Institute for Medical Engineering and Science

Founded in 2012, the Institute for Medical Engineering and Science (IMES) pioneers novel research and graduate education paradigms by bringing together engineering, science, and clinical medicine to advance human health. IMES is an integrative force, catalyzing academic and strategic partnerships within MIT and with hospital and industry to confront major challenges, particularly in the areas of infectious and autoimmune disease, neurological disorders, cardiovascular disease, and diagnostics.

IMES is home to the Harvard-MIT Division of Health Sciences and Technology (HST). HST also maintains an office at the Harvard Medical School (HMS) quadrangle campus in Boston as one of the five medical societies at HMS. HST director Emery Brown reports to the IMES director, and the director at Harvard Medical School reports to the HMS dean of medicine and dean for graduate education.

IMES is also the home for the Medical Electronic Device Realization Center (MEDRC), directed by Professor Charles Sodini; the Clinical Research Center, led by Professor Elazer Edelman; and the Center for Microbiome Informatics and Therapeutics. In addition, IMES led the creation of the strategic partnership between MIT and the Massachusetts General Hospital (MGH).

Academic Program

Graduate Degree Programs

HST is among the largest biomedical engineering and physician scientist training programs in the United States, with 303 students enrolled in its graduate degree programs during AY2016:

- 105 Medical Engineering and Medical Physics Program (MEMP) PhD students, including four MEMP/MD students
- 192 MD and MD/PhD students, (this number also includes the above-mentioned four MEMP/MD students)
- 10 Speech and Hearing Bioscience and Technology (SHBT) program PhD students

HST graduate students work with faculty and affiliated faculty members from MIT, Harvard, and affiliated teaching hospitals. Whether pursuing careers in medicine, research, industry, or government, HST graduates have made outstanding contributions to advances in human health care.

HST's MEMP PhD program, housed in IMES, trains students as engineers or physical scientists who also possess extensive knowledge of medical sciences. The program provides preclinical and clinical training to students. On average, students complete the PhD program in six years, and in some cases they also pursue an MD. MEMP students are extremely successful in obtaining outside funding support for their graduate studies, with 39% of them holding external fellowships in AY2016.

Two specialized programs within MEMP are the Neuroimaging Training Program and the PhD Program in Bioastronautics. The Neuroimaging Training Program is supported by a grant from the National Institute of Biomedical Imaging and Bioengineering. Professors Bruce Rosen and Randy Gollub, both members of the HST faculty based at the Martinos Center at Massachusetts General Hospital, co-direct the program. Trainees are identified from among those already enrolled in MEMP with specific interests in neuroimaging. They take additional classes in a curriculum tailored for the program and participate in networking and enrichment activities with faculty and students who have related research interests.

The PhD Program in Bioastronautics, founded in 2006, is funded by an education grant from the National Space Biomedical Research Institute. Professor Laurence Young of the Department of Aeronautics and Astronautics, who is also a member of the HST faculty and an associate member of the IMES faculty, directs the program, which is arguably the leading such academic program in the world. It combines the biomedical training of HST's MEMP PhD program with hands-on research exposure at NASA's Johnson Space Center. One or two new students enroll in MEMP/Bioastro each year, joining a small, focused cohort of approximately seven students. National Space Biomedical Research Institute support is scheduled to end in 2017 and no substitute funding source has yet been identified.

The HST MD program, housed at Harvard Medical School, is aimed at students interested in a research-based medical career. While eligible to complete the program in four years, many students take an optional fifth year to engage in more extensive research. Approximately 80% of HST MD alumni follow a career path in academia.

Graduate Education in Medical Sciences Certificate Program

The Graduate Education in Medical Sciences (GEMS) certificate program is open to doctoral students in MIT's Schools of Engineering and Science who are interested in working at the intersection where engineering and science meet medicine and real-world health care. GEMS runs concurrently with the normal course of an MIT PhD program and can be completed in two years without prolonging a typical PhD career. In addition to coursework in pathology and pathophysiology, participants attend seminars with HST students and engage in individually tailored clinical experiences. GEMS students learn how advances in basic science and engineering become medically relevant therapies and tools for the improvement of human health while developing a professional network that includes medical researchers, clinicians, and physician-scientists.

