Abstract Submitted
for the DFD12 Meeting of
The American Physical Society

Learning from real and tissue-engineered jellyfish: How to design and build a muscle-powered pump at intermediate Reynolds numbers JANNA NAWROTH, Division of Biology, California Institute of Technology, HYUNGSUK LEE, ADAM FEINBERG, CRYSTAL RIPPLINGER, MEGAN MCCAIN, ANNA GROSBERG, School of Engineering and Applied Sciences, Harvard University, JOHN DABIRI, Graduate Aeronautical Laboratories and Bioengineering, California Institute of Technology, KIT PARKER, School of Engineering and Applied Sciences, Harvard University — Tissue-engineered devices promise to advance medical implants, aquatic robots and experimental platforms for tissue-fluid interactions. The design, fabrication and systematic improvement of tissue constructs, however, is challenging because of the complex interactions of living cell, synthetic materials and their fluid environments. In a proof of concept study we have tissue-engineered a construct that mimics the swimming of a juvenile jellyfish, a simple model system for muscle-powered pumps at intermediate Reynolds numbers with quantifiable fluid dynamics and morphological properties. Optimally designed constructs achieved jellyfish-like swimming and generated biomimetic propulsion and feeding currents. Focusing on the fluid interactions, we discuss failed and successful designs and the lessons learned in the process. The main challenges were (1) to derive a body shape and deformation suitable for effective fluid transport under physiological fluid conditions, (2) to understand the mechanical properties of muscle and bell matrix and device a design capable of the desired deformation, (3) to establish adequate 3D kinematics of power and recovery stroke, and (4) to evaluate the performance of the design.

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Date submitted: 01 Aug 2012 Electronic form version 1.4