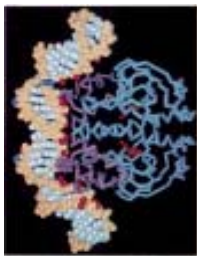
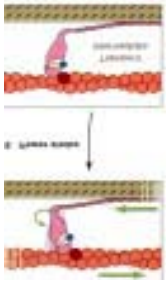
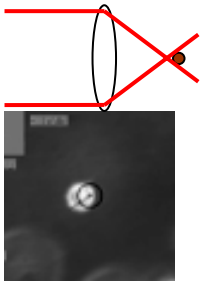
PH 476/576 Introduction to Biophysics II-2B 3 sem. hrs.



Protein-DNA complexes



Force generation in muscle



Optical trapping of micron-size objects

Time: 9:30-10:45 AM Tu/Th Class location: CH 304

Professor: Tom Nordlund Office: CH 345 Tel: 934-0340

Email: nordlund@uab.edu ; website www.phy.uab.edu/~nordlund

Texts: Required- Howard, Mechanics of Motor Proteins and the Cytoskeleton (2001);
Recommended supporting texts- Voet & Voet, Biochemistry (2004, 3rd ed.), or equiv.; Nelson, Biological Physics (2004)

Goals-- to understand the physics of selected nanometer- to micron-size biological systems and processes, especially those involving (i) biological force generation (protein-DNA complexes, microfibers and microtubules, molecular motors, micro-mechanics) and (ii) application of nanotechnology and microscopy to these systems.

Howard provides an introduction to the mechanics, dynamics, and biochemistry relevant to nm- to μm-size motor systems. Voet & Voet provide biological background and computer-animated color images of proteins and nucleic acids to aid in visualization of structures. Nelson provides a thorough introduction to mechanics, diffusion and statistical mechanics/thermodynamics appropriate to sub-μm dimension biostructures in water. Recent literature, web-based information and possible guest lectures will supplement the texts in this rapidly expanding area of molecular motors and modern micro/nanotechnology.

Prerequisites. Permission of instructor. Students should know 1st-yr college chemistry, calculus/simple differential equations, mechanics, and thermodynamics (all elementary) or should be prepared to pick them up quickly. PH 475/575 provides thorough preparation for this course.[1] Though primarily aimed at upper-level undergraduate students, PH 576 will allow graduate students to progress as far as they are able. PH 476 is a primary elective for a Physics major in the Biophysics Track, but students from (bio)chemistry, biology, engineering and biomedical backgrounds are invited. Because a large component of the course grade is derived from the student project, a student weak in one area may make up points in other areas of her/his strengths.

Course Short Outline

I. Protein-DNA complexes, transcription, translation, repair

II. Mechanical and chemical forces in the microscopic biological arena

III. Molecular Motors: muscle proteins, steps and forces

IV. Bio-nanotechnology: scanning probe microscopies, laser tweezers, microchips/microfluidics, single molecule detection

[1] PH 476/576 will be somewhat less mathematically intense than 475/575 and will focus more narrowly on biomolecular complexes, molecular motors and nano-biotechnology.

***Tentative* Class Schedule:**

Week	Topic	Reading (V&V 2nd ed.)
Jan 4,6	Nucleic acid complexes, AFM	V&V: Ch 28:Sections 1-6A
Jan 11,13	Transcription	V&V: Ch 29:Sections 1-3
	Translation.	V&V: Ch 30:Section-3D2,3
Jan 18,20	DNA Replication, Repair and Recombination 9	V&V: Ch 31:Section 1-4
Jan 25,27	Forces, mass, stiffness and damping	H: Ch's 2, 3[2]
Feb 1,3	Thermal, chemical forces	H: Ch 4,5 (also N Ch 4,5)
Feb 8,10	Polymer mechanics	H: Ch 6 (also N Ch 9)
Feb 15,17	Polymerization, cytoskeleton	H: Ch 9, 10 (also N Ch 7,8)
Feb 22,24	Active polymerization	H: Ch 11
Mar 1,3	Structures of motor proteins	H: Ch 12; V&V Ch 34, section 3.
Mar 8,10	Speeds of motors, ATP	H: Ch 13, 14
Mar 15,17	ATP hydrolysis, membrane motors	H: Ch 14, N: Ch 11
Mar 22,24	Steps and forces	H: Ch 15 (also N Ch 10)
Mar 29,31	*Spring Break*	
Apr 5,7	Steps and forces (cont'd)	Exam (Thursday)
Apr 12,14	Nanotechnology: fluidics, microchips	Articles from the literature
Apr 19,21	Nanotechnology: single molecule detection	Articles from the literature
Apr 26, May 3	Student presentations	

Basis for grading. Homework 30%, Midterm Exam 30%, Paper on selected topic 40%. PH 576 students will be expected to complete somewhat more intensive homework assignments. Each course component will be assigned a letter grade (A, A-, B+,…)[3], with grade-point equivalents (4.00, 3.67, 3.33,…).

