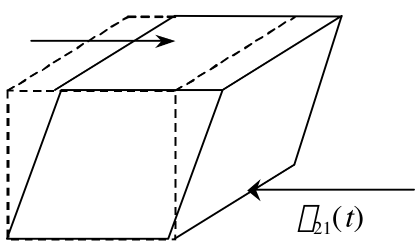
Modeling Complex Material Properties

Continuum

bending plate

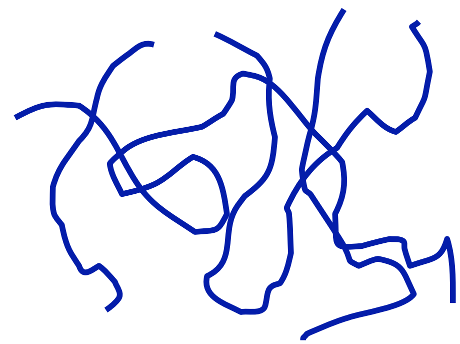
Viscoelastic or poroelastic solid



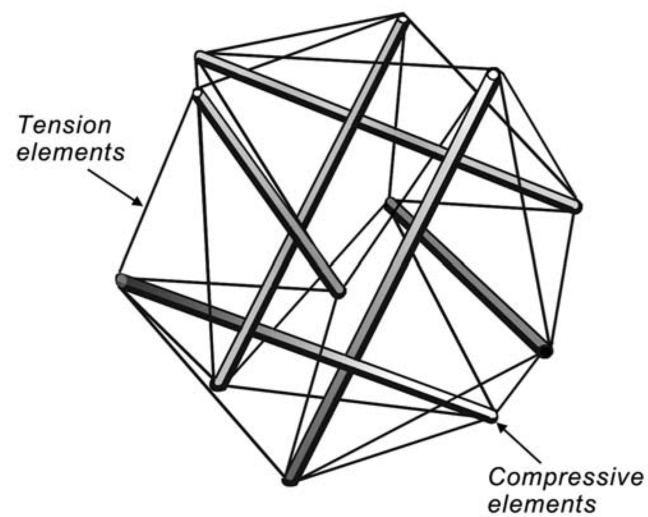
Constitutive relations and force balance

