Undergraduate Research Symposium May 19, 2017 Mary Gates Hall

Online Proceedings

SESSION 1H

HIV: DIAGNOSTICS, DRUG RESISTANCE, AND ANTIBODIES

Session Moderator: Dara Lehman, Global Health, Human Biology

MGH 251

12:30 PM to 2:15 PM

* Note: Titles in order of presentation.

Point-of-Care Nucleic Acid Amplification Diagnostic for HIV-1 Using Isotachophoresis

Amanda Moon Levenson, Senior, Chemical Engineering
CoMotion Mary Gates Innovation Scholar, Mary Gates Scholar
Mentor: Jonathan Posner, Mechanical Engineering
Mentor: Andrew Bender, Mechanical Engineering

As of 2015, approximately 36.7 million people worldwide are living with HIV/AIDS, of which almost 15 million receive antiretroviral therapy (ART). These patients require regular HIV-1 viral load (VL) tests to monitor ART effectiveness and compliance. However, the majority of affected people live in low-resource settings, where accurate diagnosis and disease monitoring through lab-based instrumentation systems, such as nucleic acid amplification tests (NAATs), are inaccessible. Thus, there is an increasing need for accurate, affordable HIV-1 VL tests at the point-of-care (POC). We have leveraged an electrokinetic separation and preconcentration technique, isotachophoresis, and an isothermal nucleic acid amplification method to develop a fully integrated POC NAAT for extraction, amplification, and detection of HIV-1 nucleic acids in whole blood. We have demonstrated the ability to extract these nucleic acids from human serum and quantify the nucleic acid amplification with fluorescent detection. The fluorescent read-out is correlated to the initial sample concentration, providing semi-quantitative VL information. Our device operates in a single step with limited equipment in 15 minutes, consequently cutting the time, cost, and complexity of NAATs for infectious disease diagnosis, especially in low-resource settings. Our POC NAAT has the potential to improve patient care, and we are currently investigating applying this technology to diagnose other infectious diseases.

POSTER SESSION 2

MGH 241, Easel 125

1:00 PM to 2:30 PM

Heterogeneous Coating of Reduced Graphene Oxide and Polydopamine on Nanostructured Substrates Using Dopamine Chemistry

Evan Jihong (Evan) Lam, Senior, Chemical Engineering
Mentor: Deok-Ho Kim, Bioengineering
Mentor: Kevin Gray, Bioengineering

The use of graphene in nanoscale systems serves many applications not only in solar cells but also in biomaterials because of the combined optical, electrical, and structural properties. Conventional methods including chemical vapor deposition and electrospraying to produce a layer of graphene on nanostructures is costly. Reduction of graphene oxide using chemical reagents presents an easier and cheaper alternative while maintaining the unique properties of graphene. But these methods are typically solution-based and further steps must be taken to coat reduced graphene oxide onto nanostructured surfaces. Dopamine chemistry was applied in a simple simultaneous approach of self-polymerization to reduce graphene oxide while creating an adhesive to incorporate a heterogeneous coating of polydopamine and reduced graphene oxide on a nanostructure. Use of various concentrations of graphene oxide demonstrated control over the sample's surface conductivity profile. Surface analysis characterizations confirmed the presence of the coating through X-ray photoelectron spectroscopy (XPS) while the electrical properties were determined using conductive atomic force microscopy (cAFM). The overall topographical morphology will be confirmed with atomic force microscopy (AFM). A potential application of the proposed device serves to provide functionally and structurally mature human pluripotent stem-cell derived cardiomyocytes (hPSC-CMs) for use in research and clinical drug trials.

