# Biological Soft Matter

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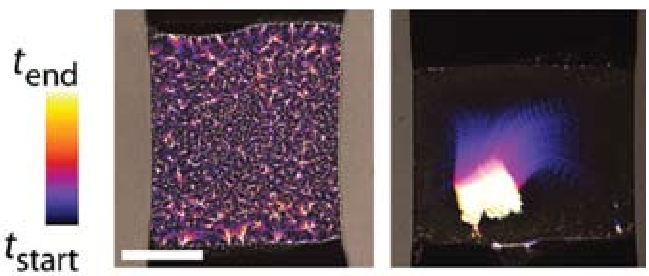
**Group members**
(31-12-2016)
5 PhD students •
5 Postdocs •
5 MSc students •
1 Guest •

We study the biophysical mechanisms that govern the self-organization and (active) mechanics of cells and tissues in the context of soft condensed matter physics. Our main strategy is to create synthetic cell models by biochemical reconstitution as well as synthetic tissue models based on cells grown in physiologically relevant extracellular matrices. We develop quantitative measurement techniques based on advanced microscopy and quantitative image analysis, optical tweezer micromanipulation, and rheology, and work closely with theoreticians to develop predictive models and with biologists to apply physical insights to problems in cell and developmental biology.

## Highlights 2011-2016

- We developed synthetic cytoskeletal networks that exhibit cell-like active contractility driven by myosin motor proteins and demonstrated that contraction is regulated by network crosslinking via a percolation transition [1].
- We reconstituted synthetic cytoskeletal systems that exhibit organizational feedback between microtubule and actin organization, providing mechanistic insights in the basis of cell polarization and migration [2, 3].
- We developed scale-bridging mechanical assays coupled with in situ structural analysis to uncover the molecular basis of biopolymer mechanics, and came up with predictive models to explain the mechanics of several key biological systems (collagen [4] and fibrin [5]).

**Time-lapse movies show that motors do not contract synthetic cytoskeletal networks (left) unless the network is crosslinked (right).**




## Plans

The central aim will remain to understand how structural and mechanical functions of cells and tissues emerge from their constituent parts. In the context of cell biophysics, we will push the boundaries of in vitro reconstitution to build synthetic cells. We will develop microfluidic technologies to create cell-like systems and study how cytoskeleton and membrane interactions conspire to allow cells to change shape, move and divide. In the context of tissue biophysics, we will develop synthetic tissue models to study the mechanoresponse of cells in environments that mimic connective tissue. We will study how cell-matrix interactions control tissue development, making new connections to biomedicine.

## Highlighted papers


1. J. Alvarado, M. Sheinman, A. Sharma, F.C. MacKintosh, and G.H. Koenderink, *Molecular motors robustly drive active gels to a critically connected state*, Nature Phys. **9**, 591–597 (2013). *Cover article.
2. M. Preciado Lopez, F. Huber, I. Grigoriev, M.O. Steinmetz, A. Akhmanova, G.H. Koenderink, and M. Dogterom, *Actin-microtubule coordination at growing microtubule ends*, Nat. Comm. **5**, 4778 (2014).
3. F. Huber, A. Boire, M.P. Lopez, and G.H. Koenderink, *Cytoskeletal crosstalk: when three different personalities team up*, Curr. Opin. Cell Biol. **32**, 39-47 (2015).
4. A. Sharma, A.J. Licup, K.A. Jansen, R. Rens, M. Sheinman, G.H. Koenderink, and F.C. MacKintosh, *Strain-controlled criticality governs the nonlinear mechanics of fiber networks*, Nature Physics **12**, 584–587 (2014).
5. N.A Kurniawan, B.E. Vos, A. Biebricher, G.J.L. Wuite, E.J.G. Peterman, and G.H. Koenderink, *Fibrin networks support recurring mechanical loads by adapting their structure across multiple scales*, Biophysical Journal **111**, 1026-34 (2016).