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2019 iSURE PROJECTS

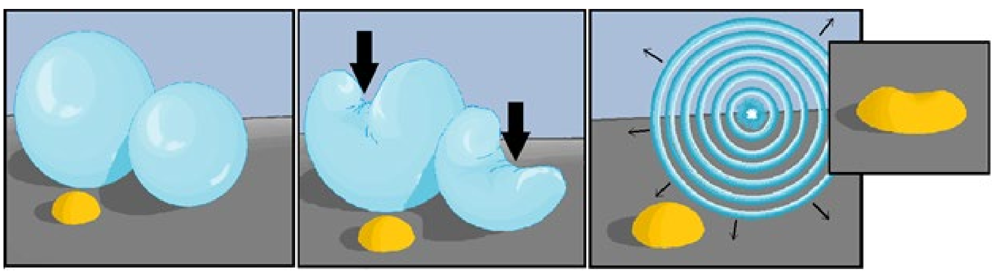
In the online application, applicants can select up to 3 research projects in Question 39, 40, and 41 in rank order.

Department of Aerospace and Mechanical Engineering

1. When Shock-Waves and Nanoparticles Collide

When a bubble rapidly collapses in solution it gives rise to a shock wave that influences its local environment. This so-called cavitation process can be detrimental to nearby metal surfaces as the cyclic stress caused by the repeated exposure to imploding bubbles can cause fatigue-related defects and failures. These same defects, however, can be highly beneficial when occurring in a metal nanostructure. This project, therefore, aims to demonstrate cavitation as a simple and inexpensive means for positively impacting the properties of metal nanoparticles dispersed in solution as well those that are immobilized on solid surfaces. Various aspects of the project include the (i) design, construction, and validation of an apparatus capable of producing collapsing cavitation bubbles, (ii) simulations of the cavitation process and its expected influence on metal nanoparticles, (iii) synthesis of nanoparticles, and (iv) characterization of nanostructures before and after their exposure to cavitation using scanning electron microscopy and transmission electron microscopy. The student working on this project will carry out the experimental aspects of this project by working in close collaboration with members of the Nanomaterial Fabrication Research Lab (Prof. Neretina) while computational work will be carried out at the Center for Shock-Wave Processing of Advanced Reactive Materials (C-SWARM, Prof. Matous).

Skills/Disciplines of Interest: Design, Computation, Fluids, Materials



2. Designing an Optical Stage for the Light-Driven Synthesis of Nanomaterials

This research position will entail the design and implementation of research devices geared towards the development and improvement of nanomaterial manufacturing processes. We are currently pioneering light-driven chemical syntheses for manufacturing nanomaterial-based high-sensitivity chemical and light sensors. With recent successes, we are looking to build an optical stage to increase the capabilities of our process. The optical stage will include mounting options for a variety of optical filters, polarizers, and light sources. Additionally, it will include a spectrometer attachment to monitor the chemical growth process in real time. The objective over the course of the summer will be to design, machine, assemble, and test the device as an improvement to current lab equipment used for light-driven growth processes. The project will involve CAD design, material selection and analysis, and culminate in the machining of the device in the AME machine shop. The undergraduate responsible for this project will work closely with Ph.D. students in the lab.

Skills/Disciplines of Interest: Design, Machining, Materials

(See graph at the next page)

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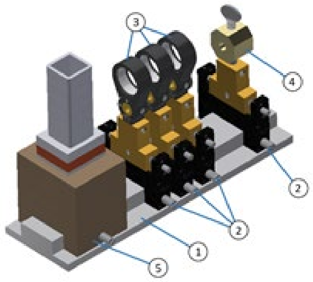
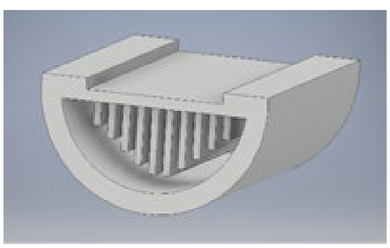


Schematic of an Optical Stage.

3. Designing a Cooling Stage for the Fabrication of Nanomaterials

Crystalline substrates are used to manufacture most of our nanomaterials, to provide a template for nanoparticles to align to. Currently we are able to achieve approximately 70% of oriented nanoparticles on a surface when heating and cooling in a tube furnace. We are looking to create a cooling stage for a tube furnace to cool substrates from underneath during the cooling phase and force a higher percentage of nanoparticles to orient to the substrate. This design will be completed by an undergraduate student with a working knowledge of heat transfer and mechanical design. The project will involve CAD design, material selection and analysis, thermal-fluid simulations in ANSYS and culminate in the machining of the device in the AME machine shop. The student responsible for the design will see the project through the testing phase, and upon successful completion, the device will be implemented into standard laboratory processes to improve the quality of produced nanomaterials. The undergraduate responsible for this project will work closely with Ph.D. students in the lab.

Skills/Disciplines of Interest: Design, Machining, Heat Transfer, Materials


Schematic of a Cooling Stage.

