Dean, School of Science

The School of Science has a long history of commitment to excellence in research and education, working at the forefront of scientific discovery and training upcoming leaders in academia, business, industry, and government. Though we have had much success, we now face some of some of the greatest challenges to our innovation and creativity. Some of these challenges are fundamental to our understanding of nature, such as discovering the properties of dark energy and dark matter. Others are crucial to the quality of life on our planet, such as developing viable sources of renewable energy and understanding disorders that affect the lives of millions, such as cancer, autism, and Alzheimer's disease.

With 300 faculty members, 1,100 graduate students, and 900 undergraduates, the School is well equipped to meet these challenges. The faculty and students produce a constant stream of important discoveries in such topics, ranging from the evolution of the human genome to the mechanisms of sight to the nature of distant planets. The significance of their work is well recognized: in the last two decades, our faculty has been distinguished by 10 Nobel Prizes, one Abel Prize (the equivalent of a Nobel in mathematics), and innumerable other awards for research and service. Many of our past graduate students now hold faculty positions at the world's best universities, and 16 of them have also won Nobel prizes.

Education

MIT is exceptional among major research institutions for its dedication to undergraduate education. Unlike most leading schools of science, MIT puts great emphasis on hiring and promoting young faculty members and using undergraduate teaching as important criterion for promotion and tenure. It is not uncommon for Nobel Prize winners and others among our best researchers to teach freshman subjects. Committed to providing MIT undergraduates with a strong science base for studies in their major, the School and its departments participate in and support a variety of programs designed to create more active, student-centered learning environments inside the classroom. The Department of Physics participates in both the d'Arbeloff Interactive Mathematics Project and the Technology-Enabled Active Learning (TEAL) program, which integrate technology into coursework to help students engage with concepts. The Undergraduate Research-Inspired Experimental Chemistry Alternatives (URIECA) curriculum integrates cutting-edge research with core chemistry concepts.

Professors Catherine Drennan (Chemistry and Biology) and Graham Walker (Biology) were named Howard Hughes Medical Institute (HHMI) Professors. These four-year grants aim to foster innovation in undergraduate science education at the professors' home universities and provide other institutions with effective models for bridging research and teaching. Professor Drennan will use her HHMI professorship to continue to create resources for chemistry educators to help students recognize the underlying chemical principles in biology and medicine, as well as to further develop mentoring and teacher-training materials for graduate students and postdoctoral fellows in chemistry. Professor Walker will use his professorship to re-establish a science education

group at the Institute, which will allow Walker to develop new tools and curricula for undergraduate students in biology and train young scientists as educators.

Building and Strengthening a Diverse Community

One of the highest priorities of the School administration is to support our outstanding faculty and to recruit exceptionally talented young researchers and educators to our faculty. As part of these efforts, the School of Science continues to focus our efforts on recruiting female and minority faculty. Individual departments have implemented a variety of strategies for recruiting a more diverse faculty and student population, including recruitment traveling for graduate students, appointment of staff members tasked with diversity recruitment, appointment of oversight representatives to hiring committees, and turning attention to minority graduate student retention.

This year, a new two-year postbaccalaureate program was established at MIT with its biotech partners, called the Biology and Biotechnology Bridge Program, or B^3. The goal of this two-year program is to provide additional research and academic preparation to talented and driven individuals from minority groups and economically disadvantaged backgrounds to prepare them for the most competitive PhD programs in the biological and biomedical sciences in the country. The academic portion of the program will take place at MIT, while the research training portion will take place at local biotech companies.

Research

The School of Science faculty made significant advances in research this year, with discoveries in such diverse areas as genetics, brain and neurological disorders, planetary science, quantum mechanics, and many others. More complete accounts of research accomplishments will be given by each department, but a few are featured here.

In concert with his colleagues at the IBM Almaden Research Center, assistant professor of chemistry Christian Degen developed the first MRI device that can capture three-dimensional images of viruses. Combining MRI with atomic force microscopy, the new magnetic resonance force microscope (MRFM) is almost as powerful as an electron microscope, but it does not damage viruses and cells. The MFRM is expected to help structural biologists discover new drug targets for viruses.

Chemistry and biology professor Catherine Drennan's lab mapped an important area of an enzyme (bifunctional carbon monoxide dehydrogenase/acetyl CoA synthase) present in some microorganisms and responsible for removing approximately 100 million tons of carbon monoxide from the environment. Professor Drennan used X-ray crystallography to study the C-cluster, a section of the enzyme that captures carbon monoxide and reacts with water to form carbon dioxide. Her research will help chemists replicate the abilities of the C-cluster, with possible applications in manufacturing hydrogen for fuel cells, removing carbon dioxide from the atmosphere, and cleaning up carbon monoxide in heavily polluted urban areas.

