5th Annual AIChE Midwest Regional Conference

January 31st – February 1st, 2013
Organized by the Chicago Local Section of the AIChE
Hosted by the Illinois Institute of Technology, Chicago, IL

Session Fr3D: 3:00pm -4:30pm, Friday February 1, 2013 (Room 005)
Advances in Biological Engineering
Session Organizer: Fouad Teymour, Illinois Institute of Technology
Session Chair: Fouad Teymour and Georgia Papavasiliou, Illinois Institute of Technology

3:00pm **Sequential Growth Factor Delivery within Fibrin Loaded Porous Degradable Hydrogels**
Bin Jiang, Banu Akar, Thomas M. Waller, Jeffery C. Larson, Alyssa A. Appel and Eric M. Brey, Illinois Institute of Technology
Proper microvascular network formation is essential for engineered tissues. Vascularization occurs via a complex temporal delivery of growth factors. The goal of this study is to develop a biomaterial system that can deliver two growth factors with distinct kinetics, while providing structural and mechanical support for tissue regeneration. PLGA microspheres encapsulated with PDGF-BB was prepared with a double emulsion process. A salt-leaching technique was used to synthesize porous PEG-PLLA-DA/PEG-DA hydrogels (300~500μm pore size) with PLGA microspheres and thrombin. Fibrinogen (Fg) solution mixed with FGF-1 and heparin was loaded in pores to where thrombin initiated polymerization of Fg to fibrin. The degradation rate of the hydrogels can be controlled by varying the ratio of PEG-PLLA-DA to PEG-DA, with degradation time ranging from less than 1 week to over 7 weeks. The incorporation of PLGA microspheres accelerated degradation. The release of PDGF-BB from microspheres showed sustained growth factor delivery for weeks, while FGF-1 exhibited rapid release from the fibrin gel within 3 days. A rodent subcutaneous implantation model was used to evaluate hydrogel degradation and tissue response *in vivo*. Preliminary animal study showed hydrogel degradation rate *in vivo* was similar to *in vitro*. By week 1, fast degradable hydrogels (degraded within 1 week *in vitro*) were completely degraded, while medium degradable hydrogels (degraded within 2 week *in vitro*) were partially degraded, and slow degradable hydrogels (degraded within 4 week *in vitro*) were mostly intact. Further histological and vascular analysis are being performed for evaluating the effect of growth factors delivery to tissue invasion and vascular formation *in vivo*. In conclusion, we described a biomaterial system with a degradable scaffold for structural support, PLGA microspheres for later stage drug delivery, and fibrin for earlier stage drug delivery, which can be used for vascular tissue engineering applications.

3:30pm **Design of Cell Instructive Hydrogel Microenvironments to Promote Vascularization of Engineered Tissues**
Georgia Papavasiliou, Illinois Institute of Technology
Cells and tissues must reside within 200 microns from the nearest capillaries for adequate oxygen and nutrient transport. Therefore, the volume of tissue that can be engineered is limited by the extent to which vascularization can be stimulated to form within the implant. Current advancements in the field of tissue engineering are highly dependent on designing scaffolds that exhibit spatial and temporal control in biomaterial properties in order to guide cell behavior and promote neovascularization. To this end, we have developed novel free-radical photopolymerization approaches to design synthetic proteolytically degradable poly(ethylene glycol) (PEG) hydrogel scaffolds that result in (1) tunable gradients of covalently incorporated cell adhesion ligands, crosslink density, and material degradation that lead to directional vascular sprout invasion in the direction of the gradients, (2) independently tuned variations in cell-mediated scaffold degradation rate and hydrogel crosslink density that promote enhanced and rapid neovascularization over a broad range of hydrogel elastic modulus and (3) controlled pore size and porosity using gelatin leaching to provide large surface area to volume ratios in the scaffolds for the enhancement of vascular ingrowth. *In vitro* and *in vivo* data suggest that these biomaterial approaches allow for systematic tuning of hydrogel properties and incorporated biofunctionality which can be tailored towards designing tissues that require controlled and rapid vascularization and regeneration.

4:00pm **Biomaterials for Vascularization of Engineered Tissues**
Eric M. Brey, Illinois Institute of Technology
The fields of regenerative medicine and tissue engineering have received significant attention for their potential to provide alternatives to traditional clinical options for organ replacement and tissue reconstruction. While success has been achieved for some clinical situations, the ability to regenerate tissues of sufficient size and complexity for many applications is limited by the ability to control vascularization. Neovascularization has been an active area of research in regenerative medicine for the past two decades. A number of different approaches for enhancing network formation in tissues have been explored, including seeding cells, delivering growth factors, prevascularizing materials through cell self-assembly, material patterning, and surgical techniques. The optimal approach is likely to vary depending on application. The goal of our research is to increase our understanding of the process of neovascularization in regenerative medicine and then use this information to guide the development of new methods for promoting tissue regeneration. In this presentation our recent

work in two areas of regenerative medicine will be presented: sustained release of soluble growth factors for vascularization of encapsulated islets for treatment of type I diabetes and the optimization of porous hydrogel scaffolds for vascularization of engineered tissues. For each area the material procedures, 3D cell culture models, novel imaging techniques, and animal models used to evaluate the success of these approaches will be described.