WPI-NSF REU in Bioengineering

National Science Foundation Research Experiences for Undergraduates (NSF REU)

Integrated Bioengineering Research, Education, and Outreach Opportunities for Females and Underrepresented Minorities at Worcester Polytechnic Institute (WPI)

Proposed projects for summer 2015*

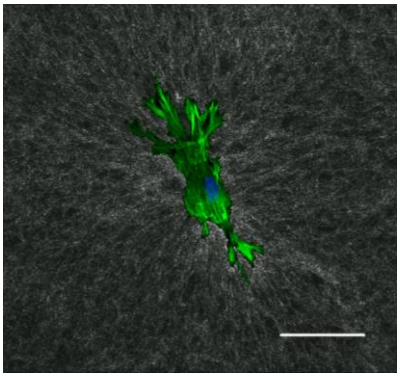
*by the time the summer rolls around, the projects may change somewhat

---

Using mechanical cues to develop functional engineered tissues

Advisor: Prof. Kristen L. Billiar, Biomedical Engineering Department
Tissue Mechanics and Mechanobiology Laboratory

Tissue engineering is a promising new approach for creating living replacements for soft connective tissues (e.g., skin, tendons, and blood vessels). A thorough understanding of the factors that stimulate and guide tissue development is necessary for engineering viable tissues; however, many of the processes involved in tissue growth are unclear. Our goal is to decipher how the cells within tissues sense and respond to *their mechanical environment*. Students involved will culture cells in 2D and 3D bioreactor systems which expose the cells to controlled mechanical stimuli such as stiffness and stretch and then analyze their responses. Due to the broad nature of this project, two REU students with different but symbiotic skills will work together (e.g., one student interested in biomechanics and one focused on cell and tissue engineering). Experience with cell culture, Labview, and CAD/machining is desired but not essential.



Medical Robotics

Advisor: Professor Greg Fischer, Mechanical Engineering Department

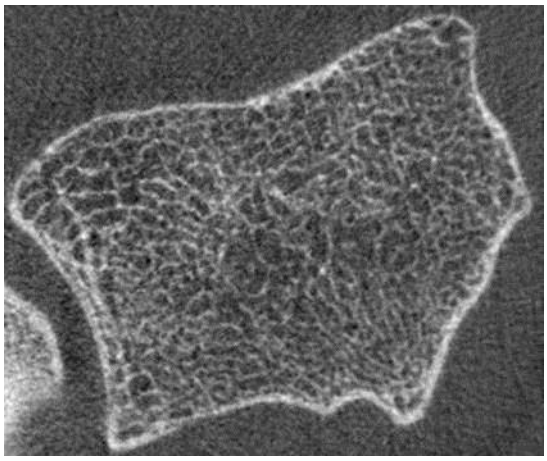
Medical robotics and computer integrated surgery is a multi-disciplinary field dedicated to providing as much information to a surgeon during a procedure and using that information in a way to produce better outcomes. The focus of the research in the WPI AIM Lab is on medical robotics - the link that allows us to enable "closed loop medicine" by using real time feedback to guide a surgical procedure. In order to take the most advantage of robots in surgery, we work towards integrating real-time medical imaging with the interventional procedure. Key research areas include: image-guided interventions, MRI-compatible robotics, robot-assisted surgery, and assistive robotics.

WPI-NSF REU in Bioengineering

Bone Remodeling

Advisor: Prof. Karen Troy, Biomedical Engineering Department

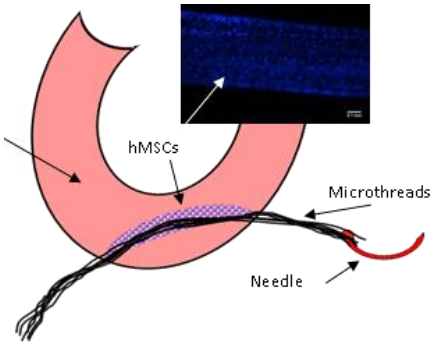
Physical activity produces mechanical strains within bone that are known to be osteogenic. Strain rate and strain magnitude are two factors that appear to be important in this process. Many investigators have shown an association between physical activity history and improved bone mass and structure within the lower extremities. Our laboratory uses an in vivo upper extremity mechanical loading model in which volunteers produce strains within the distal radius by leaning onto the palm of the hand. We have shown that this activity produces measurable changes to the radii of adult women, and are currently using the model to explore the link between mechanical loading signals and bone adaptation. Since bone adaptation is thought to be an "error signal" driven process, the more novel or unfamiliar a strain-producing activity, the larger the resulting adaptation (in theory). Thus, we might expect that women who habitually engage in a high level of strain-producing activity with their arms and hands would experience less change to their bone as a result of our experimental leaning task. *The goal of this project is to determine the relationship between past physical activity and bone microstructural parameters in the dominant and non-dominant forearms of healthy women.*



