Analysis and Modeling of Cell Mechanics

ME 599 F
University of Washington, Seattle — Spring Quarter 2009

Location: MEB 243 **Time:** MWF, 10:30 – 11:30 AM

Instructor: Nathan J. Sniadecki, MEB 318 **Phone:** 206.685.6591 **e-mail:** nsniadec@u.washington.edu

Office Hours: Thur, 12:30-1:30 PM

Website: *http://courses.washington.edu/nsniadec/ME599/S09*

Course Description:

This course is designed to guide students in understanding the architecture and mechanics of biological cells. Emphasis is placed on the mechanical analysis of cytoskeletal filaments, membranes, and adhesions and the unique instrumentation tools used for *in vitro* characterization of cells. We will explore the various models used to describe cell mechanics and discuss the role of mechanotransduction in human physiology, which converts mechanical force into a biochemical response in a cell. A review of basic cell biology is provided for those without a background. At the end of the course, the major learning goals are to become familiar with the theoretical and experimental advancements in the field of cell mechanics and recognize how cells behave as biomechanical material at the nano and microscale.

Prerequisites: None

Required Text: None. Lecture notes and lecture material will be available on the course webpage

Recommended Texts:

1) Mofrad & Kamm, *Cytoskeletal Mechanics – Models and Measurements.* Cambridge University Press, ISBN: 0521846374
2) Ethier and Simmons, *Introduction to Biomechanics: From Cells to Organisms*, Cambridge University Press, ISBN: 0521841127
3) Boal, *Mechanics of the Cell*, Cambridge University Press, ISBN: 0521796814
4) Bray, *Cell Movements*, 2nd Edition, Garland Press, ISBN: 0815332823
5) Alberts et al. *Molecular Biology of the Cell*, Garland Science, ISBN: 0815332181
6) Discher and Wang, *Methods in Cell Biology 86: Cell Mechanics*. Academic Press. ISBN: 0123705002

Grading:

1) Homework 50%
2) Project 50%

Lecture Topics:

Week 1-2: Introduction
What is cell mechanics? Length scales, protein synthesis, protein structure, filament assembly, nucleus, cytoskeleton, and the extracellular matrix

Week 3-4: Measuring the mechanics of cells
Micropipette aspiration, microneedles, atomic force microscopy, microrheology, magnetic tweezers, magnetic twisting cytometry, optical tweezers

Week 5-7: Cell mechanics models
Lumped parameter viscoelastic models, lipid systems, tensegrity, 2D and 3D polymer networks, soft glass materials, computational models

Week 8: Measuring cellular forces
Silicone wrinkling membranes, traction force microscopy, BioMEMS devices, micropost arrays

Week 9-10: Mechanotransduction
Vascular shear flow, biomechanical stretch, nanoscale force tools, focal adhesions, stretch-ion channels, and other mechanisms

Project: (due at end of term)

Students will take one of the cell mechanics models discussed in class (weeks 5-7) and use its conceptual framework to describe, in part, the findings reported in a scientific research paper (weeks 3-4, or acceptable equivalent). Students will need to make valid assumptions and approximations to compare the model to the data in the paper. The student will deliver a final report with the following sections 1) synopsis of the model used and research paper chosen, 2) disclosure of assumptions and approximations made, 3) comparison of model data to research data, 4) description of any future experiments that would help to improve the behavior of the model.

Course Policy:

All assignments must be handed in before class starts on the due date. You may discuss projects and homework with your fellow students, and even collaborate on the solution, but you must list on the homework the person(s) that collaborated with you on the solution. Please cite any material that you copied or you rewrote in your own words.

Course Outcomes and Assessment:

This course offers weekly assignments, critical reviews of scientific papers, analytical and computational descriptions of cell mechanics, and interactive lectures to facilitate the students' exposure to the field of cell mechanics.

Specific outcomes for the course:

1) To gain a working knowledge of the mechanical aspects of cells
2) To formulate the basic mechanical laws that govern cell biology
3) To compare theoretical models of biological cells to published scientific findings
4) To develop communication skills that are critical and clear-thinking
5) To understand the experimental approaches used to measure biomechanical properties at the nano and microscale