

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 65 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.

The HST Community

Faculty

HST faculty included 65 full faculty members and 183 affiliates in AY2008. Thirteen faculty members have primary appointments in HST at either MIT or HMS; 52 have joint appointments in HST and another department at either MIT or Harvard.

Graduate Students

HST programs enrolled 414 students in AY2008:

- 191 HST MD and MD/PhD students
- 179 HST PhD students (including eight MD/MEMP students also counted in the previous category): 123 in Medical Engineering and Medical Physics (MEMP), 52 in Speech and Hearing Bioscience and Technology (SHBT), and 4 in Radiological Sciences Joint Program
- 52 HST master’s students: 19 in Biomedical Enterprise Program, seven in Biomedical Informatics, 24 in Clinical Investigator Training, and two in Biomedical Engineering

Certificate Training Program Students

AY2008 saw the first two PhD students complete HST’s new Graduate Education in Medical Sciences (GEMS) 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 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.

Working in collaboration with MIT's Summer Research Program, HST offers specialized Summer Institute programs in Bioinformatics and Integrative Genomics and Biomedical Optics. In summer 2007, 26 students participated; 28 are enrolled in summer 2008.

2008 Graduation

HST's June 4, 2008 graduation involved 82 students, bringing the total HST alumni to over 1,300. The graduation keynote speaker was its founding director, Irving M. London, MD, MIT and HST professor emeritus of biology and HMS professor emeritus of medicine.

Speaker 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 announced the renaming of the medical school's first 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 are also named for pioneers in medical research and education: Walter Bradford Cannon, William Bosworth Castle, Francis Weld Peabody, and Oliver Wendell Holmes.

HST Advisory Board and Council

HST formed its Advisory Board and Council in 1998 to bring members of the private sector closer to HST. The Advisory Board and Council are comprised of leaders in the medical device, biotech, venture capital, legal, and academic sectors, and have proved to be a valuable resource to HST on numerous fronts. In 2008, the council had 40 members. The board had 11 members and was chaired by Anthony Williams, partner at Baker & McKenzie.

This year the board and council, along with the HST Alumni Association board, sponsored HST's second annual fundraiser for student support, Health, Sports and Technology, on September 24, 2007 at Fenway Park. Talks were given by: Joe Castiglione, Red Sox announcer; Dr. Stuart Hershon, Yankees team physician; Dr. Art Day, neurosurgeon at Brigham and Women's Hospital (BWH); Dr. Hugh Herr, HST faculty member; and Dr. Mark Price, HST alumnus. More than 200 people attended, and the event raised \$100,000. The HST MVP award was given to Joseph Ciffolillo, founding chair of the HST Advisory Board and retired executive vice president and chief operating officer of Boston Scientific Corporation.

HST Alumni

Now in its second year, HST's Alumni Association is dedicated to increasing and strengthening the ties among HST's 1,300 alumni. The Alumni Association provides

career development resources, facilitates alumni/student interaction, helps develop fundraising efforts, and works to foster HST brand recognition. In 2008, the alumni focused on three major initiatives: alumni/student roundtables, an annual alumni event, and a fundraiser (cosponsored with the Advisory Board and Council; see the Fenway Park event described earlier).

The HST Alumni Association and the Joint Student Council created the Alumni/Student Roundtable Initiative to increase informal interaction between the two groups.

The second annual Alumni Association gathering was held at Genzyme Corporation, and was attended by over 80 faculty, staff, students, advisers, and alumni. Genzyme Corporation and the Fleming Family Foundation sponsored the gathering.

BioMatrix

During AY2008, 118 MIT undergrads and 110 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, through smaller, more specific outside activities such as shadowing a physician or having lunch with a faculty member, and through its website network, which 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 able to create mentoring relationships with the professionals as well.

Research Program Highlights

HST brings together MIT, HMS, Harvard University, Boston-area teaching hospitals, and an assortment of research centers at all of these institutions in unique collaborations that facilitate progress in areas where the combined efforts of Harvard and MIT yield outcomes superior to the efforts of the individual institutions. The following research results were published by HST faculty during AY2008.

