Statistical mechanics of cellular motion

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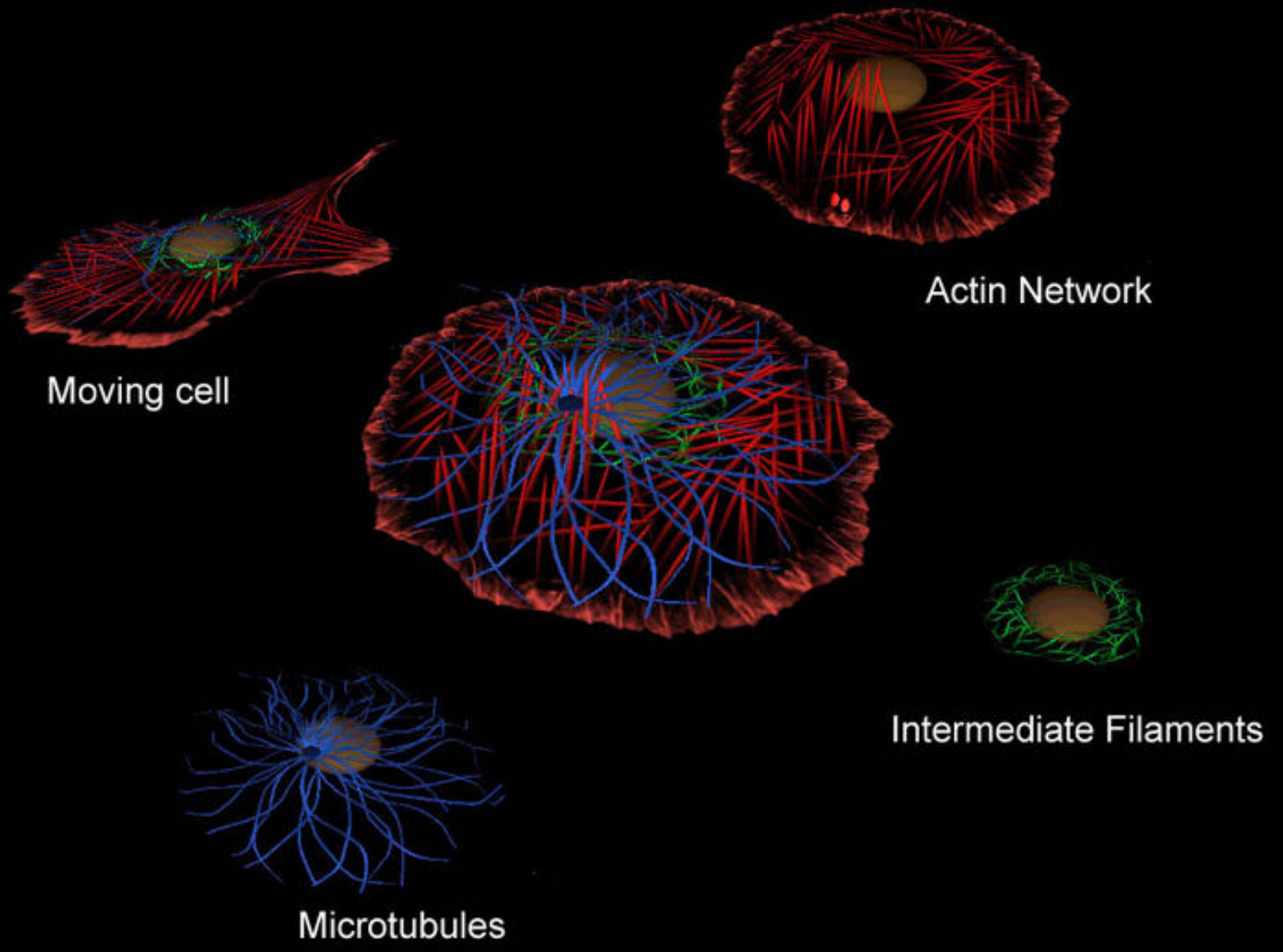
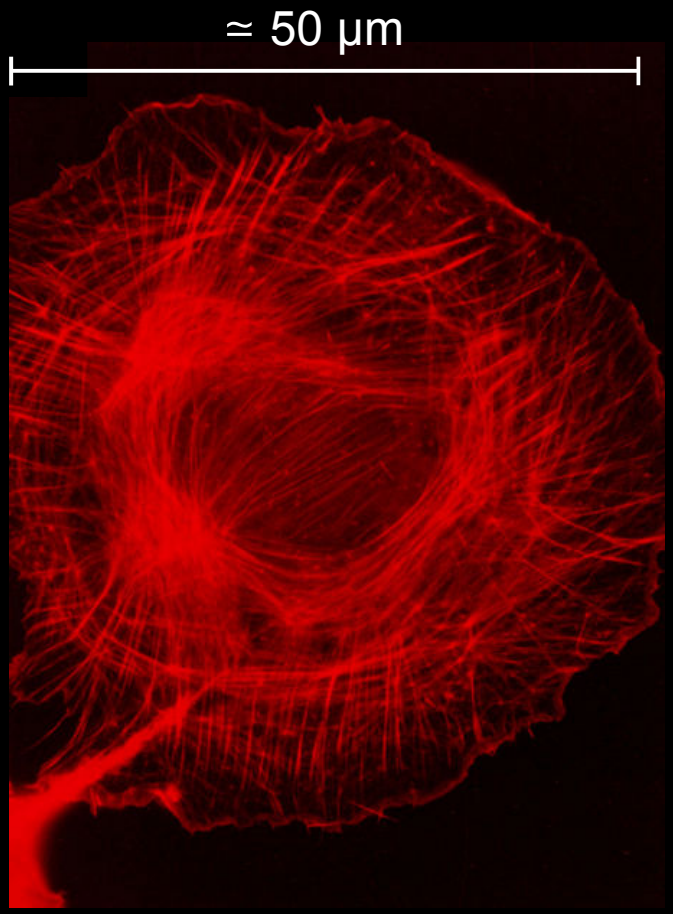
Living cells move on their own