POSTER SESSION 2

Balcony, Easel 115

1:00 PM to 2:30 PM

Stability of Biologically Safe, Surfactant-Coated Nanoparticles in Complex Media: Implications for Drug Delivery

Andrew A. (Andy) Kirk, Senior, Chemical Engineering
Mentor: Elizabeth Nance, Chemical Engineering

For a nanoparticle to become a pharmaceutical transport device, it must have shelf life stability and avoid aggregation. Spontaneous aggregate formation, or particle sedimentation, can render a therapeutic nanoparticle ineffective and potentially harmful as a pharmaceutical. Using a biologically safe material that provides steric stabilization (i.e Pluronic F127) may slow or eliminate aggregation, improving shelf life and potential for pharmaceutical use. The use of a surfactant coating instead of a chemically conjugated method will improve ease of nanoparticle formulation. To determine aggregation kinetics, various surfactant-coated nanoparticles (SCNP) have been compared in a number of medias, including standard measuring media (10mM NaCl), known aggregate media (30:70 methanol:water solution by volume), as well as in complex media such as artificial cerebral spinal fluid (aCSF) and high ion concentration media like phosphate buffered saline (PBS). These SCNP's have been compared to stock carboxylated-polystyrene nanoparticles, as well as polyethylene glycol-coated polystyrene nanoparticles. Characterizing SCNP behavior can have significant implications for nanoparticle design for drug delivery.

POSTER SESSION 2

Balcony, Easel 114

1:00 PM to 2:30 PM

An Organotypic Brain Slice Model of Glutamate Excitotoxicity

Belinda Garana, Senior, Chemical Engineering
Mary Gates Scholar
Mentor: Elizabeth Nance, Chemical Engineering

Less than 3% of therapeutics can cross the blood-brain barrier, and the lack of penetration of therapeutics into the brain is the most cited failure for neurological clinical trials. In order to assess the efficacy of developing therapeutics which have the potential to address these issues, we are working towards establishing a high-throughput organotypic ex vivo brain slice model. We are specifically interested in developing a model that allows us to study and characterize the brain in the presence of glutamate excitotoxicity. Glutamate excitotoxicity is cell death due to an excess of the excitatory neurotransmitter glutamate, and is a common disease hallmark in neurological injury. The slice model we developed consists of cultured newborn rat brain slices to simulate an *in vivo* brain environment. However, in slice form, we have the ability to systematically study key pathophysiological variables, such as exposure to various excitotoxins that induce glutamate excitotoxicity. We use quantitative assessments of cytotoxicity (cell death) through cellular staining and imaging, as well as assays for lactate dehydrogenase (LDH), an enzyme released from the cytoplasm during cell death. We have established percent cytotoxicity profiles for both healthy untreated and maximum death control brain slices, and developed a protocol for testing excitotoxins to simulate glutamate excitotoxicity. With this slice platform, we will be able to compare the efficacy of potential therapeutics based on the decreases in rates of cell death they produce in brain slices with induced glutamate excitotoxicity. This research represents a promising platform to assay behavior, mechanism, and efficacy of therapeutics in development for the treatment of neurological disorders associated with glutamate excitotoxicity.

POSTER SESSION 2

Balcony, Easel 116

1:00 PM to 2:30 PM

Characterization of Quantum Dot Toxicity for Potential Use as a Biomarker in Brain Injury

Kate Brianna Hildahl, Senior, Chemical Engineering
Mary Gates Scholar
Mentor: Elizabeth Nance, Chemical Engineering
Mentor: Mengying Zhang, Molecular Engineering and Science

Quantum dots (QDs), fluorescent semiconductor nanocrystals, can be used as a biomarker and diagnostic tool because of their unique optical and electrical properties, including high luminescence, resistance to photobleaching, and broad excitation and emission spectrums. But in order to use QDs as biomedical imaging devices, particularly in sensitive organs such as the developing brain, toxicity must be adequately characterized. Little is known about the toxic effect of QDs on the brain, especially on the neonatal brain. QDs consist of a metal core, typically cadmium selenide, and a shell to protect the core. Cadmium is known to be highly toxic to many of the body's systems, including the central nervous system. However, expanding the shell and attaching functional biomolecules prevents cadmium release and changes the characteristics of the particles. In our study, several surface ligands were tested at variable concentrations and periods of exposure to measure the toxic potential of QDs on an *ex vivo* organotypic brain slice model. Three methods of characterization were used: a lactate dehydrogenase (LDH) assay, a propidium iodide stain, and a fluoro-jade C stain. The cellular stains were evaluated using confocal microscopy. Results showed that toxicity is a function of QD exposure time, surface chemistry, and concentration. Several QD conjugations displayed minimal or no toxic effect after 24 h of exposure. The results of this study will be useful in identifying a QD conjugate as nontoxic in a biological setting. QDs can then be tailored to site and cell-specific uptake in the brain, thereby

improving the selectivity of current imaging techniques and providing a powerful diagnostic with regards to diseased cell fate.