4. Fabrication of Ductile yet Tough Polymer Composites

The purpose of this project is to create a polymer composite material with great ductility yet high tensile strength. It is uncommon for a material to exhibit both of these properties, as high strength is generally accompanied by a low ductility. However, the possible combination of these two properties is desirable as it would allow for a material to undergo significant strain without the risk of failure. This would be especially useful in the area of flexible electronics as it would allow for the development of reusable devices. Therefore, the focus of this project is to develop and optimize a procedure which would allow for the extreme flexibility of polymer film to be combined with the high tensile strength of molecularly aligned polyethylene films.

5. Engineering Biomimetic Materials to Control Stem Cell Morphogenesis

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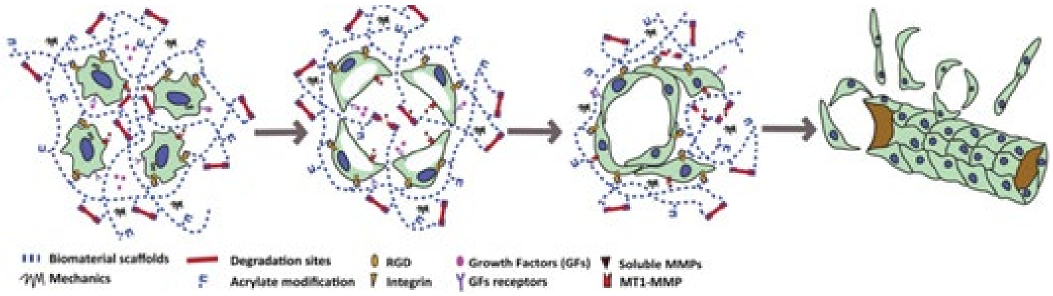
Blood and lymphatic vasculatures are two important components of the tumor microenvironments. Blood vessels supply nutrients important for tumor growth and serve as a conduit for hematogenous tumor spread, while the lymphatic vessels are used by the cancer cells to interact with the immune system as well as for lymphatic tumor metastasis. Consequently, the growth of blood and lymphatic vasculatures surrounding the tumor have been associated with tumor metastases and poor patient prognosis. The objective of this project is to understand what governs the formation of blood and lymphatic vessels from stem cells, how these processes are affected by the tumor microenvironment, and how we can use these insights to develop novel therapies.

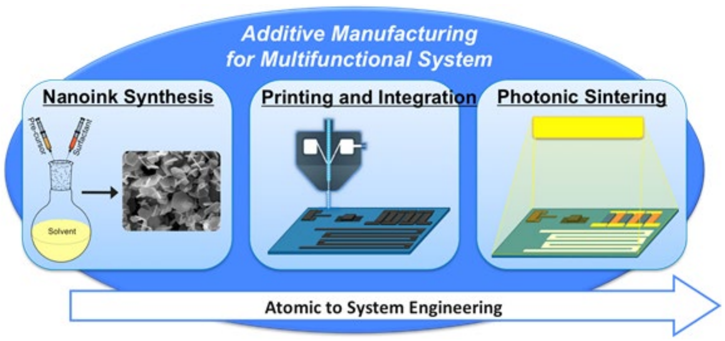
Student involvements: Student will synthesize and characterize biomaterials for in vitro evaluation using stem cell. Student is expected to maintain stem cell culture, study cell-materials interaction using microscopy and molecular biology techniques.

Preferred disciplines: Student with background in mechanical engineering, chemical/bio-engineering, material science, biochemistry is encouraged to apply. Prior lab experience is preferred.



6. Additive Manufacturing of Flexible Devices for Energy Harvesting and Sensing

The goal of this project is to develop an innovative additive printing method to fabricate flexible and multifunctional devices for Energy Harvesting and Sensing.



Research includes flexible film printing followed by a novel pulsed thermal sintering process. We aim to achieve over two-fold increases in thermoelectric figure of merit ZT compared with state-of-the-art flexible films fabricated by printing process, along with 90% cost reductions in printed film based thermoelectric devices vs. bulk devices fabricated by conventional manufacturing. It is notable that the success of this project could result in a disruptive manufacturing approach for large scale, low cost and flexible materials for broad applications beyond thermoelectrics.

This research will have broad impact on materials engineering across length scales and energy conversion and electronics technology. It will: (1) offer fundamental knowledge on the additive processing of colloidal nanocrystals and their structure and property evolutions across length scales, (2) provide a scalable and low-cost manufacturing process to fabricate efficient and flexible materials for broad applications including thermoelectrics, electronics and others, (3) increase energy efficiency and reduce emission through wide implementation of these low-cost and flexible materials, and (4) advance fast growing technology areas of sensors, energy harvesters, and flexible and wearable electronics.

