Undergraduate Research Symposium May 19, 2017 Mary Gates Hall

Online Proceedings

POSTER SESSION 1

Commons East, Easel 73

11:00 AM to 1:00 PM

3D-Printed, Elbow-Driven Orthosis for Individuals with Limited Hand Function

Jessy Ha, Senior, Mechanical Engineering
Karley Benoff, Senior, Mechanical Engineering
Mentor: Katherine Steele, Mechanical Engineering
Mentor: Keshia Peters, Mechanical Engineering

Orthotic devices are prescribed for individuals who have partially lost motor control, such as stroke survivors or those with cerebral palsy, to assist with stability and function. Unlike prostheses, devices available for those missing part of a limb, there is a limited market for upper-limb orthoses. As a result, options for users can be clunky, expensive, and hard to customize. The goal of this research was to develop a 3D-printed elbow-driven orthosis that is inexpensive, adjustable, and helps users to perform two-handed daily tasks. Inspired by our participant who has limited hand function on her left side due to a seizure reducing brain surgery, we took a user centered design approach. By tuning the cable length running from the elbow to the hand, we took advantage of her existing range of motion to activate a clamp near the palm. We chose a modular approach for the clamp to suit a variety of daily activities, such as picking up small objects and holding a drumstick. In comparison to traditional devices that can reach hundreds of dollars, our cost has been reduced to roughly $20 largely because of the use of 3D printed parts. Through a continuous cycle of prototyping, receiving feedback, and modifying the design accordingly, we have created a device adapted to suit both adult and child sizes. While feedback from unimpaired participants was primarily received, we also plan to further test the device on individuals with limited hand function for more diverse perspectives from potential users. Ultimately, we aim to publish our designs open-source to promote further modifications and availability.

POSTER SESSION 2

Commons East, Easel 65

1:00 PM to 2:30 PM

Hydrothermal Synthesis Optimization of $NaYF_4$ Nanoparticles for Photonic Upconversion and Laser Cooling Applications

Benjamin (Ben) Chin, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
Teerath Chaiteerath, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
UW Honors Program
Mentor: Xuezhe Zhou
Mentor: Peter Pauzauskie

Sodium-yttrium-fluoride ($NaYF_4$) upconverting nanocrystals are currently being investigated for their applications in bioimaging, color displays, solar cells, and photocatalysis. Recently, Yb^3+-doped-$NaYF_4$ nanoparticles have been predicted to also be a promising host material for laser refrigeration applications. However, to date, the laser-refrigeration of β-$NaYF_4$single-crystals has not been reported due to challenges in bulk Czochralski crystal growth. We have demonstrated laser refrigeration of hydrothermally synthesized β-$NaYF_4$nanowires for the first time. With a low cost, scalable hydrothermal synthesis process, we can prepare different sizes, morphologies, and phases of $NaYF_4$ nanoparticles by tuning the initial reagent concentration, synthesis time, and temperature. In the future, our results can be used to synthesize the optimal $NaYF_4$ nanowires for localized optoelectronic device cooling and physiological laser refrigeration.

SESSION 2S

MODULATION OF CELL BEHAVIOR AND ITS COMPONENTS

Session Moderator: Valerie Daggett, Bioengineering

JHN 175

3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Auto-Inhibition of SspH1, a Bacterial E3 Ubiquitin Ligase

Thomas Schweppe, Senior, Biochemistry, English
Mentor: Peter Brzovic, Biochemistry

With the rise of antibiotic resistant bacteria, understanding how pathogenic bacteria invade and survive within our bodies is becoming more important as we search for novel ways

to combat bacterial infection. Some pathogens, such as *Salmonella typhimurium*, inject host cells with proteins that suppress the host cell's ability to respond to bacterial invasion. One such protein, SspH1, is an E3 ubiquitin ligase. E3 ubiquitin ligases attach ubiquitin, an important regulatory protein used to mark other proteins for degradation, to a substrate. Ubiquitin, the biochemical machinery that activates ubiquitin, and the pathways that utilize ubiquitin as a signaling molecule, are not found in bacteria, only in eukaryotes. However, bacteria have evolved proteins, such as SspH1, that hijack a host cell's biochemical machinery in order to target host proteins for degradation. SspH1 consists of two domains: a catalytic E3 domain that transfers ubiquitin to substrate, and a substrate recognizing Leucine-Rich-Repeat (LRR) domain. I have shown through biochemical assays that the LRR domain inhibits the catalytic activity of the E3 domain. I have also shown that this inhibition is relieved in the presence of substrate. Through the use of 2D NMR and further biochemical assays, I hope to characterize the binding between the LRR and E3 domain in order to further the understanding of how SspH1 is inhibited. Understanding the mechanism of SspH1 auto-inhibition can increase our knowledge of the mechanisms and activities of related bacterial effector proteins, furthering our understanding of how pathogenic bacteria evade our immune system, and potentially lead to the development of novel treatments that can combat bacterial infection.