Optimization of stem cell seeding

Advisor: Prof. Glenn R. Gaudette, Biomedical Engineering Department

Myocardial Regeneration Lab



Cardiovascular disease is the predominant cause of death in the United States each year. A heart attack, or myocardial infarction (MI), is caused by cardiac ischemia, and results in cellular death and loss in cardiac function. Stem cell therapy is a promising approach to improve cardiac function after an MI, however current stem cell delivery methods are inefficient. Previously, the use of fibrin biological sutures to deliver human mesenchymal stem cells (hMSC's) to the heart has been shown to enhance cellular delivery compared to current methods of delivery. However, attachment rates are low initially and many of the cells are removed by shear forces when the suture is sewn into the myocardium. A possible method to increase cellular attachment and the strength of attachment to the fibrin sutures requires using different extracellular protein coatings. The first goal of this project is to determine if adding a particular extracellular protein to the surface of the fibrin sutures at different concentrations increases the amount of cells that attach to the suture. The second goal of the project is to determine if the extracellular protein increases the strength of cellular attachment through shear force testing. The focus a second, related project will be to create a system that can mechanically stretch the fibrin microthreads. Mechanical stimulation of seeded microthreads may lead to cellular alignment and improved cellular functionalities, which could enhance cellular engraftment and improve regeneration in vivo.

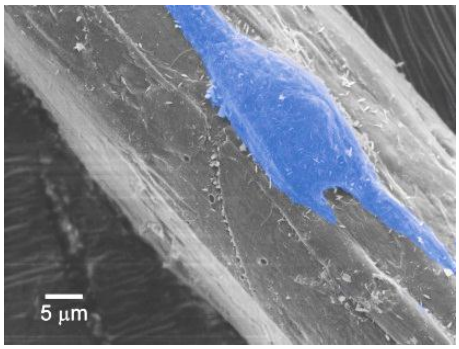
WPI-NSF REU in Bioengineering

Design of a fibrin scaffold with a microfluidics-based vascular network; and Design of a biaxially aligned fibrin scaffold for tissue regeneration

Advisor: Professor George Pins, Department of Biomedical Engineering

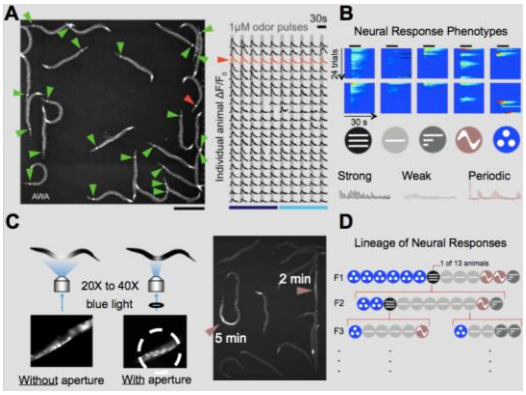
Microfluidics is a platform technology that enables the manipulation of fluids on a size scale that is similar to the microvascular network observed in tissues and organs. As the design and development of engineered tissues and organs advances, there is a growing need to integrate microvascular networks into these systems. (Inamdar. Current Opinions in Biotechnol., 22: 681) For example, engineered skin and cardiovascular tissues require microvascular networks to perfuse cells with nutrients, remove metabolites and efficiently deliver therapeutic proteins.

