MIT Industrial Liaison Program Faculty Knowledgebase Report

Humanizing Drug Development

November 2, 2020 10:30 am - 12:00 pm

10:30am	Welcoming Remarks & Introduction Sheryl Greenberg Program Director, MIT Industrial Liaison Program

Sheryl Greenberg
Program Director
MIT Industrial Liaison Program

Sheryl Greenberg initiates and promotes the interactions and development of relationships between academic and industrial entities to facilitate the transfer of new ideas and technologies between MIT and companies, and has created numerous successful partnerships. By understanding the business, technology, and commercial problems within a company, and understanding the technologies and expertise of MIT researchers, Greenberg identifies appropriate resources and expertise to foster new technology applications and collaborative opportunities.

Prior to MIT, Greenberg created and directed the Office of Technology Transfer at Brandeis University. In the process of managing intellectual property protection, marketing, and licensing, she has promoted the successful commercialization of technologies as diverse as new chemicals and manufacturing, biotechnology, food compositions, software, and medical devices. She facilitated the founding and funding of new companies, as well as creating a profitable technology transfer program. She also facilitated the patenting, marketing, and licensing of Massachusetts General Hospital technologies. In addition to her cellular, biochemical, and genetic research experience in academic and corporate environments, she has also created intellectual property for medical uses. Greenberg has been an independent intellectual property and business development consultant, is a U.S. Patent Agent, and has previously served the Juvenile Diabetes Research Foundation as Co-Chair of the Islet Research Program Advisory Committee and grant reviewer. She currently also mentors startup companies and facilitates partnering them with large life science and healthcare companies.

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10:35am

Mammalian Synthetic Biology – Foundations and Applications to Programmable Organoids
Ron Weiss
Professor, Biological Engineering
Director, MIT Synthetic Biology Center

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Ron Weiss is Professor in the Department of Biological Engineering and in the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology, and is the Director of the Synthetic Biology Center at MIT. Professor Weiss is one of the pioneers of synthetic biology. He has been engaged in synthetic biology research since 1996 when he was a graduate student at MIT and where he helped set up a wet-lab in the Electrical Engineering and Computer Science Department. After completion of his PhD, Weiss joined the faculty at Princeton University, and then returned to MIT in 2009 to take on a faculty position in the Department of Biological Engineering and the Department of Electrical Engineering and Computer Science. The research pursued by Weiss since those early days has placed him in a position of leadership in the field, as evidenced both by publications from his lab as well as a variety of awards and other forms of recognition. He pursued several aspects of synthetic biology, including synthesis of gene networks engineered to perform *in vivo* analog and digital logic computation. The Weiss lab also published seminal papers in synthetic biology focused on programming cell aggregates to perform coordinated tasks using engineered cell-cell communication with chemical diffusion mechanisms such as quorum sensing. Several of these manuscripts were featured in a recent Nature special collection of a select number of synthetic biology papers reflecting on the first 10 years of synthetic biology. While work in the Weiss lab began mostly with prokaryotes, during the last 5 years a majority of the research in the lab shifted to mammalian synthetic biology. The lab focuses both on foundational research, e.g. creating general methods to improve our ability to engineering biological systems, as well as pursuing specific health related applications where synthetic biology provides unique capabilities.

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Mammalian synthetic biology has recently emerged as a field that is revolutionizing how we design and engineer biological systems for diagnostic and medical applications. In this talk, we will describe our integrated computational / experimental approach to engineering complex behavior in mammalian cells with applications to Programmable Organoids derived from iPS cells. In our research, we apply design principles from electrical engineering and other established fields. These principles include abstraction, standardization, modularity, and computer aided design. But, we also spend considerable effort towards understanding what makes synthetic biology different from all other existing engineering disciplines by discovering new design and construction rules that are effective for this unique discipline. We will present Programmable Organoids, a new platform for drug discovery that enables rapid and effective drug screening. Based on programmed differentiation into synthetic mammalian tissues having multiple cell type architectures that are similar to human organs, Programmable Organoids mimic the response of a target organ to both positive and negative effects of drug candidates. Factors that can be non-destructively measured include cell state, viability, and function. Because they are synthetic, Programmable Organoids can host a large array of live-cell biosensors, built-in to one or more cell types, providing a rapid and real-time spatial readout of pathway-specific biomarkers including miRNAs, mRNAs, proteins, and other metabolites. Organoids programmed with both general and disease specific sensors then provide detailed information that can be used to identify candidates for further analysis. We envision a programmable common platform that can be shared among multiple drug candidates.

Microphysiological Systems as Models of Disease
Roger D. Kamm
Cecil and Ida Green Distinguished Professor of Biological and Mechanical Engineering
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Professor Kamm began his career at Northwestern University earning a degree in Mechanical Engineering. He subsequently earned both a Master's and a PhD in Mechanical Engineering at MIT. Since 1978, he has been a professor of Mechanical Engineering at MIT. Professor Kamm was one of the founding members of the Biological Engineering department when it was created in 1998.

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One of the major applications of living machines today is in the development of microfluidic platforms within which matrix and cells can be seeded in order to create a model of organ or tissue function, either in health or disease. These are often referred to as microphysiological systems (MPS), and are increasingly used by the research community to study disease processes and identify new therapies. They are also being adopted by the pharma and biotech industries for drug development and screening. This presentation will focus on two approaches to engineer MPS, either by a traditional top-down engineering approach or by drawing upon the emergent properties of cell populations to self-assemble into organ-like systems with the desired form and function. Several examples from our current research will be presented ranging from models of metastatic cancer to Alzheimer's disease.

Systems Biology Approaches for Pre-clinical to Clinical Translation
Douglas Lauffenburger
Ford Professor of Biological Engineering, Chemical Engineering, and Biology
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Ford Professor of Biological Engineering, Chemical Engineering, and Biology

Prof. Lauffenburger received his B.S. in Chemical Engineering from the University of Illinois and his Ph.D. in Chemical Engineering from the University of Minnesota. Prior to coming to MIT, Prof. Lauffenburger was a professor at the University of Illinois and the University of Pennsylvania and a visiting professor at the University of Wisconsin. Prof. Lauffenburger has also served as a visiting scientist at the University of Heidelberg, Germany.

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A vital challenge that the vast majority of biological research must address is how to translate observations from one physiological context to another—most commonly from experimental animals (*e.g.*, rodents, primates) or technological constructs (*e.g.*, organ-on-chip platforms) to human subjects. This is typically required for understanding human biology because of the strong constraints on measurements and perturbations in human *in vivo* contexts. Direct translation of observations from experimental animals to human subjects is generally unsatisfactory because of significant differences among organisms at all levels of molecular properties from genome to transcriptome to proteome and so forth. Accordingly, addressing inter-species translation requires an integrated experimental/computational approach for mapping comparable but not identical molecule-to-phenotype relationships. This presentation will describe methods we have developed for a variety of cross-species translation examples, demonstrated on applications in inflammatory pathologies and cancer.

11:40am Overview of NEET

Amitava "Babi" Mitra
Executive Director, NEET

The MIT New Engineering Education Transformation (NEET) program was launched in 2017 to reimagine engineering education at MIT. A cross-departmental endeavor with a focus on integrative, project-centric learning, NEET cultivates the essential skills, knowledge, and qualities to address the formidable challenges posed by the 21st century. NEET scholars simultaneously learn and acquire job-ready attributes such as leadership, working in teams, critical thinking, creative thinking, and ethical thinking.

11:45am Lightning Talks by NEET Living Machines Scholars

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11:55am Wrap Up