Available 2019 FYREE projects

Project Title: Using Biomedical and Engineering Approaches to Develop and Design High Efficacy Antibody Therapeutics and Vaccines

Faculty Advisor: Professor Margaret Ackerman

Our projects use high-throughput technologies, molecular approaches, engineering principles and statistical modeling to evaluate immune response during disease states. Using clever genetic engineering and molecular tools we seek to develop robust humoral response by engineering and manipulating antibodies to effectively bind and neutralize pathogenic antigens. We also work to augment immune protection by harnessing innate immunity (body’s intrinsic first line of defense) through antibody interaction to clear infections. WISP students who join our group will have the liberty to choose a project of interest within the given research domain. Students will have the opportunity to learn and apply tools in

a. Recombinant-DNA technology to engineer antibodies with high efficacy characteristics.

b. Use biochemical approaches to study antibody interactions with other proteins in the immune system, and

c. Use statistical analysis to evaluate and draw correlations which will aid in the selection of potential antibody and tools to be used as therapeutic candidates.

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Project Title: Exploring Impedance Sensing for Assessing Eating Behavior

Faculty Advisor: Professor Ryan Halter

We are actively exploring wearable technologies for tracking eating behavior. We have focused primarily on tracking when people eat and the rate at which they eat. Another goal of tracking eating behavior is to detect what a person is eating or drinking. We hypothesize that one could sense the electrical properties of food as they are in the mouth or esophagus as a means for detecting food type. This research will involve measuring the electrical properties of various food types, exploring the data, and developing classification algorithms for detecting food types. Note: This program has NSF Research for Undergraduates funding which requires US citizenship.

Grad Student Mentor: Kendall Farnham
Project Title: Image Segmentation in Traumatic Brain Injury

Faculty Advisor: Professor Ryan Halter

We are developing a novel electrical impedance sensing device to monitoring traumatic brain injury (TBI) in the intensive care unit. We have (and continue) to collect data from an animal model of TBI and are interested in recruiting a student to help with neuroimage analysis. This project provide a student exposure to image processing software, CT images of brain, and collaboration with a team of engineers and clinicians.

Grad Student Mentor: Alicia Everitt

Project Title: The Microstructural and Mechanical Properties of Permafrost

Faculty Advisor: Professor Ian Baker

The effects of global warming on the permafrost that covers up to 25% of the land in the Northern Hemisphere (permafrost also exists beneath the sea) will be quite profound. Permafrost is a combination of rock, sediment, soil and some organic matter “cemented” together by ice. Permafrost, which can be up to 1500 m deep, contains 1500 GT (1.5 x 10^{15} kg) of carbon, twice as much as the carbon in the atmosphere and in all vegetation. Each year depending on location and local climate, the top 0.3-4 m of the permafrost, the so-called “active layer”, thaws. As temperatures climb, the depth of this active layer increases and if it becomes too deep then some of the below surface layers do not refreeze in winter. There are four major issues as permafrost thaws:

1) The carbon locked up in the permafrost will be attacked by microbes leading to the production and release into the atmosphere of carbon dioxide and methane, two potent greenhouses gases - methane is 84 times more potent than carbon dioxide - that will accelerate Global warming;
2) Permafrost is impermeable to water: permafrost thawing allows water to percolate through it leading to a loss of surface water, including whole lakes;
3) Warmer permafrost is mechanically weaker and existing structures, such as buildings, roads, bridges and pipelines built on permafrost can collapse when the permafrost no longer supports the load – when the permafrost has thawed it cannot support a load but flows under its own weight;
4) As coastal permafrost regions thaw, their weakened state along with the lack of sea ice cover allows wave action to erode the coast.

All of these phenomena are currently happening. The latter two problems both affect Northern communities now and are also a challenge to construction in these regions as the temperature increases and the resources in these regions are exploited. Thus the ability to understand the behavior of permafrost as it warms and relate it to its microstructure will enable prediction of the effects of warming and possible mitigation of the effects.
The aim of this project is to relate the mechanical properties of permafrost to its microstructure determined using x-ray microcomputed tomography and scanning electron microscopy.

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**Project Title: Creep Testing of AFA Stainless Steel**

**Faculty Advisor:** Professor Ian Baker

In order for power plants to become more efficient, they need to operate at higher temperatures and pressures. Nickel-based superalloys can fulfill these requirements, but they are very expensive. Alumina forming austenitic (AFA) stainless steels are being researched as a possible alternative. Creep testing is currently being done on AFA stainless steel Fe-20Cr-30Ni-2 Nb-5Al. An important factor in the creep strength of the material is the precipitates that are present. For this project, the student will use furnaces to heat treat samples of the steel, prepare samples for scanning electron microscope (SEM) imaging, and then use the SEM images to determine the average particle size and particle density for different heat treatments.

