SYSTEMS BIOLOGY AND THE EMERGING DISCIPLINE OF BIOLOGICAL ENGINEERING

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The molecular revolution in biology and the advent of postgenomic biology place the science of biology as a new foundational science for engineering, joining the well-established engineering foundations of physics, chemistry, and math. As with other revolutions in basic science, engineering analysis, design, and synthesis are needed to translate breakthrough discoveries into products and create new industries — and to foster further developments in the basic science. Biological problems have already become a frontier application area for established engineering disciplines, and this expansion into biology continues robustly. However, each established engineering discipline is naturally limited to addressing a certain range of problems within biology that fall within the scope of tools and approaches of that discipline. The fusion of engineering with modern biology, then, requires development of a new discipline of engineering, "Biological Engineering," which brings to bear on biology the appropriate tools and perspectives from chemical, civil, computer, electrical, materials, mechanical, and nuclear engineering in an integrated way. Biological Engineering is naturally one of the contributing disciplines to the applied field of Biomedical Engineering, which may be defined as the application of engineering broadly to problems in clinical medicine, including many application areas and approaches that do not require a foundation in biology, such as development of, surgical devices and telemedicine.

Systems Biology, a focus area within Biological Engineering, encompasses approaches to collecting, organizing, and modeling biological information with the ultimate goal of developing formal models for complex living systems, combining molecular detail with predictive power. Research depends equally on the creation of new experimental paradigms —including the design of novel devices and instruments — and on the successful application of computational analysis and modeling methods, often based on techniques employed in other disciplines. A paradigm of 'measure/mine/model/manipulate' fuses systematic experimentation with computation to address biological problems. Talks in this session cover the spectrum of research goals in Systems Biology, from developing novel methods and devices that can measure, simultaneously and in a systematic and precise manner, the biochemical properties of a large number of biomolecules from the cellular to the organism level and as a function of time, to building mathematical models of biological systems that link mechanistic information on molecular function to systems-wide understanding of biological networks and interactions. Like models in mature engineering disciplines, systems biology models will capture empirical knowledge as it accumulates and will have the ability to predict experimental outcomes.