7. Nanoparticle contrast agents for quantitative molecular imaging with CT

Molecular imaging with computed tomography (CT) could offer a single, low-cost and widely available modality for combined molecular and anatomic imaging at high spatiotemporal resolution. Nanoparticles (NPs) comprising high-Z metals, such as Au, have gained recent interest as X-ray contrast agents due to enabling the delivery of a greater mass payload compared with molecular contrast agents used clinically. Core-shell NPs are designed in our laboratory for strong X-ray contrast, biostability, multimodal/multi-agent imaging, and targeted delivery. Concomitant developments in photon-counting spectral CT are also transforming the capabilities of CT by providing quantitative multi-material decomposition. Applications include quantitative molecular imaging of multiple probe/tissue compositions, specific cancer cell populations (e.g., HER2+ breast cancer cells, cancer stem cells, etc.), tumors, associated pathologies (e.g., microcalcifications), drug delivery, and biomaterial degradation using both conventional CT and photon-counting spectral CT. Research opportunities are available for nanoparticle synthesis and characterization, image acquisition, image reconstruction and decomposition, and imaging applications using in vitro and in vivo models, depending on student interest and educational background.

8. Phononic nanoparticles for low-loss, tunable nanophotonics in the mid- and far-IR

Phononic nanoparticles are a new class of optical materials with untapped potential for realizing new mid- and far-infrared detection and sensing nanotechnologies that are functionally analogous to ultraviolet and near-infrared plasmonic nanotechnologies but with even greater sensitivity. Phononic nanotechnologies have potential application in analytical chemistry, biomedicine, environmental science, homeland security, astrophysics, and geology. However, basic scientific knowledge of the governing structure-property relationships for engineering the optical properties of phononic nanoparticles are not well understood or developed. Therefore, students on this project will investigate the optical properties of candidate phononic materials using both modeling and experimental characterization of synthesized nanoparticles. As such, this interdisciplinary research experience will cut across both materials science and optical science.

9. Functional chemical sensor and coating for fluid dynamic applications

This project is an interdisciplinary topic on chemistry and fluid dynamics. The spectrum of this project has three steps: development, characterization, and application. Depending on a topic involved, a research focus for an applicant will be varied within these three steps.

A luminescent chemical sensor and hydrophobic coating are focused on the development step. In characterization step, sensor and coating performances will be related to fluid dynamic quantities, such as static and dynamic changes in pressure and temperature. Application step will be performed using a shock tube.

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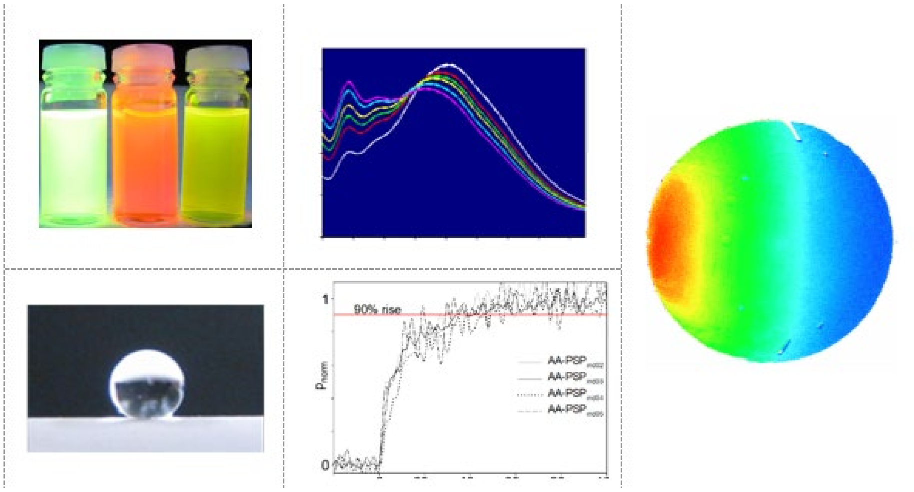

The expected and/or anticipated involvement:
A student will be involved in a chemical sensor and/or coating development, the characterizations of the developed sensor/coating using spectrometer and pressure/temperature-controlled device. The developed senor will be tested in a shock tube.

Preferred discipline, expertise, lab skills: A student from the following discipline is preferred: chemistry, chemical engineering, industrial engineering, mechanical engineering, and aerospace engineering.

Department of Chemical and Biomolecular Engineering

10. Reverse engineering embryonic regeneration

Specification of the correct spatial dimensions of tissues within embryos depends on a complex “symphony” of signals that define cellular identities and properties. When subjected to environmental hazards or genetic defects, embryos exhibit a remarkable ability to repair mistakes in specifying their size, either by re-specification of cell identity or the elimination of cells through cell death (apoptosis). Understanding the mechanism of tissue size control is particularly challenging due to the interconnected and complex nature of cell signaling and tissue mechanics. A high degree of nonlinearity in the system occurs due to feedback between cell- and tissue-level processes. Previous studies documenting pattern repair in the embryonic epidermis have principally focused on phenotypic data and tissue-level analysis. Very little is known about the dynamics at the cellular level. The objective of this project is to bridge this knowledge gap by performing live imaging studies at cellular resolution of the embryonic epidermis to track the dynamics of cell membranes during proliferation, apoptosis and cell movement. This project is multi-faceted and includes the design and testing of novel microfluidic organ-on-chips, live-imaging and imaging analysis and cell-based computational models of tissue mechanics. Experiments are compared to computational simulation predictions to identify novel mechanisms of tissue morphogenesis and regeneration.

