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Active biopolymer gels: from cells to tissues[1]

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Living cells are active soft materials that are far out of thermodynamic equilibrium. They continuously use up chemical energy in order to generate forces that drive processes such as cell migration and division. Moreover, cells actively remodel their surrounding extracellular matrix (primarily collagen), so whole tissues can also be regarded as active soft materials. The aim of our research is to understand the physical mechanisms underlying the self-organization and mechanics of cells and tissues. To this end we use an experimental approach and study simplified model systems for the cytoskeleton (purified actin, tubulin, and accessory proteins) and for tissues (fibroblast-populated collagen and fibrin gels). We use microscopy and rheology to investigate the structure and mechanics on different length scales, from the single protein up to macroscopic level. I will discuss two examples of active mechanical behavior, namely in purified actin-myosin networks, and in purified fibrin matrices with embedded contractile fibroblasts. In both cases we observe active contraction and active stiffening. We quantify the active forces and examine how the structure and mechanics of the active gels depend on motor/cell density.

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