Available 2020 FYREE projects

Project Title: ***Oxygen Loaded Nanodroplets (OLNDs) for delivering oxygen to hypoxic tumors for better radiation therapy outcomes***

Faculty Advisor: **Geoffrey Luke**

Graduate Student Mentor: Sid Jandhyala

Tumor hypoxia, the state where there is a lack of oxygen present, is one of the limiting factors of the success of radiation therapy in cancer treatment. Oxygen presence during radiation therapy is needed to create double strand DNA breakage, one of the mechanisms in stopping cancer cells from continued proliferation. We have developed nanodroplets that can carry oxygen and be activated to release the oxygen non-invasively using either a laser pulse or a focused ultrasound pulse. This project will involve nanoparticle synthesis, designing experiments to quantify oxygen release, compiling data and statistics.

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Project Title: ***Optimizing the strength of High Entropy Alloys through Thermomechanical Processing***

Faculty Advisor: Ian Baker

Graduate Student Mentor: Rachel Osmundsen

High entropy alloys are a new class of materials that are based on a combination of many elements, typically 5 or more. Most alloys are simply cast. However, it has recently been shown that a combination of cryogenic rolling, followed by warm rolling, can produce a heterogenous microstructure in eutectic $AlCoCrFeNi_{2.1}$. In this project $Fe_{30}Ni_{20}Mn_{35}Al_{15}$ + 6Cr will be subject to a similar cryogenic rolling followed by warm rolling. The resulting microstructure will be analyzed, and the room temperature mechanical properties will be determined.

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Project Title: ***Novel $L1_0$- Structured Permanent Magnets***

Faculty Advisor: Ian Baker

Graduate Student Mentor: Thomas Keller

There is a rapidly growing market for permanent magnets for wind turbines and for both hybrid and electric cars. This market is fulfilled by Rare Earth Magnets. Unfortunately, Rare Earth Magnets are both expensive and their production is associated with severe environmental degradation. MnAl and NiFe are two potential replacement magnets that are both relatively cheap and do not have environmental issues. In this project, the student will examine the microstructure of these materials processed using a number of different methods. The student will learn how to characterize the material using scanning electron microscopy and x-ray diffraction. The magnetic properties will be characterized using a vibrating sample magnetometer. Full training will be given.

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Project Title: ***Applications of micro/nano-scale systems to infectious disease diagnosis***

Faculty Advisor: Professor John Zhang

Graduate Student Mentors: Alison Burklund & Amogha Tadimety

Work on this project will support the development of a rapid micro-scale diagnostic platform for the diagnosis of bloodstream infections. Relevant scientific disciplines to this area of work include nanotechnology, microbiology, and molecular biology. Student will be trained and involved in wet lab work.

More specifically, work on this project will involve laboratory work in support of the following:

1. Nano-sensor device development
    - Device fabrication
    - Chemical functionalization of sensing platform
    - Sensor calibration.
2. Characterization of bacterial pathogens
    - Bacterial culture
    - Bacterial quantification
    - Bacterial growth curves
3. DNA amplification and quantification.
    - PCR
    - NanoString
    - Gels

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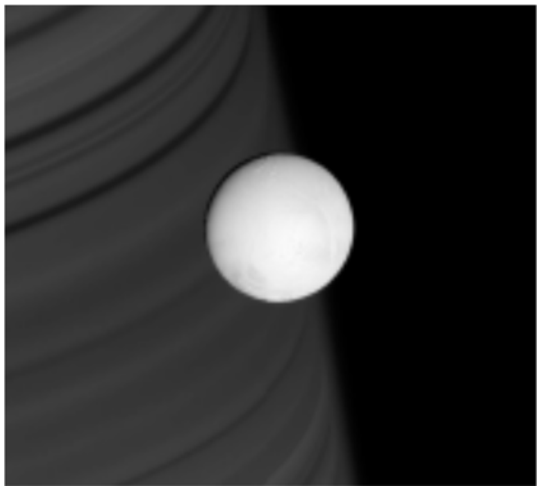
Project Title: ***Salty Friction along Icy Satellite Faults***

Faculty Advisor: Colin Meyer and Erland Schulson

Graduate Student Mentor: Andrii Murdza

The outer solar system may harbor life, and a promising location is Enceladus, a tiny moon of Saturn, due to its observed cryovolcanism and inferred liquid ocean. This rock-cored icy satellite has a liquid ocean covered by a thin outer ice shell. Tidal heating due to Enceladus' orbital eccentricity around Saturn likely maintains the liquid ocean. Faults exist along the south pole and emit geysers of salty ice crystals, i.e. cryovolcanoes. Earthquake motion along these faults generates significant heat and may be the source of the plume material. Prevailing models have treated pure fresh ice, but the ice shell is likely a binary mixture of salts and water. The friction along these faults will depend strongly on the composition of ice shell and whether or not partial melting occurs. In this project, we will conduct laboratory experiments to test the friction between two saline ice blocks as a function of their composition. We will measure the friction coefficient and the temperature decay away from the fault (e.g. Golding et al., 2010, 2013). The results will help to understand the source of the geysers of Enceladus.