Prerequisite Skills: Basic biology background and interest in experiments. Image processing/computational work requires previous MATLAB or other programming experience.

11. Investigating how calcium signaling impacts organ and tumor growth

Cells exhibit impaired calcium (Ca2+) signaling in many diseases including skin diseases, Alzheimer’s, and metastatic cancer. The cell’s internal “computer” uses calcium ions as messengers to help calculate its response to environmental stimuli. This requires regulation of Ca2+ concentrations in cells to coordinate cellular processes. However, much remains

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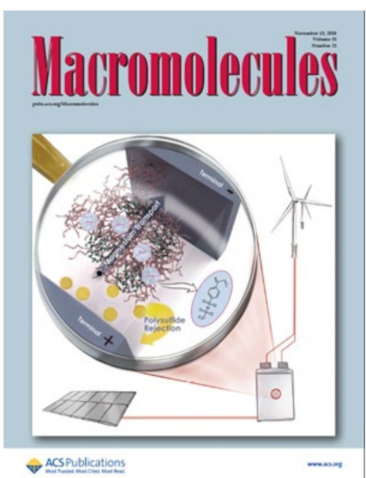
unknown about the functions of time-varying Ca2+ signals in developing or regenerating organs. Our research program seeks to discover the biochemical and mechanical basis of integrative cell communication mediated by Ca2+ signaling. In this team-based project, students contribute toward a high content, genomic screen identifying and characterizing new calcium-related genes that impact organ growth, regeneration or tumor growth. Students gain experience in functional genomics and quantitative image processing.

12. Polymers in Next-Generation Rechargeable Batteries

Advanced energy storage devices are sought after for use in electric vehicles and in conjunction with solar farms and wind farms for load leveling of the electric grid. To meet the cost and performance requirements of these applications, new battery chemistries are under development. Many of these battery designs incorporate functional organic components, such as polymer electrolytes, polymer coatings at the electrode-electrolyte interface, and polymer binders in the electrodes. In this project, the student will synthesize and characterize new organic materials for applications in rechargeable lithium, magnesium, or aluminum batteries. Multiple opportunities are available. Educational backgrounds in chemical engineering, chemistry, polymer science or engineering, and materials science or engineering are preferred.
Suggested readings:
1. H. O. Ford, L. C. Merrill, P. He, S. P. Upadhyay, and J. L. Schaefer, "Cross-Linked Ionomer Gel Separators for Polysulfide Shuttle Mitigation in Magnesium–Sulfur Batteries: Elucidation of Structure–Property Relationships," Macromolecules, 2018. (Cover) https://pubs.acs.org/doi/10.1021/acs.macromol.8b01717

2. C. T. Elmore, M. E. Seidler, H. O. Ford, L. C. Merrill, S. P. Upadhyay, W. F. Schneider, and J. L. Schaefer, "Ion Transport in Solvent-Free, Crosslinked, Single-Ion Conducting Polymer Electrolytes for Post-Lithium Ion Batteries," Batteries, 4(2), 28, 2018. (Special Issue: Recent Advances in Post-Lithium Ion Batteries)
https://doi.org/10.3390/batteries4020028



13. Intermetallic hydrogen separation membranes: towards unprecedented permeability and stability

Intermetallic compounds are solids composed of at least two metals that form an atomically-ordered crystal structure with well-defined stoichiometry, in contrast to randomly disordered alloys (see Figure 1). The ordered crystal structure of intermetallic compounds results in some unique properties that have been exploited in several fields, including building materials and catalysis. One promising application of intermetallic compounds, which has received little attention thus far, is for hydrogen separation membranes. We hypothesize that intermetallic membranes will exhibit greater permeability and stability than the current state-of-the-art disordered alloy membranes. This is important because the biggest obstacle preventing commercialization of metal-alloy membranes for industrial hydrogen separation applications is their poor chemical stability in the presence of contaminating gases that are common in hydrogen-containing gas streams, such as CO, propylene, and H2S.

The goals of this project are to determine whether intermetallic membranes are more stable than metal-alloy membranes in reactive gas mixtures, and to determine the underlying mechanisms that control their stability. To achieve these goals, the student will work closely with a graduate student to (1) prepare a series of palladium-based intermetallic membranes (PdCu, PdAu, PdRh, and PdIn) using electroless deposition, (2) measure hydrogen permeation rates across the membranes in pure hydrogen and in the presence of CO, propylene, and H2S in a membrane testing apparatus, and (3) characterize the used membranes using a variety of techniques, including temperature programmed oxidation, x-ray photoelectron spectroscopy, and scanning electron microscopy. When successful, this project will lead to new strategies for designing hydrogen separation membranes with unprecedented permeability and stability, which will reduce the costs and environmental impact of industrial chemical processes. Laboratory experience (e.g. gas chromatography, mass spectrometry) is preferred though not required.