POSTER SESSION 3

Commons East, Easel 76

2:30 PM to 4:00 PM

Two-Photon Exchange in Electron-Nucleon Scattering

Jesse Ashworth, Senior, Mathematics (Comprehensive), Physics: Comprehensive Physics

Mary Gates Scholar, NASA Space Grant Scholar, UW Honors Program

Mentor: Wally Melnitchouk, Jefferson Lab

Mentor: Peter Blunden, Physics & Astronomy, University of Manitoba

Researchers are working to determine in-depth information about the substructure of the proton. This includes the proton's fundamental charge and current distributions, described by functions called electric and magnetic form factors. These form factors have traditionally been determined by computing elastic electron-nucleon scattering cross sections, to first-order expansion in the electromagnetic fine structure constant, α_e—encompassing a process called one-photon exchange. Experimental discrepancies in the proton's electric-to-magnetic form factor ratio have prompted a need to compute cross sections to second order expansion in α_e, involving two-photon exchange (TPE) interactions. Two methods for calculating TPE cross section contributions exist: one based on hadronic degrees of freedom (suitable at low Q^2, where Q is the four-momentum transfer between the electron and nucleon) and the other on partonic (quark-level) degrees of freedom (applicable at high Q^2). Both methods have been claimed to principally account for the form factor discrepancy. However, ambiguities exist in the separation of the parts of the cross sections independent of the underlying hadronic structure ("soft" parts) and the parts dependent on such structure ("hard" parts). We aim to resolve such ambiguities by first rederiving current quark-level calculations to better understand exactly how the hard and soft parts of the cross section are separated and the underlying physical motivations. Furthermore, we plan to compare these calculations to known behavior of the hard part of the cross section in the limit that the scattering angle goes to zero. Ultimately, our objective is to pave the way toward a unified description of TPE effects at all Q^2 values. Achieving this goal will further pin down the nature of the proton's interior, and the results in turn can be used to better understand the neutron and other hadrons.

POSTER SESSION 3

Balcony, Easel 98

2:30 PM to 4:00 PM

Refining the Magnetic Polarity Stratigraphy of IODP Expedition 354 Cores

Miguel Manzueta, Senior, Environmental Science, UW Tacoma

Mentor: Peter Selkin, School of Interdisciplinary Arts & Sciences

The Bengal Fan represents much of the accumulation of sediment shed from the Himalaya throughout the course of their uplift. The rate of sediment accumulation places constraints on the amount of material eroded from Earth's highest mountains. To determine the amount of material deposited on the Bengal Fan through time, we examine the record of Earth's magnetic polarity captured by sediment cores taken from the Bengal Fan as part of International Ocean Discovery Program Expedition 354. Sediment containing magnetic minerals, such as magnetite, would have polarities that align with the direction of Earth's magnetic field as the sediment settled into the fan. This makes Bengal Fan sediments an excellent resource for deciphering Earth's paleomagnetic history. Our data supplement data collected on board ship during Expedition 354, and are being used to link magnetic polarities observed in the cores to a known reversal time scale.

POSTER SESSION 3

MGH 241, Easel 158

2:30 PM to 4:00 PM

Cardiac Mitochondrial Ultrastructure Seen by Electron Microscopy Degenerates with Age and is Partially Reversed by Treatment with SS-31 Peptide

Gabriel (Gabe) Otero, Senior, Biology (Molecular, Cellular & Developmental)
Mentor: Peter Rabinovitch, Pathology
Mentor: Ying Ann Chiao, Pathology

There are many age-related cardiac diseases that relate to impairment of muscle function, including heart failure and arrhythmia. Previous studies show that increased mitochondrial function results in the enhancement of cardiac and skeletal muscle function as mice age. In these studies, the SS-31 tetrapeptide was used, an agent that serves as an antioxidant by binding to cardiolipin in the inner mitochondrial membrane, enhancing electron transport and increasing ATP generation, and protecting against damage from Reactive Oxygen Species (ROS) by reducing their generation. However prior literature has suggested that ultrastructural morphology does not change in relation to age. The goal of this study is to quantitatively assess interfibrillar mitochondrial damage caused by these ROS', and to see if there is structural improvement after treatment with the SS-31 peptide. Eight 24 month-old mice were split into two treatment groups, four treated with SS-31 for 8 weeks and four untreated. Four 8 month-old untreated mice were used as controls for youthful, "ideal" mitochondrial structure. The mice were euthanized, and cardiac tissue was harvested, sectioned, and examined by transmission electron microscopy (TEM). Quantitative analysis using NIH ImageJ software allowed the comparison of the SS-31 treated and untreated old hearts to young hearts. This revealed stark differences when comparing the young and old ultrastructure. Untreated old mice exhibited higher amounts of vacuolation, greater lack of mitochondrial axial organization, and lower density of mitochondrial cristae than the younger untreated mice. Older mice treated with SS-31 appear to exhibit improvement in ultrastructural definition compared to untreated older mice, but additional quantitation is necessary to validate this observation. In further testing, we are examining the persistence of the SS-31 tetrapeptide's positive effects after its administration period ends, and how ultrastructure changes during this refractory period.

