

Harvard–MIT Division of Health Sciences and Technology

The Harvard–MIT Division of Health Sciences and Technology (HST) brings together MIT, Harvard Medical School (HMS), Harvard University, Boston-area teaching hospitals, and an assortment of research centers in a unique collaboration that integrates science, medicine, and engineering to solve problems in human health.

HST trains students to have a deep understanding of engineering, physical sciences, and the biological sciences complemented by hands-on experience in the clinic or in industry. Over 400 graduate students and more than 60 full-time faculty share a “dual citizenship” in medicine and fields as varied as physics, chemistry, engineering, computer science, and management. This interdisciplinary approach to biomedicine, conceived at HST in 1970, creates a unique culture that drives progress from the laboratory bench to the patient’s bedside.

HST research is committed to exploring the fundamental principles underlying health and disease and devising new diagnostics and therapeutics. Research currently focuses on technological specialties such as medical imaging, informatics, biomarkers, tissue regeneration, biomedical devices and systems, and micro- and nanoscale technologies.

On December 10, 2008, professor Ram Sasisekharan became HST at MIT’s director. Professor Sasisekharan previously held the Underwood-Prescott Professorship of Biological Engineering and Health Sciences and Technology. He has been part of the MIT faculty since 1996, and his research focuses on the study of complex polysaccharides that are involved in the disease process. Professor Sasisekharan also researches therapeutic approaches to alleviating disease. The division was fortunate to have professor Lee Gehrke as interim MIT HST director from September through December 2008.

Research Program Highlights

HST faculty members published and researched in a number of areas during AY2009, as follows.

New fetal heartbeat monitor. A new system developed by HST principal research scientist Gari Clifford and colleagues could allow much earlier, noninvasive monitoring of the fetal heartbeat. The device used today to monitor subtle changes in the fetal heartbeat during labor must be attached to the fetus itself, but the new product would be noninvasive. Among other advantages, the system is expected to be less expensive and easier to use than current technologies. It could also cut the rate of cesarean deliveries by helping clinicians rule out potential problems that might otherwise prompt the procedure. Research results have been published in such journals as *IEEE Transactions on Biomedical Engineering*.

H1N1 flu transmission. Director Ram Sasisekharan, professor of biological engineering, led the efforts of a team of MIT researchers to explain how the H1N1 virus (“swine flu”) is transmitted from one person to another, as reported in *Science*. Research showed that swine flu spreads less rapidly than other flu viruses among people. Most flu viruses contain a viral polymerase, known as PB2, that is necessary for efficient transmission,

but the H1N1 virus does not contain PB2. Professor Sasisekharan cautioned that attention needs to be paid to the virus's evolution.

New model predicts how to build a better stent. Professor Elazer Edelman, MD, PhD, and HST postdoctoral associates Vijaya Kolachalama and Abraham Tzafirri have designed a model to predict how the size and shape of a stent affect blood flow and drug distribution. The model helps explain why some stents are better than others and could predict which stents are predisposed to cause clotting.

Accordion-like, biodegradable scaffold aids engineering of new heart tissue. HST postdoctoral fellow George C. Engelmayr Jr. and HST researcher Lisa E. Freed, MD, PhD, and their team have developed a novel scaffold to engineer cardiac tissue. The biodegradable scaffold would be gradually absorbed into the body, leaving behind new tissue. The accordion-like honeycomb scaffold, reported in the November 2, 2008, online edition of *Nature Materials*, is the first to be explicitly designed to match the structural and mechanical properties of native heart tissue. As a result, it has several advantages over previous cardiac tissue engineering scaffolds.

Self-assembling nanofiber gel delivers high concentrations of clinically approved drugs. Research teams led by Jeffrey M. Karp from the HST Center for Biomedical Engineering at the Brigham and Women's Hospital and George John at the City College of New York have developed a new self-assembling hydrogel drug delivery system that is biocompatible, efficient in terms of drug release, and easy to tailor. Importantly, these structures can deliver clinically approved drugs in high concentrations without requiring carriers for the drugs or generating toxic components, a problem with hydrogel systems until now. These findings were made available on Science Direct.

Jeffrey M. Karp, HST instructor and director of the Laboratory for Advanced Biomaterials and Stem-Cell-Based Therapeutics at Brigham and Women's Hospital, was recognized by *Technology Review* magazine as one of the world's top innovators under the age of 35 for his work in developing a biodegradable and biocompatible "gecko-inspired" tissue adhesive that sticks in wet environments, such as those found in wounds and surgical procedures.

Research Program Events

HST Faculty Poster Session

More than 40 faculty members presented at the fourth annual HST Faculty Poster Session on September 25, 2008, a successful event that is an integral part of the fall academic schedule. The session allows faculty members to showcase their research and attract HST students to their labs while also introducing new HST students to the rich and varied research opportunities available to them.

HST Forum

On April 23, 2009, the HST Forum celebrated and honored Dr. Irving M. London. Forty-eight students presented posters, followed by a plenary session to honor Dr. London. More than 250 people attended the event, including alumni, faculty, students,

and friends of HST. As a special tribute, friends of Dr. London were on hand for the announcement of a new MD fellowship program to honor HST's founder.

