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Mechanical critical phenomena and the elastic response of fiber networks

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The mechanics of cells and tissues are largely governed by scaffolds of filamentous proteins that make up the cytoskeleton, as well as extracellular matrices. Evidence is emerging that such networks can exhibit rich mechanical phase behavior. A classic example of a mechanical phase transition was identified by Maxwell for macroscopic engineering structures: networks of struts or springs exhibit a continuous, second-order phase transition at the isostatic point, where the number of constraints imposed by connectivity just equals the number of mechanical degrees of freedom. We present recent theoretical predictions and experimental evidence for mechanical phase transitions in in both synthetic and biopolymer networks. We show, in particular, excellent quantitative agreement between the mechanics of collagen matrices and the predictions of a strain-controlled phase transition in sub-isostatic networks.