Nanostructures used to create a new family of bioadhesives. HST faculty members Professor Robert Langer and Jeffrey Karp created a waterproof adhesive bandage inspired by the feet of gecko lizards. The surface of the bandage has the same kind of nanoscale hills and valleys that allow the lizards to cling to walls and ceilings. Layered over this landscape is a thin coating of glue that helps the bandage stick in wet environments. Gecko-like dry adhesives have been around since about 2001 but there have been significant challenges to adapt this technology for medical applications given the strict design criteria required. Langer and Jeff Karp described the work in the February 19 issue of the *Proceedings of the National Academy of Sciences*.

Heparin contamination identified. Ram Sasisekharan, professor of biological engineering and HST, led an international team of researchers that explained how contaminated batches of heparin were able to slip past safety screens and kill dozens

of patients. They identified the chemical structure of the contaminant, known as oversulfated chondroitin sulfate (OSCS), and demonstrated how OSCS sets off an allergy-like reaction. These results provided a potential link between the presence of chemical contaminants in heparin and the clinical symptoms observed in affected patients, and suggested that a simple bioassay could help protect the global supply chain of heparin. Results were published in the online edition of *Nature Biotechnology* and the *New England Journal of Medicine*.

Remote-control nanoparticles deliver drugs directly into tumors. MIT scientists led by Dr. Sangeeta Bhatia, HST associate professor, devised remotely controlled nanoparticles that, when pulsed with an electromagnetic field, release drugs to attack tumors. The innovation was reported in the November 15 online issue of *Advanced Materials*. The tiny particles are superparamagnetic, a property that causes them to give off heat when they are exposed to a magnetic field. Tethered to these particles are active molecules, such as therapeutic drugs. Exposing the particles to a low-frequency electromagnetic field causes the particles to radiate heat that, in turn, melts the tethers and releases the drugs. The tethers in the system consist of strands of DNA. The experiment is a proof of principle demonstrating a safe and effective means of tunable remote activation. However, work remains to be done before such therapies become viable in the clinic.

Culture influences brain function. MIT researchers demonstrated that people from different cultures use their brains differently to solve the same visual perceptual tasks. The team led by John Gabrieli, HST faculty member, professor of brain and cognitive sciences, and associate director of the Martinos Center for Biomedical Imaging, asked 10 East Asians recently arrived in the United States and 10 Americans to make quick perceptual judgments while in a functional magnetic resonance imaging scanner—a technology that maps blood flow changes in the brain that correspond to mental operations. The results were reported in the January issue of *Psychological Science*.

Using mathematics to predict the evolution of language. Erez Lieberman, a graduate student in HST and in Harvard’s School of Engineering and Applied Sciences, and Jean-Baptiste Michel, a graduate student at HMS, showed that verbs evolve and homogenize at a rate inversely proportional to their prevalence in the English language. The team, which reported their findings in *Nature*, conceives of linguistic development as an essentially evolutionary scheme. Just as genes and organisms undergo natural selection, words—specifically, irregular verbs that do not take an “-ed” ending in the past tense—are subject to powerful pressure to regularize as the language develops.

New hearing mechanism discovered. HST faculty member Dennis M. Freeman, working with HST student Roozbeh Ghaffari and research scientist Alexander J. Aranyosi, found that the tectorial membrane, a gelatinous structure inside the cochlea of the ear, is much more important to hearing than previously thought. It can selectively pick up and transmit energy to different parts of the cochlea via a kind of wave that is different from that commonly associated with hearing. The research appeared in the *Proceedings of the National Academy of Sciences*.

Key protein in iron metabolism found. In previous research, Jane-Jane Chen, a principal HST research scientist, showed that a protein—heme-regulated eukaryotic translational initiation factor 2 a-subunit (eIF2-alpha) kinase, or HRI for short—keeps mice with beta-thalassemia, an inherited blood disorder, alive. This new work uncovered HRI's dual role in iron recycling: it both keeps iron in the body and puts it to work. Chen and her research team's work, described in the October 11 *Journal of Clinical Investigation*, could lead to new therapies for certain inherited blood disorders.

New technique for neural prosthetic devices. HST MD student Lakshminarayan "Ram" Srinivasan, PhD, helped develop a new algorithm for use in creating prosthetic devices that convert brain signals into action. The algorithm's diagrams represent the mathematical relationship between the person's intentions and the neural manifestation of that intention, regardless of the device used to measure the signal or the region of brain where the signals originate. The development was featured in the cover article of the October 2007 *Journal of Neurophysiology*.