The plenary opened with welcoming remarks from David E. Cohen, director of HST at HMS, and Jeffrey S. Flier, dean of the Faculty of Medicine at HMS. Featured speakers included HST alumni George Q. Daley, Judy Lieberman, David C. Page, and Dr. London, who thanked everyone for their continued commitment to HST and for attending this special tribute. Ram Sasisekharan, director of HST at MIT, presented teaching and mentoring awards elected by HST students and the MIT students certified in the 2009 Graduate Education in Medical Sciences (GEMS) program.

Administration

HST's administrative home is located at the Whitaker College of Health Sciences and Technology at MIT. HST also maintains an office at the HMS quadrangle campus in Boston, as one of the five medical societies at Harvard Medical School. The codirectors of HST report to the provost and to the vice president for research and associate provost at MIT, as well as to the HMS dean for basic sciences and graduate studies and the dean of HMS. Professor Ram Sasisekharan was appointed as HST codirector on December 10, 2008. David E. Cohen, MD (HST '87), PhD, continues as codirector of HST for HMS. Lily U. Burns joined as HST's manager of external affairs in FY2009.

Awards and Honors

Research Awards

Elazer Edelman received the Jeffrey M. Hoeg Arteriosclerosis, Thrombosis and Vascular Biology Award.

Ram Sasisekharan and Robert Langer received Nakano Citations from the National Center for Preparedness, Detection, and Control of Infectious Diseases.

Honorary Elections

Sangeeta Bhatia, John Gabrieli, and Martha Gray were elected to the American Association for the Advancement of Science.

Ram Sasisekharan was elected to the American Institute for Medical and Biological Engineering.

Faculty Mentoring and Teaching Awards

Barbara Fullerton and James Kobler (both HMS faculty and members of HST-affiliated faculty) received the Irving M. London Teaching Award.

Peter Szolovits (Department of Electrical Engineering and Computer Science faculty, member of HST joint faculty) received the Thomas McMahon Mentoring Award.

Ernst Berndt (Sloan School of Management faculty, member of HST-affiliated faculty) received the Biomedical Enterprise Program Teaching Award.

Elizabeth Thiele (HMS faculty) received the Inaugural Seidman Prize for MD Research Mentoring.

Student Awards

HST PhD student Geoffrey von Maltzahn was this year's winner of the \$30,000 Lemelson-MIT Student Prize for innovations in the fight against cancer for two promising innovations in the area of cancer therapy: a new class of cancer therapeutics and a new paradigm for enhancing drug delivery to tumors.

The National Inventors Hall of Fame awarded its \$25,000 Collegiate Inventors Competition grand prize to Timothy Lu on November 20, 2008, for his work combating antibiotic-resistant bacteria and bacterial biofilms with engineered bacteriophage and synthetic gene sensors.

Mara MacDonald, a Medical Engineering and Medical Physics (MEMP) program PhD student at HST, has been awarded a Fulbright Scholarship for the 2008–2009 academic year. Mara will use the scholarship to travel to Singapore to continue her research on growth factor release coatings. She will be working in a laboratory in Nanyang Technical University, which has a strong research relationship with MIT.

Educational Programs

Graduate Degree Programs

HST is among the largest biomedical engineering and physician scientist training programs in the United States, with 386 students enrolled in its graduate degree programs during AY2009:

- 189 MD and MD/PhD students
- 172 PhD students (including 8 MD/MEMP students also counted in the previous category [MD/PhD]): 121 in MEMP, 49 in the Speech and Hearing Bioscience and Technology (SHBT) program, and 2 in the Radiological Sciences Joint Program
- 33 master's students: 23 in the Biomedical Enterprise Program, 9 in Biomedical Informatics, and 1 in the Master of Engineering in Biomedical Engineering program

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.

Recent Program Initiatives

HST Qualifying Examination

Collaborating departments no longer qualify HST's MEMP students; the Qualifying Examination in HST (QuEHST) Committee has established technical and oral qualifying exams for our students. These exams, which have been piloted with a small group of

students over the past three semesters, are given to all MEMP students who entered the program in 2008 or later.

Technical Qualifying Exam

During the fall semester of their first year, admitted students must choose a technical concentration area in which to develop a focused engineering/physics skill set from the following list: Aeronautics and Astronautics, Brain and Cognitive Sciences, Chemical Engineering, Chemistry, Computer Science, Electrical Engineering, Mechanical Engineering, Materials Science and Engineering, Nuclear Engineering, and Physics.

Oral Qualifying Exam

The oral qualifying exam (OQE) is offered twice each year: January and May. The purpose of the OQE is to evaluate whether the student can integrate information from diverse sources into a well-thought-out and coherent research proposal, a skill essential for successful scholarship. The ability to defend this proposal during an oral presentation is a central part of the qualifying process. The OQE committee is made up of an exam chair and two other faculty members.