POSTER SESSION 2

Commons East, Easel 56

1:00 PM to 2:30 PM

Monitoring the Proper Use of Safety Glasses in the Workplace

Logan Mitchell (Logan) Stimson, Senior, Chemical Engineering
Mentor: Denise Wilson, Electrical Engineering

Safety precautions are only effective when implemented properly. This is a major obstacle when using wearable devices to promote workplace health and safety. User compliance is a serious concern: Is the user using the device and is it worn as intended? Monitoring user compliance using electronic sensing systems faces limitations. The systems must be cost effective, small, and fit the form of the wearable device all while maintaining enough power to be beneficial. This research monitors compliance in the proper wear of safety eyeglasses within these limitations and constraints. Specifically, information on safety eyeglass orientation and location on the head is gathered continuously using a hall effect sensor mounted on the glasses themselves and a magnet mounted on the user's ear. Tests on six different users (including both male and female adults) show that four different positions (on the bridge of the nose, on the tip of the nose, on the forehead, on the top of the head) of the glasses can be detected for each user and four different motions, all beginning in the proper 'on' position on the bridge of the nose, can also be detected. The overall error rate for data sets collected among six different users is less than 10% and error rates within any one user did not exceed 25%. Collecting both transient motion and steady-state position data minimizes error rates for understanding user compliance. These preliminary tests demonstrate the viability of using these safety glass monitoring systems for not only understanding where the glasses are at any point in time but also how they got there. This information is useful to not only capture non-compliance but also to understand behavior well enough to support effective measures to increase compliance (of wearing safety glasses when they are needed).

SESSION 2Q

CENTRAL NERVOUS SYSTEM DISEASE MODELS

Session Moderator: Gwenn Garden, Neurology

JHN 026

3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Quantum Dot Localization in Glia and Neuronal Cells in the Developing Brain

Binh Dang, Senior, Chemical Engineering
Mary Gates Scholar
Mentor: Elizabeth Nance, Chemical Engineering
Mentor: Mengying Zhang, Molecular Engineering and Science

Quantum dot (QD) semiconductor nanocrystals offer significant advantages over conventional fluorescent markers due to broad excitation spectrum, narrow emission spectrum, and very high photo stability, which enables long term visualization. Because of this, there is great interest in using QDs as biomarkers, where cellular uptake of QDs play an important role. In this study, we aim to characterize QD uptake in neuronal and glial populations in the developing brain as a function of QD surface functionality. Previous research has shown that the behavior of QDs in biological systems can be dictated by surface functionality; however, this has not been systematically studied, particularly in the developing brain. Here, we used cadmium-selenide (CdSe) QDs with either cadmium-sulfide (CdS) or zinc-sulfide (ZnS) shell. These QDs are coated with a layer of surface ligands to protect the core-shell and minimize their hydrophobicity. We set out to examine five different surface coatings, including: mercaptoundecanoic acid (MUA), mercaptopropionic acid (MPA), polyethylene glycol-amine (PEG-NH2), polyethylene glycol-methoxy (mPEG) and carboxylic acid (COOH). We incubated organotypic neonatal rat brain slices in 0.1 and 0.01 μM of QDs over a 24 h period. Using immunohistochemistry and co-localization analysis, we observed QDs with PEG-NH2 functionality localize in neurons, whereas QDs with MUA or MPA surface functionality remain in the brain extracellular space. High resolution confocal imaging is used to visually assess the stained brain slices, and the degree of colocalization with cell stains can be quantified using ImageJ. Furthermore, we investigated the region-dependent of QD-PEG-NH2 localization in neurons. This provides insight into the mechanism of uptake for future studies, which include using QDs as biomarkers of inflammatory processes, mediated by glia, in the developing brain.

