STEM Fellowship

2018 Spring Internships Project Opportunities For Students

THE PROJECT LIST

Below is the 2018 list of research opportunities for students in STEM Fellowship's spring internships program. Students can rank the projects in which they are most interested on the application form and we will do our best to match students in the respective labs. We cannot guarantee that students will be placed in one of their requested labs/projects.

THE BRAIN COMPUTER INTERFACE

With Dr. Ephrem Zewdie

Students will have the opportunity to work with Dr. Zewdie's brain computer interface (BCI). BCI has the potential to allow severely disabled persons to meaningfully interact with their environment. While the pediatric population might benefit most from BCI technology, research to date has been predominantly in adults. With BCI technology progressing rapidly, there is a pressing need to determine if and how children can use such systems. Dr. Zewdie's preliminary result shows that children can often quickly achieve control of multiple tasks using simple EEG-based BCI systems. Performance depends on strategy, task and age. Such success in the developing brain mandates exploration of such practical systems in disabled children.

MUSCULOSKELETAL BIOMECHANICS

With Dr. Walter Herzog

The Herzog lab conducts research on muscle properties and skeletal muscle function from the molecular level to in vivo human muscle function. They additionally study knee joint biomechanics and osteoarthritis, from the molecular cellular level to animal models of osteoarthritis and even a bit of human work. The lab additionally is involved in some applied projects pertaining to sport biomechanics and chiropractic manipulation mechanics on the back and neck with specific emphasis on injuries to vertebral and carotid arteries possibly caused by chiropractic manipulation.

CLIMATE CHANGE AND THE ARCTIC

With Dr. Susan Kutz

The Kutz Research Group is investigating the impact of climate change on disease in northern arctic wildlife. They use a combination of laboratory experiments, field work, and local and traditional knowledge to do this work. The student intern will be involved in research on wildlife health in the Arctic and will have the opportunity to work on a variety of projects in the laboratory. These may include assessing the parasite status of wildlife (such as caribou, muskoxen, Dall's sheep and bighorn sheep) through examination of fecal samples as well as doing experiments on parasite eggs and larvae. They will learn skills in microscopy and classical parasitology and will be immersed in the day to day life of an active group of wildlife health researchers.

THE FLOW OF MATTER

With Dr. Giovanni Natale

Dr. Natale's research interests lie at the interface between rheology (the branch of physics dealing with the flow of matter), soft matter and colloidal suspensions. A combination of modeling and experiments is applied to explain in depth the flow of complex/structured fluids. The student intern will have the opportunity to shadow a graduate student to explore mathematical modelling and computer simulation of matter or to experience a variety of chemical engineering based laboratory techniques.

GO GREEN

With Dr. Nashat Nassar

Dr. Nassar's research ranges from environmental remediation to energy production, to designing and configuring processes for hydrogen production and waste processing to mitigate carbon emission. The main goal is to improve oil quality, reduce gaseous emissions and improve water recyclability. His research group utilizes nanotechnology engineering to explore hypotheses related to environmental processes.

ENERGY INNOVATION AND OIL

By Dr. Hemanta Sarma, with Dapo Noah

Dr. Sarma is focused on industry-driven research in the areas of enhanced oil recovery, improved oil recovery and reservoir engineering. The student intern will have the ability shadow Dapo Noah, a recipient of the prestigious Vanier

Scholarship award for excellence in academic and leadership roles. One area of Dapo's research is centered around chemically-tuned waterflooding, which has recently been developed to overcome the deficiency in the existing waterflooding method. It has the potential to improve oil recovery from deep reservoirs. Dr. Sarma's lab is exploring tools capable of understanding the chemically-tuned waterflooding process and predicting the performance of the process. Students working on this project will learn about the development of analytical models, provide a solution to an analytical model and discuss the solution in the context of the problem statement of the research study. Students will also learn about writing research reports and running computer programs to predict experiments using analytical solutions.

Exploring Postural Tachycardia Syndrome

With Dr. Satish Raj

Postural Tachycardia Syndrome (POTS) is defined as a chronic state of consistent orthostatic tachycardia (>30 bpm increase in heart rate from lying to standing). Typical symptoms, such as palpitations, lightheadedness, chest pains, troubles breathing, tremulousness, blurred vision, and mental clouding, are worse on standing and relieved by lying down. There is data to suggest that autoantibodies may be responsible for the symptoms associated with the syndrome. Dr. Raj's lab is conducting a pilot study testing the hypothesis that patients with POTS will have a higher percentage of functional antibodies targeting adrenergic receptors compared to control subjects without POTS. The study procedure involves autonomic function testing, using equipment such as an electrocardiograph, continuous blood pressure monitoring cuff, and a tilt table.

DRILLING ENGINEERING

With Dr. Roman Shor

The integrated Drilling Research Laboratory (iDRL) is a multidisciplinary research laboratory with active research projects in drilling engineering, optimization, automation and control. Research projects will be tailored to the interests of the student and will support the current needs of the laboratory, however, they will be *hands-on and interactive*. Potential projects include the experimental characterization of drill bit – rock interaction using a miniature drilling rig, an investigation into the wave propagation properties of drillstrings, or prototyping and/or testing of novel drilling techniques. In each of these projects, the student will be working directly with Masters and/or PhD students in the laboratory to identify a problem and validate a hypothesis with a thoroughly crafted testing plan.