GEMS was initially established with support from a Howard Hughes Medical Institute program that encouraged graduate schools to integrate medical knowledge and an understanding of clinical practice into PhD curricula. Thirty-two MIT PhD students enrolled in GEMS between 2007 and 2011. The program, which became dormant after the Howard Hughes Medical Institute funding ended, was revitalized after the founding of IMES, enrolling seven new students in AY2016.

IDEA^2

Problem identification and definition are integral to graduate education and to innovation, yet the process of learning to select and develop a research question is largely unstructured for most graduate students. This is especially challenging for students in interdisciplinary fields and for those who wish to engage in research that will translate rapidly from lab to clinic. The overarching objective of IDEA^2 is to provide a structured process that guides, mentors, and supports HST students as they learn to define and develop research questions that can impact human health.

IDEA^2 accepts applications from HST students who have identified a specific biomedical research problem but are still early in their training. Following a review process, successful applicants are matched with mentors from outside their research labs, who guide the students as they refine their research proposals. Participating students benefit from an early experience in independently defining, articulating, and defending a research idea while simultaneously developing and engaging a network of advisors from different disciplines, professions, and sectors.

IDEA^2 provides partial financial support to participating students. In AY2016, IDEA^2 distributed $89,000 in student support and individually matched nine students with 26 mentors selected from a pool of established biomedical entrepreneurs, practicing clinicians, and accomplished scientists/engineers in academia and industry. IDEA^2 has been supported for almost a decade by the generosity of the Peter C. Farrell (1967) Fund. With the end of that support, the program is transitioning to a new format under the auspices of IDEA^2 Global.

Summer Institute

Patterned after MIT's Summer Research Program, HST offers two specialized Summer Institute programs, one in biomedical optics (offered in collaboration with the Wellman Center for Photomedicine at Massachusetts General Hospital) and the other in biomedical informatics (offered in collaboration with the Center for Biomedical Informatics at Harvard Medical School). Thirty-seven students participated in these two programs in summer 2015, and 34 are enrolled for summer 2016.

These programs offer a unique opportunity for outstanding undergraduate college students considering a career in biomedical engineering and/or medical science. Through hands-on research and in-depth lectures, participants learn about either biomedical optics or bioinformatics and engage in the application of these fields to solving problems in human health. Through individual tutorials and workshops, students learn to communicate their research findings effectively in written and oral formats. Shared living arrangements and a variety of technical and social activities enable Summer Institute participants to develop a network of peers and build strong, enduring connections with faculty working in the field.

Honors and Awards

Faculty Mentoring and Teaching Awards

Dr. Benjamin Ebert was honored with HST's Thomas A. McMahon Mentoring Award.

Dr. Raymond Huang was honored with HST's Seidman Prize for MD Research Mentorship.

Dr. Carl Rosow won HST's Irving M. London Teaching Award.

Student Honors, Awards, and Publications

Omar Abudayyeh, a student in the Harvard-MIT MD/PhD program enrolled in MEMP, received a National Defense Science and Engineering Graduate Fellowship and an MIT Friends of the McGovern Institute Fellowship.

Annabelle Anandappa and Andre Shomoroni, both HST MD students, received American Society of Hematology Honor Awards.

HST MD/PhD student Matthew Baum published *The Neuroethics of Biomarkers: What the Development of Bioprediction Means for Moral Responsibility, Justice, and the Nature of Mental Disorder* (Oxford University Press).

Alexander Bick (HST MD, 2016) received HST's Seidman Prize for Outstanding Graduating MD Student Thesis.

Kevin Chen, MEMP PhD student, received the Whitaker Health Sciences Fund Fellowship from MIT's Office of the Dean for Graduate Education.