Graduate Student mentor: Andrew Peterson.

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**Project title: Sampling and Identifying Novel Volatile Molecules**

**Faculty Advisor:** Professor Jane Hill

Project description: The Hill lab focuses on sampling volatile molecules for use in the development of diagnostics for infectious diseases and other applications. This project will target teaching the student how to sample volatile molecules, including study design, sample collection, sample storage, and sample analysis on advanced analytical instrumentation (with supervision). The starting project will be the sampling of something benign, such as flowering plants. The resulting data will be used to build skills that will lead the student to work on a guided, independent project in one of the key areas of the laboratory (tuberculosis, bacterial pneumonias in cystic fibrosis patients, or data analytics in those or related areas)

Mentor: Kelsey Coyne

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**Project title: Microfluidic Synthesis of Nanoparticles for Cancer Biomarkers Detection**

**Faculty Advisor:** Professor John Zhang
Microfluidics is a technique that plays with fluids of micro or nano liter. Things change a lot down to micro scale, for example, gravity never matters anymore, and it is very easy to get layers of fluids other than turbulence. The unique properties of microfluidics make it a promising tool in the synthesis of nanoparticles including silica nanoparticles and silver nanoparticles. And those nanoparticles are very useful towards the detection of cancer biomarkers (such as circulating tumor cells, DNAs or exosomes). In this project, students can not only learn how to think as an Engineer and get involved in the design of a microfluidic chip, but also gain knowledge in biomedical engineering and even towards clinical applications.

Graduate student mentor: Yuan Nie, 4th-year PhD Candidate

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Project title: Short-wave Infrared Imaging for Biomedical Imaging

Faculty Advisor: Professor Scott Davis

Our lab develops and evaluates novel diagnostic imaging strategies to identify and characterize diseased tissue. A primary focus of this work involves advancing novel techniques which use fluorescence imaging to guide surgical removal of tumors. In this application, the ability to see fluorescence from tumors below the tissue surface at high resolution is an important yet elusive goal. However, recent reports suggest that fluorescence imaging in the short-wave infrared wavelength range can overcome this challenge and provide high resolution images of fluorescence below the tissue surface. This project aims to develop and validate several new short-wave infrared imaging strategies for the assessment of vascular flow in tissue and guidance of tumor resection.

Graduate student mentor: Brook Byrd

Role 1: Create and image tissue-simulating phantoms to evaluate the ability of this novel imaging approach to see into tissue. Some wet lab work, running an instrument, and processing data.

Role 2: Help develop a novel camera platform for surgical guidance and establish imaging performance using tissue-simulating phantoms and potentially preclinical animal imaging.

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Project title: MRI-guided Fluorescence Tomography for Monitoring Immunotherapy

Faculty Advisor: Professor Scott Davis

We are investigating the capacity of a new imaging approach to assess the effect of therapies on tumors. Our technique, known as MRI-guided fluorescence tomography, merges sophisticated
optical imaging instrumentation into a clinical MRI scanner. MRI and optical images are acquired simultaneously and, analyzed together, can reveal how drugs are interacting with their intended targets in tumors. Students will have the opportunity to:

1) Participate in instrument operation and data collection in the Advance Imaging Center at DHMC
2) Work with acquired MRI images using custom visualization and image processing software.
3) Analyze and interpret MRI and optical image data, with the assistance of senior lab members.

Graduate student mentor: Boyu Meng

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Project Title: Characterize the Mutation of the DNA Polymerase III Gene and Calculate the Mutation Rate

Faculty Advisor: Professor Daniel Olsen

DNA polymerase III is the primary enzyme involved in prokaryotic DNA replication. Mutations in that gene have been shown to increase the mutation rate in *E.coli*. Recently, according to the genome sequencing datas, we found a mutation in DNA polymerase III of *Clostridium thermocellum*. Coincidently, there are more mutation in that strain than other strains (~70 more). This project is trying to confirm the effect of this mutation in *C. thermocellum*.

Mentor: Ling Tian

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Project Title: Energy System Data Acquisition & Analysis

Faculty Advisor: Professor Amro Farid

In this project, the first year student will be expect to download relevant data from online sources to support several projects in the LIINES (http://engineering.dartmouth.edu/liines/). This data will need to be converted into appropriate format for further analysis. The first year student should have a solid familiarity with a relevant programming language: Matlab, Python, C, C++, Java. The work itself will be conducted in Python.