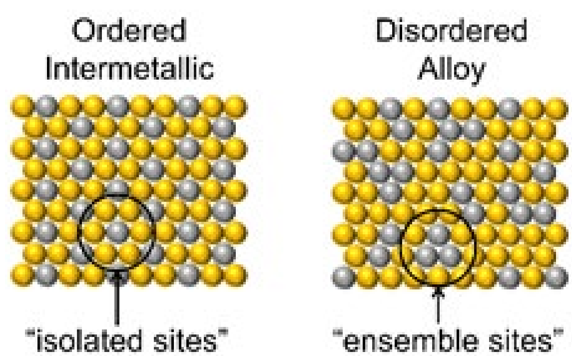


Figure 1. Ball model of ordered intermetallic compounds (left), with the different elements in well-defined positions within the lattice, and randomly disordered alloys (right), where the different elements are positioned randomly throughout the lattice.

14. Title N/A

The Notre Dame Tissue mechanics laboratory studies the mechanical properties of skeletal tissues to better understand their fitness for function, and to determine how mechanical stimuli affect cellular response. Two current studies are related to osteonecrosis of the jaw and the role of mechanics in metastatic engraftment of tumor cells in bone marrow.

Bone metastasis: Many cancers metastasize (migrate, attach, and grow) to bone marrow. The phenomenon has been attributed to the marrow providing "fertile soil" for cancer cells to grow in. This disease is problematic, because it is difficult to detect the metastasis inside the bone, where it is difficult to see, even using x-ray or MRI methods. Typically the first detection occurs when the patient experiences pain, or serious degeneration of the bone is detected. Our group is developing methods to study metastasis in human bone samples collected from our collaborator Luke Nystrom at Loyola University. We intend to study how mechanical stimuli might affect the ability of the tumor to attach and grow in bone marrow.

*Special Project: PODEMOS

15. Special Project: For directly nominated students only. Please do not select this project unless told to do so.

Department of Biological Sciences

16. The Evasion of Detachment-Induced Metabolic Defects in Breast Cancer

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Metastasis, the spread of cancer from the site of the primary tumor to distant locations in the body, is responsible for 90% of cancer deaths, yet the molecular mechanisms governing this extraordinarily complicated process remain poorly understood. It has become clear that an important barrier to metastasis is the induction of anoikis, a cell death process that is induced when epithelial cells lose attachment to the extracellular matrix (ECM). During the course of tumor progression, cancer cells will typically acquire resistance to anoikis which can facilitate the spread of these cells to distant sites. In addition to the induction of the anoikis program, we have discovered that ECM-detached cells are metabolically compromised in a fashion that prohibits their survival. Thus, ECM-detached cancer cells need to inhibit anoikis and rectify their metabolic deficiencies in order to survive. Despite its importance, there is a striking lack of information on how cancer cells successfully evade the induction of anoikis and overcome metabolic deficiencies. The overarching goal of our lab is to examine and characterize the biological mechanisms that permit cancer cell survival in the absence of ECM attachment. It is our hope that a better understanding of these mechanisms at the molecular level will reveal novel chemotherapeutic targets or approaches that may serve to compromise the survival of ECM-detached cancer cells and thus prevent tumors from successfully metastasizing.

17. Title N/A

The goal of this lab is to identify novel therapeutic targets and realize innovative combination therapy strategies to benefit cancer patients, through mechanistic investigation, functional genomics, mouse modeling and therapeutics development (most recent publications: Wang*, Lu*, et al. Cancer Discovery, 2016; Lu et al. Nature, 2017; Feng…Lu, PNAS 2018). Located at the Department of Biological Sciences at the University of Notre Dame and affiliated with Indiana University Simon Cancer Center, the Lu lab is investigating one or more of following areas: (1) Cellular, biochemical or metabolic mechanism of cancer progression and metastasis, especially for but not limited to prostate cancer and breast cancer. (2) Tumor microenvironment, tumor immunology and/or cancer immunotherapy (including combination immunotherapy). (3) Computational cancer bioinformatics, integrated analysis of oncogenomics and/or proteomics data and functional validation in cell culture and animal models. A range of available projects includes: (1) Mechanistic understanding of immunosuppressive myeloid cells; (2) Metabolic reprogramming to enhance cancer immunotherapy; (3) Molecular mechanism of prostate cancer bone metastasis; (4) Anti-metastasis and pro-metastasis functions of neutrophil subsets in breast cancer; (5) Gene identification and therapy development to treat castration-resistant prostate cancer or triple negative breast cancer.

18. Understanding Glandular Alterations and Cell Invasion in Cancer

The hosting professor in the Department of Biological Sciences at Notre Dame, works at the intersection of two exciting disciplines in the life sciences, cell biology and oncology. We seek to determine the impact of specific molecular alterations in the initiation and progression of localized and invasive cancers with the ultimate goal of extending these findings to the development of new diagnostic and therapeutic platforms.

Current projects are aimed at understanding:

(1) The cellular basis of epithelial glandular disruption as seen during early stages of breast cancer. The roles of oncogenes and cancer-associated proteins are being investigated.