Arnav Chhabra, MEMP PhD student, was named to the *Forbes* 30 Under 30 list in the field of science.

Yamicia Connor (HST MD, 2016/MEMP PhD, 2013) won the Henry Asbury Christian Award. In addition, her research with Professor Shiladitya Sengupta, a member of the HST faculty, was published in *Nature Communications*.

Husain Danish, HST MD student, received the Multiculturalism and Diversity Award from the London Society at HMS.

MEMP PhD students Davi da Silva and Simon Ye received National Science Foundation (NSF) Graduate Research Program Fellowships.

Richard Fineman, MEMP PhD student, was awarded a NASA Space Technology Research Fellowship.

MEMP PhD students Or Gadish and Kelli Xu received Hugh Hampton Young Memorial Fellowships from MIT's Office of the Dean for Graduate Education.

Jonathan Herman (HST MD, 2016) received the Henry Asbury Christian Award.

HST MD/PhD student Eran Hodis, HST MD student Vishwajith Sridharan, and HST MD/PhD student Suan Lian Tuang received Paul & Daisy Soros Fellowships for New Americans.

Travis Hughes, HST MD/PhD student, was named the inaugural recipient of the HMS Martin R. Prince Scholarship for Student Innovation.

MEMP PhD student Isha Jain published “Oxygen Deprivation Counters Deadly Mitochondrial Disease in Animals” in the online edition of *Science*.

Sheldon Kwok, HST MD/MEMP PhD student, was awarded the Wellington and Irene Loh Fund Fellowship from MIT’s Office of the Dean for Graduate Education.

Brandon Law, HST MD student, took the won second place in the MIT Sloan Healthcare and BioInnovations Conference competition.

MEMP PhD student Emily Lindemer and her team of researchers won the “Best Mental Health Hack” award at the MIT Grand Hack for their Hey, Charlie mobile app, designed for opiate addicts who are in recovery or are seeking recovery.

An article written by HST MD/MEMP PhD student William Lo, –“Longitudinal, 3D Imaging of Collagen Remodeling in Murine Hypertrophic Scars In Vivo Using Polarization-Sensitive Optical Frequency Domain Imaging,” was featured on the cover of the January 2016 edition of the *Journal of Investigative Dermatology*.

Aikaterini Mantzavinou, MEMP PhD student, received a Frontier Award from the Koch Institute for Integrative Cancer Research.

HST MD students Diana Miao, Rohit Thummalapalli, and Kathy Wang received Howard Hughes Medical Institute Medical Research Fellows Awards.

Daniel Oh (HST MD, 2016) won the Dr. John D. and Mrs. Gretchen H. Bullock Ophthalmology Award.

Sam Osseiran, MEMP PhD student, received a Natural Sciences and Engineering Research Council of Canada Postgraduate Doctoral Fellowship.

Heather Roberts, HST MD student, received the HMS Janee and Paul Freedman, MD ’59 Surgery Prize.

HST MD student Y. Raymond Shao won the Judah Folkman Prize for Clinical/Translational Science Research at the 2016 HMS Soma Weiss Undergraduate Assembly.

HST MD student Kathy K. Wang received the Elizabeth D. Hay Prize for Basic Science Research at the 2016 HMS Soma Weiss Undergraduate Assembly.

HST MD/PhD student Shuyu Wang received the MIT School of Science Koch Fellowship in Cancer Research.

Staff Awards

Elizabeth Hoy, IMES Administrative Assistant II, was presented an Infinite Mile Award by the MIT Office of the Vice President for Research. These awards recognize individuals who have made extraordinary contributions within their own organizations to help the Institute carry out its mission.

Robert Fadel, IMES assistant director, received a School of Engineering Infinite Mile Award for Excellence. This award is given to individuals whose work is of the highest quality. They stand out because of their high level of commitment and because of the enormous energy and enthusiasm they bring to their work.

