Nano and Microscale 3D Bioprinting: An Enabling Technology for Precision Regenerative Medicine

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Recent advances in 3D printing methods including stereolithography and nozzle-based bioprinting have enabled researchers to build increasingly complex architectures with tunable biophysical properties. These technologies offer significant potential in tissue engineering and regenerative medicine fields, where the development of highly-organized and functional 3D constructs able to mimic the architectural complexity of *in vivo* organ systems is in critical demand. Consequently, researchers have employed, adapted, and invented a wide range of 3D bioprinting strategies to build tissue scaffolds capable of recapitulating key features of *in vivo* tissue and organ physiology.

Despite significant advances, however, the following key challenges for bioprinting biomimetic tissue constructs remain**: a)** Methods for fabricating 3D cell-laden constructs with clinically-relevant precision require time-scales that induce cell death. **b)** Multicomponent/multicellular tissue constructs with biologically relevant architectures and characteristics are difficult or impossible to bioprint at present.

The goal of our laboratory is to develop micro- and nano-scale bioprinting techniques with a high throughput for the direct-write of 3D designer scaffolds used for tissue engineering and regenerative medicine. In this talk, I will present recent research efforts in femtosecond laser 3D printing and projection 3D bioprinting to create 3D scaffolds using a variety of biomaterials. These 3D biomaterials are functionalized with precise control of micro-architecture, mechanical (e.g. stiffness and Poisson's ratio), chemical, and biological properties. Functional nanoelements such as nanomotors, nanoparticles are incorporated in the 3D micro-architecture. Design, fabrication, and experimental results will be discussed. Such functional biomaterials allow us to investigate cell-microenvironment interactions at nano- and micro-scales in response to integrated physical and chemical stimuli. From these fundamental studies we can create both *in vitro* and *in vivo* tissue models for precision tissue engineering and regenerative medicine. Specific applications in neuron regeneration, cardiac tissue modeling, and other biomedical uses will be discussed.