Summer Undergraduate Research Experiences (SURE) 2020 Project Descriptions

Biology

The Center for Genomic Advocacy (Drs. Shaad Ahmad, Kyu Hong Cho, Hugo Gante, Rusty Gonser, Jeff Kinne, Kris Schwab, and Catherine Steding)

The Center for Genomic Advocacy (TCGA) offers a number of diverse research opportunities. The environment is collaborative with many faculty members working together. Students will first meet with Dr. Gonser, TCGA director (rusty.gonser@indstate.edu), to discuss the TCGA SURE program and their interests and goals in order to match students and faculty mentors. This method has produced a number of collaborative efforts through the years. TCGA usually takes anywhere from 4-12 students, depending on funding availability.

Some of the TCGA projects are listed below:

Dr. Ahmad's lab group is working to on the identification of Forkhead transcription factor-regulated genes in heart development. While at least eight Forkhead (Fkh/Fox) domain transcription factors are required for proper cardiac development in mammals, and mutations in four Fkh genes have been linked to human congenital heart defects, relatively little is known about the molecular mechanisms or the downstream targets by which these Fkh-mediated developmental functions are brought about. The Ahmad Lab previously found and analyzed the Drosophila orthologues of Fkh genes responsible for proper heart development and has now identified more than 2000 target genes regulated by the Drosophila Fkh genes. SURE students will attempt to identify the target genes used for heart development by disrupting the indidivdual target genes with mutations.

Dr. Cho's laboratory group studies the pathogenic mechanisms of the human bacterial pathogen, Streptococcus pyogenes. The SURE students joining the lab will be involved in investigating how the production of virulence factors such as toxins, capsules, and adhesins are regulated by environmental factors.

The Gante Lab uses a combination of approaches to study development, speciation and adaptation, traditionally but not exclusively, of freshwater fish species. The SURE students joining the lab will be involved in investigating the genetic basis of heart development or color patterns in fish.

The Gonser lab group investigates genetic and behavioral and evolutionary forces that affect populations. The white-tailed deer project utilized DNA extractions and PCR of microsatellite markers to investigate how annual harvests affect genetic diversity of an putative isolated population in Southern Maryland. The other project involves the polymorphic white-throated sparrow. These ground nesting birds come in two plumage

morphs that are determined by their genotype. Furthermore, the different morphs have distinguishable behavior and reproductive strategies. Therefore white-throated sparrows are one of the few species where we can link behavior to genotype. We utilize many research techniques to investigate why the polymorphism is maintained in the species.

The Schwab lab group investigates genetic regulation of mammalian cardiomyocyte differentiation. The development of the mammalian heart requires the step-wise activation of a complex gene regulatory network to specify and differentiate the cardiomyocyte, or heart muscle cell, populations that will generate the contraction force to propel blood through the cardiovascular system. Perturbations of this gene regulatory network can cause developmental malformations in the heart and cardiovascular system that can vary from mild to life-threatening conditions. My laboratory is interested in identifying and describing the molecular and genetic functions of cardiac genes that regulate cardiomyocyte differentiation by 1) using high-throughput gene expression data and bioinformatics to investigate cardiac gene expression changes during differentiation and 2) using an in vitro experimental system that differentiates human pluripotent stem cells (hPSCs) into cardiomyocytes to assess gene function. SURE students will utilize a combination of bioinformatic and molecular biology tools to analyze gene function during cardiogenesis.

The Steding laboratory investigates the molecular mechanisms of chemoresisance in Breast Cancer. Breast Cancer remains of critical, clinical significance as 40,000 American women are expected to succumb to advanced, metastatic disease this year. One of the most important factors limiting therapeutic efficacy for Breast Cancer treatments is the development of chemoresistance. The Steding laboratory generated a series of cell lines that show true, acquired chemoresistance to the microtubule stabilizing compound, Paclitaxel. These cell lines are now utilized to explore a variety of aspects of chemoresistance including identification of new therapeutic targets. SURE projects will focus on evaluating recently identified candidate genes for their roles in the acquisition and/or maintenance of chemoresistance.

Students working with Dr. Kinne will join with one or more of the biology research projects that requires programming and analysis. Projects are in progress with the Schwab Lab, Ahmad Lab, and Cho Lab. Each project involves understanding experimental datasets and using programming tools to perform analysis that is accurate reproducible. Each project has code and preliminary results that need to be improved and refined. The Schwab Lab project involves mining gene expression data to find key genes in heart development. The Ahmad Lab project involves automated searches of mutations to manipulate the binding of given transcription factors. The Cho Lab project involves the analysis of RNA-seq data from micro-organisms. Requirements - Completed the first two courses in the CS major with an interest in programming. Introductory biology knowledge is a plus but not required. Some experience with R would be a plus but not required.

Chemistry

Dr. Rick Fitch (richard.fitch@indstate.edu)
Project 1: Analysis of Bioactive Alkaloids in Poison Frogs. Certain tropical frogs are brightly colored and contain toxic substances, generally alkaloids. We are interested in what alkaloids are present and in what amounts. We have collaborations with two ecology groups looking at frogs in South America and Madagascar. We use Gas Chromatography-Mass Spectrometry and Liquid Chromatography-Mass Spectrometry to identify and quantify these alkaloids. Participants will get training on both as well as data analysis and automated identification techniques.

