3-D Printed Electrically and Optically Paced Skeletal Muscle Based Biological Machines

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Key Research Aims and Goals

- To use 3D printing technologies to fabricate the structure of the biological machine (bio-bot)
- To optimize the design and performance of an engineered biological machine with biological and mechanical characterization of the design and muscle strip
- To achieve net locomotion of the bio-bot using electrical stimulation
- To be able to control the directionality and pacing of the bio-bot through optogenetics and NMJs.

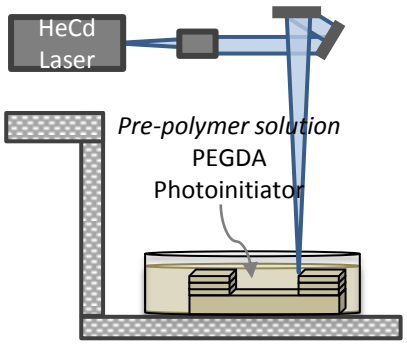
Current Research Highlights and Results

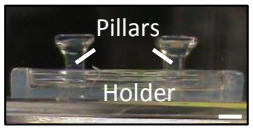
- 'Bio-bots' are integrated cellular machines whose movement relies on the contraction of muscle cells. Previous work has demonstrated the contraction force of cardiomyocytes (cardiac muscle cells) on a hydrogel with collagen on the cantilevers to move the device.
- Our 3D device is a PEGDA hydrogel-based support constructed of a beam connecting two pillars. A cell-matrix solution compacts around the pillars to form a functional 'muscle strip', which contracts to power the bio-bot upon electrical stimulation.
- Optogenetic C2C12s are transfected to express channel-rhodopsin-2 (ChR2), a membrane ion channel that responds to light. When the cells are subjected to blue light, contraction can occur. This allows for another level of control.

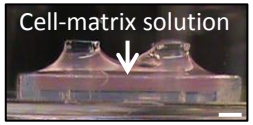
Future Research Plans

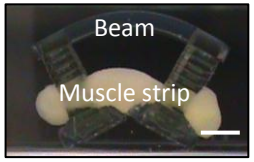
- Optimization of ECM and cell conditions that allow for optogenetic control and development of an optical stimulation set-up for localized and direct targeting of individual cells or components of the bio-bot.
- Addition of a halorhodopsin protein to oppose ChR2 and allow on/off control
- Incorporation of neurons in co-culture to develop functional NMJs in the bio-bot

Fabrication and Muscle Strip Formation

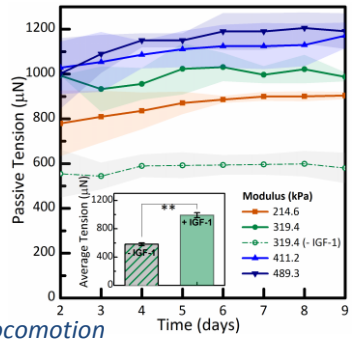








Biological & Mechanical Characterization



Electrical Control and Net Locomotion