Biology professors Michael Hemann and Michael Yaffe demonstrated the correlation between mutations in *p53* and *ATM*, two important genes in the development of

cancerous cells and in a patient's response to chemotherapy. Before Hemann and Yaffe's discovery, studies had produced conflicting conclusions about whether the loss of *p53* results in more or less effective chemotherapy treatment. However, the new study demonstrates that tumors with both *p53* and *ATM* mutations are susceptible to chemotherapy, while tumors with only one mutated gene are more resistant. The findings should lead to immediate improvements in the treatment of cancer, as well as future developments in chemotherapy drugs that target specific mutations.

Mathematics professor Steven Johnson and physics professor John Joannopoulos discovered a way to solve Casimir-force equations for any number of objects with any conceivable shape. Casimir forces, the quantum forces that affect objects only when they are extremely close together, can attract the tiny moving parts of microelectromechanical (MEM) devices together, causing them to "stick." The new method of solving Casimir-force equations models interactions at much greater scales of size and distance, and has already allowed other researchers to identify geometries where Casimir forces cause repulsion rather than attraction—an arrangement that increases the reliability of MEM devices.

Biology professor Eric Lander and a team of scientists from the Broad Institute, the University of Massachusetts Medical School, Harvard University, and MIT confirmed a theory that DNA is organized as a fractal globule. Until this study, scientists had theorized that DNA packs into a densely tangled structure called the equilibrium globule, even though these tangles would interfere with the cell being able to read its own DNA. Researchers used the new Hi-C technique to conduct a genome-wide analysis of gene proximity, verifying that DNA packs into the more functional fractal globule structure, which allows DNA to easily unfold and refold during gene activation, gene repression, and cell replication.

Biology professor and Whitehead Institute director David Page led a team that offered the first evidence that the Y chromosome, long thought to be unchanging since the loss of most of its genes hundreds of millions of years ago, is still evolving rapidly. For the first time, these researchers sequenced the chimpanzee Y chromosome; comparing the chimpanzee chromosome with that of the human revealed that the Y chromosome has changed much more dramatically than other chromosomes have since the two species emerged from a common ancestor. The Page lab and a team at the Washington University Genome Center are now sequencing and comparing Y chromosomes in other mammals to see whether the same rapid evolution is occurring in other species.

A team of researchers including earth, atmospheric, and planetary sciences (EAPS) and physics professor Sara Seager studied GJ 436b, an exoplanet 30 light-years away and about the size of Neptune, only to discover that, contrary to expectations, the planet contains abundant carbon monoxide and very little methane. Professor Seager theorizes that the planet may be exhibiting disequilibrium chemistry—the result of some other phenomena besides temperature and pressure affecting the atmosphere, the primary example of which is the presence of oxygen on Earth derived from its plant life. The study also suggests that scientists must be more flexible in their theories about the molecular composition of exoplanetary atmospheres.

In a study conducted through Project Prakash in India, brain and cognitive sciences (BCS) professor Pawan Sinha and his team helped newly sighted young adults and adolescents learn to distinguish objects at nearly normal levels by teaching them to identify objects in motion. Not only do the results refute the conventional wisdom that the brain cannot learn to process visual information after the age of five or six, but they also suggest that the brain groups together visual information through motion, correlating other attributes (such as color and orientation) to that group, and in turn using those attributes to identify stationary objects. Professor Sinha's findings may have significant impact on children born with visual impairments in developing countries, whose parents often do not have the resources to obtain early medical intervention and who are thus subject to higher risks of early mortality, illiteracy, and unemployment.

Building on the 2007 discovery of a method of wireless power transfer, physics professor Marin Soljačić's lab demonstrated that the system proves more efficient charging multiple devices at once. The new work also includes the development of a system closer to a size compatible with widespread use. Powering two devices simultaneously increased efficiency of the transfer of energy from 20 percent to 30 percent—theoretically, efficiency should approach 100 percent as more devices are added. The lab is now working on improving a system for tuning multiple devices for maximum efficiency, a process that is accomplished manually for each test but will need to be automated in a usable consumer device.

A team led by Picower Institute director and BCS professor Li-Huei Tsai demonstrated that sirtuins, proteins that slow the aging process in many animal species, also improve brain function, learning, and memory. Their new work builds on a 2007 study that showed sirtuins protect neurons against neurodegeneration caused by disorders such as Alzheimer's and suggested that improvements and learning and memory might be a byproduct of neuron protection. However, Professor Tsai's new study shows that sirtuins promote learning and memory through a novel pathway involving the manipulation of microRNA, unrelated to their ability to shield neurons from damage. The findings suggest that activating *SIRT1*, a gene involved in sirtuin production, may benefit patients with neurodegenerative diseases, and Tsai and her colleagues are now investigating the mechanism of the *SIRT1* gene and the influence of other sirtuin-related genes on memory and learning.