Microstructural

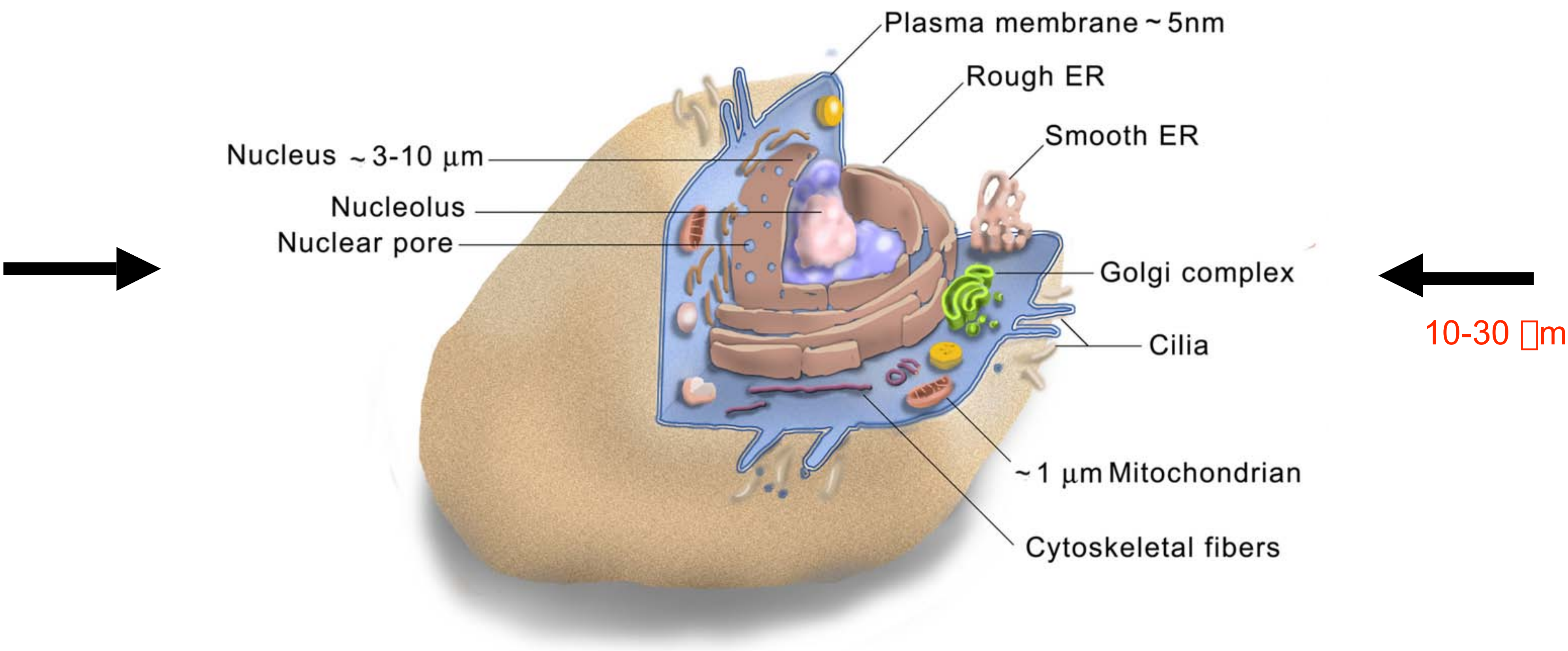
entangled polymer



strut model



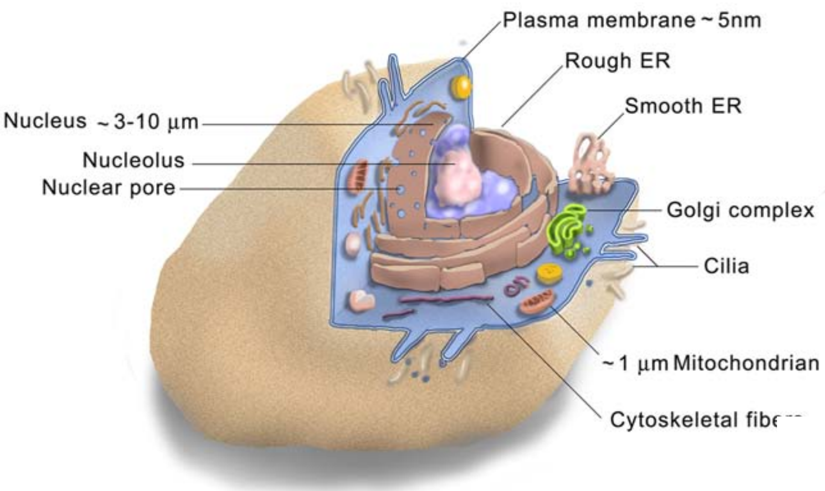
Typical Eukaryotic Cell



1 μm = 10^{-6} m
1 nm = 10^{-9} m
1 Å = 10^{-10} m

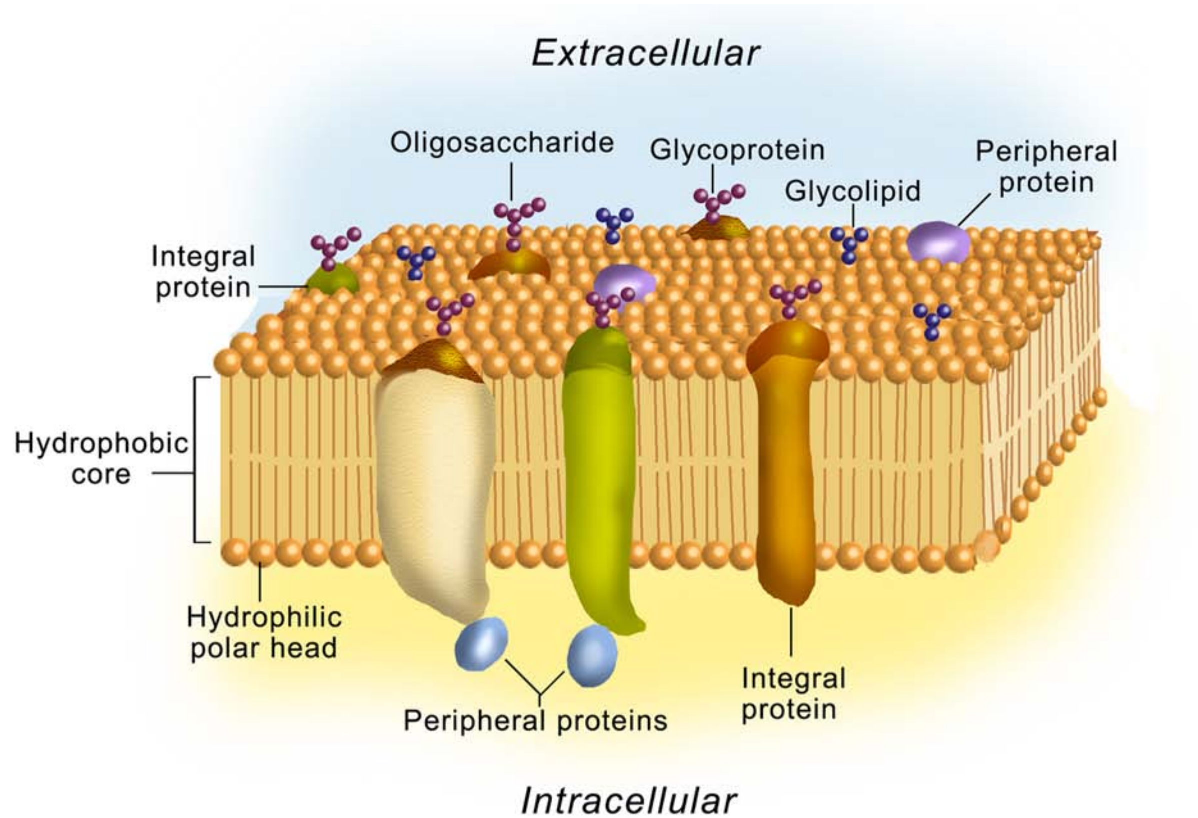
Plasma Membrane

