Incorporating spatially- and temporally-varying cues into biomaterials: From vaccines to stem cells

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Biomaterials and biomaterial-based environments, e.g. scaffolds, drug carriers, devices etc. can be designed to interact with cells and directly influence signaling pathways, differentiation and cell behavior. Most physiological and pathophysiological processes involve complex interactions of cells with their microenvironments. These interactions often vary both spatially and temporally and provide critical, instructive cues to the cells. It is therefore essential that biomaterial-based systems designed to mimic various physiological niches incorporate specific signals that vary both in space and time. These signals include biomaterial-based cues e.g. material composition, mechanical properties (e.g. modulus), surface characteristics etc. as well as soluble molecules like growth factors and drugs.

In this talk we would specifically focus on two aspects of our work:

(a) Engineering artificial niches to control stem cell fate. Specifically, we would present results from our effort to generate complex tissues with spatially varying extracellular matrix (ECM) compositions and mechanical properties. We would use articular cartilage as an example to demonstrate that layer-by-layer structures with varying material compositions can direct a single stem cell population to different cell phenotypes and create a complex, spatially varying tissue within a scaffold.

(b) Engineering synthetic immune-priming centers for vaccine delivery. In particular we would present results from our recent effort in developing an injectable, polymer-based synthetic immune-priming center that can act as an infection-mimicking niche for vaccines. We will discuss our efforts in generating more potent immune response through temporally and spatially controlled delivery of chemokines, DNA and siRNA.