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 to 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, staff, and students have enabled critical advances for applications in musculoskeletal and cardiovascular tissue repair and regeneration. At the same time, as CBE approaches its 10th anniversary, we are witnessing fundamental changes in MIT's approach to bioengineering research and education. To maintain intellectual leadership during this period of rapid evolution in bioengineering, nationwide and during times of economic uncertainty, innovative approaches are needed to stimulate fundamental research and to facilitate timely translation of new discoveries into the biomedical industrial and healthcare sectors.

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 participate in multi-investigator programs focusing on CBE's main research thrust areas. The research staff, core facilities, and administrative staff of CBE are co-located on the 2nd and 3rd floors of our new location in Building NE47 (500 Technology Square), along with several core CBE faculty members.

Major Research Areas

CBE has identified and focused 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 research thrusts have direct applications to cardiovascular and musculoskeletal physiology, pathology, tissue regeneration and repair, and drug discovery. The center has also continued to develop and improve its core research facilities and its connections with industry. Taken together, our aim is to pursue multidisciplinary biomedical research and create an outstanding training environment for a new generation of students/leaders in biomedical and biological engineering.

Major New Initiatives

CBE just received a major five-year Bioengineering Research Partnership Grant from the National Institute of Biomedical Imaging and Bioengineering (NIH/NIBIB) on the use of self-assembling peptide scaffolds for tissue engineering. This interdisciplinary research program involves a close collaboration between eight CBE faculty and staff members, postdoctoral and predoctoral fellows in these laboratories, as well as collaborating teams

at the Brigham and Women's Hospital, in Boston, and the equine Orthopaedic Research Center, at Colorado State University. 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, biological sciences, chemistry, and clinical science.

A fundamental challenge in tissue engineering is the nature and design of an appropriate 3-D scaffold. The CBE partnership is using self-assembling peptides to engineer the 3-D environment of cells with biologic functionality that can be modified and controlled, based on the basic biophysics of the material, which can be tailored for specific cell types. The use of self-assembling peptides in tissue engineering potentially enables the control of cellular adhesion, biomechanical properties, growth factor presentation and/or release, and vascularization. A fundamental theme of this partnership is that no single tissue engineering approach is suitable for the diverse structure of all tissues. However, by providing a physiologically appropriate, molecularly specific environment that can be modified by design, the program can optimize the engineering of each specific tissue. The long-term goals of this program are (1) the design and functionalization of specific peptide sequences for 3-D tissue engineering, (2) to exploration of the basic biophysics of the self-assembling peptide environment using state-of-the-art computational modeling and biophysical measurements, and (3) the exploration of the role of the self-assembling peptide environment in three major target tissues—myocardium, cartilage, and liver. This CBE collaborative team has already published extensively on in vitro studies involving cell-seeded tissue-engineered myocardium, cartilage, and liver, and now aims to extend this work to animal studies to explore the usefulness of these approaches in vivo.

Related advances by CBE researchers have focused on molecular and cell nanomechanics, which have become a focal point for structure-function studies involving intracellular as well as extracellular matrix macromolecules. These projects now have direct implications regarding the new tissue engineering initiative. A team of CBE investigators funded by a National Science Foundation Nanoscale Interdisciplinary Research Team Grant has discovered new tools for quantifying the functional biomechanical properties of macromolecular networks synthesized by cells. Experimental techniques utilizing atomic force, lateral force, and molecular force spectroscopies can now help to identify the conditions under which matrix molecules produced by cells in normal or diseased tissue, or in tissue-engineered constructs, can serve their functional biomechanical role at the tissue level. Ongoing studies involving continuum and atomic-level modeling are aimed at predicting classes of molecular structures that can best function mechanically in the matrix of tissues.

The research programs outlined above continue to be directly related to our industry connections, focusing on companies in the fields of medical devices, small molecule and biologic pharmaceuticals, and tissue engineering. CBE continues to host industrial collaborators and visiting scientists from partners at Mitsubishi Corporation, Menicon Co. Ltd., Olympus Corporation, and visiting scientists from ETH-Zurich, Milan, and Germany. CBE maintains a broad funding base with support from the U.S. Department

of Health and Human Services (65%), industry (20%), and a variety of other public and private sponsors.

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