Project 2: Synthesis of Poison Frog Alkaloid Standards. Many poison frog alkaloids are not commercially available and we are synthesizing amines similar to these alkaloids to use for quantitation and identification of natural compounds. This involves conducting microscale to prepare a large number (~100-200) analogs for use in quantitative analysis. Participants will learn organic synthesis, purification and identification techniques including chromatography, mass spectrometry and NMR spectroscopy.

Dr. Eric Glendening (eric.glendening@indstate.edu)
Applications of Natural Resonance Theory. It is common for chemists to invoke resonance theory (RT) to interpret interesting structural and energetic properties of molecules. Recent advances in natural resonance theory, an implementation of resonance theory in the natural bond orbital methods, facilitate the application of RT to larger and more complex chemical systems than previously possible. This is a computational chemistry project. I seek one or two students to work full-time on the project. Students should have completed CHEM 106 or higher at ISU.

Dr. Robert Noll (robert.noll@indstate.edu)
Dr. Noll has two possible projects in his lab. One is conducting experiments to assess the utility of a miniature gas chromatograph for field use in characterizing contamination sites. The second involves the development of a "self-re-charging" battery.

Dr. Ryan Van Hoveln (ryan.vanhoveln@indstate.edu)
Our research focuses on organometallic chemistry (the study of carbon-metal bonds). Currently, we are developing new reactions which use metal catalysts (such as copper or nickel) couple two organic pieces together. Our goal is to make challenging bonds that could not otherwise be made by traditional organic synthesis. Students will work in teams and learn a number of laboratory techniques relevant to organic research such as working under oxygen-free conditions, working with reactive chemicals, and NMR spectroscopy.

Dr. Fan Zuo (fan.zuo@indstate.edu)
Electrochemistry and photoelectrochemistry. Research in my group is to design efficient catalysts for energy application. We have a complete set of facilities to synthesize

electrocatalysts and study their electrocatalytic H_2 and O_2 evolution efficiency, and investigate the reaction mechanism. In the near future, we will add the photoelectrochemical capability into our group. Students in our group will learn how to use their chemistry knowledge to produce clean energy through electrical and photoelectrical strategy.

Earth and Environmental Systems

Dr. Jen Latimer (jen.latimer@indstate.edu)
In the Biogeochemistry Lab, we use elemental data collected from soils, sediments, and water to study environmental change. Projects include past climate change in South Africa and the Indian Ocean, bioavailability of lead and other heavy metals in urban environments, and many others. Students should be comfortable handling chemicals and should have completed CHEM105.

Dr. Jim Speer (jim.speer@indstate.edu)
In the Dendrochronology and Biogeography Laboratory we examine paleoecology and biogeographic distribution of species. We are currently working on a variety of tree-ring research projects. We are reconstructing stand-age structure of the old trees at Dobbs Park. We may be able to date some cabins at Fowler Park. And finally we are likely to use the scanning electron microscope to measure cell wall thickness related to Pandora moth outbreaks in ponderosa pine trees.

Dr. Jeffery Stone (jeffery.stone@indstate.edu)
Students who engage in summer research in the Paleolimnology lab study modern lake and river systems or microfossil remains from lake sediments. Student projects can include analysis of modern or fossil diatoms, potentially including either paleoecology, paleoclimate, or taxonomy. Research usually involves some combination of field work, laboratory work (particularly on the light microscope), and some time and training using the Scanning Electron Microscope. Student projects can include materials from lakes around the world (US, Africa, South America, the Himalayas, etc.).

Physics

Dr. Sean Bartz (sean.bartz@indstate.edu)
Project 1: Holographic model of deconfinement in quark matter. This is a project in theoretical/computational nuclear physics. We are examining the phase transition between ordinary nuclear matter and the quark-gluon plasma produced in heavy ion collisions. This project will involve reading and understanding the model from a different group's paper, and building the computer program to reproduce their results. This will allow us to extend their results in the future. I am looking for one student who has some familiarity with differential equations and basic computer programming.

Project 2: A common physics demo involves dropping a tennis ball stacked on top of a basketball and observing the surprising rebound height of the tennis ball. The general behavior of this system is quite complex. In this project, we will examine this behavior primarily using computational simulations. Some prior programming experience is beneficial, but not necessary.

Dr. Guoping Zhang (guoping.zhang@indstate.edu)
Project 1: Computer simulation of the interaction between amyloid beta plaques in Alzheimer diseases and olecanthal. The student is expected to use the computer program, Gromacs to carry out a massive simulation to understand the interaction between amyloid beta plaques in Alzheimer diseases and olecanthal (from olive oil).

Project 2. All-optical spin switching. This project targets a growing frontier for the magnetic storage devices.

Project 3. High harmonic generation in solids. High harmonic generation in solids becomes a focus of new light source for the future. Students will use some exotic materials to generate strong harmonic radiation.

IU School of Medicine—Terre Haute

Dr. Scott Canfield (sccanfie@iu.edu)
Dr. Canfield's lab is working with a human stem cell-derived blood-brain barrier model to investigate the effects of anesthesia on critical barrier properties. Propofol, a commonly used anesthetic has been found to be detrimental to the integrity of the blood-brain barrier. SURE students will attempt to identify novel cellular mechanisms that are impacted by Propofol in an attempt to inhibit/reverse the negative effects on the blood-brain barrier.