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, and to foster research in the rapidly growing discipline of biological engineering with applications to medicine and biology. To accomplish this mission, CBE has developed and maintains state-of-the-art core research facilities for students and faculty throughout the Institute.

In addition, a novel Engineering/Biology Seed Grant Program for CBE faculty provides early stage funding of high risk projects in order to develop new ideas that can translate into multi-investigator research programs funded through government and industry sources. Toward this end, CBE has an Industrial Advisory Board that plays a major role in initiating seed grants and in advising the director on the broad aims of the center. The IAB also provides important connections between MIT faculty and students and member companies.

Over 45 member faculty have participated in CBE activities during the past five years, including faculty from the School of Engineering, the School of Science, the Media Lab, the Division of Health Sciences and Technology, and Harvard and Boston University medical schools. To date, a total of 20 CBE seed grants have been awarded to interdisciplinary teams comprising 39 CBE faculty members. All seed grants must have coprincipal investigators from engineering and biology disciplines in order to insure the multidisciplinary vision of the program, and to insure that participating students have outstanding mentorship in both the engineering and biological components of their research.

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. 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, nation-wide, 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 health care sectors.

With these goals in mind, CBE has identified and focused on a set of core research thrusts. 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 Research Thrust Areas

CBE faculty participate in multi-investigator programs focusing on CBE's main research thrust areas: (1) cell and tissue engineering, (2) molecular-cell interactions, (3) mechanobiology (effects of physical forces on cell and tissue regulation), and (4) molecular and cellular mechanics. These research thrusts have direct applications to cardiovascular and musculoskeletal physiology, pathology, tissue regeneration and repair, and drug discovery.

Core Facilities in 500 Technology Square

CBE staff and core facilities are now co-located in 500 Technology Square with a half-dozen core CBE faculty members, as well as components of MIT's BioImaging Center and Center for Environmental Health Sciences. This move has enabled critically important upgrades in CBE core facilities. For example, CBE recently established a cell-tissue-organ culture facility with sufficient incubator and biosafety cabinet capacity to enable students and faculty from across MIT to perform cell culture experiments that would otherwise not be doable for lack of such a facility within individual faculty laboratories. In addition, this move has recently initiated very useful synergies with the newly established Institute for Soldier Nanotechnologies. In addition, CBE continues to maintain its cryofixation, freeze-fracture/deep etch facility, along with the multi-photon and atomic force microscopy facilities at this location.

Major New Initiatives

Recent advances by CBE researchers have led to new activities and large collaborative studies on molecular and cell nano-mechanics, which have become a focal point for structure-function studies involving intracellular as well as extracellular matrix macromolecules. These projects have important implications in CBE's ongoing sponsored research on cellular mechanotransduction in cardiovascular and musculoskeletal tissues.

We see these thrust areas as major initiatives over the next three to five years, coupled in part to new grants from the National Institutes of Health (NIH), National Science Foundation Nanoscale Interdisciplinary Research Teams (NIRT) Grant, and industry. The NSF-NIRT grant research is being carried out by CBE faculty in collaboration with research groups at Purdue and North Carolina State universities. The overall goal is to use powerful new nanoscale experimental and theoretical tools to develop a foundation for the fundamental physics of novel, technologically important polyelectrolyte brush systems, including natural biological brush molecules as well as synthetic polymeric brushes.

The goals include direct experimental characterization by atomic force microscopy, molecular force probe, and other nano-scale instrumentation. Parallel theoretical modeling studies span length scales from atomic-level molecular dynamics simulations, coarse-grained models, continuum nano-scale Poisson Boltzmann to include electrostatic interactions, and scaling up to the micro- and macro-levels to simulate the role of

specific molecular interactions in the properties of materials based on the brush molecules.

In addition, a multi-group collaboration involving the use of self-assembling peptide scaffolds for tissue engineering of cartilage, bone, liver, nerve, and heart tissue resulted in the submission of a large BRP Program proposal to NIH. This work is directly related to our industry connections—for example, with Olympus for bone tissue engineering. Taken together, 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, and to encourage academic units to hire in these areas. This multi-investigator project is also leveraging current research being carried out by visiting scientists from our international industrial partners, including Mitsubishi, Menicon, Olympus, and visiting scientists from ETH-Zurich, Milan, and Germany.

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