

## HARVARD-MIT HEALTH SCIENCES AND TECHNOLOGY PROGRAM

Founded in 1970, the Harvard-MIT Program in Health Sciences and Technology (HST) is one of the world's oldest interdisciplinary educational programs focused on translational medical science and engineering.

The program is an inter-institutional collaboration between MIT, Harvard, and local teaching hospitals, dedicated to fostering academic excellence, scientific rigor, and clinical expertise.

Our MD, PhD, and MD-PhD students study side-by-side, gaining a deep understanding of the biomedical sciences, a strong quantitative foundation, and extensive hands-on clinical experience in Boston-area hospitals. HST students engage in translational research projects, collaborating with MIT and Harvard faculty drawn from across departments and disciplines to develop preventative, diagnostic, and therapeutic innovations.

Alumni of the program are responsible for countless groundbreaking innovations, including the drug regimen that transformed HIV/AIDS into a treatable disease and the first non-invasive technology for observing the brain in action.

HST has a home on each side of the Charles River. At MIT, the program is part of the Institute for Medical and Engineering Science (IMES) (<http://imes.mit.edu>) and represents the vanguard of IMES' educational initiatives. At Harvard, the program is part of Harvard Medical School's Program in Medical Education, housed within the Irving M. London Society.

HST offers degrees in two multidisciplinary areas of graduate study:

- Medical Sciences MD Program
- Medical Engineering and Medical Physics Doctoral Program

### Graduate Study

#### ***Medical Sciences (HST MD Program)***

##### **Is this program a good fit for me?**

HST's MD program is designed for bold, curious students who aspire to careers as physician-scientists. We're committed to welcoming applicants from a wide range of communities, backgrounds, and experiences.

Half of the students in our MD program have majored in biological sciences and half in physical sciences. They're comfortable with mathematics and computational methods, biochemistry, and molecular biology.

##### **How is the HST MD program different from other MD programs?**

HST adds a new dimension to medical school. The HST MD curriculum highlights the frontiers of what is known and what remains to be discovered. HST students gain a deep understanding of the fundamental principles underlying disease and acquire the clinical skills of traditional medical training. In addition, they undertake a meaningful research project in one of several hundred laboratories at Harvard, MIT, and local hospitals. It's the perfect beginning to a multidisciplinary career as a physician-scientist.

##### **What degree will I earn?**

HST students earn an MD degree from Harvard Medical School.

##### **What can I do with this degree?**

Graduates of the program can become a pioneering physician-scientists, ready to care for patients and lead translational research to develop preventative, diagnostic, and therapeutic innovations.

##### **What can I expect?**

In their first two years, students build a deep understanding of the medical sciences and lay the groundwork for further exploration. They explore the complex mechanics of human biology, study the technical underpinnings of healthcare, and gain a fundamental knowledge of molecular biology, biotechnology, engineering, and the physical sciences. HST students also explore the human side of medical science, meeting with a variety of patients in clinical settings.

They will also conduct research in a lab at MIT, Harvard, or one of the area teaching hospitals, building their expertise and learning from a thriving community of researchers, educators, and fellow students.

Beginning in April of the second year, HST students join their classmates from the other curricular track at Harvard Medical School in clinical clerkships and electives, gaining valuable real-world experience in a clinical setting.

##### **How long will it take me to earn an MD degree from HST?**

The HST MD program is designed to be completed in four years, with an option to extend the program to five years by including a year of full-time research. This additional research year typically occurs after the second year of the MD curriculum.

##### **Can the HST MD be combined with other degree programs?**

Many HST MD students join the Harvard/MIT MD-PhD program, earning a PhD in addition to their medical training. HST MD student may also pursue dual degrees in business (MBA), public health (MPH), public policy (MPP), or law (JD).

To learn more about the HST MD curriculum, visit the HST program overview (<https://meded.hms.harvard.edu/health-sciences-technology>) on Harvard Medical School's website.

## **Medical Engineering and Medical Physics**

### **Is this program a good fit for me?**

HST's Medical Engineering and Medical Physics (MEMP) PhD program offers a unique curriculum for engineers and scientists who want to impact patient care by developing innovations to prevent, diagnose, and treat disease. We're committed to welcoming applicants from a wide range of communities, backgrounds, and experiences.

### **How is HST's MEMP PhD program different from other PhD programs?**

Each MEMP student chooses one of 11 technical concentrations and design an individualized curriculum to ground themselves in the foundations of that discipline. They study medical sciences alongside MD students and become fluent in the language and culture of medicine through structured clinical experiences. They select a research project from among laboratories at MIT, Harvard, affiliated hospitals, and research institutes, then tackle important questions through the multiple lenses of their technical discipline and medical training. As a result, MEMP students will learn how to ask better questions, identify promising research areas, and translate research findings into real-world medical practice.

### **What degree will I earn?**

MEMP students earn a PhD awarded by MIT or by the Harvard Faculty of Arts and Sciences.

### **What can I do with this degree?**

Lead pioneering efforts that translate technical work into innovations that improve human health and shape the future of medicine.

### **How long will it take me to earn a PhD in HST's MEMP program?**

The average time-to-degree for MEMP PhD students is 5.7 years.

### **What can I expect?**

MEMP students begin by choosing a concentration in a classical discipline of engineering or physical science. During the first two years in HST, each student completes a series of courses to learn the fundamentals of their chosen area.

In parallel, they will become conversant in the biomedical sciences through preclinical coursework in pathology and pathophysiology, learning side-by-side with HST MD students.

With that foundation, students will engage in truly immersive clinical experiences, gaining a hands-on understanding of clinical care, medical decision making, and the role of technology in medical practice. These experiences will help students become fluent in the language and culture of medicine and gain a first-hand understanding of the opportunities for—and constraints on—applying scientific and technological innovations in health care.

MEMP students also take part in two seminar classes that help them to integrate science and engineering with medicine while developing their professional skills.

A two-stage qualifying examination tests their proficiency in their concentration area, their skill at integrating information from diverse sources into a coherent research proposal, and their ability to defend that research proposal in an oral presentation.

Finally, as the culmination of their training, MEMP students investigate an important problem at the intersection of science, technology, and medicine through an individualized thesis research project, with opportunities to be mentored by faculty in laboratories at MIT, Harvard, and affiliated teaching hospitals.

### **Additional Application Information**

Neuroimaging and bioastronautics are areas of specialization within MEMP for which HST offers specially designed training programs. MEMP candidates may choose to apply through MIT, Harvard, or both. Those applying to MEMP through MIT should submit a single application. Those applying to MEMP through Harvard must also apply to the School of Engineering and Applied Sciences or the Biophysics Program. Additional information about applying to MEMP is available on the MEMP website (<https://hst.mit.edu/applying-hst/applying-medical-engineering-and-medical-physics-memp-phd-program>).

### **Inquiries**

Visit the website (<https://hst.mit.edu>) or email HST ([hst@mit.edu](mailto:hst@mit.edu)) for additional information on degree programs, admissions, and financial aid.

### **Faculty and Teaching Staff**

Collin M. Stultz, MD, PhD

Nina T. and Robert H. Rubin Professor in Medical Engineering and Science

Professor of Electrical Engineering and Computer Science  
Core Faculty, Institute for Medical Engineering and Science  
Co-Director, Health Sciences and Technology Program

Wolfram Goessling, MD, PhD

Robert H. Ebert Professor of Medicine, HMS  
Chief, Division of Gastroenterology, MGH  
Co-Director, Health Sciences and Technology Program

### **Professors**

Elfar Adalsteinsson, PhD

Eaton-Peabody Professor

Professor of Electrical Engineering

Core Faculty, Institute for Medical Engineering and Science

Daniel Griffith Anderson, PhD  
 Professor of Chemical Engineering  
 Core Faculty, Institute for Medical Engineering and Science

Bonnie Berger, PhD  
 Simons Professor of Mathematics  
 Member, Health Sciences and Technology Faculty

Sangeeta N. Bhatia, MD, PhD  
 John J. and Dorothy Wilson Professor of Health Sciences and  
 Technology and Electrical Engineering and Computer Science  
 Professor of Electrical Engineering and Computer Science  
 Core Faculty, Institute for Medical Engineering and Science

Emery N. Brown, MD, PhD  
 Edward Hood Taplin Professor of Medical Engineering  
 Warren M. Zapol Professor of Anaesthesia, HMS  
 Professor of Computational Neuroscience  
 Member, Institute for Data, Systems, and Society  
 Core Faculty, Institute for Medical Engineering and Science

Arup K. Chakraborty, PhD  
 Institute Professor  
 Robert T. Haslam (1911) Professor in Chemical Engineering  
 Professor of Chemistry  
 Professor of Physics  
 Core Faculty, Institute for Medical Engineering and Science

James J. Collins, PhD  
 Termeer Professor of Medical Engineering and Science  
 Professor of Biological Engineering  
 Core Faculty, Institute for Medical Engineering and Science

Elazer R. Edelman, MD, PhD  
 Edward J. Poitras Professor in Medical Engineering and Science  
 Professor of Medicine, HMS  
 Director, Institute for Medical Engineering and Science

Dennis M. Freeman, PhD  
 Henry Ellis Warren (1894) Professor  
 Professor of Electrical Engineering  
 Member, Health Sciences and Technology Faculty

John D. E. Gabrieli, PhD  
 Grover Hermann Professor of Health Sciences and Technology  
 Professor of Cognitive Neuroscience  
 Core Faculty, Institute for Medical Engineering and Science

Lee Gehrke, PhD  
 Hermann L. F. von Helmholtz Professor of Health Sciences and  
 Technology  
 Professor of Microbiology and Immunobiology, HMS  
 Core Faculty, Institute for Medical Engineering and Science