(2) Tumor cell invasion, which is the ability of tumor cells to move through the extracellular matrix. In this context, we are investigating the mechanisms that govern the formation of tumor-derived exosomes and microvesicles. The paracrine properties of signaling molecules and microRNAs contained in these vesicles, on the pre-metastatic niche will be investigated.

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Students will employ cellular and 3D organotypic model systems in their studies. They will use molecular biology techniques (such as generating and using CRISPR constructs), to study the function of individual genes.

Skills: Cell Biology, Molecular Biology, Imaging, Biochemistry

Through this research experience, students will learn to: Ask a clear research question and formulate a hypothesis; Design experiments, record data and interpret results; think like a scientist, by learning and applying problem-solving skills; Work collaboratively with other researchers

19. Title N/A

Exploring the co-evolution between tumor cells and tumor microenvironment is the central theme of my laboratory. Using the state-of-art single cell level sequencing and multiphoton based intravital imaging, we aim to reveal the in-depth molecular mechanisms of tissue dynamics during the early tumor development, drug resistance and metastasis colonization. Base on our pre-clinical findings, we also conduct pre-clinical testing of novel combinatorial therapies to overcome drug resistance and prevent tumor metastasis.

20. Title N/A

Over the past 20 years, it has become evident that breast cancer is a heterogeneous disease, with a vast number of genetic and epigenetic alterations resulting in differential responses to chemotherapeutic and targeted therapies. Our lab is focused on the Adenomatous Polyposis Coli (APC) tumor suppressor. To better understand the molecular basis of breast cancer and identify novel therapeutic approaches, the Prosperi laboratory will investigate how APC loss mediates breast tumor development by studying multiple facets of tumor biology.

21. Title N/A

Blood is composed of several different cell types, which all develop from a common precursor, the hematopoietic stem cell (HSC). The HSC differentiates into progenitor cells, which will give rise to mature red and white (immune) cells. In leukemias the differentiation of stem and/or progenitors cells is blocked and there is an accumulation of these immature non-functional cells in the blood. This hosting faculty is a professor in immunology and microbiology investigates how genes are turned on and off during the development of blood cells and how this normal process becomes disrupted in leukemia cells. To pursue the goal of understanding how regulation of gene expression directs normal and abnormal blood development, the professor's laboratory uses mouse models.

Department of Electrical Engineering

22. Probing Piezo- and Ferro- electric with a Nanoprobe

The phenomenon of ferroelectricity (FE) – the ability of a material to have a spontaneous electric polarization that can be reversed by the application of an external electric field – holds a promise to create multifunctional materials and devices for a variety of potential applications. Piezoelectricity (PE) – the ability of material to exert mechanical force on application of electric field – is a closely related phenomenon: all FE materials are required by symmetry considerations to be also PE. Both FE and PE have recently attracted a lot of attention in the electronic industry due to enormous progress in downscaling that made it possible to utilize these effects on the nanoscale. But how do we know that these tiny objects under your microscope are piezo- or ferro- electrics? This project is aimed at answering this question. We are going to add an extra capability to our existing nanoscale tool, a standard high resolution Atomic Force Microscope Agilent 5100 (Fig a). In this project, a Piezoresponsive Force Microscope will be created and applied for characterization of PE and FE ultra thin films fabricated at Notre Dame. Projects in the group of Professor Alexei Orlov study the new types of ultra-low power logic circuits that require on-chip “power distribution centers” – piezoelectric power clocks (Fig b), and aim to produce and study high quality nanoscale FE materials by solution combustion synthesis. Over the course of this project you will learn first hand how an AFM works, including all the bolts and nuts, control circuitry, feedback loops, and lock-in amplifier techniques, and get the feel for angstrom distances. You will be making and using conductive tips and figure out how to use the phase of modulating signals to obtain information about FE and PE materials. By the end of this project we will be able to characterize PE and FE materials and create beautiful 3D images of their electrical response. Students will work on the building of the system, tip and sample fabrication, and, of course, actual imaging using the system. Experience with code writing for control programs will be very useful. Physics, Electrical Engineering, Chemical Engineering, and Computer Science students are preferred. Some knowledge of programming, data analysis and soldering is helpful.

23. Design and analysis of high-performance compound semiconductor devices.

Numerical simulation and optimization of high-performance III-V compound semiconductor devices will be performed. Specific devices include photovoltaics, high-speed transistors, high voltage diodes and transistors, and novel devices for low-power digital and signal processing.

24. Fabrication process development for high-performance devices.

The student will contribute to development of fabrication processes for high-performance III-V compound semiconductor devices, working in Notre Dame’s cleanroom facility. Specific devices include high voltage diodes and transistors, as well as RF/microwave devices.