Plasma Membrane

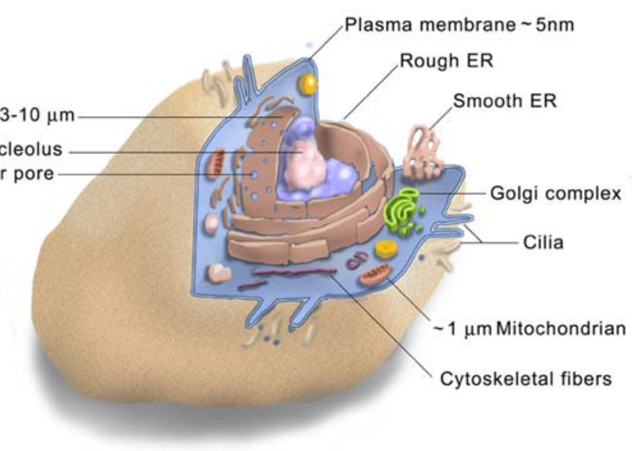


2-D Elastic Plate

~5 nm



Cytoskeleton



Cytoskeletal fibers

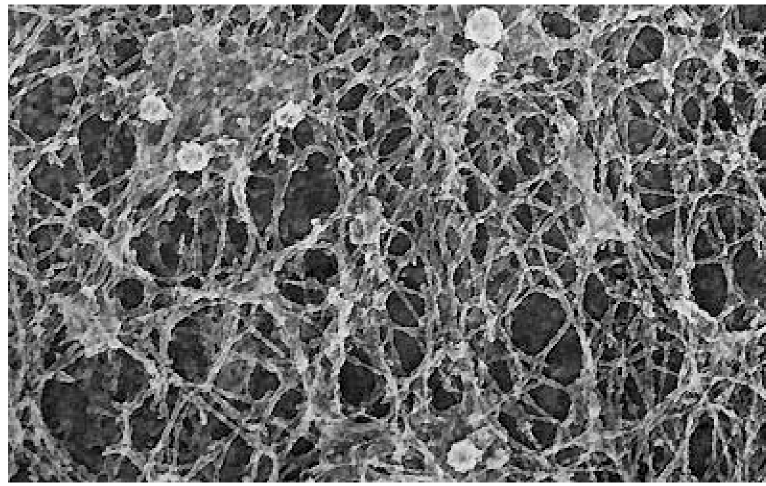
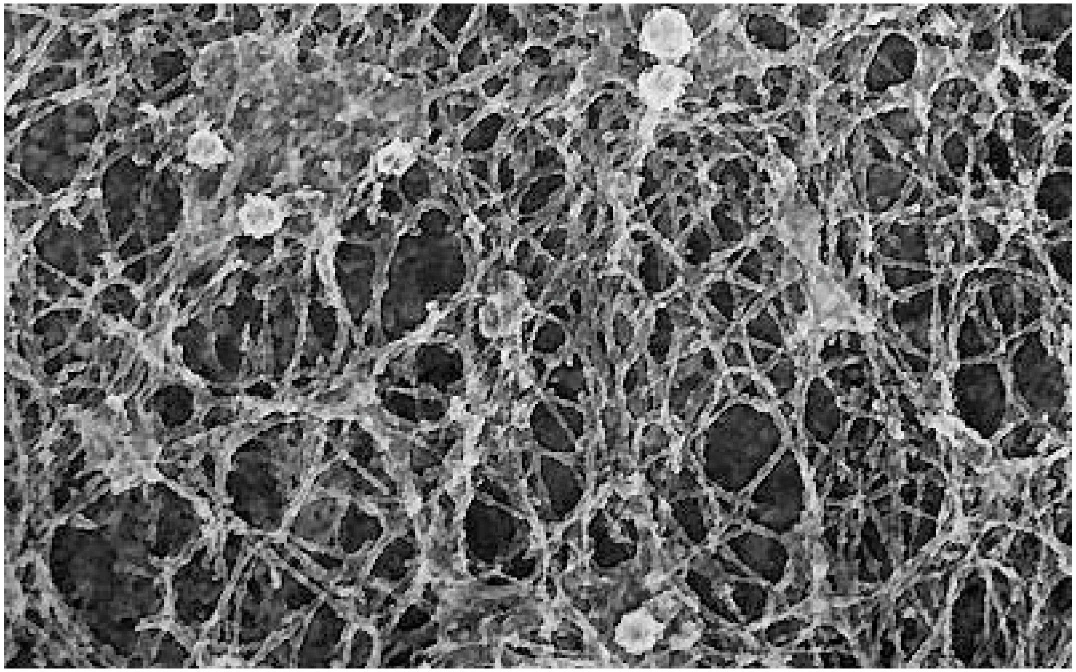


Photo from J. Hartwig

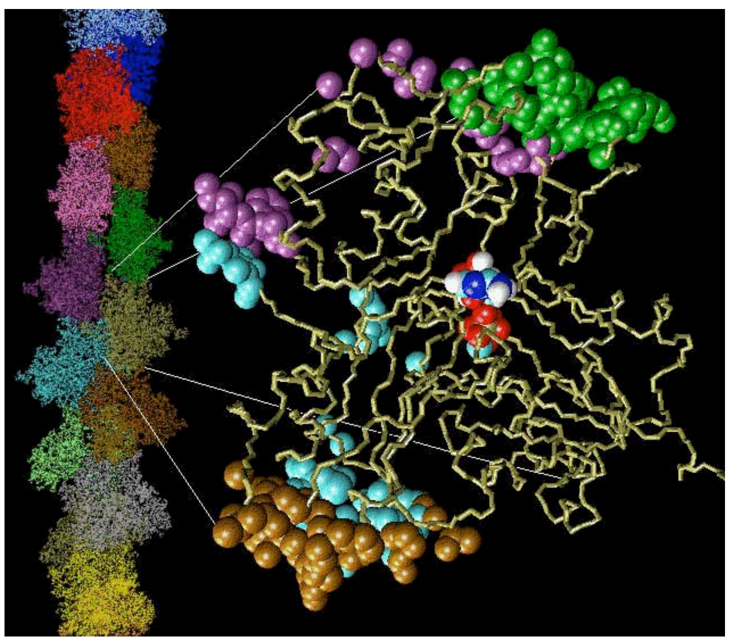
"rigidity"

	Diameter (nm)	Persistence Length (μm)
actin	6-8	15
microtubule	10	60,000
intermediate filament	20-25	1-3



TEM of cytoskeleton, Hartwick, http://expmed.bwh.harvard.edu

When stressed, cells form stress fibers, mediated by a variety of **actin-binding proteins**.