POSTER SESSION 3

Balcony, Easel 99

2:30 PM to 4:00 PM

Differences in Magnetic Properties within Turbidites of the Bengal Fan

Victor Felix (Victor) Ruiz, Junior, Interdisciplinary Arts & Sciences (Environmental Studies), UW Tacoma
Mentor: Peter Selkin, School of Interdisciplinary Arts & Sciences

A turbidity current is a rapid, density-driven underwater current, laden with sediment, that moves down a slope. Like rivers, turbidity currents can erode or flow within channels, or they can spill over channel banks to form levees and interlevee deposits. Although turbidity currents cannot be seen easily, some aspects are known: dense, coarse sediment accumulates first (at the base of a turbidite deposit), whereas finer sediment falls out of suspension later (toward the top of the deposit) as the current slows down. International Ocean Discovery Program Expedition 354 collected sediment cores containing turbidites from the Bengal Fan – the largest submarine fan on Earth – including one core from the active channel. Here we use magnetic anisotropy to examine differences in transport direction and processes between turbidite bases and tops across the submarine fan deposit. Magnetic anisotropy was measured with a Kappabridge susceptometer on cubes containing sediment from the cores. This will allow us to better understand the mechanics of turbidity currents and to add detail to models of turbidite sedimentation, a major mechanism by which both mineral material and carbon are transported from land to the oceans.

POSTER SESSION 3

Balcony, Easel 97

2:30 PM to 4:00 PM

Recording Submarine Channel Migration on the Bengal Fan through Magnetic Anisotropy

Melissa Brainard, Junior, Environmental Sci: Geosciences (Tacoma)
Mentor: Peter Selkin, School of Interdisciplinary Arts & Sciences

The Bengal Fan is the world's largest active submarine fan, collecting sediment from the Himalaya in a fan-shaped depositional system. The fan has an active channel formed by turbidity currents. This active channel behaves much like a river system on land:it meanders, eroding and depositing material, building natural levees along its banks in the same way. In this research, we used samples collected next to the active channel by International Ocean Discovery Program (IODP) Expedition 354 to investigate the anisotropy of magnetic susceptibility in terms of the direction of turbidity currents during their deposition. The direction of the currents recorded in the sample gives us a map of where the channel is in relation to the time of deposition. Through successive sampling along the core we can see how the channel has migrated over time. This should tell us how long it takes an active channel to meander or migrate along the bottom of the ocean. Understanding how this fan system works is critical in understanding the changes on the ocean floor. Knowing the timeline for these changes has both economic and societal importance. It can tell us more about where to find economically important deposits of petroleum as the sediment structures that are made by turbidity currents in active channels are repositories for oil

resources, and the sudden turbidity currents that run down active channels can cause damage to underwater structures like important seafloor cables.

POSTER SESSION 4

MGH 241, Easel 135

4:00 PM to 6:00 PM

Understanding the Role of Wnt/β-catenin Signaling in Early Heart Development

Nicholas Alexander (Nick) Strash, Senior, Chemistry, Biochemistry

Mary Gates Scholar

Mentor: Charles Murry, Pathology

Mentor: Peter Hofsteen, Pathology

Human pluripotent stem cells (hPSCs) are defined by their ability to self-renew, proliferate, and differentiate into the three germ layers. Controversy remains as to the role of canonical Wnt/β-catenin signaling (β-catenin dependent) in hPSC maintenance and mesoderm formation. Wnt/β-catenin signaling has shown to be important in the context of cellular homeostasis and embryonic development, and improper signaling can cause growth of cancerous tumors. By determining the role of this signaling pathway in hPSCs, we aim to improve our overall understanding of the molecular processes behind hPSC directed differentiations and early embryonic development. We assessed the role of Wnt/β-catenin signaling in hPSCs by generating a CRISPR/Cas9 mediated knockout (KO) of the signal transducer β-catenin. Expression levels of protein biomarkers of pluripotency (SSEA4 and OCT4) were evaluated and no difference was noted between wild type (WT) and β-catenin KO hPSCs. Additionally, the relative level of cell proliferation between WT and β-catenin KO cells was analyzed by quantification of EDU incorporation using flow cytometry, and no difference was noted between the two cell types. After confirming β-catenin KO hPSCs can self-renew and proliferate, we assessed the ability of β-catenin KO cells to differentiate to form mesoderm in vitro. In order to further demonstrate the level of pluripotency of the KO cells, we also attempted to differentiate the KO cells towards ectoderm. Analysis of the effectiveness of both the mesoderm and the ectoderm differentiations show that while KO cells cannot effectively form mesoderm, they are still able to form ectoderm. In this study, we demonstrate that hPSCs lacking β-catenin can still proliferate, fail to form mesoderm, but can still form ectoderm. Thus, β-catenin may not be required for maintaining the proliferative characteristics of hPSCs, but is required for formation of the mesoderm germ layer, and is therefore an important component of early embryonic development.