Research Program Events

HST Faculty Research Retreat

Forty faculty members met in June at the Wellesley College Club for HST's fourth annual retreat devoted to research presentations, focused this year on diagnostics and mathematical modeling of biological systems. Talks were presented by HST faculty from MIT and from HST hospital "nuclei": the Martinos Center for Biomedical Imaging (at Massachusetts General Hospital), the Wellman Center for Photomedicine (at Brigham and Women's Hospital), and the Eaton Peabody Laboratory for Hearing Research (at Massachusetts Eye and Ear Infirmary). The talks were held to 10 minutes each, each followed by a short discussion, offering faculty a wide range of research projects with potential for collaboration.

HST Faculty Poster Session

Thirty-five faculty members presented at the fourth annual HST Faculty Poster Session in September 2007, 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

The 21st annual HST Forum on student research was held in April at the New Research Building of the Harvard Medical School. The forum featured a student poster session and keynote speech "Getting to Treatments for Brain Diseases: New Partnerships" by Dennis W. Choi, MD '78, PhD, executive director, Comprehensive Neurosciences Initiative, Emory University.

The student poster session, underwritten by gifts from L'Institut de Recherches Internationales Servier, Howard Hughes Medical Institute, and Harry Lasker, featured

57 research posters that reflected a wide spectrum of research and represented all HST programs. More than 200 people attended the HST Forum.

Martinos Center Dedication

The Athinoula A. Martinos Center for Biomedical Imaging, a joint center of HST and the Massachusetts General Hospital (MGH) Radiology Department, completed a 45,000 square foot expansion this year, more than doubling its space. An official opening ceremony was held in May 2008. President Hockfield and Dr. Peter Slavin, president of MGH, thanked the Martinos family, who attended the dedication, in their remarks.

As part of the expansion, the Martinos Center assembled a new positron emission tomography (PET) scanner that will allow researchers to see magnetic resonance imaging (MRI) and PET images simultaneously. The combination of these two technologies marks the first time this approach has been employed in the United States. The center is located in the Charlestown Navy Yard on the MGH research campus, with a satellite facility on the MIT campus.

Educational Program Initiatives

HST is among the largest biomedical engineering and physician scientist training programs in the United States, with 414 students enrolled in its graduate degree programs during AY2008.

HST graduate students work with faculty and affiliated faculty members from both the MIT and Harvard communities. Admission is very competitive for all of the programs, with acceptance rates between five and 10 percent. Whether pursuing careers in medicine, research, industry, or government, HST graduates have made outstanding contributions to advances in human health care.

IDEA² Program

The process for selecting and developing a problem statement is a largely unstructured one for most graduate students. The overarching objective of the IDEA² program is to provide a structured process that guides, mentors, and supports the problem definition/development by HST students.

The principal advantage to participating students will be (1) an early experience in independently defining, articulating, and defending a thesis idea and (2) experience in developing and learning how to engage a network of advisors from different disciplines, professions, and sectors. Depending on the available resources, partial student support may be provided.

New Biomedical Imaging Curriculum

In response to demand from students and increased momentum behind funding for imaging research, HST has developed a core curriculum for neuroimaging. The core curriculum includes four fundamental courses: the engineering and physics of imaging, clinical applications, image analysis, and neuroscience. Students then complete two

courses that define an area of expertise in either image analysis or a specific imaging modality.

In spring 2008, HST introduced HST.563 Imaging Biophysics and Clinical Applications, one of the four fundamental Imaging Core courses. Rather than treating each modality as a separate technology, the course explores the similarities between imaging technologies as well as the differences. It examines clinical applications by exploring imaging targets, such as anatomical, functional, cellular, or molecular imaging, as well as disease targets, such as cancer, diabetes, or circulatory diseases.

The course is offered on the MIT campus; lab sessions are taught at different imaging centers in the Boston area so students will get a flavor for imaging procedures at each different hospital and at MIT.

The faculty members involved in this course and the entire Imaging Core curriculum include HST faculty members and researchers from MIT, Harvard, and the Harvard teaching hospitals. Their expertise spans the wide array of imaging technologies, including MRI, magnetoencephalography and electroencephalography, optical imaging, PET, computed tomography, molecular imaging, and ultrasound. Moreover, several faculty members, because of their multidisciplinary expertise, specialize in the combined use of complementary imaging approaches, an emerging clinical research focus area.

