The 2023 STEM Fellowship UCalgary Research Internships Program: Participating Research Groups

March 27th – 31st, 2023

2023 Participating Research Groups

Medicine

Dr. Sarah Childs

Our lab works on identifying genetic causes of vascular diseases, including vascular malformations and vascular stability defects. Both of these conditions can lead to vascular instability and potentially bleeding and stroke. We use the zebrafish model, genetics, molecular biology and microscopy in our research. Students in this project will have an opportunity to watch all aspects of the work and depending on safety training, may be able to participate in some simple molecular biology techniques.

Psychology

Dr. Andrea Protzner

At the Brain Dynamics Lab, we examine how cognition emerges from operations in the intact and impaired brain by focusing on healthy aging and depression. During healthy aging, the integrity of brain structures declines. The brain responds to these insults by engaging plasticity, but we know little about the 'best' types of plasticity, and even less about the specific brain mechanisms that promote this adaptive plasticity. Our research combines learning paradigms, neuropsychological approaches, and neuroimaging to address these questions. For depression, we examine how individual differences influence disease trajectories and treatment outcomes. Our aim is to combine information within-subject across multiple imaging modalities to identify unique biological signatures for predicting treatment responsiveness, and tailoring treatment strategies to individual patients.

Geoscience

Dr. Bernhard Mayer

The Applied Geochemistry group in the Department of Geoscience at the University of Calgary conducts research that investigates the quality of surface water, groundwater, and formation waters. Students will be involved in conducting laboratory-based analyses that determine the concentrations of various dissolved constituents in water, including nutrients and contaminants. The obtained data will be used to determine the sources of the analyzed water samples and to assess the water quality. Provision of sufficient quantities of high-quality water for a growing population is of key importance since high-quality is critical for: drinking water; irrigation and hence food security; and ecosystem health, the latter because groundwater sustains river flows.

Veterinary Medicine
Dr. Herman Barkema

The over-all goal of my research program is to ensure a safe and economical food supply with a reduced risk of transmission of zoonotic diseases to farm families and the general public. I have two main research interests; the first is to prevent and control infectious diseases on dairy farms, primarily mastitis and Johne's disease, including both animal and public health perspectives. New prevention and control programs in Canada, The Netherlands and other countries, have been introduced or modified based on results of my research. My second main research interest involves interactions among hosts, microbes and the environment in antimicrobial resistance.

Chemistry
Dr. Dennis Salahub

Dr. Dennis Salahub's research interests are in theoretical and computational chemistry, especially Density Functional Theory (DFT) and its applications in materials and biomolecular modelling. His overall research goal for the next decade is to develop the theoretical, computational, and conceptual expertise necessary to attain a detailed microscopic understanding of chemical reactions taking place in real, complex environments.

Exercise Physiology
Dr. Saied Aboodarda

Students will have the opportunity to work with Dr. Aboodarda's research team on evaluating neuromuscular (the brain and muscles) and cardiovascular (heart and respiratory systems) responses to different modality of exercise. Students will be provided with explanations about the physiology of the human body and how the integration of physiological and psychological factors determine athletic performance. In Dr. Aboodarda's lab, athletes undertake cycling tasks to exhaustion, during which respiratory measures (e.g., O2/Co2 exchange), ventilation and heart rate will be measured consistently. Before and after each cycling exercise, the brain and exercising muscles will be stimulated using non-invasive magnetic and electrical stimulation. Also, athletes will be asked to rate their perceived pain, fatigue and effort during the cycling exercise.

Petroleum Engineering
Dr. Nashaat Nassar

1. Enhancing the performance of commercially used shampoo and spa personal care products by nanotechnology
Foams, a gas dispersion in a liquid, are widely used in our daily life through various products such as detergents and personal care products. However, the currently used products lack long-lasting stability unless high concentrations of foaming agents are used, which increases the product's performance and costs. Nanotechnology can provide innovative solutions to the drawbacks of various traditional products. In this research, naturally occurring and environmentally friendly nanoparticles are used to enhance the stability and performance of the commercially used foaming agents. This research evaluates the performance of foaming agents using the American standard test method of foaming agents and nanoparticles to assess the performance of generated foams and their performance, including foam half-life time and bubble sizes. Joined students will have a piece of wide knowledge of chemistry, statistics, and coding.

