# The Role of Tissue Mechanics in Biological Responses to Mechanical Loading

**Sponsored by:**

**The University of Notre Dame Center for the Study of Biocomplexity**

**and**

**Indiana University School of Medicine**

**November 8, 9 and 10th 2002**
**The University of Notre Dame McKenna Center for Continuing Education**

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**Welcome**

On behalf of the organizing committee and the University I would like to extend a warm welcome to Notre Dame. In addition to attending the scientific sessions, we hope that you will have an opportunity to tour our campus and enjoy the brisk Northern Indiana autumn.

This is the third in a series of workshops organized by the Notre Dame Center for the study of biocomplexity. The theme of this meeting is "The Role of Tissue Mechanics in Biologic Responses to Mechanical Loading." We are pleased to have brought together this distinguished group of invited speakers, who will present research and educational talks on mechanical behavior of biological materials ranging from the cellular to the organ level. In addition to the 26 invited lectures we are happy to have Dr. Steven Vogel of Duke University present a "pre-workshop warmup talk" and Dr. Stephen Cowin to present our Keynote address, which will highlight the importance of Mechanobiology. Several submitted talks will also be presented throughout the weekend.

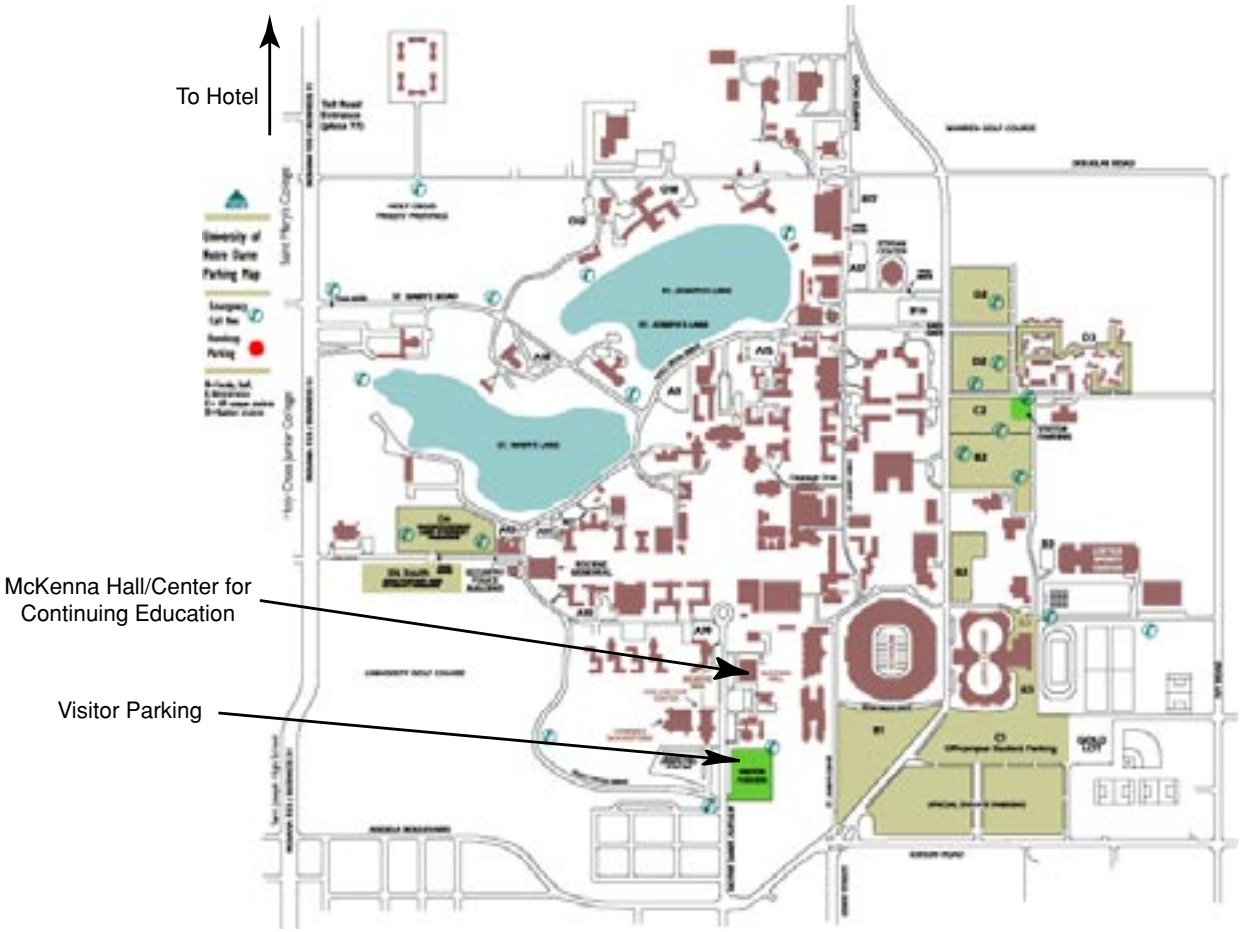
We have organized several social events, including Friday and Saturday lunches, a Friday reception following the Keynote Address, and a Saturday Banquet. It is our intent that these social gatherings will provide opportunities for discussions and will foster future collaborations.

