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## **Analysis and Modeling of Cell Mechanics**

ME 599

University of Washington, Seattle

Winter Quarter 2013

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**Location:** MEB 234 **Time:** MWF, 10:30 – 11:20 AM

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

**Office Hours:** W 9:30-10:20 AM or by appointment

**Website:** <http://courses.washington.edu/nsniadec/ME599/W13>

### **Course Description:**

This course will 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) Jacobs, Huang, & Kwon, *Introduction to Cell Mechanics and Mechanobiology*. Garland Science, ISBN: 0815344252
- 3) Ethier and Simmons, *Introduction to Biomechanics: From Cells to Organisms*, Cambridge University Press, ISBN: 0521841127
- 4) Boal, *Mechanics of the Cell*, Cambridge University Press, ISBN: 0521796814
- 5) Bray, *Cell Movements*, 2<sup>nd</sup> Edition, Garland Press, ISBN: 0815332823
- 6) Alberts et al. *Molecular Biology of the Cell*, Garland Science, ISBN: 0815332181
- 7) Discher and Wang, *Methods in Cell Biology 83: Cell Mechanics*. Academic Press. ISBN: 0123705002

### **Grading:**

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| 1) Homework | 50% |
| 2) Project  | 50% |

## Lectures:

Date	Day	#	Topic
7-Jan	M	1	Introductory - Analysis and Modeling of Cell Mechanics
9-Jan	W	2	Introductory - Building Blocks
11-Jan	F	3	Introductory - Nucleus
14-Jan	M	4	Introductory - Cytoskeleton
16-Jan	W	4	Introductory - Cytoskeleton
18-Jan	F	5	Introductory - Extracellular Matrix
21-Jan	M	--	No Class (MLK Day)
23-Jan	W	6	Cell Mechanical Analysis - Microneedles
25-Jan	F	7	Cell Mechanical Analysis - Micropipette Aspiration
28-Jan	M	8	Cell Mechanical Analysis - Atomic Force Microscopy
30-Jan	W	9	Cell Mechanical Analysis - Microrheology
1-Feb	F	10	Cell Mechanical Analysis - Magnetic Twisting Cytometry
4-Feb	M	--	No Class
6-Feb	W	--	No Class
8-Feb	F	11	Cell Mechanical Analysis - Optical Tweezers
11-Feb	M	12	Modeling Cell Mechanics - Lumped Parameter Viscoelastic Models
13-Feb	W	13	Modeling Cell Mechanics - Pure Lipid systems
15-Feb	F	--	No Class
18-Feb	M	--	No Class (President's Day)
20-Feb	W	--	No Class
22-Feb	F	14	Modeling Cell Mechanics - Tensegrity
25-Feb	M	15	Modeling Cell Mechanics - Foams
27-Feb	W	16	Modeling Cell Mechanics - Polymer Networks
1-Mar	F	17	Modeling Cell Mechanics - Soft Glassy Material
4-Mar	M	18	Modeling Cell Mechanics - Computational Models
6-Mar	W	19	Cellular Forces - Adhesions and Traction
8-Mar	F	20	Cellular Forces - Traction Force Microscopy
11-Mar	M	21	Cellular Forces - MEMS Tools
13-Mar	W	22	Mechanotransduction - Whole Cell
15-Mar	F	23	Mechanotransduction - Nanoscale Analysis
18-Mar	M	--	<b>Final Project Report Due</b>

## Project: (due at end of term)

Students will take one of the cell mechanics models discussed in class and use its conceptual framework to describe, in part, the findings reported in a scientific research paper. 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