Martha L. Gray, PhD  
 Whitaker Professor in Biomedical Engineering  
 Professor of Electrical Engineering and Computer Science  
 Member, Health Sciences and Technology Faculty  
 Core Faculty, Institute for Medical Engineering and Science  
 (On leave)

Robert Langer, ScD  
 David H. Koch (1962) Institute Professor  
 Professor of Chemical Engineering  
 Professor of Mechanical Engineering  
 Professor of Biological Engineering  
 Affiliate Faculty, Institute for Medical Engineering and Science

Roger Greenwood Mark, MD, PhD  
 Distinguished Professor Post-Tenure in Health Sciences and  
 Technology  
 Core Faculty, Institute for Medical Engineering and Science

Leonid A. Mirny, PhD  
 Richard J. Cohen (1976) Professor in Medicine and Biomedical  
 Physics  
 Professor of Physics  
 Core Faculty, Institute for Medical Engineering and Science

Dava Newman, PhD  
 Apollo Professor of Astronautics and Engineering Systems  
 Member, Institute for Data, Systems, and Society  
 Affiliate Faculty, Institute for Medical Engineering and Science  
 Member, Health Sciences and Technology Faculty

David C. Page, MD  
 Professor of Biology  
 Member, Health Sciences and Technology Faculty

Alex K. Shalek, PhD  
 J. W. Kieckhefer Professor  
 Professor of Chemistry  
 Core Faculty, Institute for Medical Engineering and Science

Charles G. Sodini, PhD  
 Clarence J. LeBel Professor Post-Tenure in Electrical Engineering  
 Professor Post-Tenure of Electrical Engineering  
 Core Faculty, Institute for Medical Engineering and Science

David A. Sontag, PhD  
 Hermann L. F. von Helmholtz Professor  
 Professor of Electrical Engineering and Computer Science  
 Core Faculty, Institute for Medical Engineering and Science  
 (On leave, fall)

Peter Szolovits, PhD  
 Professor of Computer Science and Engineering  
 Core Faculty, Institute for Medical Engineering and Science

Ioannis V. Yannas, PhD  
Professor of Polymer Science and Engineering  
Member, Health Sciences and Technology Faculty

**Associate Professors**

Lydia Bourouiba, PhD  
Associate Professor of Civil and Environmental Engineering  
Core Faculty, Institute for Medical Engineering and Science

Kwanghun Chung, PhD  
Associate Professor of Chemical Engineering  
Associate Professor of Brain and Cognitive Sciences  
Core Faculty, Institute for Medical Engineering and Science

Thomas Heldt, PhD  
Associate Professor of Electrical Engineering and Computer Science  
Core Faculty, Institute for Medical Engineering and Science

Laura D. Lewis, PhD  
Athinoula A. Martinos Associate Professor  
Associate Professor of Electrical Engineering and Computer Science  
Core Faculty, Institute for Medical Engineering and Science

Tami Lieberman, PhD  
Associate Professor of Civil and Environmental Engineering  
Core Faculty, Institute for Medical Engineering and Science

Ellen Roche, PhD  
Latham Family Career Development Professor  
Associate Professor of Mechanical Engineering  
Core Faculty, Institute for Medical Engineering and Science

**Assistant Professors**

Marzyeh Ghassemi, PhD  
Herman L. F. von Helmholtz Career Development Professor  
Assistant Professor of Electrical Engineering and Computer Science  
Core Faculty, Institute for Medical Engineering and Science  
(On leave)

Lonnie Petersen, MD, PhD  
Charles Stark Draper Professor  
Assistant Professor of Aeronautics and Astronautics  
Core Faculty, Institute for Medical Engineering and Science

**Senior Lecturers**

Julie E. Greenberg, PhD  
Senior Lecturer, Institute for Medical Engineering and Science

**Lecturers**

Max Cotler, PhD  
Lecturer, Institute for Medical Engineering and Science

Sonal Jhaveri, PhD  
Lecturer, Institute for Medical Engineering and Science

William M. Kettyle, MD  
Lecturer, Institute for Medical Engineering and Science

Emily Lindemer, PhD  
Lecturer, Institute for Medical Engineering and Science

**HST Affiliated Faculty**

Ana Paula Abreu, MD, PhD  
Assistant Professor of Medicine, BWH

Aaron Dominic Aguirre, MD, PhD  
Assistant Professor of Medicine, MGH

Pierre Ankomah, MD, PhD  
Instructor in Medicine, MGH

Robert L. Barry, PhD  
Assistant Professor of Radiology, MGH

Daniel Bauer, MD, PhD  
Associate Professor of Pediatrics, CHB

Berkin Bilgic, PhD  
Assistant Professor of Radiology, MGH

Joseph V. Bonventre, MD, PhD  
Samuel A. Levine Professor  
Professor of Medicine, BWH

Brett Bouma, PhD  
Professor of Dermatology, MGH  
Affiliate Faculty, Institute for Medical Engineering and Science

Mary L. Bouxsein, PhD  
Professor of Orthopedic Surgery, BIDMC

Sydney S. Cash, MD, PhD  
Associate Professor of Neurology, MGH

Elliot L. Chaikof, MD, PhD  
Johnson and Johnson Professor  
Professor of Surgery, BIDMC

Yee-Ming Chan, MD, PhD  
Assistant Professor of Pediatrics, BCH

George M. Church, PhD  
Robert Winthrop Professor  
Professor of Genetics, HMS

George Daley, MD, PhD  
Dean of the Faculty of Medicine, HMS  
Professor of Biological Chemistry and Molecular Pharmacology, CHB  
Professor of Pediatrics, CHB  
Caroline Shields Walker Professor of Medicine, CHB

Georges el Fakhri, PhD  
Professor of Radiology, MGH

Stan N. Finkelstein, MD  
Associate Professor of Medicine, BIDMC

Stuart A. Forman, MD, PhD  
Professor of Anaesthesia, MGH

Jason Aaron Freed, MD  
Assistant Professor of Medicine, BIDMC

Matthew P. Frosch, MD, PhD  
Lawrence J. Henderson Professor  
Professor of Pathology and Health Sciences and Technology, HMS

Georg K. Gerber, MD, PhD  
Associate Professor of Pathology, BWH

Randy L. Gollub, MD, PhD  
Professor of Psychiatry, MGH

C. Corey Hardin, MD, PhD  
Associate Professor of Medicine, MGH

Tayyaba Hasan, PhD  
Professor of Dermatology, MGH

Howard M. Heller, MPH, MD  
Assistant Professor of Medicine, MGH

Miguel Hernan, MD, DrPH  
Kolkotrones Professor of Biostatistics and Epidemiology, HSPH

Paul L. Huang, MD, PhD  
Professor of Medicine, MGH

David Izquierdo-Garcia, PhD  
Assistant Professor of Radiology, MGH

Rakesh K. Jain, PhD  
A. Werk Cook Professor  
Professor of Radiation Oncology (Tumor Biology), MGH

Ursula B. Kaiser, MD  
Professor of Medicine, BWH

Sanjat Kanjilal, MD  
Assistant Professor in Population Medicine, HPHCI

Jeffrey M. Karp, PhD  
Professor of Anaesthesia, BWH

Isaac S. Kohane, MD, PhD  
Marion V. Nelson Professor  
Professor of Biomedical Informatics, HMS  
Professor of Pediatrics, CHB  
Associate Professor of Medicine, BWH

Anastasia Herta Koniaris, MD  
Assistant Professor of Obstetrics, Gynecology, and Reproductive  
Biology, BIDMC

Trevin Lau, MD  
Assistant Professor of Obstetrics, Gynecology, and Reproductive  
Biology, MGH

Scott B. Lovitch, MD, PhD  
Assistant Professor of Pathology, BWH

Mohini Lutchman, PhD  
Lecturer on Neurobiology, HMS

Richard N. Mitchell, MD, PhD  
Professor of Pathology and Health Sciences and Technology, HMS

Sahar Nissim, MD, PhD  
Assistant Professor of Medicine, BWH

Timothy P. Padera, PhD  
Associate Professor of Radiation Oncology, MGH

Shiv S. Pillai, MD, PhD  
Professor of Medicine, MGH

Jonathan R. Polimeni, PhD  
Assistant Professor of Radiology, MGH

Nathaniel O. Price, MB, ChB  
Assistant Professor of Medicine, MAH

Bruce R. Rosen, MD, PhD  
Laurence Lamson Robbins Professor  
Professor of Radiology, MGH

Douglas A. Rubinson, MD, PhD  
Assistant Professor of Medicine, DFCI

Sol Schulman, MD, PhD  
Assistant Professor of Medicine, BIDMC

Shiladitya Sengupta, PhD  
Associate Professor of Medicine, BWH

Ann K. Shinn, MD  
Assistant Professor of Psychiatry, McLean

Harvey B. Simon, MD  
Associate Professor of Medicine, MGH

David Sosnovik, MD  
Associate Professor of Medicine, MGH

Myron Spector, PhD  
Professor of Orthopedic Surgery (Biomaterials), BWH/VAMC-Boston