Research Program

Core Faculty

The contract for the Madrid-MIT M+Visión Consortium ended on June 30, 2016. Elfar Adalsteinsson served as the associate director of the consortium, which recruited 34 fellows, engaged a cohort of over 100 collaborators on both sides of the Atlantic, and filed 25 disclosures of intellectual property.

Notable for Adalsteinsson's magnetic resonance imaging (MRI) group, the National Institutes of Health (NIH) awarded new funding for a four-way collaboration among Professors Adalsteinsson, Ellen Grant (Boston Children's Hospital), Larry Wald (MGH), and Polina Golland (MIT) that expands ongoing work in the relatively underserved space of fetal imaging to the study of the placenta via MRI.

This year Sangeeta Bhatia's laboratory engineered genetic circuits in bacteria to treat cancer. Building off work last year that developed programmable probiotics for detection of cancer in the urine, her team, together with Jeff Hasty at the University of California, San Diego, engineered bacteria to produce three different drug cargos to treat cancer by damaging membranes, triggering programmed suicide, and stimulating the immune system. To prevent potential side effects from these drugs, the genetic circuit allows cells to detect how many other bacteria are in their environment through a process known as quorum sensing. When the bacteria reach a predetermined target level, the cells self-destruct, releasing their toxic contents all at once. A few of the cells survive to begin the cycle again, which takes about 18 hours, allowing for a repeated release of drugs. Thus, the burden of bacteria is kept at a low level in the organism while drugs are pumped into the tumor. In a mouse model of colon cancer, tumors reduced in size and the animals survived longer than controls. Bhatia's group is now investigating which combination of bacterial strains and tumor-targeting circuits would be most effective against different types of tumors.

Over the past year, Emery Brown's laboratory published two papers providing detailed characterizations of the neurophysiological (electroencephalogram) signatures of a pair of widely used anesthetic drugs: sevoflurane and ketamine.

Sevoflurane is a modern-day ether anesthetic. Characterizing the signatures of sevoflurane is especially significant because they offer for the first time insight into the specific neural circuit mechanisms of how ether anesthetics act in the brain to produce states of unconsciousness. Similar to the anesthetic propofol, sevoflurane produces highly structured alpha (8 to 12 Hz) and slow (0.1 to 1 Hz) oscillations. These oscillations have been shown in propofol to disrupt normal information transmission among brain regions. This work makes explicit what is likely to be the primary neural circuit mechanism of ether, the first recognized anesthetic drug.

In contrast, unconsciousness induced by ketamine, which acts by blocking NMDA (N-methyl-D-aspartate) receptors, produces large-amplitude, slow-delta (0.1 to 4 Hz) oscillations that alternate with gamma (approximately 27 to 40 Hz) oscillations. This unique pattern of oscillations suggests specific cortical, thalamic, and brainstem mechanisms for ketamine's actions.

This year Professor Brown was elected a fellow of the National Academy of Inventors and a fellow of the Institute for Mathematical Statistics. Also, he received the American Society of Anesthesiologists Excellence in Research Award.

Professor Arup K. Chakraborty continued his efforts to understand the mechanistic bases of how a specific and systemic immune response to pathogens occurs and how its aberrant regulation leads to disease. Research aimed toward understanding how this knowledge can be harnessed for the rational design of vaccines and therapies is also an important facet. In addition to serving as the director of IMES, Professor Chakraborty taught a core chemical engineering graduate subject and, with Tyler Jacks, coordinated the crafting of a white paper on health. He was elected to the National Academy of Sciences this year, and he continues to serve as a member of the US Defense Science Board and as a senior editor of *eLife* (one of the premier journals in biology).