Cytoskeleton: backbone of the living cell

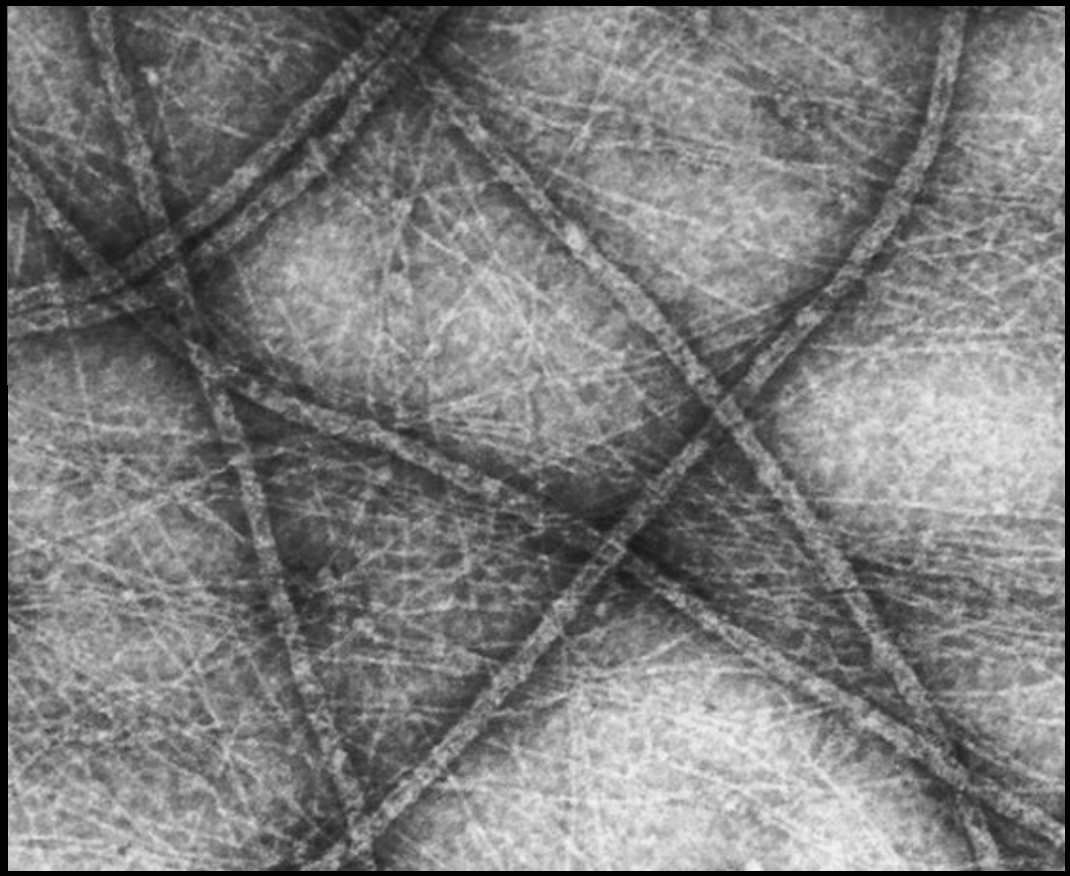


Not one, but three cytoskeletons



actin

optical microscopy:
resolution = 300 nm



electron microscopy:
resolution < 1 nm

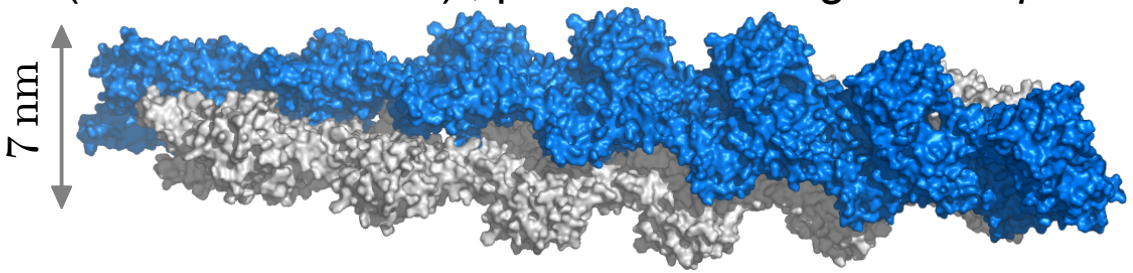
Pushing and pulling: actin moves the cell

myosin
actin

min:sec
10 µm

Meet actin and myosin, major players of cell motility

F-actin (filamentous actin) ; persistence length ≈ 10 *μ*m



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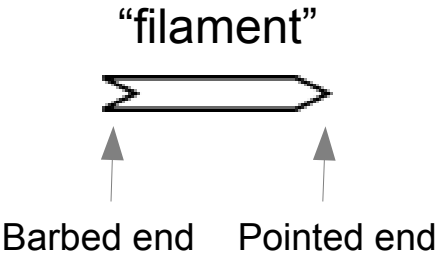
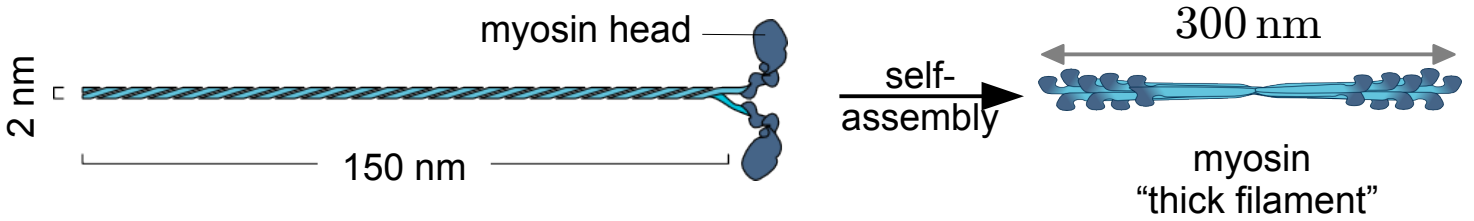


