Bioinspired Microfluidic Approaches for Cell and Organism-based Applications

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Due to the complex structures of living systems, with size scales spanning from the micron to millimeter range, the use of micro-scale technology to recreate in vivo-like architectures and disease models has exciting potential applications for drug evaluation and medical diagnosis. Currently, great progress in micro-scale technologies has allowed complex chemical and biological processes to be integrated on a single microdevice. Adaptation of these approaches to a microfluidics (or lab-on-chip) format is providing a novel platform for the investigation of bioinspired engineering by constructing biomimetic microsystems that are connected to health care and controlled down to micro-scale dimensions.

In this talk, various microfluidics approaches will be demonstrated for building functional and biomimetic models from cellular to organism levels. By incorporating unique structures, channel-based microfluidic devices will be described that mimic tumor microenvironments consisting of multiple cells communicating in a 3D co-culture matrix and investigate the tumor invasion patterns regulated by carcinoma-associated fibroblasts in stroma. This approach provides solutions to fabricate hierarchical microenvironments with controlled microarchitectures and 3-D configurations of multiple cell types; this will be helpful in modeling and understanding cancer progression and in testing therapeutics in a biologically relevant context.

In addition, a novel droplet-based microfluidic device will be described that recapitulates a Parkinson's disease model in a miniaturized version by using*C.elegans* as a model organism. The incorporated tiny droplets array could serve as bioreactors for characterizing the worm behaviors in response to external stimuli in parallel. The utility of this device was demonstrated by pharmaceutical evaluation of neurotoxin-triggered mobility defects, neuron degeneration and oxidative stress in individual worms simultaneously, which is not possible by other methods. This approach is more stable and biocompatible, which has the potential to accelerate current whole-animal assays and high-throughput drug screening for neurodegenerative diseases at single animal resolution.