Time: 3:00 – 3:50 MWF
Location: 102 Earth Science

Instructor:

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145 Multidisciplinary Research Building e-mail: dwagner@nd.edu

Office Hours: Thursday 2:00-3:00 p.m. or by appointment

Website: Information on the class can be found at
http://www.nd.edu/~dwagner/courses/60672/60672.html
including this syllabus.

Goals:
This course is designed to introduce students to the cell as a structure, emphasizing the mechanical analysis and characterization of its components including the membrane, filaments and networks of these components. At the end of the course, students should be able to read and understand the current literature in the field of cell mechanics. Of particular interest is mechanotransduction, whereby cells detect loading and respond. A review of basic cell biology is provided for those without a background.

Prerequisites: none
Required texts: Articles from the literature on electronic reserve
Recommended texts: Boal, *Mechanics of the Cell*, Cambridge University Press, ISBN: 0-521-79681-4
Alberts et al., *Essential Cell Biology, 2nd Edition*, Garland Science, ISBN: 0-8153-3480-X
Other texts:
Alberts et al, *Molecular Biology of the Cell*, Garland Science, ISBN: 0-8153-3218-1
Lodish et al, *Molecular Cell Biology*, W.H. Freeman
Howard, *Mechanics of Motor Proteins and the Cytoskeleton*, Sinauer, ISBN: 0-87893-333-6
Nelson, *Biological Physics: Energy, Information, Life*, Freeman, ISBN: 0-7167-4372-8
Gonick and Wheelis, *Cartoon Guide to Genetics*, Collins Reference, ISBN: 0-06-273099-1

Assessment:
Your performance in this course will be measured by homework assignments, and examinations, and a final project.

Grading:

Homework	20%
Midterm	20%
Final Project	20%
Final Exam	30%
Participation/Class preparedness	10%

Additions, amendments, or corrections to this syllabus may be made throughout the semester via in class announcements, handouts, or e-mail.

Topics covered

Date	Topic	Assignments
8/27/08 - 8/29/08	Course overview, Cell Bio (Alberts)	
9/1/08 - 9/5/08	Cell Bio (Alberts), Experimental Techniques	
9/8/08 – 9/12/08	Mechanics of Small Things (Howard/Nelson), Mechanics of Filaments (Boal/Howard)	HW #1
9/15/08 – 9/19/08	Mechanics of Filaments (Boal/Howard)	Read articles 1-2
9/22/08-9/26/08	Mechanics of 2D networks (Boal)	HW#2 due
9/29/08 – 10/3/08	Mechanics of 2D networks (Boal) No lecture on Friday – exam?	HW #3 due Read articles 3 -4
10/6/08 – 10/10/08	Membranes	Read articles 5-6
10/13/08 – 10/17/08	Whole cell – viscoelasticity and indentation	HW #4 due Read articles 7-11
10/20/08 – 10/24/08	Fall Break	
10/27/08 – 10/31/08	Whole cell – membrane/cytoskeleton, tensegrity, cytoskeletal tension	Read articles 12-17,
11/3/08 – 11/7/08	Motor proteins and muscle	Read articles 18-20, HW #5 due
11/10/08 – 11/14/08	Cell adhesion	
11/17/08 – 11/21/08	Mechanotransduction	Read articles 21-25, HW #6 due
11/24/08	Mechanotransduction	
12/1/08 – 12/5/08	Mechanotransduction	
12/8/08 – 12/10/08	Projects	

1. Gittes F, Mickey B, Nettleton J, and Howard J (1993) Flexural Rigidity of Microtubiles and Actin Filaments Measured from Thermal Fluctuations in Shape, J Cell Bio

2. Smith SB, Finzi L, and Bustamante C (1992) Direct Mechanical Measurements of the Elasticity of Single DNA Molecules by Using Magnetic Beads, Science

3. Lee JC-M, Wong DT, and Discher DE (1999) Direct Measures of Large, Anisotropic Strains in Deformation of the Erythrocyte Cytoskeleton, Biophysical Journal

4. Lee JC-M, Discher DE (2001) Deformation-Enhanced Fluctuations in the Red Cell Skeleton with Theoretical Relations to Elasticity, Connectivity, and Spectrin Unfolding, Biophysical Journal