2. Optimization of dynamic foam properties by nanotechnology
Bubble column, the flow of foam in a pipe, is used in various industrial applications, including wastewater treatment and the petroleum industry. The foam flow regime in a column significantly depends on the gas flow rate, which can produce either a homogenous, transitional or heterogeneous flow. This research will evaluate the properties of dynamic foams, including gas holdup and bubble sizes, in a 1-meter transparent bubble column with various surfactants and nanofluids. Furthermore, the dynamic foam properties will be evaluated at gas flow superficial velocity in the range of 1-60ml/min and a temperature of 20-60 C. Joined students will have a piece of wide knowledge of chemistry, physics and engineering.

Medicine
Dr. Shalina Ousman

The research interest of the Ousman Lab is neuroimmunology, specifically, how interactions between the immune system and nervous systems leads to neurological disorders. We have focused our efforts on multiple sclerosis (MS) and peripheral nerve injury since they are the yin and yang of each other. In MS, one goal is to prevent neuroinflammation, a hallmark feature of the disease, while following peripheral nerve injury, an immune response is critical for successful axon regeneration to occur. Thus the two disorders inform us as to what comprises a beneficial vs a detrimental immune response. One of our research goals is to identify and delineate the underlying cellular and molecular mechanisms of endogenous protective molecules in MS and after peripheral nerve injury so as to harness their beneficial properties for suppressing autoimmunity and/or promoting beneficial immunity, remyelination and neuro-repair. Thus far, we have shown that CRYAB, a small heat shock protein that is highly expressed in MS brains as well as Schwann cells in the peripheral nervous system (PNS), plays an important role in dampening inflammation in the periphery and CNS in a model of MS *(Ousman et al., 2007, Nature)* as well as promoting remyelination after PNS injury *(Lim et al, 2017, PNAS)*. We have also shown that Cystatin C, another factor that is highly upregulated in the brains of people with MS, plays a detrimental role in a model of MS by promoting immune cell activation; this however only occurs in females *(Hoghooghi et al., 2020, Cell Rep)*. Going forward, we are interested in understanding how CNS resident cells such as oligodendrocytes and astrocytes contribute to repair functions such as remyelination and neuronal survival. We are also interested in how aging disrupts natural protection in both MS and peripheral nerve injury. Aging is a key factor associated with progression in MS as well as poor regeneration of injured, aged PNS axons. It appears that declines in the levels of endogenous protective molecules are involved and we are pursuing how to reverse these molecular deficits.

Geoscience
Dr. Benjamin Tulolo

The Reactive Transport Group studies the interaction between water and rocks. We particularly focus on climate change solutions, such as the conversion of CO2 into solid rock through a technology known as mineral carbonation, as well as the history of habitability on Earth as well as Mars. To provide constraints on these processes, we measure the properties of water, rocks, and gases recovered from field sites and also perform laboratory experiments to assist in the interpretation of these measurements. Finally, we use computational models in order to build upon these interpretations and predict the long-term behavior of Earth and planetary systems.

Mathematical Sciences

Dr. Anatoliy Swishchuk

Mathematical/quantitative finance: Mathematical finance, also known as quantitative finance and financial mathematics, is a field of applied mathematics, concerned with mathematical modelling of financial markets. Grad students in our lab are learning and doing research on how to apply mathematical models and methods to financial and energy markets, and how to deal with big data associated with those markets.

Biomechanics

Dr. Walter Herzog

(i) Molecular mechanisms of muscle contraction and muscle properties.
In this research, we use experimental unique experimental approaches on the scale of single cells and single myofibrils to elucidate the role of the structural protein titin in active force production. Our group identified that titin's force changes with activation, and we proposed a theory of how titin might be involved with the force production of the contractile proteins actin and myosin. We have been leading this area of research with novel experimental approaches and with theoretical models of skeletal muscle force production
(ii) Our second area is the study of obesity and metabolic disease and its effect on musculoskeletal tissues (bones, ligaments, tendons, cartilage, joints, muscles).
We induce obesity and associated metabolic disease by feeding rats a high fat, high sucrose diet. This increases the fat content in these animals, increases body weight and causes chronic, low level inflammation related to metabolic disease. We also study dietary interventions (fibre based diets) and exercise (aerobic and resistance) to reduce the effects of the high fat, high sucrose diet. Presently, we are interested in studying if aerobic capacity in muscles and the entire animal system are protective against high fat sucrose diet-induced musculoskeletal degeneration.