SESSION 2Q

CENTRAL NERVOUS SYSTEM DISEASE MODELS

Session Moderator: Gwenn Garden, Neurology
JHN 026
3:30 PM to 5:15 PM
* Note: Titles in order of presentation.

Glial Cell Characterization in an mGluR5 Knockout Rat Model of Autism Spectrum Disorders
Holly Lin (Holly) Sullivan, Senior, Chemical Engineering Amgen Scholar, Mary Gates Scholar, UW Honors Program, Undergraduate Research Conference Travel Awardee
Mentor: Elizabeth Nance, Chemical Engineering

Autism Spectrum Disorder (ASD) affects 1 in 68 children and has been steadily growing in incidence in recent years. As a developmental disability, ASD causes social, communication, and behavioral challenges. ASD is as mysterious as it is diverse—no two cases are the same. This not only complicates treatment methods but also makes physical characterization of the autistic brain a tedious challenge. As the number of ASD cases begins to increase, so does the urgency for answers at the developmental and biological level that may unravel this condition and lead to more effective and targeted treatment. Microglia and astrocytes are key non-neuronal cells that exhibit altered activity levels in the autistic brain. The changes in behavior and the role these cells play in ASD, and many other neurological diseases, make them potential therapeutic targets. Leveraging this fact, the focus of my research is to study the morphology and distribution of glial cells in wild type and knock-out (autistic-like) mGluR5 rats using confocal microscopy. Regions of interest for changes in cell behavior and morphology include the hippocampus, cortex, and thalamus. Rats with ASD have microglial cells with enlarged soma, retracted and thickened processes, and processes encircling neurons. Fluorescent antibody stains are used to visualize these cells and structures. By defining a physical distinction between healthy and autistic brains, a new wave of therapeutics that target and mitigate the overactivation and inflammation of microglia and astrocytes can be explored.

POSTER SESSION 3

Commons East, Easel 77
2:30 PM to 4:00 PM

Improved Cooling Efficiency and Cost-Effectiveness of Bitter-Type Solenoid
Peter Yuthachack, Freshman, Chemical Engineering, Edmonds Community College
Collin Rhodes, Sophomore, Mechanical Engineering, Edmonds Community College
Duy Nguyen, Sophomore, Chemical Engineering, Physics, Mathematics, Edmonds Community College
Minpyo Kim, Sophomore, Mechanical Engineering, Edmonds Community College
Mentor: Tom Fleming, Department of Physics, Edmonds Community College
Mentor: Billy D. Jones, Edmonds Community College

High-powered electromagnets are used in many different fields of science such as quantum physics and synthesis chemistry. Some projects require a very strong magnetic field to work. This magnet will allow students the freedom to design complex projects that utilize a strong magnetic field However, they are generally quite expensive and only available for use at well-funded research facilities and universities. Thus, we present our research in the design and construction of a cost-effective electromagnet capable of producing a highly-uniform magnetic field that can be used to further undergraduate research at Edmonds Community College. Our principal focus is on the reduction of engineering, fabrication and maintenance costs through a novel radial-flow cooling system which can be easily 3D-printed using high-temperature plastics in conjunction with a solid Bitter-plate solenoid design, requiring far less intricate and less expensive machining processes than conventional staggered-channel Bitter-plate designs. In order to make meaningful comparisons of generated field and thermal profiles with other published designs, our design maintains general shape and structural congruence to a design by Sabulsky, et. al., yet differing significantly in the design of the cooling system.

POSTER SESSION 3

Commons West, Easel 26
2:30 PM to 4:00 PM

Comparison of C18 and QuEChERS for the Isolation and Detection of Imidacloprid in Honey Samples Using GC-MS
Maxwell Runyon, Sophomore, Chemical Engineering, Bellevue College
Mentor: Richard Glover, Science, Lane Community College
Mentor: Grady Blacken, Chemistry, Bellevue College

Neonicotinoid pesticides have been identified as a possible contributor to colony collapse disorder (CCD), decimating honeybee populations. Development of methods to extract neonicotinoids from environmental matrices are important in exploring the correlation between pesticide exposure and