Space

Construction continues on the building destined to house the new David H. Koch Institute for Integrative Cancer Research, which is projected to open on time and on budget in November 2010. The building is designed to encourage close interaction among various MIT-affiliated researchers in science and engineering, both in terms of floor plan and its central location at Ames and Main streets. Its 180,000 square feet of state-of-the-art laboratory and workspace will be equipped with the most sophisticated research tools currently available, including facilities for bioinformatics and computing, genomics, proteomics, and flow cytometry; large-scale facilities for genetic engineering and testing; advanced imaging equipment; and nanomaterials characterization labs.

Events

The Great "Climategate" Debate

In the Great "Climategate" Debate on December 10, 2009, a panel of MIT scientists including EAPS professors Richard Lindzen, Ronald Prinn, and Kerry Emanuel, addressed scientific and political issues resulting from the leaked emails from climate scientists at the University of East Anglia's Climate Research Unit. Topics ranged from the validity of climate science and the motives of the email hackers to the need for ethical standards in responsible scientific reporting and how the public interprets scientific information.

Dean's Colloquium

The Dean's Colloquium is a new series of lectures designed to recognize scientists with unusual career paths. At the first Dean's Colloquium in October 2009, Dr. Edward Scolnick detailed research milestones from a remarkably varied career as a physician, as a researcher at the National Institutes of Health, Merck Research Laboratories, and MIT, and as director of the Broad Institute of MIT and Harvard, where he has pioneered research breakthroughs and treatments for a broad range of diseases, including the development of the important AIDS drug, Crixivan.

School of Science Breakfast Series

This year, the School of Science continued its successful Breakfast Series. The series featured talks by faculty from all departments in the School, including chemistry professor Moungi Bawendi's discussion of his research on nanocrystal quantum dots and their applications in fields such as emissive displays, lighting, solar energy conversion, and biological and biomedical fluorescence imaging, and mathematics professor Gigliola Staffilani's talk on the connections between her work on applying dispersive equations to problems in physics with the problems of everyday life.

Other talks included "A Change in Climate: A Fresh Approach to Climate Science" by EAPS professors Kerry Emanuel and Daniel Rothman, "Charting the Fate of 'Good' Cholesterol" by biology professor Monty Krieger, and a talk to MIT alumni and friends in Palo Alto, California, on "Amazing People Doing Amazing Things: The School of Science at MIT" by dean Marc Kastner.

Communication

The School of Science is working to enhance communications both inside and outside the Institute. The School continues to expand its website, which serves as a central respository of information and resources for prospective and current students, alumni, staff, and faculty. Our newsletter for friends and alumni of the School were published in the fall and spring.

Awards and Honors

Faculty Awards and Honors

Every year, academic and professional organizations honor numerous School of Science faculty for their innovative research, as well as their service to the community. Because this past year was no exception, the individual reports from the School's departments, labs, and centers will document these awards more completely. Several notable awards deserve additional mention here:

Biology and civil and environmental engineering professor Sallie Chisholm was awarded the 2010 Alexander Agassiz Medal for her pioneering studies of the dominant photosynthetic organisms in the sea and for integrating her results into a new understanding of the global ocean.

Mathematics professors Tobias Colding and Paul Seidel were awarded the 2010 Oswald Veblen Prize in Geometry, Colding for his new structure theory for embedded minimal surfaces and Seidel for his fundamental contributions to symplectic geometry.

Biology professor and Whitehead Institute founding member Gerald R. Fink was awarded the 2010 Genetics Prize by the Peter and Patricia Gruber Foundation for his groundbreaking discovery of cell transformation and recent work on variances in cell expression in yeast.

Alan Guth, the V.F. Weisskopf professor of physics, was awarded the prestigious Isaac Newton Medal by the Institute of Physics in London.

Professor of mathematics Tomasz Mrowka was named a 2010 Guggenheim Fellow for his work with mathematical tools borrowed from particle physics analyzing three- and four-dimensional mathematical objects. He received the sole fellowship in pure mathematics awarded this year.

Novartis professor of chemistry and professor of biology Joanne Stubbe was awarded the 2009 National Medal of Science for her work in understanding the mechanisms of enzymes that play an essential role in DNA replication and repair. In further recognition of her pioneering work on enzymes, she was also given the 2009 Benjamin Franklin Medal in Chemistry and the 2010 Welch Award.