Medicine

Dr. Benedikt Hallgrimsson

The two main areas of research in the lab are:
1. The developmental genetic basis for phenotypic variation. Despite the tremendous progress made in recent years towards understanding fundamental developmental mechanisms, we know very little about the genetic or developmental causes of phenotypic variation within species or among related species. This is a central area for evolutionary biology as phenotypic variation is the raw material on which evolution acts. It is also an area that has important implications for understanding etiologically complex malformations such as cleft lip and palate. Such malformations occur at the extremes of multifactorial phenotypic distributions and must be understood within the same theoretical framework as other aspects of variation.

2. The developmental-genetic basis for variation in canalization, morphological integration, and developmental stability. How developmental systems modulate the translation of genetic into phenotypic variation is a fundamental question in current evolutionary developmental biology. It is clear that most genetic variation is cryptic, as evidence by the ubiquity of recessivity. It is also clear that the expression of genetic variation is dependent on genetic background and that pleiotropy is the norm. At the phenotypic level, the complexities of the genetic to phenotypic translation can be grouped into three phenomena. Canalization and developmental stability (DS) refer to the tendency of developmental

processes to follow particular trajectories despite external or internal perturbation. Canalization is the tendency for development of a specific genotype to follow the same trajectory under different conditions (different environment or different genetic backgrounds) while DS is the tendency for development of a specific genotype to follow the same trajectory under the same conditions. Morphological integration refers to the tendency for structures to show correlated variation because they are affected by shared developmental processes. All three phenomena are emergent properties of developmental systems that complicate the translation of genetic to phenotypic variation.

Engineering
Dr. Leo Belostotski

Our laboratory is involved in developing receiver instrumentation for radio astronomy telescopes. Our particular focus is on developing front-end low-noise amplifiers and high-speed analog-to-digital converters. Our graduate students develop their circuits in advanced semiconductor process. Each circuit is experimentally validated in the laboratory.

Veterinary Medicine
Dr. Faizal Abdul Careem

With a view of economic and public health importance of avian respiratory viral infections, my research program focuses on (a) studying mucosal innate and adaptive immune responses to respiratory viral infections (b) identifying key immunological mediators involved in host responses elicited at respiratory mucosa, particularly in lungs (c) designing infection control strategies based on immune modulators to prevent respiratory viral infections.

Geoscience
Dr. Christopher Clarkson

Dr. Clarkson's research group focuses on the evaluation of low-permeability ('unconventional') reservoir properties in the laboratory and in the field. Applications of this research include efficient hydrocarbon extraction and the evaluation of clean energy pathways, such as carbon capture and storage (CCS), hydrogen production and storage (HPS), and geothermal energy. Dr. Clarkson's laboratory has developed novel methods for measuring petrophysical, geological, and geomechanical properties of unconventional reservoir rocks, and evaluating fluid (water, oil, gas)/rock interaction,.which can be used to simulate fluid storage and flow for the various applications mentioned.

Social Science
Dr. Christine Walsh

This is a research experience at the University of Calgary's Faculty of Social Work titled "Aging in the Right Place (AIRP)" project. The project is focused on documenting promising practices of shelter/housing and supports for older persons experiencing homelessness in three urban centres - Calgary, Montreal, and Vancouver. AIRP is a Social Sciences and Humanities Research Council and Canada Mortgage and Housing funded project.

The students will be involved with coordinating with other research sites in Vancouver and Montreal, and engage in research activities such as literature reviews (data extraction and analysis) and participate in local and partnership team meetings. The students will be introduced to participatory action research

procedures, may be able to shadow interviews that research assistance are conducting with older formerly homeless adults using photovoice

Medicine
Dr. Satish Raj

Our lab is a human Physiology Lab. We do a lot of work in POTS (Postural orthostatic Tachycardia), IOH and OH. Most of our patient population comprises of young women of child bearing age. Our lab is also involved in studies involving gases (O2,CO2 and CO). We have a long COVID project going on. If you need more detail, I can also pass that on.

Engineering
Dr. Apostolos Kantzas

Our group works in two different areas. One deals with fundamentals of flow in porous media under the FUR acronym and the second in geothermal energy and energy harvesting in general under the GeoS centre. The students will work in projects related to harvesting heat for electricity, applications of electromagnetics and electroacoustics in porous media, complex mass transfer phenomena and nanotechnology applications for underground applications (related both to environmental remediation and hydrocarbon recovery).