Summer 2006

Sylabus
Biophysics II
(Cell Biophysics)

Lecturer: Josef A. Käs / Co-lecturer: Friedrich Kremer

English: Wed 15.15-16.45 SR224
German: Thu 9.15-10.45 SR224
Lecture notes with the according literature references will be published in the web.
Total of 16 lectures (each 2x45 minutes)

Studies of soft matter physics on the scale of nanometers to tens of microns, i.e., on the scale of proteins and cells, in complex multifunctional biological matter – often far from equilibrium and frequently behaving in a highly nonlinear manner – are the next big challenge for physics. This lecture is based on the idea that a complete understanding of cell biological systems calls forth a new type of fundamental physics, biological physics, which can describe biological soft matter with active elements and which is adaptive to multipurpose. Over the last decade there has been tremendous progress in molecular biology. Nevertheless, this progress will only impact the design and development of new materials if a novel combination of nanosciences and soft matter physics is developed – bridging biology and engineering. This synergetic research in physics, chemistry, engineering and biology simultaneously advances our fundamental knowledge-base and provides novel applications in biomedicine and materials science.

Topics:

1. **Basic Cell Biology** (cell types, components of a cell, signal transduction and gene expression, cell division) *1 lecture* (Käs 5.4/6.4)
2. **Membrane Biophysics**
   a. **Basic Physics of Liquid Crystals** (nematic ordering, Onsager criteria, different liquid crystal phases, self assembly of lipid membranes) *1 lecture* (Kremer 12.4/13.4)
   b. **Membrane Elasticity and Membrane Morphology** (bending modulus, vesicle shapes, endo- and exocytosis, viral entry, membrane tethers) *1 lecture*(Käs 19.4/20.4)
   c. **Diffusive Transport in Membranes** (single particle tracking, anomalous diffusion, lipid rafts, signal transduction) *1/2 lecture* (Guck/Selle 26.4/27.4)
   d. **Ion Channels and Proton Pumps** (different types, stress-induced signaling, actively driven membrane fluctuations) *1/2 lecture* (Guck/Selle 26.4/27.4)
3. **Biophysics of the Cytoskeleton**
   a. **Basic Polymer Physics** (Gaussian chain, polymer size, polymer concentration regimes, Flory-Huggins, rubber elasticity, persistence length) *2 lectures* (Kremer 3.5/4.5+ 10.5/11.5)
   b. **Stiffness of Cytoskeletal Filaments** (Brownian motion, micromanipulation, end-to-end distance) *1/2 lecture* (Käs 17.5 + Guck/Selle 18.5)
   c. **Rheological Properties of Cytoskeletal Filaments** (entangled and crosslinked filaments, repation, filament bundles, microgelation, strain hardening) *1 lecture* (Käs 17.5 + Guck/Selle 18.5 + Käs 24.5 lecture on 25.5 will take place on 24.5)
   d. **Cell Elasticity** (measurement techniques, cell marker, mechanotransduction) *1 lecture* (Käs 24.5 lecture on 25.5 will take place on 24.5 + Käs 31.5/1.6)
   e. **Active Polymer Gels** (self organization, viscoelastic properties) *1/2 lecture* (Käs 31.5/1.6)
   f. **Cell motility** (thermal ratchets, bead motility, stress fibers, lamellipodial motion, traction forces, Flagella motion) *1 lecture* (Käs 14.6/15.6)
4. **Biophysics of the Cell Nucleus**
   a. **Polyelectrolytes** (stiffening, Manning condensation) *1/2 lecture* (Guck/Selle 21.6/22.6)
   b. **Lipofection** (DNA-lipid phase, plasmids and cell entry) *1/2 lecture* (Guck/Selle 21.6/22.6)
   c. **From DNA to a Chromosome** (self organization, mechanical properties) *1/2 lecture* (Guck/Selle 28.6/29.6)
   d. **Cell mitosis** (the mechanics of cell division) *1/2 lecture* (Guck/Selle 28.6/29.6)
5. **Neurophysics**
   a. **Electrical Signaling** *1/2 lecture* (Käs 5.7/6.7)
   b. **The Synapse** *1/2 lecture* (Käs 5.7/6.7)
   c. **Neuronal Networks** *1 lecture* (Guck/Selle 12.7/13.7)
   d. **Stochastic Resonance in Hearing and Neuronal Growth** *1 lecture*
6. **Cell Organization and Nonlinear Pattern Formation** (slime molds, Ca-waves, bacterial colonies) *1 lecture*