Designing and utilizing responsive biomaterials in tissue regeneration and disease

Abstract: The nano- to macro-scale physical and chemical properties of the environment that surrounds a cell are known to play an important role in cell function and fate. Yet, less is known about how combinations of and changes in these properties influence biological functions. For example, driven by transient bidirectional crosstalk between cells and the extracellular matrix (ECM), cell activation and tissue remodeling are complex processes that often involve the presentation of multiple cues that are tightly regulated over multiple time and size scales. Studying and directing such complex and dynamic processes can be challenging. Biomaterials, particularly hydrogels, are useful tools for probing how microenvironment cues regulate cell behavior toward directing cellular functions in the treatment of disease and regeneration of tissue. Further, these materials can be utilized to deliver therapeutics, from proteins to cells, to regulate these processes in vivo. Engineering hydrogel-based materials from the bottom up enables controlled presentation of selected cues at the appropriate time and place within the cellular niche. This talk will focus on simple strategies to impart highly-regulated property control by synthesizing monomers capable of forming hydrogels in the presence of cells and proteins and subsequently allowing triggered modification (e.g., light, enzymes, or reducing conditions) to tune the physical or chemical properties of the network. In particular, we will highlight recent results in the construction of soft, well-defined synthetic matrices with controlled nanostructure, mechanical properties, and biochemical content for two- and three-dimensional culture studies, such as the activation of wound-healing cells or cancer cells, with relevance for improved culture models and regenerative medicine. Additionally, we will highlight efforts in the design and in vivo deployment of responsive hydrogel-based depots for local, controlled release of therapeutics to modulate cell microenvironments in the body.