Homework. Weekly problem sets from the text and other sources; light assignments during last 3 weeks.
Exam. The exam will cover approximately the first 12 weeks of material in the syllabus. It will be a full-class-period, closed-book exam. There will be no exam during finals week.
Written Paper and Oral Presentation.
• Write a 15- to 20-page[4], double-spaced review-style[5] paper, complete with references and in a format appropriate to submit to the Biophysical Journal or other approved journal.
• Present a 20-minute talk to the class during the last week of class. Use transparencies or computer projection to present the talk.
• Clear the topic with instructor by the end of the 6th week (no earlier than end of 4th week). Each student's topic should be different.
• By the scheduled final exam day (May 3), turn in a folder containing the report and copies of your presentation transparencies/slides, plus floppy disk(s) or CD containing your report in Microsoft Word, html, pdf or other format approved by the journal and by your professor. To be graded on written paper (85%) and oral presentation (15%). Grading rubrics for the report will be handed out separately.

References:[6]

Ashkin, A. (1970). "Acceleration and trapping of particles by radiation pressure." Phys. Rev. Lett. **24**(4): 156-159.

[2] Students who have not taken PH 475/575 should read Howard Ch's 1-2.
[3] 476 and 576 are graded separately, as letter grades have different meanings in the two systems.
[4] 15 pp, not including title page, references, figures.
[5] "Review-style" means that you will "review the literature" of your approved topic, to set the context and import of your paper, but then concentrate on a review of results from 2-4 published articles.
[6] More to be added; to be discussed further in class.

Berns, M. W. (1998). “Laser scissors and tweezers.” Sci. Amer. **278**(4): 62-67.

Binnig, G. and C. F. Quate (1986). “Atomic force microscope.” Phys. Rev. Lett. **56**: 930-933.

Brinkman, U. (1998). "Nanofocused light structures materials." Laser Focus World. 34: 38-44.

Bustamante, C. and D. Keller (1995). “Scanning force microscopy in biology.” Physics Today(Dec.): 32-38.

Dickman, K., J. Jersch, et al. (1996). "Building nanostructures." Photonics Spectra. 30: 80-85.

(editors) (1998). "Molecular light antenna". Research & Development. 40: 9.

Godar, K. (1997). “DNA strands link nanoparticles to assemble new materials.” R&D Magazine 39(3): 21.

Hansma, H. G. and J. H. Ho (1994). “Biomolecular imaging with the atomic force microscope.[Review].” Ann. Rev. Biophys. Biomolec. Struct. **24**: 115-139.

Jülicher, F., A. Ajdari, et al. (1997). “Modeling molecular motors.” Rev. Mod. Phys. **69**(4): 1269-1281.

Knapp, M. R., S. Sundberg, et al. (1998). "Laboratory on a chip: a new experimentation format." Amer. Laboratory. 30: 22-26.

Koehl, M. A. R. (1998). “Biomechanics: The quirks of jerks.” Nature 396(6712): 621.

Marshall, S. (1997). "Microinstrumentation in the coming decade." R&D Magazine. 39: 12-18.

Perkins, T. T., D. E. Smith, et al. (1994). “Direct observation of tube-like motion of a single polymer chain.” Science **264**: 819-822.

Samuel, A. D. T. and H. C. Berg (1996). “Torque-generating units of the bacterial flagellar motor step independently.” Biophys. J. **71**(2): 918-923.

Studt, T. (1998). "Gene chip technologies transform biological research." Research & Development. 40: 38-42.

Svoboda, K. (1996). “New insights into the workings of the ultimate swimming machine.” Biophys. J. **71**(2): 539-540.

Svoboda, K. and S. M. Block (1994). “Biological applications of optical forces.” Ann. Rev. Biophys. Biomol. Struct. **23**: 247-285.

Yin, H., M. D. Wang, et al. (1995). “Transcription against an applied force.” Science **270** (Dec): 1653-1657.