CCD. Imidacloprid was chosen as representative neonicotinoid given it is the most commonly used agricultural pesticide in its class. Two extraction methods, QuEChERS and SPE C18, were evaluated for their effectiveness in quantifying imidacloprid concentrations in honey and water. The effectiveness of each extraction method was evaluated using gas chromatography-mass spectrometry (GC-MS). QuEChERS kits use a buffered extraction technique to absorb excess water and stabilize the pH of the solution and cleanup with weak, anionic and cationic exchange resins to remove complex sugars/macro organic molecules. The SPE C18 extraction method used a non-polar solid phase to isolate Imidacloprid from other undesirable solutes in the solution. Preliminary experiments have indicated the SPE C18 extraction method appeared to have better performance with water based solutions. However, honey solutions were ineffective due to more organic interference. Additionally, QuEChERS extraction appears to be more efficient for isolating analyte, but did not concentrate as efficiently compared to SPE C18 extraction. We hypothesize that QuEChERS and SPE C18 extraction methods will be more effective in tandem, as QuEChERS will remove organic interference, while SPE C18 extraction will concentrate the samples. The impact of pH adjustment of samples on peak area and shape was also investigated in both polar and non-polar GC-MS columns. The results obtained will help identify best practices for extraction and detection of imidacloprid in honey samples.

POSTER SESSION 3

MGH 241, Easel 160

2:30 PM to 4:00 PM

Library Generation and Functional Phenotyping of Genetic Variation in the Human Fanconi Anemia Genes FANCA and FANCG

Thomas Tianan (Thomas) Liu, Senior, Biochemistry, Chemical Engineering
Mentor: Alessio Ligabue

Mutations are imbedded in every individual's DNA. A key challenge in human genetics is to determine the functional phenotype of specific mutations. The goal of my research in the Monnat Lab is to develop an efficient, quantitative, cell-based assay to study the phenotype of mutations in a gene in parallel. Our target disease is Fanconi Anemia (FA), a recessive human genetic disease associated with cancer, bone marrow failure, and sensitivity to crosslinking agents such as mitomycin-C. Among of the 21 "FANC" genes that could result FA, we focused on FANCA gene as it is mutated in 2/3 of FA patients. A set of nearly 500 FANCA variants was then used to build a plasmid library encoding each protein variant. In order to achieve this, each variant, linked to a unique DNA molecular 'barcode', will be inserted at a unique chromosomal location in FANCA-mutant human cells in order to determine their cellular phenotype. We will assess cell survival as a function of mitomycin-C dose and the expressed transgene. Preliminary results have already been generated to confirm the feasibility of this approach. My effort thus far has been focused on generating a library of ˜500 single nucleotide variants of FANCA. In addition to capturing each variant, I developed an optimized workflow to generate barcoded plasmids with only desired variant without additional mutations in the FANCA. In the coming quarter, I will work with other members to develop a corresponding cell library in which each of these FANCA variants is expressed in a common, FANCA-deficient background for functional phenotyping. Results of my research will help identify new and existing deleterious as well as innocuous FANCA variants, and thus will enable a more accurate molecular diagnosis of FA.

POSTER SESSION 3

Balcony, Easel 104

2:30 PM to 4:00 PM

A Multi-Technique Approach for Studying the Effect of Protein G B1 Orientation on Antibody Binding

Nhu T. Nguyen, Senior, Chemical Engineering
Mentor: David Castner, Bioengineering
Mentor: Elisa Harrison, Chemical engineering

Development of antibody-based diagnostics, biomolecular sensors, and biomaterial with reactive surface requires the ability to control the adsorption of bioactive protein at a surface. All medical devices exposed in an in vivo biological environment are immediately coated with a layer of adsorbed protein that plays an important role in the body's behaviors towards the devices and the effectiveness of the devices themselves. In this study, we use a multi-technique approach to characterize the effect of protein G B1 (6 kDa) orientation on multi-layer antibody binding. By conjugating a cysteine group at different positions along the protein's surface, we can immobilize five variants of the protein (V21C, D35C, E42C, T11C, and WT) onto maleimide and bare gold surfaces. We have confirmed through X-ray photoelectron spectroscopy and time-of-flight secondary ion mass spectrometry experiments that the proteins adsorb onto these surfaces. In addition, we introduced primary IgG and secondary F(ab')2 antibodies to investigate if the protein's orientation will affect the binding of the antibodies. The adsorbed mass are measured using quartz crystal microbalance with dissipation monitoring. We have demonstrated that the cysteine mutants orient better on maleimide surfaces and encourage more IgG binding. We will also study the effect of temperature on adsorption mass and extend the experiments to amine and carboxyl functionalized surfaces. Fully developed techniques to accurately characterize the orientation and quantify the amount of protein and secondary adsorption will significantly contribute to understanding the interactions of biomaterials

with the biological environment.