Judith M. Strymish, MD  
Assistant Professor of Medicine, VAMC-Boston

Steven M. Stuffelbeam, MD  
Associate Professor of Radiology, MGH

Joshua Tam, PhD  
Instructor in Dermatology, MGH

Guillermo J. Tearney, MD, PhD  
Professor of Pathology, MGH

Nii Ashitey Tetteh, MD  
Assistant Professor of Medicine, MGH

David Tsai Ting, MD  
Associate Professor of Medicine, MGH

Mehmet Toner, PhD  
Helen Andrus Benedict Professor  
Professor of Surgery, MGH

Benjamin Vakoc, PhD  
Associate Professor of Dermatology, MGH

Lawrence L. Wald, PhD  
Professor of Radiology, MGH

M. Brandon Westover, MD, PhD  
Emily Fisher Landau Professor  
Professor of Neurology, BIDMC

Seok-Hyun Yun, PhD  
Professor of Dermatology, MGH

Joshua Charles Ziperstein, MD  
Instructor in Medicine, MGH

### Professors Emeriti

George B. Benedek, PhD  
Alfred H. Caspary Professor Emeritus of Physics  
Professor Emeritus of Biological Physics

Richard J. Cohen, MD, PhD  
Professor Emeritus of Biomedical Engineering  
Core Faculty, Institute for Medical Engineering and Science

Thomas F. Weiss, PhD  
Professor Emeritus of Electrical and Bioengineering  
Professor Emeritus of Health Sciences and Technology

**IMPORTANT NOTES regarding preclinical subjects (HST.011-HST.200)\*:**

*Students not enrolled in an HST program are limited to two HST preclinical courses and must provide justification for enrolling in these courses. This action must be approved by the course director and the student's advisor. These subjects are scheduled according to the Harvard Medical School academic calendar, which differs from the MIT calendar. Students whose graduation depends upon completing one or more of these subjects should take particular care regarding the schedule. \*HST.141, HST.163 & HST.198 are NOT included in the two-course limit.*

### HST.011 Human Functional Anatomy

Subject meets with HST.010  
Prereq: Permission of instructor  
G (Fall)  
3-11-10 units

Lectures, detailed laboratory dissections, and prosections provide a thorough exploration of the gross structure and function of the human body. Fundamental principles of bioengineering are employed to promote analytical approaches to understanding the body's design. The embryology of major organ systems is presented, together with certain references to phylogenetic development, as a basis for comprehending anatomical complexity. Correlation clinics stress both normal and abnormal functions of the body and present evolving knowledge of genes responsible for normal and abnormal anatomy. Lecturers focus on current problems in organ system research. Only HST students may register under HST.010, graded P/D/F. Lab fee. Enrollment restricted to graduate students.

*T. Van Houten, R. Mitchell*

### HST.015 MATLAB for Medicine

Prereq: None  
G (Summer)  
2-0-4 units

Practical introduction to use of quantitative methods in medicine and health research. Each session covers a different topic in quantitative techniques, provides an application to medicine, and includes a modeling activity using MATLAB. Students also complete problem sets. Restricted to first year HST MD students.

*M. Frosch*

### HST.021 Musculoskeletal Pathophysiology

Subject meets with HST.020  
Prereq: HST.030 and HST.160  
G (Spring)  
3-0-3 units

Growth and development of normal bone and joints, the biophysics of bone and response to stress and fracture, calcium and phosphate homeostasis and regulation by parathyroid hormone and vitamin D, and the pathogenesis of metabolic bone diseases and disease of connective tissue, joints, and muscles, with consideration of possible mechanisms and underlying metabolic derangements. Only HST students may register under HST.020, graded P/D/F. Enrollment limited; restricted to medical and graduate students.

*M. Bouxsein, L. Tarter*



**HST.031 Human Pathology**

Subject meets with HST.030

Prereq: Biology (GIR), Physics I (GIR), and permission of instructor G (Fall)

4-3-8 units

Credit cannot also be received for HST.034, HST.035

Introduction to the functional structure of normal cells and tissues, pathologic principles of cellular adaptation and injury, inflammation, circulatory disorders, immunologic injury, infection, genetic disorders, and neoplasia in humans. Lectures, conferences emphasizing clinical correlations and contemporary experimental biology. Laboratories with examination of microscopic and gross specimens, and autopsy case studies emphasizing modern pathology practice. Only HST students may register under HST.030, graded P/D/F. Lab fee. Enrollment limited.

*R. N. Mitchell, R. Padera*

**HST.035 Pathology of Human Disease**

Subject meets with HST.034

Prereq: 7.05 or permission of instructor G (Spring)

Not offered regularly; consult department

4-2-10 units

Credit cannot also be received for HST.030, HST.031

Provides a comprehensive overview of human pathology with emphasis on mechanisms of disease and modern diagnostic technologies. Topics include general mechanisms of disease (inflammation, infection, immune injury, transplantation, genetic disorders and neoplasia); pathology of lipids, enzymes, and molecular transporters; pathology of major organ systems; and review of diagnostic tools from surgical pathology to non-invasive techniques such as spectroscopy, imaging, and molecular markers of disease. The objectives of this subject are achieved by a set of integrated lectures and laboratories, as well as a student-driven term project leading to a formal presentation on a medical, socioeconomic, or technological issue in human pathology. Only HST students enrolled in specific degree programs may register under HST.034, graded P/D/F. Credit cannot also be received for HST.030 or HST.031.

*S. Lovitch*

**HST.041 Mechanisms of Microbial Pathogenesis**

Subject meets with HST.040

Prereq: Biology (GIR), 7.05, and permission of instructor G (Fall)

4-2-6 units

Deals with the mechanisms of pathogenesis of bacteria, viruses, and other microorganisms. Approach spans mechanisms from molecular to clinical aspects of disease. Topics selected for intrinsic interest and cover the demonstrated spectrum of pathophysiologic mechanisms. Only HST students may register under HST.040, graded P/D/F. Lab fee. Enrollment limited.

*S. Kanjilal, K. Hysell*

**HST.061 Endocrinology**

Subject meets with HST.060

Prereq: Biology (GIR), 7.05, and permission of instructor G (Spring)

3-0-6 units

Physiology and pathophysiology of the human endocrine system. Three hours of lecture and section each week concern individual parts of the endocrine system. Topics include assay techniques, physiological integration, etc. At frequent clinic sessions, patients are presented who demonstrate clinical problems considered in the didactic lectures. Only HST students may register under HST.060, graded P/D/F. Enrollment limited.

*W. Kettyle, Y-M. Chan, A. Abreu*

**HST.071 Human Reproductive Biology**

Subject meets with HST.070

Prereq: 7.05 and permission of instructor G (Fall; first half of term)

4-0-2 units

Lectures and clinical case discussions designed to provide the student with a clear understanding of the physiology, endocrinology, and pathology of human reproduction. Emphasis is on the role of technology in reproductive science. Suggestions for future research contributions in the field are probed. Students become involved in the wider aspects of reproduction, such as prenatal diagnosis, in vitro fertilization, abortion, menopause, contraception and ethics relation to reproductive science. Only HST students may register under HST.070, graded P/D/F.

*A. Koniaris, D. Page, T. Lau*

### **HST.081 Hematology**

Subject meets with HST.080

Prereq: 7.05 and permission of instructor

G (Spring; partial term)

2-1-3 units

Intensive survey of the biology, physiology and pathophysiology of blood with systematic consideration of hematopoiesis, white blood cells, red blood cells, platelets, coagulation, plasma proteins, and hematologic malignancies. Emphasis given equally to didactic discussion and analysis of clinical problems. Enrollment limited.

*D. Bauer, S. Schulman*

### **HST.091 Cardiovascular Pathophysiology**

Subject meets with HST.090

Prereq: (HST.030 or HST.031) and permission of instructor

G (Spring)

4-3-8 units

Normal and pathologic physiology of the heart and vascular system. Emphasis includes hemodynamics, electrophysiology, gross pathology, and clinical correlates of cardiovascular function in normal and in a variety of disease states. Special attention given to congenital, rheumatic, valvular heart disease and cardiomyopathy. Only HST students may register under HST.090, graded P/D/F.

Enrollment limited.

*C. Stultz, T. Heldt*

### **HST.101 Respiratory Pathophysiology**

Subject meets with HST.100

Prereq: Physics I (GIR), 7.05, and permission of instructor

G (Spring)

4-0-8 units

Lectures, seminars, and laboratories cover the histology, cell biology, and physiological function of the lung with multiple examples related to common diseases of the lung. A quantitative approach to the physics of gases, respiratory mechanics, and gas exchange is provided to explain pathological mechanisms. Use of medical ventilators is discussed in lecture and in laboratory experiences. For MD candidates and other students with background in science. Only HST students may register under HST.100, graded P/D/F. Enrollment limited.

*C. Hardin, E. Roche, K. Hibbert*

### **HST.111 Renal Pathophysiology**

Subject meets with HST.110

Prereq: 7.05 and permission of instructor

G (Spring)

4-0-8 units

Considers the normal physiology of the kidney and the pathophysiology of renal disease. Renal regulation of sodium, potassium, acid, and water balance are emphasized as are the mechanism and consequences of renal failure. Included also are the pathology and pathophysiology of clinical renal disorders such as acute and chronic glomerulonephritis, pyelonephritis, and vascular disease. New molecular insights into transporter mutations and renal disease are discussed. Only HST students may register under HST.110, graded P/D/F. Enrollment limited.

*G. McMahon, M. Yeung*

### **HST.121 Gastroenterology**

Subject meets with HST.120

Prereq: Biology (GIR), Physics I (GIR), 7.05, and permission of instructor

G (Fall; second half of term)

3-1-2 units

Presents the anatomy, physiology, biochemistry, biophysics, and bioengineering of the gastrointestinal tract and associated pancreatic, liver, and biliary systems. Emphasis on the molecular and pathophysiological basis of disease where known. Covers gross and microscopic pathology and clinical aspects. Formal lectures given by core faculty, with some guest lectures by local experts. Selected seminars conducted by students with supervision of faculty. Only HST students may register under HST.120, graded P/D/F. Enrollment limited.