Kwanghun Chung started his position in IMES and the Department of Chemical Engineering in October 2013 as the Samuel A. Goldblith Career Development Assistant Professor. He is also a principal investigator at the Picower Institute for Learning and Memory. His interdisciplinary research team is devoted to developing and applying novel technologies for integrative and comprehensive understanding of the brain. His group has continued to develop enabling technologies to accelerate the pace of scientific discovery and the development of therapeutic strategies in a broad range of biomedical research areas. Chung was awarded a 2015 Packard Fellowship for Science and Engineering and received a 2016 McKnight Technological Innovations in Neuroscience Award. Over the past year, he taught HST.562 Imaging and Sample Processing and 10.032 Transport Phenomena. He also served on the IMES Committee for Academic Programs. The following are examples of new technologies developed by Professor Chung and his lab:

- Stochastic electrotransport, which enables 30- to 50-fold faster labeling of target molecules and structures in the brain. This method will accelerate the pace of brain mapping and phenotyping of animal disease models and human clinical samples.

- SWITCH, which allows high-dimensional proteomic imaging of complex biological systems. This technique will enable researchers to study complex interactions among pathogenic factors and various cell types.
- MAP, which enables super-resolution proteomic imaging of the brain. This method will allow researchers to extract subcellular details of cells as well as their brain-wide intercellular connectivity.

The Chung lab will use these technologies to establish comprehensive high-resolution maps of the normal brain as well as diseased brains.

Professor Richard Cohen contributed to MIT's entrepreneurship efforts and the Sloan Healthcare Certificate program by serving on the certificate program's board and by teaching one of its required courses (15.132/HST.972 Medicine for Managers and Entrepreneurs Proseminar) as well as one of its elective courses (HST.973/15.124 Evaluating a Biomedical Business Concept). In addition, he co-founded and helped secure financing for Sirona Medical Technologies Inc., a company developing a novel catheter technology for the treatment of cardiac arrhythmias. This technology, which combines local electrical mapping with focused radio frequency ablation, promises to increase the efficacy and reduce the adverse effects of this important and growing means of therapy.

James J. Collins, Termeer Professor of Medical Engineering and Science, continued to develop innovative synthetic biology platforms that can be used to address critical issues in medicine, biotechnology, and the life sciences. Most notably, this past year Collins and his team developed an inexpensive, rapid, paper-based Zika diagnostic test that utilizes cell-free, freeze-dried synthetic biology components. This programmable, in vitro platform includes a highly innovative CRISPR-based component for discriminating among the American, African, and Asian strains of the virus. This breakthrough work, which was published in *Cell*, garnered worldwide interest. Collins and his team are currently working with health care groups in Brazil, Colombia, Honduras, Ecuador, Peru, and Puerto Rico to use the newly developed diagnostic platform to help address this growing health crisis.

Professor Elazer Edelman's research interests combine his scientific and medical training, integrating multiple disciplines, including controlled drug delivery, growth factor biology, tissue engineering, and biomaterials-tissue interactions. His laboratory set the way for optimization of endovascular stents and percutaneous heart valves. His work on angiogenesis includes basic studies of endothelial cell and vascular biology, computational modeling of vessel formation, and clinical trial examinations of controlled angiogenic factor release. This year he and his group published some 28 critical papers.

Over the past year, Professor Edelman was named a fellow of the National Academy of Inventors. Among many plenary lectures this year, he presented the Dean's Distinguished Lecture at Weill-Cornell Medical School, the Massimo Calabresi Lecture at Yale University, and the Flexner Discovery Lecture at Vanderbilt University Medical Center.

Professor Lee Gehrke is a molecular virologist who studies RNA viruses, including Zika virus, West Nile virus, and dengue virus. One focus of Gehrke's research is on understanding how cells detect invading pathogens via the innate immune system. A second research area involves designing and building rapid diagnostic tests to detect viruses in serum and urine. During the past year, Gehrke and his group traveled to Colombia, Brazil, and Honduras to conduct field studies of their multiplexed diagnostic device.