Our laboratory has developed technologies to create biopolymer microfibers, threads and membranes. The 3D structural, morphological and mechanical properties and cellular microniches make these scaffolds comparable to the structural building blocks of native tissues and organs. As our laboratory exploits these technologies for the modular design of larger scale, complex tissues and organs it will be essential to integrate microvascular networks into the scaffolds to perfuse the local cellular microenvironments. The objective of this REU is to develop a bilayered microfluidic network that can be integrated into the development of a complex tissue structure such as bioengineered skin or myocardium.



(Cornwell, **Tissue Eng.**, 16: 3669)

A separate project will be to develop an automated system to create a biaxially aligned scaffold that can be integrated into the design of a complex engineered tissue. Biopolymer microthreads are discrete fibrous scaffold elements with structural, mechanical and biochemical cues that mimic the fundamental building blocks of native, fibrous tissue constructs. These microthreads have been designed as scaffolding elements to promote tendon, ligament, peripheral nerve and skeletal muscle regeneration. We hypothesize that these microthreads can be designed to create the individual functional tissue components of a biaxially aligned, tissue engineered scaffold with the structural and functional properties of native tissue.



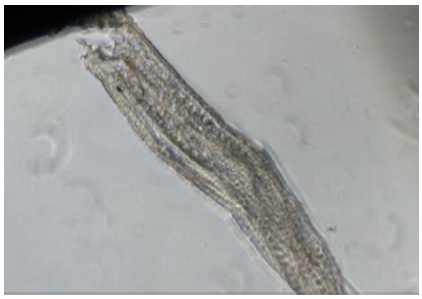
Rapid chemical screening of model organisms

Advisor: Professor Dirk Albrecht, Department of Biomedical Engineering

We are developing a platform for rapid in vivo chemical screening in a nematode model of neurological disorders. Sample projects include: robotic delivery from multiwell chemical libraries to the microfluidic neural imaging system; image processing for automated measurement of fluorescent calcium signals; genetic engineering of animals for parallel mapping of neuropeptide-receptor interactions.

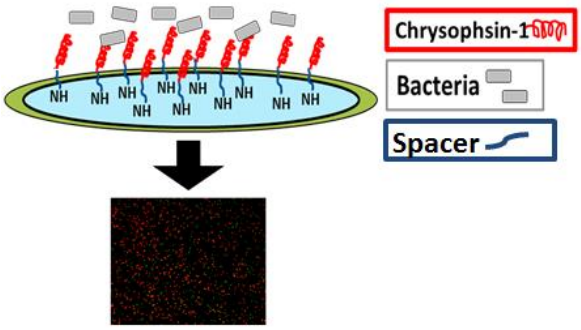
WPI-NSF REU in Bioengineering

Tissue Engineered Skeletal Muscle Using Primary Adult Human Cells
Advisor: Professor Raymond L. Page, Biomedical Engineering Department
Soft Tissue Engineering and Regeneration Laboratory



Tissue engineering by cell assembly is a promising new approach for creating living mimetic constructs of human skeletal muscle function to create models of skeletal muscle disease or to study skeletal muscle development and maturation. A thorough understanding of the factors that stimulate and guide tissue development is necessary for engineering viable tissues; however, many of processes involved in tissue formation, growth and maturation are unclear. Our goal is to determine factors needed to amplify primary adult muscle stem cells (satellite cells) while maintaining their potential to create functional skeletal muscle tissue. We are also interested in the role of extracellular matrix producing connective tissue fibroblasts in the formation of functional skeletal muscle. Due to the broad and complex nature of this project, two REU students with different but symbiotic skills will work together (e.g., one student interested in biomechanics and one focused on cell cultivation and tissue engineering). Experience with cell culture and CAD/machining is desired but not essential.

Fighting Food-Borne Pathogens with Antimicrobial Peptides
Advisor: Prof. Terri Camesano, Department of Chemical Engineering
Bacterial Adhesion and Interaction Forces Laboratory



Antimicrobial peptides (AMPs) are a class of small molecules, part of the innate immune system of many species, which have vast potential as therapeutic agents. These peptides can be used for a variety of applications including antibacterial coatings due to their broad spectrum activity and low likelihood of resistance. These peptides can be used to improve patient outcomes. Two of the major areas we focus on are orthopedic and catheter applications. Biocompatibility and stability is extremely important for these applications due to the long term usage of the devices. The goal of this project is to determine the biocompatibility and stability of our novel antimicrobial coatings.