Computational and Systems Biology Initiative

The MIT Computational and Systems Biology Initiative (CSBi) is a campus-wide education and research program that links biologists, computer scientists, and engineers in a multidisciplinary approach to the systematic analysis of complex biological phenomena. CSBi places equal emphasis on computational and experimental methods and on molecular and systems views of biological function. Multi-investigator research in CSBi is supported through shared funding mechanisms that support integrated projects.

From its inception, CSBi has developed and coordinated activities in the nascent computational and systems biology field by facilitating interaction at the interface of life science, engineering, and computation; by building the CSBi Technology Platform; and by launching programs in education and outreach. CSBi has grown to include more than 90 faculty members.

Goals and Priorities

CSBi's mission is to advance research and education in the emerging field of systems biology and to pursue high-impact collaborations with companies engaged in biomedical and pharmaceutical research.

CSBi is currently active in five main areas:

- Multi-investigator research projects that integrate systematic experimentation and computational modeling
- Development of new technologies, particularly those involving micro-fabricated devices and sensors, for monitoring biological processes and manipulating biological systems
- Establishment of high-end instrumentation and computer facilities
- Creation of a new curriculum to educate the next generation of undergraduate and graduate students
- Outreach to a broad industrial and academic community interested in systems biology

The priorities for CSBi in 2012 include the following:

- Leveraging current multi-investigator research programs
- Ensuring the continuing maintenance and support of current CSBi resources while continuing to meet the growing needs of the community
- Enhancing the Computational and Systems Biology PhD program
- Encouraging economically disadvantaged, minority, and female students to pursue careers at the biology-engineering interface
- Strengthening ties with research entities at MIT and in the Boston area

Research

The overall goal of CSBi is to foster links among biology, engineering, and computer science and to create interdisciplinary, multi-investigator teams to undertake the systematic analysis of complex biological phenomena. CSBi retains a fundamental commitment to an academic tradition placing graduate students and postdoctoral researchers at the forefront of scientific inquiry. CSBi recognizes that significant research advances in this emerging cross-disciplinary field will come from integrating concepts, technologies, and tools from different disciplines. With this in mind, CSBi fosters the development and integration of multidisciplinary teams and sophisticated technologies to approach problems at the frontiers of biomedical research. Cross-disciplinary research will also provide new concepts, technologies, and tools developed through studying biological systems that will have important applications in engineering and computer science.

CSBi is active in research in areas as diverse as molecular science, tissue engineering, microbial communities, and structure and function of the brain and neural processes, with applications to cancer, Alzheimer's disease, diabetes, mental health, and infectious disease, to name but a few. CSBi researchers are active participants in National Institutes of Health (NIH)–funded centers as part of the Integrative Cancer Biology Program (ICBP), a multi-investigator and cross-disciplinary research program focused on understanding cancer biology. ICBP is based in the David H. Koch Institute for Integrative Cancer Research and links the Koch Institute's research on cancer biology with CSBi's emphasis on quantitative modeling and computational analysis of biological datasets. CSBi faculty, postdoctoral researchers, and students also work in the Cell Decision Process Center, also NIH-funded, which is aimed at developing computational models of how human cells make certain life-or-death decisions throughout their life cycles. CSBi researchers are members of the infectious disease and the biosystems and micromechanics projects within the Singapore-MIT Alliance for Research and Technology, and are at the forefront of the new synthetic biology field. They are investigating fundamental biological questions from the molecular level through tissues, organs, and individuals; they are engineering new technologies to probe, analyze, and manipulate biological systems; and they are transferring the operational principles from living systems to produce new applications and new improvements in the engineering world.

Technology Development

The goal of the CSBi Technology Platform is to develop state-of-the-art technologies for systems biology research and to make them available to the research community at MIT. CSBi research scientists facilitate the development of technologies that are useful for the community and provide expertise to advance systems biology research. Successful high-end research platforms have been established, including microarray and bioinformatics, high-end computing and data storage, automated high-content imaging, advanced imaging, and biophysics, and user groups have been established in high-performance computing and microarray analysis. CSBi is continuing to forge new corporate partnerships in technology development in an effort to continue to provide the latest technology to the MIT community.

Education

The Computational Systems Biology (CSB) PhD program is an Institute-wide program that was jointly developed by the Department of Biology, the Department of Electrical Engineering and Computer Science, and the Department of Biological Engineering. The program is the first of its kind in the United States and focuses on foundational material from computer science and engineering and its application to complex processes in biology. The program integrates biology, engineering, and computation to address problems in biological systems at the molecular, cellular, and organismal levels, and CSB PhD students have the opportunity to work with CSBi faculty from across the Institute. Thirty-six students were enrolled in the CSB PhD program as of October 2010; six students received the PhD degree in AY2011.

Outreach

This year CSBi organized a large program on systems and synthetic biology for the Institute of Electrical and Electronics Engineers' annual conference of its Engineering in Medicine and Biology Society, which will take place August 30–September 3, 2011, in Boston. The program will highlight the integrative framework spanning engineering, computation, and the life sciences that is paradigmatic of the CSBi approach. Presentations will cover the interplay among experimental and computational methods of analysis, top-down and bottom-up studies, and mechanistic as well as data-driven modeling approaches. Speakers will include current MIT faculty, postdoctoral researchers, and students, as well as alumni and like-minded researchers from around the world in academia and industry.

Future Directions

To build on its current success in the formation of new multi-investigator cross-disciplinary research programs, CSBi will continue to provide mechanisms of support from both the nonprofit and for-profit sectors. CSBi will also seek to initiate research collaborations with new industry partners, as well as expand successful ongoing industrial research collaborations to provide opportunities for crucial peer-to-peer collaboration with industry. Lastly, the value of CSBi outreach programs as well as graduate and postdoctoral fellowship programs is essential to the CSBi mission, and the further development of these programs will be explored.

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