MICRO-TISSUES AND CELL SURVIVAL

By Dr. Mark Ungrin, With Derek Toms

The Ungrin lab is currently developing high throughput and microfluidic platforms for the investigation and application of tissue engineering at the micro-scale. By controlling the size and composition of these micro-tissues, we hope to improve cell survival and function compared to native tissues. During the STEM internship, students will assist in building support technologies and running experiments using open-source liquid handling robots. The students will have the opportunity to analyze cell aggregates ('microtissues') using automated fluorescent microscopy. The current projects involve the production of engineered, insulin-secreting pancreatic microtissues for the treatment of type 1 diabetes.

MODELLING CARDIOMYOPATHY WITH STEM CELLS

By Dr. Steven Greenway, With Pranav Machiraju

Pranav's project is centered around induced pluripotent stem cells (iPSCs), which are not only able to differentiate into various cell types, but are also capable of self renewal, allowing for easier maintenance of a stem cell model system. His research revolves around characterizing iPSCs and iPSC-derived cardiomyocytes from patients with the dilated cardiomyopathy with ataxia syndrome (DCMA). DCMA is a genetic condition, from a mitochondrial dysfunctional mutation, that can result in patients developing lethal dilated cardiomyopathy, conduction defects and other systemic features. His project involves four major objectives: a) Establishment of an induced pluripotent stem cell model, b) Differentiation of iPSCs into cardiomyocytes c) Comprehensive characterization of iPSC-CMs and d) Testing of novel therapeutics for recovery of mitochondrial structure and function. Potential activities for the student include shadowing stem cell culture techniques, observation of spontaneously contracting cardiomyocytes and helping stain the iPSC-CMs for cardiomyocyte markers. The student may also observe cutting edge microscopy platforms such as a confocal laser microscope. The student will learn stem cell basics such as morphology, growth conditions and how to induce directed differentiation of iPSCs into various cell types.

CELL-FREE DNA AND HEART DEFECTS

By Dr. Steven Greenway, With Ashna Maredia

Bicuspid aortic valve (BAV) is a common congenital heart defect that results from abnormal fusion or formation of the aortic valve. This condition may lead to progressive aortic dilatation (bicuspid aortopathy). Surgical intervention on the

dilated aorta is highly dependent upon individual preference and institutional practice. Thus, biomarkers are important to predict risk, guide practice decisions for patients with BAV and its associated aortopathy. This project will be using cell-free DNA (cfDNA), found in blood, as a potential biomarker of aortic dilation and severity of anatomic abnormality. Recently demonstrated, tissue-specific differentially methylated regions (DMRs) can be identified from plasma cfDNA and quantified as a biomarker for tissue injury. Levels of aorta DMRs measured in patients' tissue will be correlated with the severity of aortic dilation as assessed by clinical imaging (echocardiography, CT and/or MRI) and histology. The students will tour the lab space, learn the various methods of handling plasma samples, and be introduced to computational genomic methylation analysis for the identification of DMRs.

THE MICROBIOME AND METABOLISM

By Dr. Steven Greenway, With Michael Taylor

The human gut microbiome plays a significant role in health outcomes. One factor shaped by the microbiome is the metabolism of therapeutic drugs, which has large implications in the treatment of disease as the gut microbiome may be interacting with drugs in an undesirable way. For example, transplant patients treated with the immunosuppressant mycophenolate mofetil (MMF), often suffer from gastrointestinal side effects, such as diarrhea, abdominal pain, and weight loss. The Greenway lab believes these side effects are due to an interaction between MMF and the gut microbiome resulting in the production of toxic molecules that induce inflammation in the gut. Unfortunately, the mechanism behind the interaction of MMF and the gut microbiome is unknown. The Greenway lab is attempting to unravel this mystery using various laboratory techniques such as spectroscopy assays, 16s rRNA amplicon sequencing, and ultra-high performance liquid chromatography coupled to mass spectrometry (UHPLC-MS). The student will be able to learn some of these techniques by performing enzyme extractions to isolate a desired enzyme and measure its activity using a spectroscopy assay, perform bacterial DNA isolations and amplification of the 16s rRNA gene for sequencing, or by performing metabolite extractions for identification with UHPLC-MS.

BIOINFORMATICS AND THE HEART

By Dr. Steven Greenway, With Sabrina Pattar

The aim of Sabrina's project is to develop a non-invasive assay that can be used to monitor and detect heart transplant rejection in recipients. This assay utilizes plasma samples, which can be obtained relatively frequently and non-invasively from each patient. The key biomarker of rejection in this assay is cell free DNA

(cfDNA), which is fragmented genomic DNA that is released into the blood when cells undergo apoptosis, a result of antibody-mediated rejection (AMR). The student working with Sabrina will learn how cfDNA is typically isolated from a plasma sample and different methods of quantifying the isolates. Her project is also heavily based in bioinformatics so the student will also learn about different software used for her analysis, and be able to try the important commands for each type of analysis. The students will also get to attend a lab meeting to see how each project is discussed and future goals are established. If any seminars or journal clubs are taking place, the student can attend with Sabrina as well.

GENETICS OF CELL FATE

With Dr. William Brook

The Brook lab is interested in how genes control cell fate during embryogenesis. They study the fruit-fly, *Drosophila melanogaster*, which is a simple experimental organism with many powerful genetic tools that allow them to ask very specific questions about development. They are interested in the very early choices that cells make, for example, how cells choose to be part of the developing limb or other organs. These choices are controlled by genes that code for transcription factors, which are proteins that turn genes on or off. Specific transcription factors act as genetic switches that 'tell' cells what tissue to form by activating sets of tissue specific genes. They are studying several of these transcription factors using genetics and molecular biology. The STEM Fellowship research experience being offered will involve using fly genetics and fluorescence microscopy to analyze gene expression in dissected fly embryos.