*A. Rutherford, S. Flier*

### **HST.131 Neuroscience**

Subject meets with HST.130

Prereq: Permission of instructor

G (Fall)

6-3-6 units

Comprehensive study of neuroscience where students explore the brain on levels ranging from molecules and cells through neural systems, perception, memory, and behavior. Includes some aspects of clinical neuroscience, within neuropharmacology, pathophysiology, and neurology. Lectures supplemented by conferences and labs. Labs review neuroanatomy at the gross and microscopic levels. Only HST students may register under HST.130, graded P/D/F. Limited to 50.

*J. Assad, M. Frosch*



**HST.147 Biochemistry and Metabolism**

Subject meets with HST.146  
 Prereq: Permission of instructor  
 G (Fall)  
 4-0-5 units

First-year graduate level intensive subject in human biochemistry and physiological chemistry that focuses on intermediary metabolism, structures of key intermediates and enzymes important in human disease. Subject is divided into four areas: carbohydrates, lipids, amino acids and nucleic acids. The importance of these areas is underscored with examples from diseases and clinical correlations. Preparatory sessions meet in August. Only HST students may register under HST.146, graded P/D/F. Enrollment limited.

*R. Sharma*

**HST.151 Principles of Pharmacology**

Subject meets with HST.150  
 Prereq: Biology (GIR), Physics I (GIR), and 7.05  
 G (IAP, Spring; partial term)  
 6-0-6 units

An introduction to pharmacology. Topics include mechanisms of drug action, dose-response relations, pharmacokinetics, drug delivery systems, drug metabolism, toxicity of pharmacological agents, drug interactions, and substance abuse. Selected agents and classes of agents examined in detail. Course follows HMS calendar. Restricted to HST MD & HST PhD students.

*S. Forman*

**HST.161 Genetics in Modern Medicine**

Subject meets with HST.160  
 Prereq: 7.05  
 G (Fall; second half of term)  
 2-0-4 units

Provides a foundation for understanding the relationship between molecular biology, genetics, and medicine. Starts with an introduction to molecular genetics, and quickly transitions to the genetic basis of diseases, including chromosomal, mitochondrial and epigenetic disease. Translation of clinical understanding into analysis at the level of the gene, chromosome, and molecule; the concepts and techniques of molecular biology and genomics; and the strategies and methods of genetic analysis. Includes diagnostics (prenatal and adult), cancer genetics, and the development of genetic therapies (RNA, viral, and genome editing). The clinical relevance of these areas is underscored with patient presentations. Only HST students may register under HST.160, graded P/D/F.

*S. Nissim*

**HST.163 Molecular Diagnostics and Bioinformatics**

Subject meets with HST.162  
 Prereq: Permission of instructor  
 G (Fall; first half of term)  
 2-0-4 units

Introduction of molecular diagnostic methods in medicine and relevant bioinformatics methods. Discussion of principles of molecular testing for diagnosis of somatic and germline diseases using FISH, classical genotyping, array CGH, next generation sequencing, and other technologies. Case conferences emphasize clinical correlation and integration of information from multiple diagnostic tests. Bioinformatics lectures, problem sets, and laboratory sessions will introduce key concepts in biological sequence analysis and provide experience with bioinformatics tools. HST.015 and HST.191 recommended. Only HST students may register under HST.162, P/D/F. Enrollment limited, preference to HST students.

*G. Gerber, L. Li*

**HST.165 Principles of Biomedical Imaging**

Subject meets with HST.164  
 Prereq: Permission of instructor  
 G (IAP)  
 2-0-4 units

Reviews fundamental principles and techniques underlying modern biomedical imaging, as well as their application in modern medicine. Particular emphasis on magnetic resonance; also covers ultrasound, computed tomography, positron emission tomography and optical techniques. Didactic lectures accompanied by problem sets and experiments with portable magnetic resonance systems and ultrasound systems. Focuses on the quantitative aspects of biomedical imaging and requires a knowledge of differential equations, MATLAB, and intermediate-level physics. Only HST students may register under HST.164, P/D/F. Restricted to HST students.

*S. Huang, D. Sosnovik*

**HST.176 Cellular and Molecular Immunology**

Subject meets with HST.175

Prereq: 7.05

G (Fall)

6-0-6 units

Covers cells and tissues of the immune system, lymphocyte development, the structure and function of antigen receptors, the cell biology of antigen processing and presentation including molecular structure and assembly of MHC molecules, lymphocyte activation, the biology of cytokines, leukocyte-endothelial interactions, and the pathogenesis of immunologically mediated diseases. Consists of lectures and tutorials in which clinical cases are discussed with faculty tutors. Details of each case covering a number of immunological issues in the context of disease are posted on a student website. Only HST students may register under HST.175, graded P/D/F. Limited to 45.

*S. Pillai, B. Cherayil*

**HST.191 Introduction to Biostatistics**

Subject meets with HST.190

Prereq: Calculus II (GIR)

G (Summer)

3-0-3 units

Provides training on how to comprehend, critique and communicate findings from biomedical literature. Considers how to assess the importance of chance in the interpretation of experimental data. Topics include probability theory, chi-squared and t-tests, ANOVA, linear and logistic regression, survival analysis, and statistical analysis using MATLAB. Includes critical reading of studies published in medical literature. Enrollment limited; restricted to HST students.

*N. Hejazi*

**HST.192 Medical Decision Analysis and Probabilistic Medical Inference**

Prereq: Permission of instructor

G (IAP)

2-0-2 units

Teaches the essentials of quantitative diagnostic reasoning and medical decision analysis. Guides participants through the process of choosing an appropriate contemporary medical problem in which risk-benefit tradeoffs play a prominent role, conducting a decision analysis, and ultimately publishing the results in a medical journal. Topics include decision trees, influence diagrams, Markov decision models and Monte Carlo simulation, methods for quantifying patient values, Bayesian inference, decision thresholds, and the cognitive science of medical decision making. HST.191 recommended. Limited to 8; preference to HST students.

*M. B. Westover*

**HST.195 Clinical Epidemiology**

Subject meets with HST.194

Prereq: HST.190

G (IAP, Spring; first half of term)

1-0-1 units

Introduces methods for the generation, analysis, and interpretation of data for clinical research. Major topics include the design of surveys, predictive models, randomized trials, clinical cohorts, and analyses of electronic health records. Prepares students to formulate well-defined research questions, design data collection, evaluate algorithms for clinical prediction, design studies for causal inference, and identify and prevent biases in clinical research. Emphasizes critical thinking and practical applications, including daily assignments based on articles published in major clinical journals and the discussion of a case study each week. Trains students to comprehend, critique, and communicate findings from the biomedical literature. Familiarity with regression modeling and basic statistical theory is a prerequisite. Only HST students may register under HST.194, graded P/D/F. Enrollment limited; restricted to medical and graduate students.

*M. Hernan*

**HST.196 Teaching Health Sciences and Technology**

Prereq: None

G (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

For teaching assistants or instructors in HST where the teaching assignment is approved for academic credit by the department.

*HST Faculty*

**HST.198 Independent Study in Health Sciences and Technology**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Opportunity for independent study of health sciences and technology under regular supervision by an HST faculty member. Projects require prior approval from the HST Academic Office, as well as a substantive paper.

*HST Faculty*

**HST.199 Research in Health Sciences and Technology**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

0-10-0 units

Can be repeated for credit.

For HST MD students with research assistantships where the assigned research is approved for academic credit by the department.

*HST Faculty***HST.200 Introduction to Clinical Medicine**

Prereq: Permission of instructor

G (IAP, Spring; partial term)

9-19-12 units

Intensive preparation for clinical clerkships that introduces the basic skills involved in examination of the patient in addition to history taking and the patient interview. Provides exposure to clinical problems in medicine, surgery, and pediatrics. Students report their findings through history taking and oral presentations. Restricted to MD program students.

*W. Goessling, D. Rubinson, D. Solomon***HST.201 Introduction to Clinical Medicine and Medical Engineering I**

Prereq: Permission of instructor

G (Summer)

0-20-0 units

Develop skills in patient interviewing and physical examination; become proficient at organizing and communicating clinical information in both written and oral forms; begin integrating history, physical, and laboratory data with pathophysiologic principles; and become familiar with the clinical decision-making process and broad economic, ethical, and sociological issues involved in patient care. There are two sections: one at Mount Auburn Hospital and one at West Roxbury VA Hospital, subsequent registration into HST.202 must be continued at the same hospital as HST.201. Restricted to MEMP students.

*C. Stultz, N. Price, J. Strymish***HST.202 Introduction to Clinical Medicine and Medical Engineering II**

Prereq: HST.201

G (Fall, IAP, Spring, Summer)

0-20-0 units

Strengthens the skills developed in HST.201 through a six-week clerkship in medicine at a Harvard-affiliated teaching hospital. Students serve as full-time members of a ward team and participate in longitudinal patient care. In addition, students participate in regularly scheduled teaching conferences focused on principles of patient management. Restricted to MEMP students.

*C. Stultz, N. Price, J. Strymish***HST.207 Introduction to Clinical Medicine and Medical Engineering**

Prereq: Permission of instructor

G (Spring; partial term)

0-30-0 units

Introduction to the intricacies of clinical decision-making through broad exposure to how clinicians think and work in teams. Instruction provided in patient interviewing and physical examination; organizing and communicating clinical information in written and oral forms; and integrating history, physical, and laboratory data with pathophysiologic principles. Attention to the economic, ethical, and sociological issues involved in patient care. Consists of immersive clinical experiences at Massachusetts General Hospital, leveraging extensive educational resources across inpatient clinical floors, ambulatory clinics, procedural/surgical suites, diagnostic testing areas, simulation learning lab, and didactic settings, followed by a focused experience in which students develop a proposal to solve an unmet need identified during their clinical experiences. Equivalent to combination of HST.201 and HST.202. Restricted to HST MEMP students.

