Undergraduate Research Symposium May 16, 2014 Mary Gates Hall

Online Proceedings

POSTER SESSION 2

MGH 241, Easel 156

1:00 PM to 2:30 PM

Development of a Kinetic Model of Isothermal Strand Displacement Amplification

Isabela Covelli, Senior, Bioengineering
Mary Gates Scholar, UW Honors Program
Mentor: Paul Yager, Bioengineering

The majority of the world's population resides in the developing world where infectious diseases are the leading cause of mortality and morbidity. Due to the lack of affordable and accurate diagnostic tests in low-resource settings, proper treatment of patients with infectious diseases such as malaria, HIV, and tuberculosis is greatly limited. As a result, there is an urgent need for point of care (POC) diagnostic tools targeted for low-resource settings that are inexpensive, rapid, portable, accurate, and require little to no training to operate. Paper-based diagnostic tests are portable and low-cost, and have shown promise for POC diagnostics appropriate for the developing world. The Yager Laboratory is currently developing a paper-based POC diagnostic platform for methicillin-resistant Staphylococcus aureus (MRSA) that utilizes an isothermal strand displacement amplification (iSDA) technique. The amplification method operates at a constant temperature and uses a mutant restriction endonuclease that cleaves only one strand of DNA, which is then displaced by a strand displacing DNA polymerase. While the incorporation of iSDA in the POC platform has been promising, it has been challenging to optimize performance in the paper matrix without a full understanding of its operation. The purpose of this investigation is to develop a kinetic model for iSDA. The model currently considers the major steps associated with the amplification technique and incorporates kinetic rate constants that have been selected from other published studies. Next, simulation results for various conditions will be compared to experimental results to validate the developed model. A successful kinetic model will provide a better understanding of the iSDA method and should enable optimizing the amplification technique. Ultimately, the information produced from this project could be used to improve paper-based POC devices that utilize iSDA technology.

POSTER SESSION 2

MGH 241, Easel 155

1:00 PM to 2:30 PM

Electromechanical Cell Lysis using a Mobile Electronic Device

Alec Wollen, Senior, Bioengineering
Mentor: Paul Yager, Bioengineering
Mentor: Joshua Buser, Bioengineering

Nucleic acid amplification tests (NAATs) performed in the laboratory are the gold standard for pathogen detection due to single copy sensitivity, and could be a useful tool for widespread diagnostics in a global health setting. Unfortunately these assays tend to be expensive and complex, but new developments in isothermal NAATs will allow for cheaper, simpler diagnostics to be possible. Another problem is that current NAATs require a preparation step of cell lysis to release DNA, which traditionally requires bench top equipment or harsh chemicals that can interfere with the assay. My research addresses this barrier in the diagnostic ability of NAATs through development of a low-cost, cell phone based point-of-care device capable of efficiently lysing cells in through mechanical agitation. By placing a sample tube with beads and a magnet into a coil of wire and using a portable audio device to play an audio signal that feeds power through said coil, the alternating magnetic field produced in the coil spins the magnet and agitates the beads. The spinning of the magnet also produces an alternating magnetic field of its own that can be used as real-time feedback. Thus far, experiment results have had moderate variability, potentially because they are carried out with a live model organism, *Staphylococcus Epidermidis*: a common and moderately difficult pathogen to lyse. Conventional NAATs are used to measure success of this new methodology, and results so far have shown up to 60% efficiency from the experimental device compared to a bench top standard. This device may also be capable of DNA shearing, where larger DNA strands are broken into smaller pieces, but more research is needed to confirm and quantify the process. Additional research will also look into developing a theoretical model for lysis, isolating potential sources of variability, and reducing negative control background noise.

POSTER SESSION 3

Balcony, Easel 90

2:30 PM to 4:00 PM

Massive Deep-Sea Carbonates on the Washington Margin

Una Miller, Senior, Oceanography, Biology (Ecology, Evolution & Conservation)
UW Honors Program
Mentor: Harlan Paul Johnson, Oceanography

Calcium carbonate deposits precipitate in ocean sediments when biochemically-produced bicarbonate ions react with calcium ions in seawater. Bicarbonate is the product of a reaction that consumes methane derived from thermal and biological degradation of organic matter. In areas of the Washington margin where tectonic activity squeezes water and entrained methane up through the subseafloor sediments, methane flux is very high. During a research cruise on the Washington margin in August 2013, we discovered a field of unusually large carbonate deposits at a depth of approximately 1000 meters in close association with active methane seeps. As previous studies of carbonates in this area have been limited to dredge sampling, our study will be the first to utilize sonar mapping and in-situ photos acquired with remotely operated vehicle (ROV) Jason. In order to address questions regarding the spatial extent and formation of these carbonates, we will 1) assemble photomosaics from the ROV photos, 2) process multichannel seismic data to assess whether the methane driving the formation of our carbonates was transported though the sediments via linear faults, single vents, or diffuse venting, and 3) create a large-scale sonar map using both bathymetric and acoustic backscatter data of the area. Multichannel seismic data reveals faults and other subseafloor structures through interpretation of reflected seismic waves that travel through the sediment. Acoustic backscatter data provides us with an image of the seafloor through interpretations of reflected sonar waves. We are also attempting to date the growth of the carbonates by testing embedded mineral grains for the presence of volcanic ash from the Mazama volcanic eruption that occurred 6000+ years ago. With these four datasets, we anticipate gaining an understanding of how these carbonates formed and over what time scale, ultimately contributing to the growing geological knowledge of the Washington margin.

POSTER SESSION 4

Commons East, Easel 64

4:00 PM to 6:00 PM

Merkel Cell Carcinoma is an Aggressive Skin Cancer: Can Some Patients be Treated with Surgery Alone?

Tessa Holmes, Senior, Biology (General)
Seesha Rose (Seesha) Takagishi, Senior, Biochemistry, Mathematics (Philosophy)
Mentor: Paul Nghiem, Dermatology
Mentor: Astrid Blom, Dermatology

Merkel Cell Carcinoma (MCC) is a rare, yet aggressive skin cancer with a disease-associated mortality of approximately 40%. Although surgery is typically a component of standard care, it is unclear how often patients should also receive radiation to control disease at the primary site. One retrospective study of 1254 patients found that of the patients who received surgery alone, 39% recurred locally compared to only 12% of the patients who received surgery in combination with radiation therapy. In contrast, in a cohort of 243 patients from New York treated with surgery alone, only 3.8% recurred locally. In order to establish a better standard of care for low risk MCC patients and attempt to resolve this discrepancy in the literature, we identified low risk patients within our cohort based on the following inclusion criteria: 1) primary tumor $\leq$1cm in diameter, 2) microscopically negative margins on the surgical excision, 3) absence of lymphovascular invasion in the primary tumor, 4) absence of profound, chronic immunosuppression, and 5) no microscopic evidence of nodal metastasis in the sentinel lymph node biopsy. Of the 29 patients who met these criteria, 17 were treated with surgery alone, while 12 received adjuvant radiation to the primary site after surgery. We found that 4 patients recurred locally (24%) among the patients treated with surgery monotherapy, while there were no recurrences among patients treated with surgery and adjuvant radiation. Even patients with low-risk MCC still have an appreciable chance of local recurrence if treated with surgery alone. While this risk may be acceptable to some patients, adding radiation therapy can lower the chance of local recurrence.