SCHOOL OF BIOMEDICAL ENGINEERING
COLORADO STATE UNIVERSITY

2020 Biomedical Engineering Senior Design Project Descriptions

JUDGING TEAM 1: Ellen Brennan-Pierce, Team Lead/Moderator

Smart Well-Plate System (Tom Chen)

This project involves development of hardware, software, and mechanical parts needed for a complete smart well-plate system. The smart well- plate system consists of an array of wells, an array of sensors in each well, a built-in electronic circuit board supporting all sensors in each well, a smart-phone based user interface, and all the mechanical parts supporting the operation of the system. The number of wells and the arrangement of the wells are fully compatible with existing commercial well-plate format. Therefore, all existing infrastructure that support experiments using well-plates can be used for the smart well-plate systems. The development the senior design team to be engaged in includes sensor design and manufacturing for wells, design, manufacturing, and testing of the built-in electronic circuit board, design and testing of the user interface. Technical skills in wet experiments, electronic circuit design, mechanical design, fluid dynamics simulations, and system integration are needed for the project. **Team of 3 students (EE+BME, ME+BME): Jacob Alfieri, Sam Ritter, Alden Tennison**

Cell Separations (Terumo BCT)

Terumo BCT has current product lines that use continuous flow centrifugation while maintaining functionally closed (sterile) systems. We are interested in increasing fluid flow rates through our centrifuges while maintaining the same or better cell recoveries. This project will use an existing centrifuge design to develop single use disposable prototypes to increase throughput for more efficient cell separations. Increasing flow rates can be done by increasing G's via higher RPM's or larger radius; however, we are looking to achieve the same effect using more intelligent design methods. Higher G's may negatively affect machine or disposable reliability. By predicting fluid flow characteristics using computational fluid dynamics (CFD) software it may be possible to predict fluid behavior within the centrifuge. Also, by performing design of experiments (DOE's) it may be possible to predict important characteristics of the disposable to allow for faster development cycles. The students will be responsible for analysis and production of the prototypes. Lab testing with human blood cells will be done at Terumo BCT (Lakewood Colorado). Prototypes may be made with 3D printing or traditional manufacturing methods. This is a continuation of a CSU BME senior design project from 2018/2019. **Team of 4 students (CBE+BME, ME+BME): Daniel Corbett, Evan Dummer, Jake Stewart, Cole Watkins**

Magnetic tweezer for active microrheology (David Bark, Ashok Prasad)

Over the last few years a significant body of research on cell and tissue mechanics has led to a growing appreciation of their role in physiological processes with links to human disease. However, measurement of mechanical properties of cells and tissues, as well is identifying the response of these cells and tissues to force is still not routine. We propose to address these challenges by building a low-cost system that can carry out active microrheology and force production inside or on living cells. Active microrheology is the most straightforward method of measuring cellular mechanical properties and the application of a force probe to a particle on a cell is ideal for measuring the cell's active response to external forces since these methods involve the application of force to a probe particle within or on a cell and the measurement of thesubsequent response. The oldest, simplest and the most suited to our needs uses micron and sub-micron sized magnetic particles, combined with oscillatory or rotatory forces applied to these particles using external magnetic fields in an apparatus called a magnetic tweezer. The response is measured by video tracking microscopy. The goal of this senior design project is to design and build an instrument that can exert oscillatory, rotational and more complicated forces on magnetic beads in or on cells and tissues, and measure the response using video tracking microscopy. The instrument will also incorporate a method to insert particles in cells developed by one of the project advisors. The instrument will be initially tailored to work with the confocal system in WSCOE, but we will also develop methods to use it with fluorescence microscopes to reduce costs for applications in future. **Team of 5 students (CBE+BME, ME+BME): Chandler Birrell, Claire Fenton, Nicholas Mitchell, Lyndsey Nold, Stephanie Pascua**

Self-Suturing Laparoscopic Port (NIH funded, advised by Medtronic Minimally Invasive Therapies Group and Mike Stanton MD)