*P. Ankomah, C. Stultz, A. Puig, J. Ziperstein*

**HST.220 Introduction to the Care of Patients**

Prereq: Permission of instructor

G (Spring)

1-0-2 units

Provides an introduction to the care of patients through opportunities to observe and participate in doctor-patient interaction in clinical settings and a longitudinal preceptorship experience with HST alumni physicians. Students are exposed to some of the practical realities of providing patient care. Topics include basic interviewing; issues of ethics, bias, and confidentiality; and other aspects of the doctor-patient relationship. The introductory session is held at HMS or Massachusetts General Hospital and the preceptorships are at several Harvard hospitals in Boston. Requirements include attendance at the introductory session and meetings scheduled with the preceptor.

*N. Tetteh*

**HST.240 Translational Medicine Preceptorship**

Prereq: HST.035

G (Fall, Spring, Summer)

0-12-0 units

Individually designed preceptorship joins together scientific research and clinical medicine. Students devote approximately half of their time to clinical experiences, and the remaining part to scholarly work in basic or clinical science. The two might run concomitantly or in series. Follow a clinical preceptor's daily activity, including aspects of patient care, attending rounds, conferences, and seminars. Research involves formal investigation of a focused and directed issue related to selected clinical area. Final paper required. Limited to students in the GEMS Program.

*E. Edelman*

**HST.420[J] Principles and Practice of Assistive Technology**

Same subject as 2.78[J], 6.4530[J]

Prereq: Permission of instructor

U (Fall)

Not offered regularly; consult department

2-4-6 units

See description under subject 6.4530[J]. Enrollment may be limited.

*R. C. Miller, J. E. Greenberg, J. J. Leonard*

**HST.431[J] Infections and Inequalities: Interdisciplinary Perspectives on Global Health**

Same subject as 11.134[J]

Prereq: None

U (Spring)

Not offered regularly; consult department

3-0-9 units. HASS-S

See description under subject 11.134[J]. Limited to 25.

*E. James, A. Chakraborty*

**HST.434 Evolution of an Epidemic (Study Abroad)**

Prereq: None

U (IAP)

3-0-1 units

Examines the medical, scientific, public health and policy responses to a new disease, by focusing on the evolution of the AIDS epidemic. Begins with a review of how this new disease was first detected in the US and Africa, followed by the scientific basis as to how HIV causes profound dysfunction of the body's immune defense mechanisms, the rational development of drugs, the challenge of an HIV vaccine, and how public health and policy decisions have influenced the course of the global epidemic. Class conducted in Johannesburg Durban, South Africa. Open to all majors. Limited to 20. Application required; see class website for eligibility details.

*H. Heller, B. Walker*

**HST.438[J] Viruses, Pandemics, and Immunity**

Same subject as 5.002[J], 10.380[J]

Subject meets with 5.003[J], 8.245[J], 10.382[J], HST.439[J]

Prereq: None

U (Spring)

Not offered regularly; consult department

2-0-1 units

Covers the history of infectious diseases, basics of virology, immunology, and epidemiology, and ways in which diagnostic tests, vaccines, and antiviral therapies are currently designed and manufactured. Examines the origins of inequities in infection rates in society, and issues pertinent to vaccine safety. Final project explores how to create a more pandemic-resilient world. Subject can count toward the 6-unit discovery-focused credit limit for first-year students. Preference to first-year students; all others should take HST.439[J].

*A. Chakraborty*

**HST.439[ ] Viruses, Pandemics, and Immunity**

Same subject as 5.003[ ], 8.245[ ], 10.382[ ]  
 Subject meets with 5.002[ ], 10.380[ ], HST.438[ ]  
 Prereq: None  
 U (Spring)  
 Not offered regularly; consult department  
 2-0-1 units

Covers the history of infectious diseases, basics of virology, immunology, and epidemiology, and ways in which diagnostic tests, vaccines, and antiviral therapies are currently designed and manufactured. Examines the origins of inequities in infection rates in society, and issues pertinent to vaccine safety. Final project explores how to create a more pandemic-resilient world. HST.438[ ] intended for first-year students; all others should take HST.439[ ].

*A. Chakraborty*

**HST.450[ ] Biological Physics**

Same subject as 8.593[ ]  
 Prereq: 8.044 recommended but not necessary  
 G (Spring)  
 Not offered regularly; consult department  
 4-0-8 units

See description under subject 8.593[ ].

*G. Benedek*

**HST.452[ ] Statistical Physics in Biology**

Same subject as 8.592[ ]  
 Prereq: 8.333 or permission of instructor  
 Acad Year 2023-2024: Not offered  
 Acad Year 2024-2025: G (Spring)  
 3-0-9 units

A survey of problems at the interface of statistical physics and modern biology: bioinformatic methods for extracting information content of DNA; gene finding, sequence comparison, phylogenetic trees. Physical interactions responsible for structure of biopolymers; DNA double helix, secondary structure of RNA, elements of protein folding. Considerations of force, motion, and packaging; protein motors, membranes. Collective behavior of biological elements; cellular networks, neural networks, and evolution.

*M. Kardar, L. Mirny*

**HST.460[ ] Statistics for Neuroscience Research**

Same subject as 9.073[ ]  
 Prereq: Permission of instructor  
 G (Spring)  
 3-0-9 units

See description under subject 9.073[ ].

*E. N. Brown*

**HST.482[ ] Biomedical Signal and Image Processing**

Same subject as 6.8801[ ]  
 Subject meets with 6.8800[ ], 16.456[ ], HST.582[ ]  
 Prereq: (6.3700 or permission of instructor) and (2.004, 6.3000, 16.002, or 18.085)  
 Acad Year 2023-2024: U (Spring)  
 Acad Year 2024-2025: Not offered  
 3-1-8 units

See description under subject 6.8801[ ].

*J. Greenberg, E. Adalsteinsson, W. Wells*

**HST.500 Frontiers in (Bio)Medical Engineering and Physics**

Prereq: None  
 G (Spring)  
 3-0-9 units

Provides a framework for mapping research topics at the intersection of medicine and engineering/physics in the Harvard-MIT community and covers the different research areas in MEMP (for example, regenerative biomedical technologies, biomedical imaging and biooptics). Lectures provide fundamental concepts and consider what's hot, and why, in each area. Training in scientific proposal writing (thesis proposals, fellowship applications, or research grant applications) through writing workshops. Topics include how to structure a novel research project, how to position research within the scientific community, how to present preliminary data effectively, and how to give and respond to peer reviews.

*S. Bhatia, D. Anderson, S. Jhaveri*

**HST.504[ ] Topics in Computational Molecular Biology**

Same subject as 18.418[ ]  
 Prereq: 6.8701, 18.417, or permission of instructor  
 G (Fall)  
 3-0-9 units  
 Can be repeated for credit.

See description under subject 18.418[ ].

*B. Berger*

**HST.506[ ] Computational Systems Biology: Deep Learning in the Life Sciences**

Same subject as 6.8710[ ]  
 Subject meets with 6.8711[ ], 20.390[ ], 20.490  
 Prereq: Biology (GIR) and (6.3700 or 18.600)  
 Acad Year 2023-2024: Not offered  
 Acad Year 2024-2025: G (Spring)  
 3-0-9 units

See description under subject 6.8710[ ].

*D. K. Gifford*

**HST.507[J] Advanced Computational Biology: Genomes, Networks, Evolution**

Same subject as 6.8700[J]  
 Subject meets with 6.8701  
 Prereq: (Biology (GIR), 6.1210, and 6.3700) or permission of instructor  
 G (Fall)  
 4-0-8 units

See description under subject 6.8700[J].  
*M. Kellis*

**HST.508 Evolutionary and Quantitative Genomics**

Prereq: Permission of instructor  
 G (Fall)  
 4-0-8 units

Develops deep quantitative understanding of basic forces of evolution, molecular evolution, genetic variations and their dynamics in populations, genetics of complex phenotypes, and genome-wide association studies. Applies these foundational concepts to cutting-edge studies in epigenetics, gene regulation and chromatin; cancer genomics and microbiomes. Modules consist of lectures, journal club discussions of high-impact publications, and guest lectures that provide clinical correlates. Homework assignments and final projects develop practical experience and understanding of genomic data from evolutionary principles.

*L. Mirny, T. Lieberman*

**HST.515[J] Aerospace Biomedical and Life Support Engineering**

Same subject as 16.423[J], IDS.337[J]  
 Prereq: 16.06, 16.400, or permission of instructor  
 Acad Year 2023-2024: Not offered  
 Acad Year 2024-2025: G (Spring)  
 3-0-9 units

See description under subject 16.423[J].  
*D. J. Newman*

**HST.518[J] Human Systems Engineering**

Same subject as 16.453[J]  
 Subject meets with 16.400  
 Prereq: 6.3700, 16.09, or permission of instructor  
 G (Fall)  
 3-0-9 units

See description under subject 16.453[J].  
*L. A. Stirling*

**HST.522[J] Biomaterials: Tissue Interactions**

Same subject as 2.79[J]  
 Prereq: (Biology (GIR), Chemistry (GIR), and Physics I (GIR)) or permission of instructor  
 G (Fall)  
 Not offered regularly; consult department  
 3-0-9 units

Principles of materials science and cell biology underlying the development and implementation of biomaterials for the fabrication of medical devices/implants, including artificial organs and matrices for tissue engineering and regenerative medicine. Employs a conceptual model, the "unit cell process for analysis of the mechanisms underlying wound healing and tissue remodeling following implantation of biomaterials/devices in various organs, including matrix synthesis, degradation, and contraction. Methodology of tissue and organ regeneration. Discusses methods for biomaterials surface characterization and analysis of protein adsorption on biomaterials. Design of implants and prostheses based on control of biomaterials-tissue interactions. Comparative analysis of intact, biodegradable, and bioreplaceable implants by reference to case studies. Criteria for restoration of physiological function for tissues and organs.