POSTER SESSION 3

Commons East, Easel 78

2:30 PM to 4:00 PM

Growth of Nickel Sulfate Hexahydrate Crystals in a Magnetic Field

Kim-Lien Vu, Sophomore, Chemical Engineering, Edmonds Community College
Shannay Kammann, Sophomore, Mechanical Engineering, Edmonds Community College
Zumrat Makhkamova, Senior, Chemical Engineering , Edmonds Community College
Erica Toikka, Sophomore, Bioengineering, Biology, Nursing, Edmonds Community College
Lauren Valdez, Junior, Computer Science Engineering, Edmonds Community College
Mentor: Tom Fleming, Department of Physics, Edmonds Community College

Nickel sulfate hexahydrate (NiSO4.6H2O) is an important industrial compound most commonly used in the nickel-plating industry. Approximately 40,000 tons are produced and consumed each year by manufacturers requiring corrosion-resistant components ranging from consumer electronics to medical devices and aerospace engineering. Freitas et. al. found that zinc sulfate heptahydrate crystal growth increased by 38% under a magnetic field of 0.3-0.7T compared to crystallization under earth's magnetic field alone, whereas Lundager et. al. have presented evidence that paramagnetic materials such as CuSO4.5H2O do not exhibit such magnetically-induced increases in crystal growth rate. We present here our progress on confirmatory experiments aimed at fitting Nyvlt theory of cumulative crystal weight fraction M(L) and average growth rate G in batch synthesis of diamagnetic ZnSO4.7H2O and paramagnetic NiSO4.6H2O under external, uniform, homogeneous magnetic fields 0.0T<B<1.0T. Our study will examine the differences in the growth rate of paramagnetic and diamagnetic sulfate crystals under the influence of a manipulated magnetic field. Recrystallization is a method of purification during the synthesis process of many compounds. If recrystallization can be improved to increase percent yield by influencing the magnetic field surrounding the compound, it may be a profitable method for drug manufacturers to consider.

POSTER SESSION 4

Commons West, Easel 29

4:00 PM to 6:00 PM

Refinement of Dry Etching Parameters to Improve Sidewall Profile of High Aspect Ratio Through-Silicon Vias

Paisley F (Paisley) Zelaya, Senior, Chemical Engineering
Mentor: Michael Khbeis, Washington Nanofabrication Facility

Current research in microelectronic devices made of semiconducting silicon wafers focuses on developing high aspect ratio vertical connections between stacked wafers, known as through-silicon vias (TSV), which result in 3D integrated circuits. These 3D integrated circuits are used to increase density of memory chips, enhance performance, and reduce power requirements, resulting in smaller and more efficient electronic devices. After processing silicon wafers with preliminary photolithography, a dense pattern of high-aspect ratio TSV "holes" is achieved with a deep reactive ion etching (DRIE) tool which utilizes the Bosch process. When a hardware change in the electrostatic chuck of the DRIE tool used for this project resulted in poor etch quality and inconsistent sidewall profile, this experiment attempted to develop a new sequence of steps, or "recipe," for the DRIE tool in order to correct the new issues. Etching parameters were refined in order to achieve the primary goal, to improve sidewall conditions which were not consistently 90 degrees, as well as secondary goals, to obtain the tool's etch rate and selectivity towards photoresist against silicon. Sidewall profile, etch rate, and selectivity were determined by sample analysis via scanning electron microscopy. The conclusion of this experiment was a process recipe which could reliably achieve the desired high aspect ratio vias and continue downstream processing of TSV development.