Professor Martha Gray leads the Biomedical Technology Innovation Group. Her research program focuses on formalizing approaches that drive innovation to create impact, particularly in the context of predoctoral and postdoctoral research training. Highlights during 2015–2016 included the launching of the MIT IMPACT career development program and the continued success of the Catalyst Program, which opened new lines of work and attracted significant new funding (approximately $15 million) thanks to a $20 million investment by the community of Madrid.

Professor Thomas Heldt directs the Integrative Neuromonitoring and Critical Care Informatics Group in IMES. Using physiologically based dynamic models, his group leverages multivariate bedside monitoring data (on the second to hour timescale) to understand the physiology of the injured brain, to improve diagnoses, and to accelerate treatment decisions for the critically ill. The group has very strong collaborative ties with clinicians at Boston Children's Hospital, Boston Medical Center, Massachusetts General Hospital, and the Beth Israel Deaconess Medical Center in the areas of neurocritical and neonatal critical care.

A key research accomplishment over the past year has been further improvements in the group's model-based noninvasive and patient-specific approach to intracranial pressure estimation. The results of this work were presented at the 16th International Conference on Intracranial Pressure & Neuromonitoring, held on the MIT campus. The conference brought together over 300 attendees from 21 countries to discuss recent research and clinical progress on monitoring patients with critical neurological conditions. Professor Heldt served as the conference chair.

The objective of Professor Roger G. Mark's laboratory is to improve health care by generating new clinical knowledge and monitoring technology and applying data science and machine learning technology to large collections of critical care data. His lab has developed the widely used MIMIC (Medical Information Mart for Intensive Care) database, which is freely available to credentialed investigators worldwide. The lab also developed and supports PhysioNet, an extensive open archive of physiological signals. This year the Association for the Advancement of Medical Instrumentation recognized PhysioNet with its highest award as a result of the archive's impact on the development of modern intensive care unit monitoring systems.

Professor Mark serves as chair of the MEMP Board of Advisors, as a MEMP faculty advisor, and as a graduate student counselor for the Department of Electrical Engineering and Computer Science. Over the past year, he taught 6.022J/HST.542J Quantitative Systems Physiology, which enrolls undergraduates and early graduate students, and HST.201/202 Introduction to Clinical Medicine and Medical Engineering I/II, which enrolls advanced MEMP students.

Professor Leonid Mirny was named co-director of the new Center for 3D Structure and Physics of the Genome, funded by the NIH 4D Nucleome Program. The program is a focused, interdisciplinary directive to map the 3D architecture of the human genome and its reorganization in time—the fourth dimension. In the last year, the Mirny lab has published several high-profile papers on 3D genome organization, putting forward a proposal that a universal mechanism of active loop extrusion can be responsible for chromosome condensation during cell cycles as well as for the maintenance of functional chromosomal domains during interphases.

This year, in collaboration with the Christopher Love lab (Chemical Engineering), Professor Alex Shalek's lab co-developed an ultra-high-throughput, low-cost, microwell-based single-cell RNA sequencing platform called "Seq-Well." This technology, which relies on the co-confinement of uniquely barcoded mRNA capture beads and individual cells using a polydimethylsiloxane microwell array, allows simultaneous analysis of mRNA transcripts from thousands of individual cells while still retaining each transcript's cell of origin. Importantly, relative to previous embodiments, Seq-Well can be applied to many samples at once (using multiple devices), works with as few as 500 cells (due to the elimination of most upstream processing steps), and is portable (it does not require complex peripherals), making it ideally suited for profiling complex biological specimens in both basic and clinical research settings. Shalek envisions that Seq-Well will inform an era of precision medicine, accelerating biological discovery by enabling routine and cost-effective transcriptional profiling of clinical samples at single-cell resolution. Toward realizing this goal, in collaboration with several researchers, he began investigating the composition of multiple tissues and clinical samples, including tumor resections, gut pinch biopsies, female genital tract cytobrushes from HIV patients, and tuberculosis-infected bronchial alveolar lavages.

This year, Professor Shalek was named an NIH New Innovator and an associate scientific advisor for *Science Translational Medicine*.