Other Subjects Added or Significantly Modified in AY2008

New subjects:

HST.240 Translational Medicine Preceptorship

HST.547 Human Pathophysiology

HST.594 Translational Medicine Seminars

HST.939 Designing and Sustaining Technology Innovation for Global Health Practice

Special Topics Offered:

(as HST.187) Heavy Charged Particles for Cancer Radiation Therapy

(as HST.481) D-Lab II—ICT4D Information and Communications Technologies for Development

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 HMS codirectors 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.

This is a transition year for HST. Most significantly, after 12 years of leadership as codirector of HST for MIT, Martha L. Gray, PhD (HST '86), announced her decision to

step down at the end of the academic year in November 2007. She will continue through August 2008 while the search committee works on naming her successor. David E. Cohen, MD (HST '87), PhD, continues as codirector of HST for HMRichard N. Mitchell, MD, PhD, and Lee Gehrke, PhD, serve as the division's associate directors. Sherene Aram joined HST this year as administrative officer, and Lynn Hinds became the HST fiscal officer.

Space at MIT

The renovation of MIT Building E25 was completed in 2008 and a celebration was held in February. This renovation helps unify many of MIT's HST faculty, administration, and research offices under one roof, and enhances interactions and collaborations among the faculty and student communities. The project is also a step toward building an HST space where we can invite partners and collaborators to come in and explore everything that HST has to offer.

Unifying Activities at Other Sites

An ongoing goal of HST is to continue to facilitate MIT-Harvard interactions and collaborations, including interactions with the Harvard teaching hospitals.

Appointments, Promotions, Awards, and Honors

HST Faculty Appointments and Promotions at MIT

Leonid Mirny was granted tenure and is now associate professor in HST with a joint appointment in the Department of Physics.

Sangeeta Bhatia was promoted to full professor in HST and the Department of Electrical Engineering and Computer Science (EECS).

Elfar Adalsteinsson was promoted to associate professor in HST and EECS.

Collin Stultz was promoted to associate professor in HST and EECS, and was also appointed to the W.M. Keck career development professorship in EECS.

HST Faculty Appointments and Promotions at HMS

Matthew Frosch (HST alumnus) was appointed to HST faculty this year. His primary appointment is associate professor of pathology at HMS, MGH. Dr. Frosch has taught HST neuroscience courses for more than seven years, and has recently assumed chairmanship of HST's MD admissions committee.

Isaac Kohane was promoted to full professor of pediatrics and HST at HMS, Children's Hospital.

Martha Bulyk was promoted to associate professor of medicine, pathology and HST at HMS, BWH.

Vikas Sukhatme, HST alumnus, member of HST-affiliated faculty, was named Beth Israel Deaconess Medical Center's chief academic officer.

David Cohen, HST alumnus and associate professor of medicine and HST at HMS, BWH, was named HST director based at HMS.

Research Awards

Sangeeta Bhatia received a 2008 Howard Hughes Medical Institute investigator award.

Emery Brown received a National Institutes of Health Pioneer Award.

Utkan Demirci received a Deshpande Research Award and an honorary Bionanotechnology Award from the Turkish Technology Development Foundation and other Turkish organizations.

Elazer Edelman received a Deshpande Research Award.

Hugh Herr received the 13th annual Heinz Award for Technology, the Economy, and Employment.

Jeffrey Karp received a Massachusetts Technology Transfer Center Spring 2008 Investigation Award for "Tissue Adhesive Tape Inspired by Nature."

Ali Khademhosseini received four awards: 2007 LaMer Award of the American Chemical Society, recognizing the outstanding PhD thesis of the year; 2008 Institute of Electrical and Electronics Engineers-Engineering in Medicine and Biology Society Early Career Achievement Award for significant contributions to the field of biomedical engineering; 2007 BMW Science Award in the doctoral thesis category; and the 2007 Technology Review TR35, recognizing outstanding innovators under the age of 35.

Martha Gray, along with a student, received best paper award at the ASME Bioengineering Conference.

Robert Langer received the 2008 Millennium Technology Prize for intelligent drug delivery.

