and perceptions have been consistent (i.e., are new myths appearing, or are new opinions developing?). On the other hand, we are interested in seeing if these opinions have become more favorable or unfavorable over time.

As a final aim, we want to compare regions with the goal of extracting insights from local policies with contrasting trends. We will initially work with the opinions on these two drugs, but we expect that in the future, other matters of public health will be addressed.