Associate Faculty

This past year, Professor Lydia Bourouiba's lab published key papers at the interface of fluid dynamics and respiratory and agricultural diseases. In human health, the work performed by Bourouiba showed the importance of the development of direct visualizations of human respiratory emissions such as sneezes and coughs to better understand the fundamental mechanics of respiratory disease transmission. Her group's visualizations and image analysis algorithms enable tracking of the sneeze cloud and elucidation of the physics governing the formation of the droplets it contains. The techniques used by Bourouiba and her team to capture and analyze recordings from human subjects revealed that much more than droplets are emitted during violent expirations. In fact, mucosalivary fluid is emitted in the form of sheets that burst and then form ligaments and, finally, respiratory droplets. It is this rich cascade of stretching and destabilization competing with the physical properties of mucosalivary fluid that ultimately determines the final size, speed, and composition of the respiratory droplets shaping transmission. In addition to studying these application-driven phenomena, Bourouiba focuses on investigating the fundamental fluid dynamics governing droplet formation from splashes and inertial detachments, both of which play a central role in transmission of diseases in a variety of conditions, including nosocomial and foliar diseases.

Professor Bourouiba's work continues to draw significant attention from the lay press (e.g., BBC, CBS) as well as the scientific literature, where her work was featured in *Nature.* In addition, she traveled on the invitation of the Bill and Melinda Gates Foundation to assist in a programmatic review of the foundation's tuberculosis transmission portfolio. She was also an invited speaker at a number of universities in the United States and abroad and at the Beyond 2016—MIT's Frontiers of the Future research symposium. Bourouiba taught two classes: 1.631/HST.537/2.250 Fluids and Diseases and 1.068-1.686/18.358/2.033 Nonlinear Dynamics Continuum Systems.

In collaboration with Professor Adalsteinsson's group and clinical colleagues at Boston Children's Hospital, led by Dr. Ellen Grant, Professor Polina Golland's group started a new project that aims to develop MRI-based biomarkers of placental function. The researchers are using MRI to characterize how well oxygen and other nutrients are transferred from the maternal bloodstream to the fetus. Based on their expertise in medical image analysis, Professor Golland's group developed novel algorithms for accurately delineating placental and fetal organs for in utero MRI time series. Moreover, the collaborative team demonstrated initial results suggesting that MRI-based signals can be used to visualize the normal function of the placenta and its dysfunctions. The results of this research have been presented at the annual meetings of the International Society for Magnetic Resonance in Medicine and the MICCAI (Medical Image Computing and Computer Assisted Intervention) Society.

Professor Robert Langer received honorary degrees from the Karolinska Institute, Carnegie Mellon University, the University of Maryland, Hanyang University, and the University of New South Wales. In addition, he was presented the Queen Elizabeth Prize for Engineering, the Sackler Award for Sustained National Leadership, the Benjamin Franklin Medal in Life Science, the Hoover Medal, the Scheele Award, and the Royan Institute's Kazemi Award for Research Excellence in Biomedicine. He was named the Cornell University Entrepreneur of the Year. He presented numerous named lectures, including the Robert E. Gross Lecture (at the annual meeting of the American Pediatric Surgical Association), the Baker Symposium Lecture (at Cornell University), and the Irving Shain Lecture (at the University of Wisconsin, Madison).

Professor Charles Sodini leads the MIT Medical Electronic Device Realization Center, which seeks to revolutionize medical diagnostics and treatments by bringing health care directly to individuals and to create enabling technology for the future information-driven health care system. MEDRC, launched in May 2011, currently has five member companies (ADI, General Electric, Maxim Integrated, Nihon Kohden, and Philips Research) supporting approximately 15 projects; 25 students/postdocs and seven principal investigators take part, and funding for the program is about $2 million annually. MEDRC serves as a focal point for engagement with researchers across MIT, the medical device and microelectronics industries, venture-funded startups, and the Boston medical community.