myosin II



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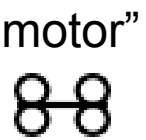


Wikipedia
Alberts *et al.*, Molecular Biology of the Cell, 2002

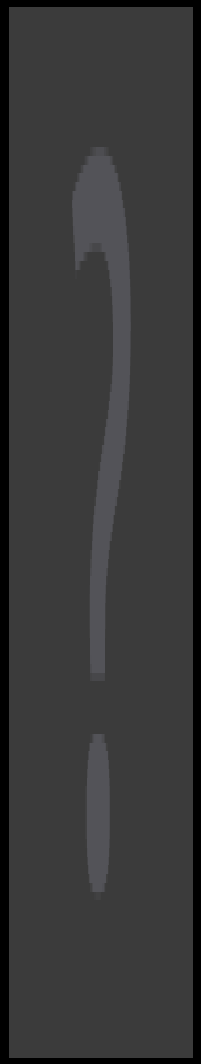
1 filaments

2 motors

1 filaments

2 motors

Actin is rigid, but not that rigid



radii of curvature induced by
thermal fluctuations $\simeq \ell_p \simeq$ 10 μm

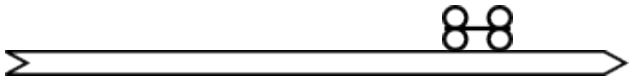
Actin is very dynamic

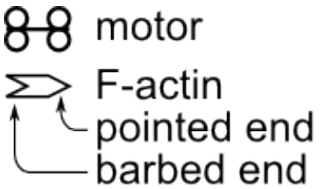
So-called *actin treadmilling* requires constant energy input under the form of ATP

