MAR05-2004-002974

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Tissue architecture, cell traction, deformable scaffolds, and the forces that shape the embryo during morphogenesis.

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Morphogenesis is the process of constucting form and shape. Morphogenesis during early development of the embryo involves orchestrated movements of cells and tissues. These morphogenetic movements establish the body plan and organs of the early embryo. The rates and trajectories of these movements depend on three physical features of the early embryo: 1) the forces generated by cells, 2) the mechanical properties of the tissues, and 3) the architecture of the tissues. These three mechanical features of the embryo are some of the earliest phenotypic features generated by the genome. We are taking an interdisciplinary approach combining biophysical, cell biological, and classical embryological techniques to understand the mechanics of morphogenesis. Using nanoNewton-sensitive force transducers we can apply forces and measure time dependent elastic modulii of tissue fragments 100 micrometers across. Using traction-force microscopy we can measure forces generated by cells on their environment. We use drugs and chimeric proteins to investigate the localization and function of molecular complexes responsible for force generation and the modulus. We use microsurgery to take-apart and construct novel tissues to investigate the role of geometry and architecture in the mechanics of morphogenesis. Together with simulation techniques these quantitative approaches will provide us with a practical nuts-and-bolts understanding of how the genome encodes the shapes and forms of life.