Please do not hesitate to contact the organizers or the staff at the Center for Continuing Education if you need information or assistance during your time here.

Enjoy the workshop.

Glen L. Niebur, Ph.D.

# Campus Map


To Hotel
McKenna Hall/Center for Continuing Education
Visitor Parking

The mechanical properties of biological tissues have been studied by mathematicians and mechanicians for centuries. Biological tissues are of interest from an applied perspective, as they form the structural components that allow organisms to interact with their environment. From a theoretical standpoint, the mechanics of biological materials range from simple linear elasticity to complex coupled fluid-solid-electrochemical models, providing ample challenges for mathematicians, physicists and engineers.

Perhaps the most interesting characteristic of biological tissues is that cells on the surface, embedded within, or in close proximity to the tissue cause active or passive responses of the tissue to mechanical loading. Thus, tissues are not only structural components, but also act as transmitters and modulators of mechanical stimuli from the environment to cells. The cells in turn respond to these stimuli, resulting in altered mechanical properties or structure of the tissue.

This symposium will explore the function of biological tissues as modulators of mechanical stimuli applied to cells and as transducers of mechanical forces. A wide variety of lectures will be presented, ranging from tissue formation and remodeling, to methodologies for probing the mechanical properties of tissues and cells.

## Thursday, November 7

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|---|---|---|
| 4:00 – 5:00 | *The Biomechanics of Ancient Tasks* | Steven Vogel<br>Duke University |

## Friday, November 8

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|---|---|---|
| 8:00 | *Welcome* | Jeff Kantor, Vice-President for Research |
| 8:15 – 8:55 | *Nanobiotechnology: The convergence of engineering with modern biology* | Carlo Montemagno<br>UCLA |
| 8:55 – 9:35 | *TBA* | Charles Pell<br>Duke University |
| 9:35 – 9:45 | *Break* | |
| 9:45 – 10:25 | *Torsional versus flexural stiffness in natural structures* | Steven Vogel<br>Duke University |
| 10:25 – 11:05 | *Tissue Liquidity and Organogenesis* | Malcolm Steinberg<br>Princeton |
| 11:05 – 11:15 | *Break* | |
| 11:15– 11:30 | *Reaction Diffusion Mechanisms for Cell Condensation During Avian Limb Development* | Tilmann Glimm<br>Emory University |
| 11:30 – 11:45 | *Response of Guinea Pig Spinal Cord Ventral Matter to Controlled Stretch* | Riyi Shi<br>Purdue University |
| 11:45 – 12:00 | *Mechanics of Lipid Membranes* | Yi Jiang<br>LANL |
| 12:00 – 1:00 | *Lunch - McKenna Center Dining Room* | |
| 1:00 – 1:40 | *Mechanical Interactions and Mechanosensing during Fibroblast Migration* | Yu-Li Wang<br>Massachusetts |
| 1:40 – 2:20 | *Nanoelectromechanical Transduction in Auditory Hair Cells* | Rob Rafael<br>Rice |
| 2:20 – 2:30 | *Break* | |
| 2:30 – 3:10 | *Membrane Free Volume Theory for Mechanochemical Transduction* | John Frangos<br>La Jolla Bioengineering Inst. |
| 3:10 – 3:50 | *Mechanobiology* | M. van der Meulen<br>Cornell |
| 4:00 – 5:00 | ***Keynote Address:***<br>*How does nature build tissues?* | Stephen Cowin<br>CUNY |
| 5:00 – 7:00 | *Reception – Morris Inn Donors Room* | |