1 filaments

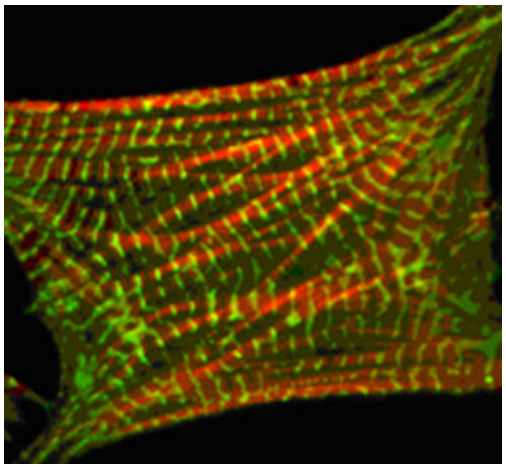
2 motors

Myosin motors exert forces on actin

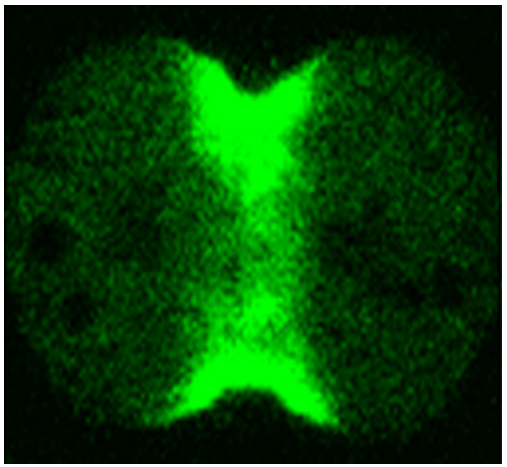




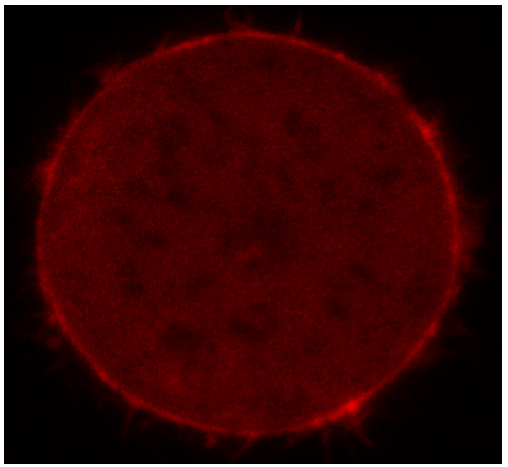
striated muscle



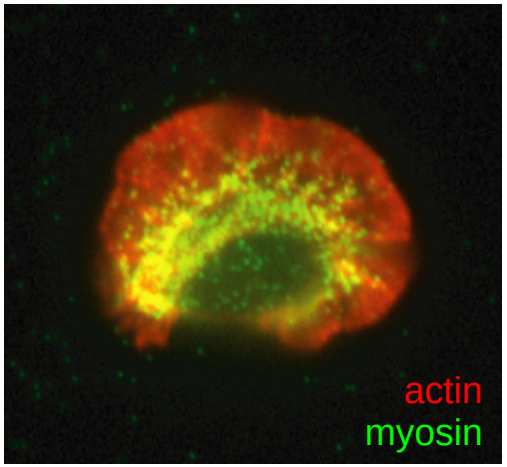
cytokinetic ring (1d)



cell cortex (2d)



lamellar network (3d)



ordered

disordered

Lappalainen lab website ; Yumura *J. Cell. Biol.* 2001 ; Clark *et al. Biophys. J.* 2013 ; Barnhart *et al. PLoS Biol.* 2011

Actomyosin contractility is well understood in striated muscle

Course outline

Part 1: The cell's building blocks at equilibrium

1. Entropic elasticity of a semiflexible filament
2. From filament to gel: effective medium theory
3. Soft modes, bending and nonaffine elasticity

Part 2: The cell's building blocks out of equilibrium

1. The brownian ratchet
2. Molecular motors
3. Rectifying and amplifying stresses

Part 3: Hydrodynamic theories of the cell

1. Generalized hydrodynamics
2. Spontaneous flow in an active gel: a model of cellular motion