*I. V. Yannas, M. Spector*

**HST.523[J] Cell-Matrix Mechanics**

Same subject as 2.785[J]  
 Prereq: (Biology (GIR), Chemistry (GIR), and 2.001) or permission of instructor  
 G (Fall)  
 Not offered regularly; consult department  
 3-0-9 units

See description under subject 2.785[J].  
*I. V. Yannas, M. Spector*

**HST.524[J] Design of Medical Devices and Implants**

Same subject as 2.782[J]  
 Prereq: (Biology (GIR), Chemistry (GIR), and Physics I (GIR)) or permission of instructor  
 G (Spring)  
 3-0-9 units

See description under subject 2.782[J].  
*I. V. Yannas, M. Spector*



**HST.525[J] Tumor Microenvironment and Immuno-Oncology: A Systems Biology Approach**

Same subject as 10.548[J]

Prereq: None

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Fall)

2-0-4 units

Provides theoretical background to analyze and synthesize the most up-to-date findings from both laboratory and clinical investigations into solid tumor pathophysiology. Covers different topics centered on the critical role that the tumor microenvironment plays in the growth, invasion, metastasis and treatment of solid tumors. Develops a systems-level, quantitative understanding of angiogenesis, extracellular matrix, metastatic process, delivery of drugs and immune cells, and response to conventional and novel therapies, including immunotherapies. Discussions provide critical comments on the challenges and the future opportunities in research on cancer and in establishment of novel therapeutic approaches and biomarkers to guide treatment.

*R. K. Jain***HST.526[J] Future Medicine: Drug Delivery, Therapeutics, and Diagnostics**

Same subject as 10.643[J]

Subject meets with 10.443

Prereq: 5.12 or permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-6 units

See description under subject 10.643[J]. Limited to 40.

*D. G. Anderson***HST.531 Medical Physics of Proton Radiation Therapy**

Prereq: None

Acad Year 2023-2024: G (Spring)

Acad Year 2024-2025: Not offered

2-0-4 units

Acceleration of protons for radiation therapy; introduction into advanced techniques such as laser acceleration and dielectric wall acceleration. Topics include the interactions of protons with the patient, Monte Carlo simulation, and dose calculation methods; biological aspects of proton therapy, relative biological effectiveness (RBE), and the role of contaminating neutrons; treatment planning and treatment optimization methods, and intensity-modulated proton therapy (IMPT); the effect of organ motion and its compensation by use of image-guided treatment techniques; general dosimetry and advanced *in-vivo* dosimetry methods, including PET/CT and prompt gamma measurements. Outlook into therapy with heavier ions. Includes practical demonstrations at the Proton Therapy Center of the Massachusetts General Hospital.

*B. Winey, J. Schuemann***HST.533 Medical Imaging in Radiation Therapy**

Prereq: 18.06

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Spring)

2-0-4 units

Introduces imaging concepts and applications used throughout radiation therapy workflows, including magnetic resonance imaging (MRI), positron emission tomography (PET), and computed tomography (CT). Advanced topics include proton imaging modalities, such as prompt gamma imaging and proton radiography/CT. Includes lectures regarding image reconstruction and image registration. Introduces students to open-source medical image computing software (3D Slicer, RTK, and Plastimatch). Includes imaging demonstrations at Massachusetts General Hospital.

*B. Winey, J. Schuemann*

**HST.535[ ] Tissue Engineering and Organ Regeneration**

Same subject as 2.787[ ]

Prereq: (Biology (GIR), Chemistry (GIR), and Physics I (GIR)) or permission of instructor

G (Fall)

3-0-9 units

Principles and practice of tissue engineering (TE) and organ regeneration (OR). Topics include factors that prevent the spontaneous regeneration of tissues/organs in the adult (following traumatic injury, surgical excision, disease, and aging), and molecular and cell-biological mechanisms that can be harnessed for induced regeneration. Presents the basic science of organ regeneration. Principles underlying engineering strategies for employing select biomaterial scaffolds, exogenous cells, soluble regulators, and physical stimuli, for the formation of tissue in vitro (TE) and regeneration of tissues/organs in vivo (OR). Describes the technologies for producing biomaterial scaffolds and for incorporating cells and regulatory molecules into workable devices. Examples of clinical successes and failures of regenerative devices are analyzed as case studies.

*M. Spector, I. V. Yannas*

**HST.537[ ] Fluids and Diseases**

Same subject as 1.631[ ], 2.250[ ]

Subject meets with 1.063

Prereq: None

Acad Year 2023-2024: G (Spring)

Acad Year 2024-2025: Not offered

3-3-6 units

See description under subject 1.631[ ].

*L. Bourouiba*

**HST.538[ ] Genomics and Evolution of Infectious Disease**

Same subject as 1.881[ ]

Subject meets with 1.088

Prereq: Biology (GIR) and (1.000 or 6.100B)

G (Spring)

3-0-9 units

See description under subject 1.881[ ].

*T. Lieberman*

**HST.539[ ] Advances in Interdisciplinary Science in Human Health and Disease**

Same subject as 5.64[ ]

Prereq: 5.13, 5.601, 5.602, and (5.07[ ] or 7.05)

G (Spring)

3-0-9 units

See description under subject 5.64[ ].

*A. Shalek, X. Wang*

**HST.540[ ] Human Physiology**

Same subject as 7.20[ ]

Prereq: 7.05

U (Fall)

5-0-7 units

See description under subject 7.20[ ].

*M. Krieger, O. Yilmaz*

**HST.541[ ] Cellular Neurophysiology and Computing**

Same subject as 2.794[ ], 6.4812[ ], 9.021[ ], 20.470[ ]

Subject meets with 2.791[ ], 6.4810[ ], 9.21[ ], 20.370[ ]

Prereq: (Physics II (GIR), 18.03, and (2.005, 6.2000, 6.3000, 10.301, or 20.110[ ])) or permission of instructor

G (Spring)

5-2-5 units

See description under subject 6.4812[ ].

*J. Han, T. Heldt*

**HST.542[ ] Quantitative and Clinical Physiology**

Same subject as 2.792[ ], 6.4820[ ]

Subject meets with 2.796[ ], 6.4822[ ]

Prereq: Physics II (GIR), 18.03, or permission of instructor

U (Fall)

4-2-6 units

See description under subject 6.4820[ ].

*T. Heldt, R. G. Mark*

**HST.552[ ] Medical Device Design**

Same subject as 2.75[ ], 6.4861[ ]

Subject meets with 2.750[ ], 6.4860[ ]

Prereq: 2.008, 6.2040, 6.2050, 6.2060, 22.071, or permission of instructor

G (Spring)

3-3-6 units

See description under subject 2.75[ ]. Enrollment limited.

*A. H. Slocum, E. Roche, N. C. Hanumara, G. Traverso, A. Pennes*

**HST.560[ ] Radiation Biophysics**

Same subject as 22.55[ ]

Subject meets with 22.055

Prereq: Permission of instructor

Acad Year 2023-2024: G (Fall)

Acad Year 2024-2025: Not offered

3-0-9 units

See description under subject 22.55[ ].

*Staff*

**HST.562[J] Pioneering Technologies for Interrogating Complex Biological Systems**

Same subject as 9.271[J], 10.562[J]

Prereq: None

G (Spring)

3-0-9 units

Introduces pioneering technologies in biology and medicine and discusses their underlying biological/molecular/engineering principles. Topics include emerging sample processing technologies, advanced optical imaging modalities, and next-gen molecular phenotyping techniques. Provides practical experience with optical microscopy and 3D phenotyping techniques. Limited to 15.

*K. Chung*

**HST.563 Imaging Biophysics and Clinical Applications**

Prereq: (8.03 and 18.03) or permission of instructor

G (Spring)

Not offered regularly; consult department

2-1-9 units

Introduction to the connections and distinctions among various imaging modalities (x-ray, optical, ultrasound, MRI, PET, SPECT, EEG), common goals of biomedical imaging, broadly defined target of biomedical imaging, and the current practical and economic landscape of biomedical imaging research. Emphasis on applications of imaging research. Final project consists of student groups writing mock grant applications for biomedical imaging research project, modeled after an exploratory National Institutes of Health (NIH) grant application.

*C. Catana*

**HST.565 Medical Imaging Sciences and Applications**

Prereq: None

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Fall)

3-0-9 units

Covers biophysical, biomedical, mathematical and instrumentation basics of positron emission tomography (PET), x-ray and computed tomography (CT), magnetic resonance imaging (MRI), single photon emission tomography (SPECT), optical Imaging and ultrasound. Topics include particles and photon interactions, nuclear counting statistics, gamma cameras, and computed tomography as it pertains to SPECT and PET (PET-CT, PET-MR, time-of-flight PET), MR physics and various sequences, optical and ultrasound physics foundations for imaging. Discusses clinical applications of PET and MR in molecular imaging of the brain, the heart, cancer and the role of AI in medical imaging. Includes medical demonstration lectures of SPECT, PET-CT and PET-MR imaging at Massachusetts General Hospital. Considers the ways imaging techniques are rooted in physics, engineering, and mathematics, and their respective role in anatomic and physiologic/molecular imaging.