Ioannis Yannas and Francois Berthiaume received a Deshpande Research Award.

Honorary Elections

Emery Brown was elected to the Institute of Medicine and the American Association for the Advancement of Science.

Emery Brown and Roger Mark were named Institute of Electrical and Electronics Engineers fellows.

Faculty Mentoring and Teaching Awards

Elfar Adalsteinsson, associate professor of HST and EECS, received the Thomas McMahon Mentoring Award, chosen by HST students.

Jeffrey Karp, instructor in medicine and HST at HMS, BWH, won the MIT Undergraduate Research Opportunities Program faculty mentor of the year award.

Elazer Edelman, professor of HST at MIT and professor of medicine at HMS, BWH, won the HMS Clifford Barger Mentoring Award.

Henry Klapholz received the Irving M. London Teaching Award, chosen by HST students.

Hal Churchill received the HST Directors' Award for his many years of teaching Introduction to Clinical Medicine to HST medical students.

Student Awards and Achievements

Leah Acker (SHBT) and Kay Furman (Harvard-MEMP), and four incoming students, Maria Berezina (SHBT), James Ankrum (MEMP), Arjun Manrai (MEMP), and Kartik Trehan (MEMP), were awarded a 2008 fellowship grant through the National Science Foundation's Graduate Research Fellowship Program.

Erez Lieberman (HST-MEMP) and teammate Theresa Tribble, Harvard Business School, were awarded Grand Champion in the Lunar Ventures 2008 Competition for their business venture, iShoe.

Roozbeh Ghaffari and his team were awarded the grand prize in the MIT \$100K Entrepreneurship Competition and the Harvard Business School Business Plan Contest for "Diagnostics for All," a nonprofit company that has developed a unique process for making simple medical test kits out of paper, which require only a single drop of blood to provide a color-coded response indicating the presence of any of several different diseases.

Robert Koffie and Vijay Yanamadala (both MD class of 2011) received the 2008 Paul and Daisy Soros Fellowship for New Americans.

Erez Lieberman (HST MEMP) was a Lemelson-MIT Student Prize finalist for his work on an artificial intelligence system to enable early diagnosis of poor balance in aging adults. Lieberman's diagnostic system is currently in use by NASA astronauts.

Timothy Lu (HST MEMP '08) received the Lemelson-MIT Student Prize. Lu has invented processes that promise to help eradicate layers of bacteria known as biofilms in order to combat bacterial infections, such as those caused by Escherichia coli biofilms and MRSA (methicillin-resistant Staphylococcus aureus).

Benjamin Rapoport (HST MD/PhD) received a MIT-Center for Integration of Medicine and Innovative Technology Medical Engineering Fellowship. Rapoport's research is part of an effort to build thought-controlled prosthetic limbs for paralyzed patients.

Nicolas Gonzalez Castro (HST MEMP) received a Schweitzer Fellowship, honoring the legacy of Dr. Albert Schweitzer by committing to a year of service with a community agency. Castro and 33 other 2007–2008 Schweitzer Fellows will each devote more than 200 hours of service to local communities lacking access to adequate health services.

Future

In the coming year, HST has plans to continue to strengthen its community, educational programs, and research centers, as well as a new initiative in India.

Indian Health Sciences and Technology Institute

In November 2007, MIT and the government of India's Department of Biotechnology launched a partnership to create a new Translational Health Science and Technology Institute (THSTI) in India. The new institute will be modeled after HST; it will include faculty from multiple disciplines and professions, offer degrees through multidisciplinary programs, and develop strong ties with other institutions. Funded by the Indian government, the Indian HST will be a multidisciplinary, multiprofessional research and training center highly interconnected with regional centers of excellence. Martha Gray, former codirector of HST, will direct the program.

HST will help recruit and train new THSTI faculty members. Each year starting in September 2008 and continuing until 2011, four recruited THSTI faculty fellows will join the HST faculty. These faculty fellows will train at HST for two years. During their stay they will develop translational research programs, design courses and curricula for THSTI, and develop close relationships with HST faculty and students. These fellows will benefit from HST's experience bringing together science, engineering, and medicine in education and translational medical research.

Martha L. Gray, PhD

Director

Edward Hood Taplin Professor of Medical and Electrical Engineering

David E. Cohen, MD, PhD

Director

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/>.