Five professors in the Chemistry Department won awards from the American Chemical Society this past year:

- Moungi Bawendi, Award in Colloid and Surface Chemistry
- Stephen Buchwald, Gustavus J. Esselen Award for Chemistry in the Public Interest
- Stephen Lippard, Ronald Breslow Award for Achievement in Biomimetic Chemistry
- Mohammad Movassaghi, Elias J. Corey Award for Outstanding Original Contribution in Organic Synthesis by a Young Investigator
- Alice Ting, Arthur C. Cope Scholar Award

Several professors were elected to prestigious academic and scientific societies this past year:

- BCS and CSAIL professor Edward Adelson, Fellow, American Academy of Arts and Sciences
- Tomaso Poggio (BCS) and Jeffery Steinfeld (Emeritus, Chemistry), Fellows, American Association for the Advancement of Science
- Raymond Ashoori (Physics) and John Bush (Mathematics), Fellows, American Physical Society
- Tyler Jacks (Biology), Member, Institute of Medicine
- Angelika Amon (Biology) and Barbara Imperiali (Chemistry and Biology), Members, National Academy of Sciences.

School of Science Rewards and Recognition

The School of Science Rewards and Recognition Program continues to acknowledge the dedication and hard work of the people who fill our departments, labs, and centers and whose efforts are the source of our prestige. The Dean's Educational and Student Advising Award Program rewards employees for their dedication to the success of their educational programs and of the students they advise. The School continues its Spot Awards, which rewards employees "on the spot" for going beyond the requirements of their normal duties. The Infinite Mile Award rewards employees in the School of Science for their dedication to the School and their willingness to go far beyond the extra mile to accomplish everything that needs to be done. Lastly, the School has extended the Infinite Mile Award by instituting the Infinite K Award, which has smaller cash awards than the Infinite Mile, but is awarded to more of the School's deserving staff members at all levels.

Personnel

Appointments and Promotions

Sylvia Ceyer, the J. C. Sheehan professor of chemistry, was appointed head of the Department of Chemistry, beginning July 1, 2010; John Essigmann, William R. and Betsy P. Leitch professor of chemistry and biological engineering, joined her as associate department head.

Jacqueline Hewitt, professor of physics, was reappointed as the director of the MIT Kavli Institute for Astrophysics and Space Research; her three-year term began July 1, 2010.

Christopher Burge (Biology) and Christoph Paus (Physics) were promoted to full professor.

Guoping Feng joined the Department of Brain and Cognitive Sciences this year as full professor.

Chemistry professors Mohammad Movassaghi and Troy Van Voorhis and physics professors Scott Hughes and Hong Liu were granted tenure.

The following faculty were promoted to associate professor: Laura Schulz (BCS), Dennis Kim (Biology), Peter Reddien (Biology), Katrin Wehrheim (Mathematics), Jan Egedal-Pedersen (Physics), Joseph Formaggio (Physics), Steven Nahn (Physics), and Marin Soljačić (Physics).

Matthew Vander Heiden (Biology), Christian Degen (Chemistry), Elizabeth Nolan (Chemistry), Laurent Demanet (Mathematics), Jeff Gore (Physics), and Jesse Thaler (Physics) were all appointed to assistant professorship.

The following professors were appointed to chairs over the past year:

- Benjamin Brubaker (Mathematics), Cecil and Ida Green career development professor
- Tobias Colding (Mathematics), Norman Levinson professor of applied mathematics
- John Marshall (EAPS), Cecil and Ida Green professor
- John McGreevy (Physics), Class of 1922 career development professor
- Paul O'Gorman (EAPS), Victor P. Starr career development professor
- Mary-Lou Pardue (Biology), Boris Magasanik professor of biology
- J. Taylor Perron (EAPS), Cecil and Ida Green career development professor
- Krishna Rajagopal (Physics), MacVicar Faculty Fellow
- Weifeng Xu, Whitehead career development professor

Tenure-Track Faculty Lunch Program

These lunch meetings are intended to help junior faculty meet their peers in different departments and to provide a forum for discussion of important issues. At some meetings, relevant speakers will discuss key topics of particular interest to junior faculty. Meetings for this academic year included research presentations and workshops on "MIT Benefits and Resources" and "Mental Health Awareness."

School of Science Learn@Lunch Series

To provide administrative staff the support they need to do their jobs effectively as possible, the School of Science holds a monthly lunch series for staff members on a variety of subjects. Topics for the past academic year focused on ethics, integrity, and active bystander skills.

Marc A. Kastner
Dean
Donner Professor of Physics