*G. El Fakhri*

**HST.576[J] Topics in Neural Signal Processing**

Same subject as 9.272[J]

Prereq: Permission of instructor

G (Spring)

3-0-9 units

See description under subject 9.272[J].

*E. N. Brown*

**HST.580[J] Data Acquisition and Image Reconstruction in MRI**

Same subject as 6.8810[J]

Prereq: 6.3010

Acad Year 2023-2024: G (Fall)

Acad Year 2024-2025: Not offered

3-0-9 units

See description under subject 6.8810[J].

*E. Adalsteinsson*

**HST.582[J] Biomedical Signal and Image Processing**

Same subject as 6.8800[J], 16.456[J]

Subject meets with 6.8801[J], HST.482[J]

Prereq: (6.3700 and (2.004, 6.3000, 16.002, or 18.085)) or permission of instructor

Acad Year 2023-2024: G (Spring)

Acad Year 2024-2025: Not offered

3-1-8 units

See description under subject 6.8800[J].

*J. Greenberg, E. Adalsteinsson, W. Wells*

**HST.583[J] Functional Magnetic Resonance Imaging: Data Acquisition and Analysis**

Same subject as 9.583[J]

Prereq: 18.05 and (18.06 or permission of instructor)

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Fall)

2-3-7 units

Provides background necessary for designing, conducting, and interpreting fMRI studies in the human brain. Covers in depth the physics of image encoding, mechanisms of anatomical and functional contrasts, the physiological basis of fMRI signals, cerebral hemodynamics, and neurovascular coupling. Also covers design methods for stimulus-, task-driven and resting-state experiments, as well as workflows for model-based and data-driven analysis methods for data. Instruction in brain structure analysis and surface- and region-based analyses. Laboratory sessions include data acquisition sessions at the 3 Tesla MRI scanner at MIT and the Connectom and 7 Tesla scanners at the MGH/HST Martinos Center, as well as hands-on data analysis workshops. Introductory or college-level neurobiology, physics, and signal processing are helpful.

*J. Polimeni, A. Yendiki*

**HST.584[J] Magnetic Resonance Analytic, Biochemical, and Imaging Techniques**

Same subject as 22.561[J]

Prereq: Permission of instructor

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Spring)

3-0-12 units

Introduction to basic NMR theory. Examples of biochemical data obtained using NMR summarized along with other related experiments. Detailed study of NMR imaging techniques includes discussions of basic cross-sectional image reconstruction, image contrast, flow and real-time imaging, and hardware design considerations. Exposure to laboratory NMR spectroscopic and imaging equipment included.

*L. Wald, B. Bilgic*

**HST.590 Biomedical Engineering Seminar Series**

Prereq: None

G (Fall, Spring)

1-0-0 units

Can be repeated for credit.

Seminars focused on the development of professional skills for biomedical engineers and scientists. Each term focuses on a different topic, resulting in a repeating cycle that covers biomedical and research ethics, business and entrepreneurship, global health and biomedical innovation, and health systems and policy. Includes guest lectures, case studies, interactive small group discussions, and role-playing simulations.

*E. Lindemer, M. Cotler*

**HST.599 Research in Health Sciences and Technology**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

For students conducting pre-thesis research or lab rotations in HST, in cases where the assigned research is approved for academic credit by the department. Hours arranged with research supervisor. Restricted to HST students.

*Consult Faculty*

**HST.714[J] Introduction to Sound, Speech, and Hearing**

Same subject as 9.016[J]

Prereq: (6.3000 and 8.03) or permission of instructor

G (Fall)

Not offered regularly; consult department

4-0-8 units

Introduces students to the acoustics, anatomy, physiology, and mechanics related to speech and hearing. Focuses on how humans generate and perceive speech. Topics related to speech, explored through applications and challenges involving acoustics, speech recognition, and speech disorders, include acoustic theory of speech production, basic digital speech processing, control mechanisms of speech production and basic elements of speech and voice perception. Topics related to hearing include acoustics and mechanics of the outer ear, middle ear, and cochlea, how pathologies affect their function, and methods for clinical diagnosis. Surgical treatments and medical devices such as hearing aids, bone conduction devices, and implants are also covered.

*S. S. Ghosh, H. H. Nakajima, S. Puria*

**HST.716[J] Signal Processing by the Auditory System: Perception**

Same subject as 6.8830[J]

Prereq: (6.3000 and (6.3700 or 6.3702)) or permission of instructor  
G (Fall)

Not offered regularly; consult department

3-0-9 units

See description under subject 6.8830[J].

*L. D. Braida*

**HST.723[J] Audition: Neural Mechanisms, Perception and Cognition**

Same subject as 9.285[J]

Prereq: Permission of instructor

G (Spring)

6-0-6 units

Neural structures and mechanisms mediating the detection, localization and recognition of sounds. General principles are conveyed by theme discussions of auditory masking, sound localization, musical pitch, cochlear implants, cortical plasticity and auditory scene analysis. Follows Harvard FAS calendar.

*J. McDermott, D. Polley, B. Delgutte, M. C. Brown*

**HST.728[J] Spoken Language Processing**

Same subject as 6.8620[J]

Prereq: 6.3000 and 6.3900

Acad Year 2023-2024: G (Spring)

Acad Year 2024-2025: Not offered

3-1-8 units

See description under subject 6.8620[J].

*J. R. Glass*

**HST.916[J] Case Studies and Strategies in Drug Discovery and Development**

Same subject as 7.549[J], 15.137[J], 20.486[J]

Prereq: None

G (Spring)

Not offered regularly; consult department

2-0-4 units

See description under subject 20.486[J].

*A. W. Wood*

**HST.918[J] Economics of Health Care Industries**

Same subject as 15.141[J]

Prereq: None

G (Spring; first half of term)

3-0-3 units

Credit cannot also be received for 15.1411

See description under subject 15.141[J].

*J. Doyle*

**HST.920[J] Principles and Practice of Drug Development**

Same subject as 10.547[J], 15.136[J], IDS.620[J]

Prereq: Permission of instructor

G (Fall)

3-0-6 units

See description under subject 15.136[J].

*S. Finkelstein, A. J. Sinskey, R. Rubin*

**HST.936 Global Health Informatics to Improve Quality of Care**

Subject meets with HST.937, HST.938

Prereq: None

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Spring)

2-0-1 units

Addresses issues related to how health information systems can improve the quality of care in resource poor settings. Discusses key challenges and real problems; design paradigms and approaches; and system evaluation and the challenges of measuring impact. Weekly lectures led by internationally recognized experts in the field. Students taking HST.936, HST.937 and HST.938 attend common lectures; assignments and laboratory time differ. HST.936 has no laboratory.

*L. G. Celi, H. S. Fraser, V. Nikore, K. Paik, M. Somai*

**HST.937 Global Health Informatics to Improve Quality of Care**

Subject meets with HST.936, HST.938

Prereq: None

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Spring)

2-2-2 units

Addresses issues related to how health information systems can improve the quality of care in resource poor settings. Discusses key challenges and real problems; design paradigms and approaches; and system evaluation and the challenges of measuring impact. Weekly lectures led by internationally recognized experts in the field. Students taking HST.936, HST.937 and HST.938 attend common lectures; assignments and laboratory time differ. HST.936 has no laboratory.

*L. G. Celi, H. S. Fraser, V. Nikore, K. Paik, M. Somai*

**HST.938 Global Health Informatics to Improve Quality of Care**

Subject meets with HST.936, HST.937

Prereq: None

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Spring)

2-2-8 units

Addresses issues related to how health information systems can improve the quality of care in resource poor settings. Discusses key challenges and real problems; design paradigms and approaches; and system evaluation and the challenges of measuring impact. Weekly lectures led by internationally recognized experts in the field. Students taking HST.936, HST.937 and HST.938 attend common lectures; assignments and laboratory time differ. HST.936 has no laboratory.

*L. G. Celi, H. S. Fraser, V. Nikore, K. Paik, M. Somai*

**HST.940[J] Bioinformatics: Principles, Methods and Applications**

Same subject as 10.555[J]

Prereq: Permission of instructor

G (Spring)

Not offered regularly; consult department

3-0-9 units

See description under subject 10.555[J].

*Gr. Stephanopoulos, I. Rigoutsos*

**HST.953 Clinical Data Learning, Visualization, and Deployments**

Prereq: (6.7900 and 6.7930[J]) or permission of instructor

Acad Year 2023-2024: Not offered

Acad Year 2024-2025: G (Fall)

3-0-9 units

Examines the practical considerations for operationalizing machine learning in healthcare settings, with a focus on robust, private, and fair modeling using real retrospective healthcare data. Explores the pre-modeling creation of dataset pipeline to the post-modeling "implementation science," which addresses how models are incorporated at the point of care. Students complete three homework assignments (one each in machine learning, visualization, and implementation), followed by a project proposal and presentation. Students gain experience in dataset creation and curation, machine learning training, visualization, and deployment considerations that target utility and clinical value. Students partner with computer scientists, engineers, social scientists, and clinicians to better appreciate the multidisciplinary nature of data science.

*M. Ghassemi, L. A. Celi, N. McCague and E. Gottlieb*

**HST.956[J] Machine Learning for Healthcare**

Same subject as 6.7930[J]

Prereq: 6.3900, 6.4100, 6.7810, 6.7900, 6.8611, or 9.520[J]

G (Spring)

4-0-8 units

See description under subject 6.7930[J]. Limited to 55.

