Undergraduate Research Symposium May 19, 2017 Mary Gates Hall

Online Proceedings

Poster Session 1

Commons West, Easel 28

11:00 AM to 1:00 PM

Fully Reversible Hydrogel Photopatterning for 4D Stem Cell Culture

Gabrielle Myung Hui (Gabby) Benuska, Senior, Biochemistry

Mary Gates Scholar, NASA Space Grant Scholar, Washington Research Foundation Fellow

Mentor: Cole DeForest, Chemical Engineering

Mentor: Jared Shadish, Chemical Engineering

The ability to recapitulate the dynamic presentation of signals in a stem cell's microenvironment remains a major hurdle in tissue engineering. By controlling cell growth and differentiation in 4 dimensions (i.e., time and 3D space) heterogeneous synthetic tissues could be produced that match the complexity of their native counterparts. Combining strategies in both light-programmable hydrogels and recombinant protein engineering, we control the cellular microenvironment. Previously, we have demonstrated the ability to photopattern gels with fluorescent proteins by introducing a biorthogonal synthetic handle site-specifically modified onto our proteins via the sortase enzyme, and a photocaged reactive group in the hydrogrels. The photocaged group uncages upon UV light exposure, allowing for a reaction to occur and a covalent bond to form between the synthetic handle and the hydrogel. While covalent interactions form strong bonds, they are generally irreversible using mild, cytocompatible chemistries. In addition, this technique uses UV light, which may be harmful to cells. By incorporating LOVTRAP into the photopatterning system, we introduce a greater amount of control by allowing for full reversibility. In the dark, LOV2 and Zdk1 dimerize to form a protein-protein bond with similar stability to an antibody-antigen interaction. Upon exposure to blue light, the dimer dissociates, allowing for fully reversible control over conjugation. The Zdk1 domain can be incorporated into a protein of interest using genetic engineering, while still maintaining its binding affinity for LOV2. LOV2 can then be conjugated throughout a hydrogel to make a light responsive protein binding material. By utilizing a light controlled dimerization event between proteins, the LOVTRAP system is fully reversible using only blue light. This technique could be used for tissue engineering applications that require mild treatment conditions and full dynamic control over the presentation of biochemical cues.

Session 2E

Advanced Technologies for Healthcare and Other Applications

Session Moderator: Daniel Kirschen, Electrical Engineering

MGH 238

3:30 PM to 5:15 PM

* Note: Titles in order of presentation.

Photomediated Oxime Ligation as a Bioorthogonal Tool for Spatiotemporally-Controlled Hydrogel Formation and Modification

Payam Farahani, Senior, Chemical Engr: Nanosci & Molecular Engr

Mary Gates Scholar, NASA Space Grant Scholar, UW Honors Program, Undergraduate Research Conference Travel Awardee, Washington Research Foundation Fellow

Mentor: Cole DeForest, Chemical Engineering

Mentor: Steven Adelmund, Chemical Engineering

Water-absorbent polymer networks known as hydrogels are attractive materials from which functional tissue substitutes could be developed using patient-derived stem cells. While hydrogels demonstrate biocompatibility conducive to harboring cells, they lack mechanical and biochemical aspects of the native extracellular matrix (ECM), the intricate microenvironment about which cells function. Conventional photopolymerization-based techniques provide an avenue for incorporating these stimuli within hydrogels, but at the expense of introducing propagating free radicals that are prone to non-specific reactions with biological systems. In light of these limitations, we have developed a strategy for hydrogel formation and modification absent of propagating free radicals, proceeding through oxime ligation moderated by a photocaged alkoxyamine. Upon mild UV light exposure, the photocage is cleaved, liberating the alkoxyamine and permitting localized condensation with an aldehyde to form an oxime-based linkage. After synthesizing multi-arm crosslinkers, functionalized with either benzaldehydes or photocaged alkoxyamines, I demonstrated successful formation of oxime-based hydrogels within minutes of light expo-

sure in the presence of live cells. Through a series of rheological studies, I found polymerization rates and final mechanical properties of these gels could be systematically tuned by varying crosslinker concentrations, light intensity, aniline catalyst concentration, and pH. Harnessing the light-driven aspect of this chemistry, I controlled hydrogel geometry and final mechanical properties by dictating the location and extent of UV exposure, respectively. I then translated photomediated oxime ligation toward the biochemical modification of hydrogels, where full-length proteins containing photocaged alkoxyamines were immobilized in user-defined regions exposed to UV light. The programmability afforded by photomediated oxime ligation can recapitulate mechanical and biochemical stimuli found throughout the ECM, which are dynamic and heterogeneous in their presentation. Consequently, photopolymerized oxime-based hydrogels will enable an enhanced understanding of cell-matrix interactions by serving as improved 3D cell culture platforms, thereby leading to advancements in tissue engineering and regenerative medicine.

POSTER SESSION 3

MGH 206, Easel 169

2:30 PM to 4:00 PM

Sea Urchin Larval Development in a Warming Ocean

Zoe Rae (Zoe) Ludwig, Senior, Biology (Molecular, Cellular & Developmental)
Suzannah Yu, Senior, Psychology, Biology (General)
Mary Gates Scholar
Mentor: Colette Feehan, Marine and Coastal Sciences, Rutgers University

Ocean warming, due to climate change, is currently altering marine ecosystems. In the Salish Sea, temperature anomalies of up to 4C per year have been reported. Sea urchins hold an important ecological role as community engineers with the ability to alter the ecosystem in which they are found. The green sea urchin (*Strongylocentrotus droebachiensis*) relies on phytoplankton as a food source for development in the field, but has been shown to consume kelp detritus in the laboratory. Studies have separately shown the effects of different diets and temperatures on larval growth but have not studied the stresses of increasing ocean temperature with changing food sources and abundance. Here we studied the combined effects of food concentration, food type, and temperature on sea urchin larval development. Contrary to prior studies, our results show that at warmer temperatures, larvae can develop under lower food concentrations, but in agreement with past studies we confirm that larvae develop best under a high concentration phytoplankton diet. Interestingly, we saw increased mortality for larvae grown under warm temperatures and fed a high concentration kelp detritus diet, potentially caused by the introduction of microbes that thrive at warmer temperatures. Warming ocean conditions, causing nutrient composition shifts, could be harmful for sea urchin larvae.