25. Energy recovery for ultra-low energy computation

Anyone who owns a laptop knows that power dissipation and the associated heat are a problem for the microelectronics industry. As electronic devices scale down in size, they use less power (and hence energy), but is there a lower limit to the energy that must be dissipated by each device? Recent experimental measurements have demonstrated our ability to measure energy dissipation in the range of a ~15 yJ (1 yJ is 10-24 J), and we are building CMOS circuits to operate in this range. Projects in this group will explore the limits of ultra-low power computing, and designing, building and measuring circuits that test these limits, and clock circuits that can recycle the energy used in computation. The projects will include building circuits and amplifiers for energy measurements of the CMOS circuits as well as the actual measurements. The project will also include the design of the next generation of the adiabatic circuits. A student involved in these projects will gain experience in programming, CMOS design, and device measurement techniques. Students will work on the construction of circuits, writing control programs, and making measurements. Students in electrical engineering, physics, and computer science students are preferred. Some knowledge of programming and soldering is helpful.

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26. Measuring properties of nano magnets with laser

Nanometer scale magnetic elements belong to the rapidly growing new area in research with many potential "beyond CMOS" applications featuring low-power consumption and small footprints. How do we study the properties of tiny little magnets? One of the very promising and capable techniques to do this is to subject them to electromagnetic irradiation in form of laser beam and study the change in polarization of reflected light. Light from the nanomagnets will be reflected differently for different orientations of nanomagnets due to the so called magneto-optic Kerr effect. This change is then detected electrically by converting light into electrical signal. In the conversion process signal needs to be filtered from various ambient noise sources using sophisticated signal processing. This project is aimed at building a a high resolution and high-speed Kerr microscope and applied for characterization of nanomagnets fabricated at Notre Dame. Over the course of this project you will learn "bolts and nuts" of Kerr microscopy, including optical tools, laser control circuitry, lock-in amplifier and averaging techniques, and get the feel for magnetism of nanoscaled elements. Physics, Electrical Engineering, Chemical Engineering, and Computer Science students are preferred. Some knowledge of programming, data analysis and soldering is helpful.

Department of Psychology

27. Statistical Social Network Analysis for Behavioral Research

Network analysis is becoming a popular interdisciplinary research topic in computer science, statistics, sociology, political science and psychology. In our Lab for Big Data Methodology, we study the covariates that are related to the formation and development of networks, such as a friendship network, as well as how a network is related to behavioral outcomes such as smoking and alcohol use. We develop new models and software using both Bayesian and Frequentist methods for better network data analysis. We welcome students with strong background in any of the areas - statistics, mathematics, or computer science - to join our lab.

Department of Chemistry and Biochemistry

28. Title N/A

The Webber Lab is interested in new, modular routes to deliver drugs to sites of need. By using high-affinity interactions, nanoparticle drug carriers and hydrogel depots can be designed to facilitate drug localization and controlled release in combating cancer. These approaches are intended to be "mix-and-match" where a series of drugs could be combined with different delivery platforms to enable patient- and disease-specific therapeutic intervention.

29. Title N/A

The overall research focus is in the area of molecular mechanisms of metastasis in ovarian and oral cancers. Understanding the molecular mechanisms by which tumor cells orchestrate multiple micro-environmental cues to regulate the expression and activity of metastasis-associated proteinases is the major focus of the laboratory.

30. Title N/A

The Schwarz lab uses transgenic mice, three dimensional cell culture, in vivo tumor, and lung developmental models to determine mechanisms by which the vasculature regulates cancer progression and alveolar formation.

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Our main interests are the role that the anti-angiogenic mediator Endothelial Monocyte Activating Polypeptide II (EMAP II, also known as AIMP-1, Scye-1, and p43) has in lung and tumor development. On the cell surface, EMAP II undergoes proteolytic cleavage to generate an extracellular »22-kDa C-terminal peptide that functions as an anti-angiogenic protein through inhibition of endothelial cell adhesion to fibronectin, blockade of fibronectin matrix assembly via a5b1 integrin, and interference with vascular endothelial growth factor (VEGF) induced pro-angiogenic signaling.

31. Title N/A

The research is grounded in understanding the mechanisms of cancer progression and in identifying therapies that prevent or reverse cancer in patients. The professor develops and uses integrated mouse models and genome-wide association studies to understand the contributions of specific genes in vivo at multiple points in cancer progression, spanning from normal mammary development to tumor progression and metastasis and chemotherapy resistance.

The professor uses a combination of mouse and human xenograft in vivo models, cell culture and organotypic cultures, and systems biology approaches to study biomarkers of epithelial plasticity and to determine how these genes drive aberrations in fundamental biological processes, e.g., differentiation state, progenitor cell maintenance, metabolism, and genomic integrity.

The professor also is identifying targeted therapies appropriate for personalized treatment of cancer patients based on these biomarkers.

Department of Computer Science and Engineering

32. Taming Science Literature with AI Technology

In this project, we will study full-text and tabular-data analysis of scholarly publications. There are two research tasks: One is to turn the full text into a scientific knowledge graph where scientific concepts, concepts attributes, concept's relations, scientific facts, and fact's conditions are extracted using state-of-the-art natural language processing techniques. The other is to build an experimental evidence database that integrates information from all the tables in the publication PDFs. A preliminary study achieved a success in last year's iSURE program. If both tasks would be completed, the newly developed artificially intelligent tools would automate how hypotheses are generated and validated. Students are expected to have (1) professional programming skills (including algorithms and data structures) on at least one programming language among C++, Java, and Python, (2) fundamental knowledge in the field of data mining and machine learning, and (3) good English reading and writing.