Streamlining of PhD Programs

The graduate faculty committees in the Department of Nuclear Science and Engineering (NSE) and HST retired the joint doctoral program in radiological sciences in spring 2009. The last student graduated on February 18, 2009. The program, established in the early 1990s, trained students in nuclear physics and radiation engineering and their applications to biological and biomedical issues. We retired this joint program as a result of the recent refocusing of NSE's core disciplines away from the medical applications area. The training needs of applicants interested in this area of study can be met within HST's Medical Engineering/Medical Physics doctoral program.

Educational Grants

- *Bioinformatics and Integrative Genomics (BIG) training grant, renewed in September 2008 for an additional five years:* Funded by the National Institutes of Health (NIH), the BIG training grant supports MEMP PhD students specializing in bioinformatics and functional genomics.
- *Bioastronautics PhD training grant, year three of six-year grant:* Funded by the National Space Biomedical Research Institute, this training program combines the biomedical and engineering disciplines of HST's MEMP curriculum with space life science and human factors specialization along with hands-on experience in the human space flight arena.
- *SHBT training grant, year 17 of program and year two of current grant:* Funded by NIH, the SHBT training program provides support for PhD training in the speech and hearing sciences. Research foci range from the basic mechanisms responsible for normal function to the development of methods of diagnosis and treatment relevant to communication disorders.
- *Neuroimaging training grant, competing renewal submitted in January 2009:* Funded by NIH, this training grant supports a limited number of HST PhD students to further specialize in biomedical imaging.

- *GEMS, year three of four-year grant and competing renewal submitted in AY2009: An award from the Howard Hughes Medical Institute funds GEMS as part of the larger effort to integrate medical knowledge into graduate education.*

Nondegree Programs

Graduate Education in Medical Sciences

This was the third year of the GEMS program. In AY2009, we admitted a class of seven students, and four students completed the program. GEMS students participate in this two-year certificate program concurrently with PhD work in the School of Science or School of Engineering. An award from the Howard Hughes Medical Institute funds GEMS as part of an initiative to incorporate the knowledge and skills of medicine and pathobiology into graduate education. The goal is to train biomedical scientists who are better prepared to translate the discoveries of basic biological science into the treatment of human diseases. In addition to coursework in pathology and pathophysiology, GEMS students attend specialized seminars on translational issues and participate in an individually tailored clinical experience.

Summer Institutes

Patterned after MIT's Summer Research Program, HST offers specialized Summer Institute programs in bioinformatics and integrative genomics as well as in biomedical optics. Twenty-eight students participated in summer 2008, and 29 are enrolled in summer 2009. These programs offer a unique opportunity for outstanding undergraduate college students considering a career in biomedical engineering and/or medical science. Through a hands-on research experience and in-depth lectures, participants learn about a particular technical area (optics or bioinformatics) and engage in its application to solve problems in human health. Through individual tutorials and workshops, students gain the skills to communicate their research findings effectively in written and oral formats. Through shared living arrangements and a variety of technical and social activities, Summer Institute participants develop a network of peers and build strong, enduring connections with HST faculty working in the field. These kinds of seminal experiences go far in helping students make the choice to pursue graduate study. As proof of this concept, four HST MEMP students matriculating in September 2009 are alumni of the HST Summer Institute.

BioMatrix

During AY2009, 127 MIT undergraduate students and 67 graduate students participated in BioMatrix, a mentoring program that revolves around a series of monthly dinner meetings. BioMatrix offers students the opportunity to build mentoring relationships over time by making contacts at the dinners; engaging in smaller, more specific outside activities such as shadowing a physician or having lunch with a faculty member; and through its website network that provides member profile information.

Mentors are faculty, clinicians, researchers, industry professionals, public policy experts, and others who are willing to spend time with students to offer advice, friendship, and a look at what their own personal/professional path has been. Graduate and medical

students are also part of the community, mentoring the younger students and creating mentoring relationships with the professionals as well.

Resources to Ease Friction and Stress Program

MIT's Resources to Ease Friction and Stress (REFS) program is a peer support program run by graduate students. The HST REFS began in fall 2009, joining six other MIT graduate departments that are running such programs. In AY2009, the HST program was led by five PhD students and had representatives from both the MEMP and SHBT PhD programs.

2009 Graduation

Eighty-two students graduated from HST on June 4, 2009, bringing the total HST alumni to over 1,300. Institute Professor Robert Langer presented the keynote speech.

Dr. Jeffrey Flier, the new dean of HMS, recognized Dr. London at the graduation ceremonies for his pivotal role in fostering the development of HST. Dr. Flier also announced the renaming of the medical school's academic society as the Irving M. London Society of the Harvard-MIT Division of Health Sciences and Technology. The HMS academic societies provide academic and social home bases for medical students at the HMS quadrangle campus in Boston. The other four academic societies are also named for pioneers in medical research and education: Walter Bradford Cannon, William Bosworth Castle, Francis Weld Peabody, and Oliver Wendell Holmes.

Ram Sasisekharan

Director, MIT

Edward Hood Taplin Professor of Medical and Electrical Engineering

David E. Cohen, MD, PhD

Director, HMS

Associate Professor of Medicine and Health Science and Technology

More information about the Harvard-MIT Division of Health Sciences and Technology can be found at <http://hst.mit.edu/>.