## Saturday, November 9

| | | |
|---|---|---|
| 8:00 – 8:40 | *TBA* | Elliot Rosen<br>Notre Dame |
| 8:40 – 9:20 | *Probing polymerization forces using actin-propelled lipid vesicles* | Arpita Upadhyaya<br>MIT |
| 9:20 – 9:30 | *Break* | |
| 9:30 – 10:10 | *Biomechanics of the intracellular environment studied with magnetic tweezers* | Gabor Forgacs<br>Missouri |
| 10:10 – 10:50 | *Biomechanical Adaptation of Cells* | Wes Jackson<br>California |
| 10:50 – 11:00 | *Break* | |
| 11:00 – 11:40 | *Atomic Force Microscopy in Cells* | Agnes Ostafin<br>Notre Dame |
| 11:40 – 11:55 | *Multi-dimensional measurements of tissue micro-biomechanical behavior* | Blayne Roeder<br>Purdue |
| 12:00 – 1:00 | *Lunch – Morris Inn Donors Room* | |
| 1:00 – 1:40 | *The Plasticity of Skeletal Muscle: Mechanical Consequences* | Vince Caiozzo<br>U. California Irvine |
| 1:40 – 2:20 | *Micromechanics of heart valve tissues* | Michael Sacks<br>Pittsburgh |
| 2:20 – 2:35 | *Force Transmission within Smooth Muscle Tissues* | Richard A. Meiss<br>Indiana University<br>School of Medicine |
| 2:35 – 2:45 | *Break* | |
| 2:45 – 3:25 | *Mechanics of Cardiovascular Development* | Larry Taber<br>Washington University,<br>St. Louis |
| 3:25 – 4:05 | *Negative Diffusion and Aggregation of Blood Cells due to Elastic Deformation in Shear Flow* | Chia Chang<br>Notre Dame |
| 4:05 – 4:15 | *Break* | |
| 4:15 – 4:55 | *Cartilage Mechanics and Tissue Engineering* | Gerard Ateshian<br>Columbia |
| 4:55 – 5:35 | *Contractile response of fibroblasts on a collagen-based matrix used in tissue engineering* | Lorna Gibson<br>MIT |
| 6:00 | *Banquet – Morris Inn Donors Room* | |

## Sunday, November 10

| | | |
|---|---|---|
| 8:00 – 8:40 | *Modulation of Cell Adhesion during Migration* | William Parks<br>Washington University, St. Louis |
| 8:40 – 9:20 | *Matricellular proteins: Extracellular modulators of bone cell biology* | Kurt Hankenson<br>University of Michigan |
| 9:20 – 9:30 | *Break* | |
| 9:30 – 10:10 | *Nonlinearities in bone remodeling* | Charles Turner<br>Indiana University School of Medicine |
| 10:10 – 10:50 | *Bone Adaptation after Joint Replacement* | Rick Sumner<br>Rush Medical Center |
| 10:50 – 11:00 | *Break* | |
| 11:00 – 11:40 | *Implications of Fluid Flow for Bone Function, from an Organ to a Cellular Level* | Melissa Knothe Tate<br>Cleveland Clinic |
| 11:40 – 11:55 | *Interstitial Flow and the Organization of the Interstitium: Implications for Tissue Engineering* | Melody Swartz<br>Northwestern |
| 12:00 – 1:00 | *Lunch – On your own* | |
| 1:00 – 1:40 | *The Relationship Between Bone Microstructure and Its Mechanical Properties* | Subrata Saha<br>Alfred University |
| 1:40 – 2:00 | *Bone remodeling studied by stochastic lattice models* | Richard Weinkamer<br>Austrian Academy of Sciences |
| 2:00 – 2:40 | *How to Find out When Bones Break* | Gemunu Gunaratne<br>Houston |