



ME Department Seminar

Mechanical response of fibrous materials to local contractile loads



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Tuesday, December 11, 2018

**3-4 p.m.
2153 GGB**

Abstract

When cells contract or migrate within a three-dimensional fibrous matrix, they pull on the fibers surrounding them, generating displacements in the fibrous network. As there is no clear constitutive relationship for fibrous materials, the connections between force, displacement, and the fibrous structure are unclear. This is especially true for nonuniform forces such as those applied by a contractile cell. This talk will describe experiments to simulate the contraction of a cell using particles made of poly(N-isopropylacrylamide), a hydrogel that undergoes a phase transition when heated, resulting in a dramatic decrease in volume. By embedding particles made of this gel into networks of fibrous collagen I and controlling the temperature, we can generate well-controlled, repeatable contractile forces within the network. The data show two properties that differ from homogeneous, linear materials. Firstly, displacements propagate over a longer range than predicted by classical linear theory. We provide evidence that the long-range propagation results from nonlinearity caused by weakening of the fiber network under compression. Secondly, the random fibrous structure induces heterogeneity in both the displacement field and the modulus at different positions within the same material. Experiments are ongoing to connect these findings to how cells sense and deform the surrounding fibrous matrix.

Bio

Jacob Notbohm is an Assistant Professor in the Department of Engineering Physics at the University of Wisconsin-Madison. After receiving his Ph.D. from the California Institute of Technology in Mechanical Engineering in 2013, he worked as a postdoctoral researcher at the Harvard Chan School of Public Health. Notbohm studies mechanical properties of biological materials and how physical interactions between cells and their surroundings control cell adhesion, contraction, and migration. In all cases, the focus of this research is on mechanics with an emphasis on experiments. Notbohm has received multiple awards, including a 3M Non-Tenured Faculty Award and an NSF CAREER Award