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Project title: ***Exosome profiling towards biomarker signature of cancer***

Faculty Advisor: John Zhang

Graduate Student Mentor: John Molinski

Exosomes are small phospholipid vesicles (30-150 nm in diameter) containing large amounts of genetic information which once were thought to be merely cellular waste. Recent research surrounding this field has elucidated their important for cell-to-cell communication, and potential links to tumor progression and metastasis in cancer. For this project the student will first undergo cell culture of various cancer cell lines to isolate cancer-cell derived exosomes. Molecular profiling of these vesicles will be completed using NanoString Technology to examine the molecular make-up. Various cancer cell lines will be profiled in order to build library of key biomarkers which can differentiate between these cancers. Data processing techniques including image processing and machine learning will be applied in hopes of building a classifier which can distinguish between cancer subtypes.

Tools:

- Student will learn cell culture and exosome isolation techniques as well as molecular biology methods to allow for miRNA characterization of exosomes
- Student will learn how to characterize exosomes and elucidate key functions and mechanisms within cancer
- Student will learn how to effectively use advanced data processing tools such as machine learning and image processing
- Students will work closely with clinical lab setting and equipment used within Clinical Genomics laboratory at Dartmouth Hitchcock
- Student will work closely with device development to develop platform technology for diagnostics

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Project title: ***Fundamental and applied aspects of microbial cellulose utilization relevant to production of sustainable biofuels***

Faculty Advisor: Lee Lynd

A variety of projects related to microbial cellulose utilization and biofuels production are possible within the research group of Professor Lee Lynd (http://engineering.dartmouth.edu/lyndlab/). Interested students are encouraged to contact Professor Lynd (Lee.R.Lynd@Dartmouth.edu) or Dr. Evert Holwerda (Evert.K.Holwerda@dartmouth.edu)

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Project title: Metabolic engineering of thermophilic bacteria for sustainable biofuel production

Faculty Advisor: Lee Lynd

A variety of projects related to microbial cellulose utilization and biofuels production are possible within the research group of Professors Lynd (http://engineering.dartmouth.edu/lyndlab/) or Olson (Daniel.G.Olson@dartmouth.edu).

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Project title: ***Characterization of antibody responses to influenza vaccination and infection***

Faculty Advisor: Jiwon Lee

Graduate Student Mentor: Nick Curtis

NOTE: This project is off campus at DHMC

Recently, our understanding of the human immune system has grown substantially over the years. This development has now placed engineers at the forefront of a new and very rapidly growing interdisciplinary field of immunoengineering, which is a research area that aims to apply engineering principles and tools to better comprehend our immune system and develop drugs and vaccines for numerous diseases. My research interests are particularly focused on antibody molecules that our immune system produces to combat various diseases (http://lee-lab.engineering.dartmouth.edu/). The FYREE project will be centered around characterizing antibody molecules that are elicited by influenza vaccination and/or infection, which will guide our efforts to engineer potent therapeutic antibodies or effective vaccination strategies against flu. Please note that our lab is located in Dartmouth-Hitchcock Medical Center in Lebanon

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Project title: ***High precision measurements of low-loss power electronics components***

Faculty Advisor: Charlie Sullivan

Graduate Student Mentor: Andrew Nadler

Power electronics is the application of electronics to process energy for applications such as energy efficiency, renewable energy, and powering other types of electronics hardware. Our lab is developing electromagnetic components for high-frequency power electronics with extremely lower power loss. This requires developing, testing and maintaining equipment and techniques for high-precision high-frequency impedance measurement, including special custom fixtures for interfacing components under test to measurement equipment. The student will learn to make these measurements and maintain and improve the hardware used for them. Variations on the project focus are possible according to skills and interest.

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Project title: ***Fluorescence imaging standards for medical imaging applications***

Faculty Advisor: Brian Pogue

Graduate Student Mentor: Alberto Ruiz

Fluorescence imaging for surgical guidance is a growing field that has an urgent need for fluorescence-imaging standards that enable system characterization and performance monitoring. Over this past summer we have developed the technology to manufacture the first widely available fluorescence standards for medical imaging applications. We are looking for motivated students with strong work ethic and a passion for learning to help us continue the development of these imaging standards. You will be mentored by a PhD graduate student and will learn a wide array of skills including: fluorescence imaging, 3D printing, optics, electronics, design for manufacturing, as well as general laboratory skills. You might also become involved in other laboratory projects during the second term depending on your interests, with a possibility of extending into the summer.