Many medical professionals prefer to use laparoscopic and arthroscopic devices and procedures over open surgeries because they not only reduce the number of incisions as well as size, but also have been found to reduce pain, surgical complications, overall surgery time and the amount of blood loss. However, despite the improvements to these areas of surgery, there is still a lot of time taken in suturing the incisions for the laparoscopic ports. Therefore, creating a cannula or laparoscopic port that has the ability to self-suture and close the incision hole upon removal would provide benefits for medical surgeries. **Team of 4 students (ME+BME): Annie Elefante, Kirsten Kauk, Michael Poland, Blair Whitworth**

Novel Solution for Antibiotic Resistant Infections (Christie Peebles, Claudia Gentry- Weeks)

Antibiotic resistant infections are a growing health concern and could become a leading cause of death within the next 30 years. The goal of this multidisciplinary project is to design a novel solution to combat antibiotic resistant infections. In particular, we are focusing on combating *Staphylococcus aureus* that infects wounds on the surface of the skin. The project will combine the fields of synthetic biology, modeling of gene circuits, microbiology, and device engineering to design a genetic switch to detect the presence of a pathogen, produce a kill mechanism, and to deliver the novel biologic system to the wound using a cream, foam, or bandage. **Team of 3 students (CBE+BME, ME+BME,** CBE and MIP students may also participate**): Jasmine Akers, Torin Moore, Hayden Yarbrough**

JUDGING TEAM 2: Michael Nguyen-Truong, Team Lead/Moderator

Sensor Technology for Enhanced Prosthesis Production (STEPP) (WSCOE entrepreneurial senior design project, advised by Steve Simske and prosthetists)

The STEPP senior design project believes in empowering and enabling patients through mobility. This project was conceptualized during the 2018 Prosthetic Innovation in Ecuador Study Abroad Program. Access to appropriate technology, properly trained technicians and the cost of prosthetic devices act as an insurmountable barrier for many amputees living in developing countries. The purpose of the STEPP senior design project is to address the need for simple, cost effective prosthesis fitting, design and manufacture, especially for communities in developing countries. This project was funded by entrepreneurial funds last year and has a lot of room for student input on project direction. The concept of the project is to create a custom force probe that can differentiate between different types of tissues. This project will have lots of opportunities for product design and fabrication, testing, material engineering, product development, 3D printing and software development. Due to the entrepreneurial nature of the project there will also be opportunity for market research and learning the economics behind developing a product. **Team of 4 students (ME+BME): Bella Demiranda, Josh Floyde, Stephen Haag, David Kimmey**

Quatro Socket Analysis (Quorum Prosthetics, engineering advisor Kirk McGilvray)

The primary project goal is to develop and conduct an efficiency analysis of the patented Quatro above knee adjustable prosthetic socket. We have anecdotal evidence indicating that the Quatro socket is much more comfortable than other designs from our patients but needs to be backed up by empirical data. Initially this is to be analyzed in a static situation, with limited patient interaction. Volume change will be the metric by which the efficiency of the system will be measured, with both the adjustable Quatro socket and other socket designs that utilize prosthetic socks that are not adjustable. Digital imaging and comparison of the socket would be the preferred method for data acquisition. If a simple method is developed, patient interaction may be included with their cooperation in a study. A secondary goal is to expand on the volume measurements, and potentially obtain data with a self-contained system that would measure the pressure within a prosthetic socket. This would also be used to obtain evidence validating the Quatro design over other non-adjustable sockets. **Team of 4 students (ME+BME): Emily Bergum, Olivia Hahn, Zach Leighton, Sean McClure**

Brain Train (WSCOE entrepreneurial senior design project, advised by Chuck Anderson)