This year, Professor Leia Stirling began work related to her NSF CAREER Award, whose objective is to enable wearable motion sensing technology for monitoring upper extremity joint kinematics by bridging the domains of biomechanics, control theory, and human factors. While wearable technology is expanding at an incredible rate, current technology is limited as a decision-making aid as a result of difficulties in interpreting the underlying data in the context of the natural environment. Stirling's research is designed to extend the capabilities of wearable motion-sensing technologies through advances in dynamic system modeling and signal processing to account for the underlying variability in human motion and compliant structure, as well as through a formalized cognitive task analysis to define relevant decision-making parameters. This cyber-human platform is being developed for those with limited knowledge (nonexperts) in sensor technology and physiological systems. The platform has the potential to be extended beyond upper-extremity evaluations to full-body monitoring for aiding clinicians as well as individuals in the community.

Professor Peter Szolovits continued to conduct research on natural language processing of clinical notes and building predictive models that estimate the risks of various morbid events and the likelihood of success of different therapeutic interventions. He served as the overall principal investigator in a medical collaboration between Philips and MIT. Collaborations with Harvard and MGH continue as well.

Events

HST Faculty Poster Session

Approximately 125 people attended the ninth annual HST Faculty Poster Session, held on September 24, 2015, at the Tosteson Medical Education Center at Harvard Medical School. Fifty-one faculty posters representing 46 labs were on exhibit. Some posters represented broad research programs, while others presented specific research projects; some included student co-authors. This annual event familiarizes faculty members with their colleagues' research and allows them to recruit students to their laboratories. It also assists students who are beginning the process of selecting laboratories and mentors for their research.

HST Forum

The 29th HST Forum was held on April 14, 2016, at the Tosteson Medical Education Center at Harvard Medical School. This event highlights the depth and breadth of HST student research for applicants admitted to HST's MD and PhD programs as well as current students, faculty, staff, and other members of the Harvard and MIT communities.

This year approximately 125 people attended the forum, including 39 students who presented posters on their current research. The poster session was followed by a keynote address given jointly by Harvard Medical School professor Guillermo Tearney and his advisee, HST MD student Bradford Diephuis, who treated the audience to a unique view of a dynamic mentor/mentee relationship. The joint address was well received by current and prospective members of the HST community.

In the context of an impressive array of articulately presented student research, the following students received the Martha Gray Prize for Excellence in Research in the categories named:

- Jonathan Herman (MD/PhD program), Bioinformatics and Integrative Genomics
- Wendy Liu (MD/PhD program), Physiology and Systems Biology
- Jonathan Whitton (SHBT program), Biomedical Devices
- Rishi Puram (MD/PhD program), Cell and Molecular Biology
- **Veena Venkatachalam (MD/PhD program),** Imaging, Acoustics, and Optics

IMES Distinguished Lecture Series

This year IMES held six invited lectures that included the following speakers and subjects:

- Helen Mayberg, "Targeted Therapeutic Modulation of Depression Circuits Using Deep Brain Stimulation" (September 17, 2015)
- Sridevi Sarma, "Characterizing the Pathophysiology of Neural Networks in Disease and the Effects of Deep Brain Stimulation Treatment" (October 15, 2015)
- Nicholas Schiff, "Recruiting Cognitive Reserve in the Structurally Injured Brain with Central Thalamic Deep Brain Stimulation" (December 3, 2015)
- Nicholas Peppas, "Intelligent Macromolecular Structures for Protein Delivery, Targeting, and Molecular Sensing" (March 3, 2016)
- Leor Weinberger, "Harnessing 'Noise' for Cell-fate Control and Therapy" (April 7, 2016)
- James M. Hughes, "Reflections on Emerging Microbial Threats" (co-sponsored by the Department of Civil and Environmental Engineering; May 2, 2016)

Arup Chakraborty, Director
Robert T. Haslam Professor of Chemical Engineering
Professor of Physics, Chemistry, and Biological Engineering