Keck Graduate Institute

Summer Undergraduate Research Experiences (SURE) Program

June 16 – July 25, 2025

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: Evolution of antibody molecules

Advisor: Animesh Ray

Description:

Antibody molecules are manufactured by B-cells through a Darwinian evolutionary process. We are interested to learn more about it through generating combinatorial libraries of antigen sequences and determining the extent of binding of competing antibodies by in vitro translation and binding assays. Students with a background in genetics/biochemistry/chemistry are encouraged to apply

Project Number: A2

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: A3

Project Title: Alzheimer's Disease drug discover

Advisor: Derick Han and Gerome Garcia

Description:

The goal of the project is to explore and test drugs in cell culture that may modulate proteins that regulate amyloid-beta for potential therapy in Alzheimer's disease.

Project Number: A4

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

Advisor: Jeniffer Hernandez

Description:

We are characterizing G-protein coupled receptors (GPRCRs) expressed on Th17 cells to determine if targeting GPCRs will lead to the treatment of Th17 cell-mediated diseases, such as multiple sclerosis. Following RNAseq analysis on Th17 cells treated with forskolin, a CREB agonist, we have identified several GPCRS that are highly expressed on Th17 cells compared to other T cells. Modulation of these GPCRS would lead to novel therapies for the treatment of Th17 cell-mediated diseases. This project involves characterizing different GPCRS by western blot analysis, real time quantitative PCR, flow cytometry, metabolic assays, cell line and primary cell culturing. Once a candidate GPCR is identified, small molecules are used to modulate the GPCR in vitro and in vivo using the multiple sclerosis mouse model, experimental autoimmune encephalomyelitis (EAE). Students with a background in molecular cell biology and/or immunology would do well on this project.

Project Number: A5

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.

B: Computational Biology

Project Number: B1

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: B2

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: B3

Project Title: Enzymatic lignin depolymerization in deep eutectic solvent

Advisor: Yian Chen, Ilya Tolstorukov and Animesh Ray

Description:

Lignin, an abundant but underutilized aromatic biopolymer, has great potential to serve as a feedstock to produce value-added chemicals through biorefinery activities and thus benefit the circular economy. Lignin valorization requires efficient and cost-effective conversion pathways, including enzymatic degradation in harsh industrial conditions. In this project, we will attempt to mine sequenced genomes for lignin degrading enzymes resistant to these conditions. Students with a background in computational biology/bioinformatics, or in Biochemistry/molecular biology who is conversant with coding in python, will have the opportunity to participate in computationally identifying novel lignin degrading enzymes from genomic sequence databases.

Project Number: B4

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: B5

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 to these single cells. Students with a background in genetics/biochemistry/data science are encouraged to apply.

Project Number: B6

Project Title: Improvement of proteins by computational design, expression in the yeast Pichia pastoris and analysis of properties of the purified novel proteins.

Advisor: Ilya Tolstorukov and Animesh Ray

Description:

We utilize computational tools developed by this year's Nobel Prize laureates in chemistry to analyze and optimize the structures and properties of anti-SARS-CoV-2 antibodies, as well as enzymes perspective for medical and technical applications. The designed protein sequences are used to synthesize corresponding genes, which are then cloned into yeast vectors to create yeast strains that express these proteins. Using advanced bioprocessing technology, we produce and purify these novel proteins, followed by detailed analysis of their properties, such as antibody-antigen interactions or the catalytic activity of enzymes. We invite students with a background in computational biology or bioinformatics, or those with basic laboratory skills in microbiology, molecular biology, or biochemistry.

Project Number: B7

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.