*D. Sontag, P. Szolovits*

**HST.962 Medical Product Development and Translational Biomedical Research**

Prereq: Permission of instructor

G (Spring; second half of term)

1-0-3 units

Explores the translation of basic biomedical science into therapies. Topics span pharmaceutical, medical device, and diagnostics development. Exposes students to strategic assessment of clinical areas, product comparison, regulatory risk assessment by indication, and rational safety program design. Develops quantitative understanding of statistics and trial design.

*M. Cima*

**HST.971[J] Strategic Decision Making in Life Science Ventures**

Same subject as 15.363[J]

Prereq: None

G (Spring)

3-0-6 units

See description under subject 15.363[J].

*J. Fleming, A. Zarur*

**HST.974 Innovating for Mission Impact in Medicine and Healthcare**

Prereq: Permission of instructor

G (Fall, Spring)

3-0-9 units

Can be repeated for credit.

Through a mentored experience, and in conjunction with the MIT Catalyst program, participants develop and validate a small portfolio of research opportunities/proposals. Provides experience with critical professional skills (interfacing with diverse experts, research strategy, critically evaluating the landscape and potential to add value, proposal development, communication, etc.) that heightens the potential to have meaningful impact through their work and career. Restricted to MIT Catalyst Fellows.

*M. Gray, B. Vakoc, T. Padera*



**HST.978[J] Healthcare Ventures**

Same subject as 15.367[J]

Prereq: None

G (Spring)

3-0-9 units

Addresses healthcare entrepreneurship with an emphasis on startups bridging care re-design, digital health, medical devices, and new healthcare business models. Includes prominent speakers and experts from key domains across venture capital, medicine, pharma, med devices, regulatory, insurance, software, design thinking, entrepreneurship, including many alumni from the class sharing their journeys. Provides practical experiences in venture validation/creation through team-based work around themes. Illustrates best practices in identifying and validating health venture opportunities amid challenges of navigating healthcare complexity, team dynamics, and venture capital raising process. Intended for students from engineering, medicine, public health, and MBA programs. Video conference facilities provided to facilitate remote participation by Executive MBA and traveling students.

*M. Gray, Z. Chu*

**HST.980 Emerging Problems in Infectious Diseases**

Prereq: None

G (IAP)

1-0-2 units

Introduces contemporary challenges in preventing, detecting, diagnosing and treating emerging and newly emerging pathogens. Provides students with team-based opportunities to brainstorm, propose and present innovative solutions to such challenges. Expert lecturers discuss emerging problems in infectious diseases. Includes brainstorming sessions in which student teams identify problems in infectious diseases and propose innovative solutions. The teams then prepare and deliver short presentations, outlining identified problems and solutions.

*J. J. Collins*

**HST.999 Practical Experience in Health Sciences and Technology**

Prereq: None

G (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

For HST students who seek practical off-campus research experiences or internships related to health sciences and technology. Before enrolling, students must have a written offer from the outside organization, approval from their HST thesis supervisor (not required for summer registration), and approval of HST's Academic Office. Upon completion of the activity, the student must submit a letter from the employer describing the work accomplished, along with a substantive final report written by the student. Consult HST's Academic Office for details on procedures and restrictions.

*J. Greenberg*

**HST.THG Graduate Thesis**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Units arranged

Can be repeated for credit.

Program of research leading to the writing of a PhD or ScD thesis or an HST SM thesis; to be arranged by the student and an appropriate faculty advisor.

*Faculty*

**HST.UR Undergraduate Research in Health Sciences and Technology**

Prereq: None

U (Fall, IAP, Spring, Summer)

Units arranged [P/D/F]

Can be repeated for credit.

Extended participation in the work of a faculty member or research group. Research is arranged by mutual agreement between the student and a member of the faculty of the Harvard-MIT Program Health Sciences and Technology, and may continue over several terms. Registration requires submission of a written proposal to the MIT UROP, signed by the faculty supervisor and approved by the department. A summary report must be submitted at the end of each term.

*J. Greenberg*

**HST.URG Undergraduate Research in Health Sciences and Technology**

Prereq: None  
U (Fall, IAP, Spring, Summer)  
Units arranged  
Can be repeated for credit.

Extended participation in the work of a faculty member or research group. Research is arranged by mutual agreement between the student and a member of the faculty of the Harvard-MIT Program in Health Sciences and Technology, and may continue over several terms. Registration requires submission of a written proposal to the MIT UROP Office; signed by the faculty supervisor and approved by the department. A summary report must be submitted at the end of each term.

*J. Greenberg*

**HST.S16 Special Graduate Subject: Health Sciences and Technology**

Prereq: None  
G (Fall, IAP, Spring, Summer)  
Not offered regularly; consult department  
Units arranged [P/D/F]  
Can be repeated for credit.

Opportunity for group study of advanced subjects related to Health Sciences and Technology not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S17 Special Graduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
G (Fall, IAP, Spring, Summer)  
Not offered regularly; consult department  
Units arranged [P/D/F]  
Can be repeated for credit.

Opportunity for group study of advanced subjects related to Health Sciences and Technology not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S18 Special Graduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
G (Fall, IAP, Spring, Summer)  
Not offered regularly; consult department  
Units arranged  
Can be repeated for credit.

Opportunity for group study of advanced subjects related to Health Sciences and Technology not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S19 Special Graduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
G (Fall, IAP, Spring, Summer)  
Not offered regularly; consult department  
Units arranged  
Can be repeated for credit.

Opportunity for group study of advanced subjects related to Health Sciences and Technology not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S46 Special Undergraduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
U (Fall, IAP, Spring, Summer)  
Not offered regularly; consult department  
Units arranged [P/D/F]  
Can be repeated for credit.

Group study of subjects related to health sciences and technology not otherwise included in the curriculum. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S47 Special Undergraduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
 U (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged [P/D/F]  
 Can be repeated for credit.

Group study of subjects related to health sciences and technology not otherwise included in the curriculum. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S48 Special Undergraduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
 U (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged  
 Can be repeated for credit.

Group study of subjects related to health sciences and technology not otherwise included in the curriculum. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S49 Special Undergraduate Subject: Health Sciences and Technology**

Prereq: Permission of instructor  
 U (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged  
 Can be repeated for credit.

Group study of subjects related to health sciences and technology not otherwise included in the curriculum. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S56 Special Graduate Subject: Medical Engineering and Medical Physics**

Prereq: Permission of instructor  
 G (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged [P/D/F]  
 Can be repeated for credit.

Opportunity for group study of advanced subjects related to the Medical Engineering and Medical Physics Program not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S57 Special Graduate Subject: Medical Engineering and Medical Physics**

Prereq: Permission of instructor  
 G (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged [P/D/F]  
 Can be repeated for credit.

Opportunity for group study of advanced subjects related to the Medical Engineering and Medical Physics Program not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S58 Special Subject: Medical Engineering and Medical Physics**

Prereq: Permission of instructor  
 G (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged  
 Can be repeated for credit.

Opportunity for group study of advanced subjects related to the Medical Engineering and Medical Physics Program not otherwise included in the curriculum. Offerings are initiated by HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*HST Faculty*

**HST.S59 Special Graduate Subject: Medical Engineering and Medical Physics**

Prereq: Permission of instructor  
 G (Fall, IAP, Spring, Summer)  
 Not offered regularly; consult department  
 Units arranged  
 Can be repeated for credit.

Opportunity for group study of advanced subjects related to the Medical Engineering and Medical Physics Program not otherwise included in the curriculum. Offerings are initiated by IMES/HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*IMES/HST Faculty*

**HST.S78 Special Subject: Speech and Hearing Sciences**

Prereq: Permission of instructor

G (Fall, IAP, Spring)

Not offered regularly; consult department

Units arranged

Can be repeated for credit.

Opportunity for group study of advanced subjects related to the Speech and Hearing Sciences not otherwise included in the curriculum. Offerings initiated by members of the SHS faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic; consult faculty at time of offering.

*P. Cariani*

**HST.S96 Special Graduate Subject: Biomedical Entrepreneurship**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged [P/D/F]

Can be repeated for credit.

Opportunity for group study of advanced subjects relating to biomedical entrepreneurship not otherwise included in the curriculum. Offerings are initiated by HST/IMES faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic. Consult faculty at time of offering.

*HST/IMES Faculty*

**HST.S97 Special Graduate Subject: Biomedical Entrepreneurship**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged [P/D/F]

Can be repeated for credit.

Opportunity for group study of advanced subjects relating to biomedical entrepreneurship not otherwise included in the curriculum. Offerings are initiated by HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic. Consult faculty at time of offering.

*HST Faculty*

**HST.S98 Special Graduate Subject: Biomedical Entrepreneurship**

Prereq: Permission of instructor

G (Fall, Spring)

Not offered regularly; consult department

Units arranged

Can be repeated for credit.

Opportunity for group study of advanced subjects relating to biomedical entrepreneurship not otherwise included in the curriculum. Offerings are initiated by HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic. Consult faculty at time of offering.

*M. Gray, F. Murray*

**HST.S99 Special Graduate Subject: Biomedical Entrepreneurship**

Prereq: Permission of instructor

G (Fall, IAP, Spring, Summer)

Not offered regularly; consult department

Units arranged

Can be repeated for credit.

Opportunity for group study of advanced subjects relating to biomedical entrepreneurship not otherwise included in the curriculum. Offerings are initiated by HST faculty on an ad hoc basis subject to program approval. Prerequisites may vary by topic. Consult faculty at time of offering.

*HST/IMES Faculty*