Forward Engineering of Multi-cellular Living Biological Machines

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ABSTRACT

The integration of living cells with 3D printed soft scaffolds can enable the realization of multi-cellular machines for a range of applications in engineering and medicine. We will review our group's efforts and present recent results towards developing such centimeter scale biological machines that are actuated by skeletal muscles cells. These machines are controlled via electrical or optogenetic signals and demonstrate improved healing after a damage when exercised via optical stimulation. We have developed approaches for uni- and bidirectional movement and steering, and most recently are also working to integrate neural control in these biological machines. Using stem cells, a fibrin matrix, and 3D printed molds, we are able to form functional in vitro neural tissue mimic of different shapes, which can eventually be integrated in the walking machines. As these cellular machines increase in capabilities, exhibit emergent behavior, and potentially reveal the ability for self-assembly and self-repair, important questions can also arise about the ethical implications for this direction of research, which are very important to consider and address. These cellular systems present many opportunities in the next decade and beyond with potential applications in drug delivery, power generation, and other biomimetic systems.