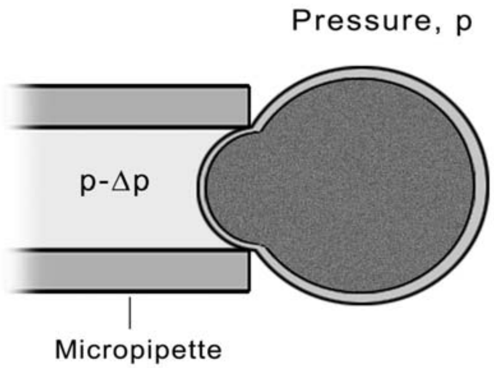


Actin filament: a force of 10 pN supported by a single actin filament ($E \sim 10^9$ Pa) produces a strain of $\sim 2\times10^{-4}$!!)

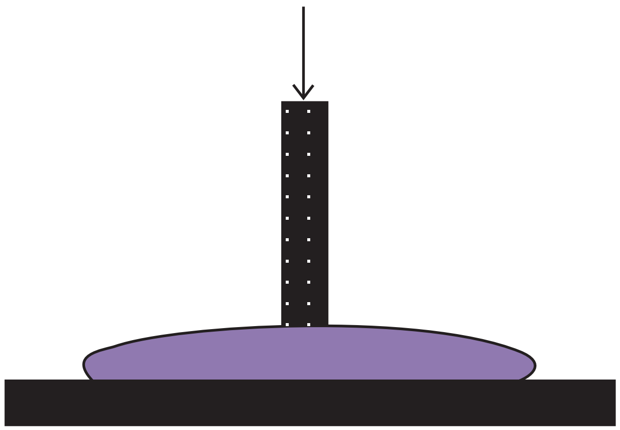
Structure of actin, http://www.scripps.edu/mb/wriggers/projects/actin/

Measuring Complex Material Properties

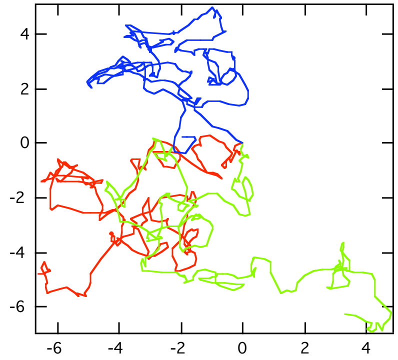
Aspiration



Cell Poking



Thermal tracers

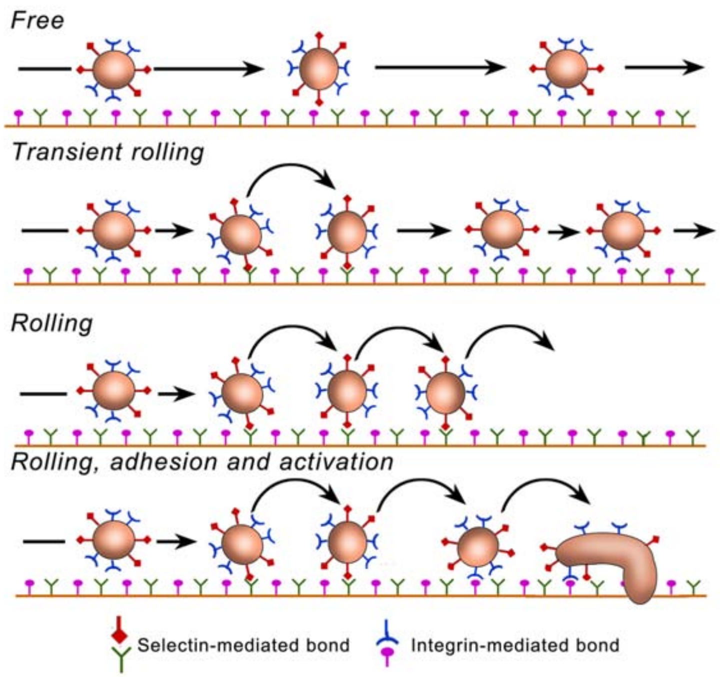


Cell Adhesion

310 Review TRENDS in Biotechnology Vol.19 No.8 August 2001

Molecular properties in cell adhesion: a physical and engineering perspective

Chase E. Orsello, Douglas A. Lauffenburger and Daniel A. Hammer



Physical forces effect bond association/dissociation

Finite contact times

Cell deformation