Biomedical Mechanics

The study of biomechanics is the foundation for many areas in Biomedical Engineering. Traditionally, whole organs and tissues have been analyzed for global material properties, but more recent approaches have developed detailed understanding of biomechanics at the cell and molecular length scales. Furthermore, the influence of mechanical forces on biological processes (mechano-biology) plays critical regulatory roles in many physiological and disease processes. Cornell’s Biomedical Mechanics research team has a rich 40+ year history of collaborations between engineers, life scientists, veterinary, and medical professionals and continues to pioneer new fundamental and applied directions in this exciting field.

A research program of top notch engineering, veterinary, and medical schools has enabled Cornell to pursue unparalleled breadth and depth in biomechanical and mechanobiological inquiry. Our research subjects extend across 10 orders of magnitude in length, from nanoscale mechanics in bone to cardiac function in large animal models. Cornell is also pushing the frontiers of biomechanical analysis towards the meso-scale of elemental tissue structure, creating new theory, computational models, and experimental test systems. We have additionally combined these platforms with genetic and molecular tools to discover new functional principles of heterogeneous biological structures and tailor their mechanical performance.

Some specific faculty projects

Prof. Jan Lammerding’s lab is developing and applying novel experimental techniques to probe subcellular mechanics and the cellular response to mechanical stimulation, with a particular focus on the cell nucleus. They are investigating to what extent impaired nuclear mechanics and increased cellular sensitivity to mechanical strain contribute to human diseases such as muscular dystrophy and cardiomyopathies, and whether increased nuclear deformability could also aid metastatic cancer cells to spread through the human body.

Prof. Cynthia Reinhart-King’s lab studies the role of tissue mechanics in atherosclerosis and tumor growth and metastasis. Implementing techniques such as Traction Force Microscopy and Atomic Force Microscopy in combination with tailored biomaterials and molecular biology approaches, her lab is uncovering how tissue mechanics influence cell-cell and cell-matrix interactions.

Prof. Michael King’s lab studies how fluid shear stress can modulate the response of cells to receptor-mediated biochemical signals. Such phenomena are observed in the response of leukocytes to inflammatory signals like N-formyl-methionyl-leucyl-phenylalanine (fMLP), and the apoptosis response of cancer cell death receptors.

Prof. Larry Bonassar’s lab focuses on elucidating mechanisms by which the complex microstructure of cartilage gives rise to its ability to resist multiaxial loading and minimize friction. They then apply these multiscale structure-property paradigms toward understanding the biomechanical uniqueness of different cartilages, including articular cartilage, auricular cartilage, airway cartilage, meniscus, and intervertebral disc.
Prof. Chris Hernandez's research concentrates on the microstructure of the skeleton and interactions between tissue failure processes and cell repair processes. His laboratory uses sub-micron scale imaging approaches in large formats to relate cell activity to tissue mechanical function and failure. His group uses clinical tissue, in vivo models, and micro- and nano-fabricated devices to perform clinical and translational investigations.

Prof. Jonathan Butcher's lab has developed novel approaches to study the biomechanics of soft tissue growth and development, focusing on embryonic heart and valve development. His group has developed sub-millimeter tensile testing devices that can integrate with fluorescence microscopy to simultaneously understand global and local cell and matrix fiber responses. He applies these to understand differences in cardiac microstructure-function relationships across embryonic gestation and vertebrate species.

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Representative publications


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