The Brain Train is a closed loop, noninvasive brain stimulation (NIBS) device that utilizes live electroencephalography (EEG) feedback about ongoing neural activity to adjust transcranial alternating current stimulation (tACS) therapy. This project will primarily focus on improving working memory to maintain a realizable scope and impactful outcome. This proposed direct-to- consumer medical device alters neural oscillations by either amplifying or stifling various brain waves. This is done by delivering weak sinusoidal currents to the scalp to modulate the excitability of the cerebral cortex in a frequency-specific manner. The ability to perform simultaneous EEG monitoring during therapy allows for the immediate effects to be recorded and for the therapy parameters to be adjusted as a result. This creates therapy that is fine-tuned to each individual. The development of this system will involve designing and manufacturing the headset, developing a method to remove the tACS artifact from the EEG readings, creating a closed loop system to adjust the therapy parameters, and designing and performing experiments to gather data on working memory changes due to therapy. **Team of 4 students (CBE+BME, ME+BME): Zach Haigh, Corey Lauck, Jeremy Tabke, Juliette Talarico**

Process to manufacture periosteum fibers (AlloSource)

AlloSource is evaluating a potential new product that will require the addition of periosteum recovered from long bones. Currently, AlloSource does not have a good method for removing and processing the periosteum. The project would include:

- Design and build any prototype equipment needed.
- Evaluate different processing methods.
- Method should be efficient as possible and maximize the tissue recovered
- Process should consider technician safety
- Materials that touch the tissue must be sterilizable (autoclavable).
- Other materials used must be compatible with AlloSource's cleaning agents.
- Detailed design provided with drawings; SolidWorks preferred.
- Material specifications

Team of 4 students (CBE+BME, ME+BME): Sarah deBoer, Will McCormick, Analia Quirk, Erin Solis

Diagnostic system for viral infections (Brian Geiss, David Dandy, Chuck Henry)

We propose that an interdisciplinary team design and construct protypes of an integrated point-of- care diagnostic platform that we call **MAVEN (Multiplexed Amplified Virus Etiology Network)** that will be able to simultaneously detect multiple viruses and virus-specific antibodies at the point-of-care from a variety of small-volume sample types in a simple, rapid, and inexpensive format. MAVEN will be a fundamentally different point-of-care system that integrates a highly sensitive and accurate electrochemical detection modality with automatic sample preparation and reagent handling to provide a robust and portable diagnostics solution. The MAVEN cartridge will contain a multiplexed sensor system integrated into a disposable cartridge containing the necessary fluidics handling for sample pretreatment and the stabilized reagents for virus particle, antigen, and virus-specific antibody detection. We have demonstrated that our sensing platform can detect as few as 500 virus particles/mL and 10 virus-specific host antibodies, and we propose to couple the sensing platform with rapid paper-based sample preparation and handling to yield sensitive and selective analyte detection in a self-contained low-cost format. The prototype MAVEN cartridge will be interfaced with a commercial potentiostat that provides exquisitely sensitive detection of small quantities of virus specific antibodies and virus particles at the point-of-care. This system will have the potential to be a robust commercial diagnostic device at an inexpensive price point with a large market potential (global pathogen diagnostics and treatment market). MAVEN will provide a powerful point-of- care system that rapidly provides physicians with critical information that can help save lives locally and globally. **Team of 4 students (CBE+BME, ME+BME): Elias Espin, Marina Larson, Nick Peters, Skyler Hochmuth**

JUDGING TEAM 3: Tara Wigmosta, Team Lead/Moderator

Mechanical Bladder Device (Hiep “Bob” Nguyen MD, Shawn Smith PA, engineering advisor Katie Sikes)

In the United States, about 200,000 people require bladder augmentation or replacement each year. The current treatment methods can leave patients with urine leakage, urinary tract infections, kidney damage, and complications such as bladder rupture that can lead to sudden death. This clinician-led multi-year project seeks to design, prototype, and test a device for supporting the emptying of the bladder of a patient and a method for operating such a device. Phase I (2017-2018) finished with a complete design which includes a tested artificial silicone bladder surrounded by an outer protective hard shell. During Phase I, fluid sensors were implanted into the silicone shell to alert a sensor application of the bladder's filling status. One- way valves were proven to eliminate refluxing of urine back into the native ureter, and an app was designed to detect and alert of fluid levels. Phase II (2018-2019) finished with a complete design of the bladder inlet and surgical technique for connection to the native ureters. Additionally, Phase II included full functionality and leak testing which was successful, and re- design of the electrical system so that it was smaller and could detect fluid levels regardless of position (e.g. upright, or lying or side, back, or front). Phase III will encompass the design and incorporation of an outlet mechanism which allows for catheterization or automatic bladder emptying. Proof of design will include functionality with other system components previously designed and ensuring the outlet is watertight and does not leak urine into the abdominal cavity. **Team of 4 students (CBE+BME, ME+BME): Teryn Degenhart, Emma Hurley, Anugrah Mathew, Jordan Schlitzer**

