Center for Biomedical Engineering

The mission of the Center for Biomedical Engineering (CBE) is to combine engineering with molecular and cellular biology to develop new approaches to biomedical technology with applications for medicine and biology. CBE has played a lead role in the evolution of MIT's activities in tissue engineering. In addition, fundamental discoveries in cellular and molecular mechanics and mechanobiology by CBE faculty and students have enabled critical advances for applications in musculoskeletal and cardiovascular tissue repair and regeneration.

MIT's approach to bioengineering research and education has been undergoing fundamental changes. To maintain intellectual leadership during this nationwide period of rapid evolution in bioengineering, innovative approaches are needed to stimulate fundamental research and to facilitate timely translation of new discoveries into the biomedical industrial and health care sectors. With these goals in mind, CBE has identified and focused on a set of core research thrusts. It has also continued to develop and improve its core research facilities and its connections with industry. Our aim is to pursue multi-disciplinary biomedical research and create an outstanding training environment for a new generation of students/leaders in biomedical and biological engineering. _

Major Research Areas

CBE continues to focus on a set of core research thrusts:

- Cell and tissue engineering
- Molecular-cell interactions
- Mechanobiology (effects of physical forces on cell and tissue regulation)
- Molecular and cellular biomechanics and biophysics

These basic research thrusts are being applied to problems in cardiovascular and musculoskeletal physiology, pathology, tissue regeneration and repair, and drug discovery. CBE's core faculty members represent a variety of academic units, primarily within the School of Engineering, but with substantial participation from School of Science faculty and collaborating faculty from Harvard Medical School and Boston University School of Medicine. These faculty members participate in multi-investigator programs focusing on CBE's main research areas. CBE maintains a broad funding base with support from the US Department of Health and Human Services (65%), industry (20%), and a variety of other public and private sponsors.

Major New Initiatives

Recent advances by CBE researchers have led to new activities and large interdepartmental, multidisciplinary collaborative studies on cellular mechano-transduction and engineering of cardiovascular and musculoskeletal tissues, as well as other organ and tissue systems. A multigroup collaboration between laboratories at MIT, Harvard Medical School, and the Colorado State University Department of Clinical Sciences is now studying the use of self-assembling peptide scaffolds for tissue

engineering of cartilage, bone, liver, nerve, and heart tissue. This research is supported in part by a Bioengineering Research Partnership Grant from the National Institute of Biomedical Imaging and Bioengineering (NIH/NIBIB) that is now in its second year. The partnership includes CBE investigators in biophysics, bioengineering, cell biology, molecular biology, physiology, chemistry, and imaging, with specialists in electrical engineering, mechanical engineering, chemical engineering, chemistry, biological sciences, and clinical science. The long term goals of this program are:

- Design and functionalization of specific peptide sequences for 3D tissue engineering
- Exploring the basic biophysics of the self-assembling peptide environment using state-of-the-art computational modeling and biophysical measurements
- Exploring the role of the self-assembling peptide environment in three major target tissues—myocardium, cartilage, and liver.

This work is related in part to industry connections with 3-D Matrix (scaffold), Olympus Corporation (bone tissue engineering), Menicon Co. Ltd., and Mitsubishi Corporation (tissue engineering). In addition, research grants and partnerships with Centocor (Johnson & Johnson) and Pfizer Inc. now focus on cartilage degradation in osteoarthritis and rheumatoid arthritis. These studies reinforce the need for regenerative technologies.

CBE investigators have recently discovered mechanisms involved with the growth of microvasculature in the peptide scaffold system. In addition, chondrogenesis of marrow-derived equine mesenchymal stem cells within the peptide scaffold is being studied for cartilage tissue engineering—investigators have documented the combined ability of growth factor and mechanical stimulation to enhance chondrogenesis of adult stem cells. Additional research has resulted in the discovery that peptide nanofibers can be used to tether specific growth factors for tissue engineering applications, and can be used for drug delivery applications. Both these results enhance the importance of peptide scaffolds in a wide variety of tissue engineering applications.

Another multidepartment multi-institutional collaborative study between investigators at MIT, North Carolina State University, and Purdue University has focused on molecular and cell nanomechanics. Structure-function studies involving intracellular as well as extracellular matrix macromolecules are of interest in order to relate tissue-level biomechanical properties to the contributions of specific molecular constituents. We see these thrust areas as major initiatives over the next three to five years, coupled in part with recently funded grants from the National Institutes of Health (NIH), National Science Foundation Nanoscale Interdisciplinary Research Team (NSF/NIRT), and industry. These activities will require increased expertise in the biophysics and rheology of biomolecular networks. In addition, computational modeling and simulations at the level of molecular dynamics will be essential. CBE will therefore attempt to attract new faculty affiliations to meet these needs.

Core Facilities

CBE has also continued to develop and improve its core research facilities. CBE now maintains core facilities with Institute-wide availability for multiphoton microscopy, quick-freeze deep etch electron microscopy, and surface plasmon resonance (using the Biacore 2000 instrument) to quantify bind reaction constants between molecules and between molecules and surfaces. In addition, facilities for cell, tissue, and organ culture are available to faculty and students who would otherwise not be able to explore new ventures in biomedical engineering involving living cells because of a lack of specialized facilities in their own laboratories (such as incubators, biosafety cabinets, and an array of associated instruments and peripherals needed for maintaining and experimenting with living cells and tissues). This year, we have added a new facility for quantitative polymerase chain reaction (PCR) studies. This facility is based on the Applied Biosystems 7900HT Fast Real-Time 384-well plate instrument and its peripherals. Many CBE students and staff participated in training workshops that were held this past summer to test the utility of the instrument. While there are many 96-well plate PCR instruments on campus, there appear to be no other 384-well plate instruments easily available to our students, and this 384-well format has unique features that are very important in enabling a variety of systems-level genomics applications that are of interest to many CBE faculty and their students.

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More information about the Center for Biomedical Engineering can be found at http://web.mit.edu/cbe/www/.