5. Needham D, and Hochmuth RM (1992) A Sensitive Measure of Surface Stress in the Resting Neutrophil, Biophysical Journal

6. Needham D, and Nunn RS (1990) Elastic Deformation and Failure of Lipid Bilayer Membranes Containing Cholesterol, Biophysical Society

7. Trickey WR, Lee, GM, and Guilak, F (2000) Viscoelastic Properties of Chondrocytes from Normal and Osteoarthritic Human Cartilage, Journal of Bone and Joint Surgery

8. Mathur AB, Collinsworth AM, Reichert WM, Kraus WE, and Truskey GA (2001) Endothelial, Cardiac Muscle and Skeletal Muscle Exhibit Different Viscous and Elastic Properties as Determined by Atomic Force Microscopy, Journal of Biomechanics

9. Costa KD, and Yin FCP (1999) Analysis of Indentation: Implications for Measuring Mechanical Properties with Atomic Force Microscopy, Journal of Biomechanical Engineering

10. Costa KD, Sim AJ and Yin FCP (2006) Non-Hertian Approach to Analyzing Mechanical Properties of Endothelial Cells Probed by Atomic Force Microscopy

11. Mahaffy RE, Park S, Gerde E, KKas J, and Shih CK (2004) Quantitative Analysis of the Viscoelastic Properties of Thin Regions of Fibroblasts Using Atomic Force Microscopy, Biophysical Journal

12. Ingber DE (2003) Tensegrity I. Cell structure and hierarchical systems biology, Journal of Cell Science

13. Heidemann SR, Kaech S, Buxbaum RE, and Matus A (1999) Direct Observations of the Mechanical Behaviors of the Cytoskeleton in Living Fibroblasts, Journal of Cell Biology

14. Ingber DE, Heidemann SR, Lamoureux P, and Buxbaum RE (2000) Opposing Views on Tensegrity as a Structural Framework for Understanding Cell Mechanics, Journal of Applied Physiology

15. Tan JL, Tien J, Pirone DM, Gray DS, Bhadrirajo K, and Chen CS (2003) Cells Lying on a Bed of Microneedles: An Approach to Isolate Mechanical Force, Proceedings of the National Academy of Science

16. Chen CS, Alonso JL, Ostuni E, Whitesides GM, and Ingber DE (2003) Cell Shape provides global control of focal adhesion assembly, Biochemical and Biophysical Research Communications

17. McBeath R, Pirone DM, Nelson CM, Bhadriraju K, and Chen CS (2004) Cell Shape, Cytoskeletal Tension, and RhoA Regulate Stem Cell Commitment, Developmental Cell

18. Visscher K, Schnitzer MJ, and Block SM (1999) Single Kinesin Molecules Studied with a Molecular Force Clamp, Nature

19. Hua W, Chung J, Gelles J (2002) Distinguishing Inchworm and Hand-Over-Hand Processive Kinesin Movement by Neck Rotation Measurements, Science

20. Asbury CL, Fehr AN, and Block SM (2003) Kinesin Moves by an Asymmetric Hand-Over-Hand Mechanism, Science

21. Carter DR, Beaupre GS, Giori NJ, Helms JA (1998) Mechanobiology of Skeletal Regulation, Clinical Orthopaedics and Related Research

22. Prendergast PJ, Lacroix D (2002) A Mechano-regulation Model for Tissue Differentiation during Fracture Healing: Analysis of Gap Size and Loading, Journal of Biomechanics

23. Claes LE, and Heigele CA (1999) Magnitudes of Local Stress and Strain along Bony Surfaces Predict the Course and Type of Fracture Healing, Journal of Biomechanics

24. Isaksson H, Wilson, W, van Donkelaar CC, Huiskes R, and Ito K (2006) Comparison of Biophysical Stimuli for Mechano-Regulation of Tissue Differentiation during Fracture Healing, Journal of Biomechanics

25. Isaksson H, van Donkelaar CC, Huiskes R, and Ito K (2006) Corroboration of Mechanoregulatory Algorithms for Tissue Differentiation during Fracture Healing: Comparison with In Vivo Results, Journal of Orthopaedic Research