Optical Neurolink for a High Data Rate Brain-Computer Interface (Kevin Lear, Susan Hunter)

In 2012, a consortium demonstrated a brain-machine interface that allowed a paralyzed woman to control a robotic arm using her mind (see https://www.youtube.com/watch?v=ogBX18maUiM). To make neural prosthesis practical, engineers need to design communications devices to get Mb/s of data from an electrocorticogram (ECoG) array implanted in the brain out of the user’s head without large cables (as can be seen in the video) and without overheating the neighboring tissue with communications circuitry or computational power. One approach being considered is using light to beam the information through the scalp. This approach is being explored by the Wyss Center as illustrated in the video at https://www.youtube.com/watch?v=4g87Oyy61Cs. The purpose of this project is to determine the requirements for such an optical brain-computer interface, design and prototype an optical transmitter suitable for subcutaneous implantation as well as a compatible receiver, and develop and apply testing methodology to explore the capabilities and limitations of this technology. **Team of 4 students (CBE+BME, EE+BME, ME+BME): Sarah Maclean, Mauri Richards, Kieran Simske, Justin Southerland**

Spine Phantom (Medtronic Restorative Therapies Group)

Design and produce a spine phantom that can move in a physiologically realistic way for a least a few modes of motion. Such a phantom will be valuable for internal Medtronic work on applications for spine robotics and navigation. The phantom should include at least 3 vertebrae including S1 and preferably 5 vertebrae L2 to S1. It should be able to return to a standard home position. It should be modular so vertebrae can be replaced with different vertebral levels. Each vertebra should have 6 degrees of freedom. The phantom should be imageable by CT and MRI and be easily portable. The phantom might be motorized or otherwise have sensors that measure its motion. **Team of 4 students (ME+BME): Joe Clouse, Megan English, Matt Helmreich, Ryan Henry**

Anti-Cancer Photochemical Cell Inactivation Device (PhotonPharma)

PhotonPharma, Inc. is a start-up company with offices and labs located at the Research Innovation Center on the Foothills campus of CSU. Its focus is the development of a novel cancer therapeutic which is based on the use of inactivated, autologous tumor cells taken from patients in the form of a biopsy our surgical excision. These cells are treated with a photochemical process that prevents them from replicating but leaves cell antigens and metabolic function intact. Such products act as an attenuated antigen presenting agent that can be used in immunotherapy applications to stimulate patient immune response to their tumor in a specific fashion. The product has been demonstrated in in vitro studies and mouse studies to generate immune responses. An initial safety trial with canine patients has recently been initiated at the Veterinary Hospital at Colorado State University and is progressing well. This project will involve the development of a photochemical device that will be utilized for preparing inactivated tumor cells for use in a novel immunotherapy approach. The project requires the development of microfluidic systems that allow exposure of tumor cells to UV light at specific light doses and durations in the presence of a photosensitizer. The device will require the evaluation of light exposure and measurement methods, uniform mixing, temperature control and design of disposables that can be produced and maintained in a sterile form. This project will involve the development of a photochemical device that will be utilized for preparing inactivated tumor cells for use in a novel immunotherapy approach. The project requires the development of microfluidic systems that allow exposure of tumor cells to UV light at specific light doses and durations in the presence of a photosensitizer. The device will require the evaluation of light exposure and measurement methods, uniform mixing, temperature control and design of disposables that can be produced and maintained in a sterile form. **Team of 5 students (CBE+BME, EE+BME, ME+BME): Katherine Conger, Isaac Griess, Andy Hegemann, Jacob Stockebrand, Cameron Taylor**