33. Visual Data Analytics

This project is looking for students with programming in C/C++, OpenGL/GLSL/WebGL, or D3.js who will assist in the design and implementation of visualization and analytics programs for analyzing and understanding a wide variety of data and models (e.g., simulation data, deep learning models), and for teaching and learning essential visualization concepts and techniques.

Department of Physics

Note: To ensure fairness of the admissions process, applicants should not contact faculty during the application phase and may be disqualified for this reason. Please contact globalprograms@nd.edu for any questions.

34. Control Theory of Ecosystems

Evolutionary control has a long history starting with agricultural domestication and culminating into contemporary genome editing technologies. However, this history is largely limited to controlling individual species. We view ecological and biosocial networks as the new circuit board, and evolution as a manufacturing process capable of fabricating *eco-machines.* Evolutionary control promises terraforming worlds, degrading pollution, and manufacturing astonishing compounds.

This is a theoretical / computational project that aims to establish an analytical framework to steer the evolution of multiple populations that strongly interact with one other. Specifically, we wish to theoretically understand how to manipulate the connectivity of networks representing ecological or biosocial webs, which range from bacterial biofilms to rainforests. The project particularly focuses on ecological control under noisy or incomplete knowledge of the existing interactions and population levels of species.

(See graph on the next page)

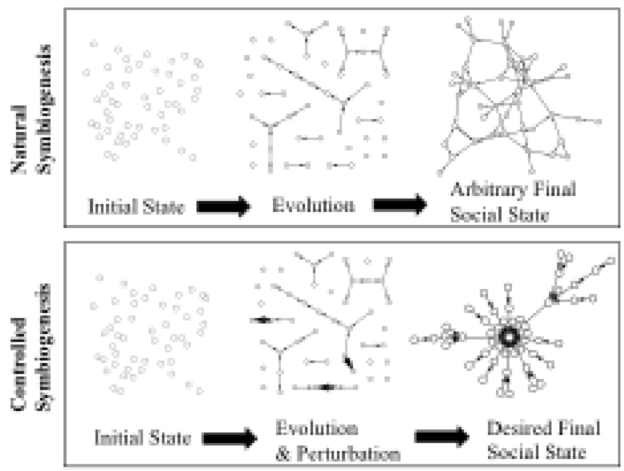

Figure 1. Schematics of Evolutionary Control. Our goal is to develop a theory that will allow manipulating biosocial evolution by topological and parametric perturbations. The fundamental object we aim to control is not populations, but the structure of interactions.

Benefit of the work to ND-Nano:

1.The student will generate preliminary work which will be used to write a proposal.

2. The proposed project involves the use of control theory, common in many branches of engineering, in the non-conventional context of ecology. This will illustrate the students and also the cohort the versatility of a good mathematical background.

3. The project will greatly add to the diversity of subjects funded. This way the cohort will be working on a diverse array of topics, and synergize and inspire each other.

Student requirements: The project requires mathematical and computational dexterity. Applicants are expected to be familiar with matlab, differential equations / dynamic systems, and linear algebra.

Link to Publication:

https://www3.nd.edu/~dvural/papers/uppal,%20vural,%20shear.pdf
https://www3.nd.edu/~dvural/papers/morsky%20vural.pdf
https://arxiv.org/pdf/1810.06620

Note: To ensure fairness of the admissions process, applicants should not contact faculty during the application phase and may be disqualified for this reason. Please contact globalprograms@nd.edu for any questions.

#35 and #36 are for students who can participate in the 6/2 - 7/27 time frame ONLY.

Center for Research Computing

35. Data Intensive Scientific Computing-DISC

Students in the DISC program will learn how to use high performance computing and big data technologies to enable new discoveries in computer science, physics, and biology. We work on grand challenge problems, like discovering new galaxies in digital imagery, discovering new fundamental particles, using gene sequencing to understand disease, predicting the effect of new drugs using computational modeling, and many more. To do this, we harness large scale computing clusters and big data systems composed of hundreds or thousands of machines, all working together in concert. To make advances in these areas, our goal is to train the next generation of scholars to be adept in both scientific domains and advanced computing techniques.

36. Computational Social Science REU

This Computational Social Science project is a program where ten students will work collaboratively with expert mentors and select from a wide variety of computational social science projects at the University of Notre Dame. Computational social science as an approach to analyzing the social world is has been growing rapidly. An increasing number of social interactions are taking place in the virtual world, using social media, mobile phones, and other electronic means. The digital traces of such interactions and the greater availability and detail of CSS data sets (e.g. surveys, census data, historical records) yield and exponential growth in data available for analysis. New cyberinfrastructure tools and methodologies for data analytics are needed to capitalize on this resource and enhance American economic competitiveness. This REU training environment will develop multidisciplinary social scientists with the appropriate expertise to answer the computational social science data growth challenges and opportunities.