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: Mammalian cell culture for adeno-associated virus (AAV) production

Advisor: Saurav Datta

Description:

In order to treat patients suffering from genetic disorders, delivery of the “correct gene” is necessary. This modality of treatment is known as gene therapy. In gene therapy, a delivery vector is used to transport the “correct gene” as a cargo to the patient, and adeno-associated virus (AAV) is widely used as a delivery vector for gene therapy. We are exploring methods to produce AAV via mammalian cell culture using Human Embryonic Kidney 293 (HEK293) cells. This project aims to develop AAV production strategy in shake flask and bioreactor with a goal of increasing AAV yields and quality. Design of Experiment (DoE) approach using JMP software will be utilized to find the optimum conditions for enhanced production of AAV. The work will involve plasmid purification, transfection, HEK293 cell culture, metabolite analysis, AAV characterization and process optimization using JMP. Students with a background in Biological Sciences or Biotechnology or Chemical/Bio Engineering or similar fields, and interest in cell culture and biopharmaceutical processing are encouraged to apply.

Project Number: C3

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: C4

Project Title: Waste valorization process development in lignocellulosic biorefinery

Advisor: Yian Chen

Description:

During the enzymatic conversion of lignocellulose biomass into fermentable sugar, we often generate a lignin-containing waste stream. In this project, we are developing and optimizing a biorefinery process to valorize the waste stream by recovering and fractionating lignin as a valuable byproduct and at the same time recycling the green solvent. Our preliminary life-cycle assessment (LCA) indicate that this process intensification of lignocellulosic refinery has the potential to reduce over 65% greenhouse gas emissions. Students with a background in Chemical Engineering or Material Engineering will have the opportunity to participate in functionalized polymeric material synthesis, process development and optimization, process simulation, technoeconomic analysis, life-cycle assessment, and process scale-up.

D: Business / Social Sciences

Project Number: D1

Project Title: Developing Medicines for Neglected Disease

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 exist, much less data exists for earlier, discovery and pre-clinical research. For this project, a team of students will focus on gathering data on drug discovery projects in malaria 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 collaboration that have 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: Design Thinking in Healthcare

Advisor: Haibo Liu

Description:

The healthcare industry is facing numerous challenges, including inefficiencies in service delivery, equity in access to quality care, and the overall patient experience. From improving patient-centered care to streamlining processes and enhancing technological integration, there is a critical need for innovative solutions to address these pressing issues.

This project will introduce students to the concepts and applications of Design Thinking as a human-centered, multidisciplinary approach to innovation. Students will explore how the Design Thinking process can be applied to both the development of new healthcare services and the improvement of existing ones. They will learn the basics of innovation and discover how Design Thinking can uncover opportunities for healthcare innovation, considering the needs of patients, providers, suppliers, and other stakeholders. The project will emphasize a systemic and holistic approach, enabling students to reimagine healthcare solutions that benefit the entire ecosystem.

The project will be team-based, with two to three students working together. While no lab work is required, students will mostly collaborate remotely. A background in behavioral sciences or social sciences is preferred, as you will need to conduct interviews or surveys as part of the research process.

Project Number: D4

Project Title: Content and Sentiment Analysis of popular culture narratives about medications for opioid use disorder (MOUDs)

Advisor: Maxim Polonsky

Description:

Opioid agonist treatment (OAT) is an evidence-based treatment for opioid use disorder that is also effective for primary and secondary HIV prevention. OAT reduces HIV transmission by 58% in PWID, and reduces criminal activity, recidivism, drug use, overdose, and death. Despite its well-documented effectiveness, negative attitudes, ideological biases and prejudices remain a significant barrier to OAT adoption for clients, with many eligible patients refusing to enroll. Numerous identified barriers to OAT include beliefs that it worsens physical health, is addictive, and that coming off it is difficult. Many patients perceive taking OAT as stigmatizing and inconsistent with being in recovery, a sentiment that is commonly reinforced by peers and family. The proposed research seeks to understand the prevalent sentiment around the OAT initiation and adherence in popular culture (i.e., music, TV, and movies), as well as its role in shaping the public attitudes toward OAT via a content-analysis of its narratives.

Students with clinical or social/behavioral research experience will be coding content in excel to learn how to conduct an independent content analysis study, with continuity and publication potential.

Project Number: D5

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: 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.