Dean, School of Science

As MIT celebrated its 150th anniversary this past spring, the School of Science celebrated its role in establishing MIT's leadership in the world. The School of Science's history of commitment to excellence in education and cutting-edge scientific discovery began with the election of Karl Taylor Compton as president in 1930, when MIT began not only to add basic science to its curriculum, but also to hire faculty who would create new scientific knowledge. It would take a long time before investments in basic science would pay off; for example, while faculty at Columbia University, the University of Chicago, Harvard University, and the University of California, Berkeley, were winning Nobel Prizes in the 1930s, MIT faculty and staff did not begin to win them until the 1950s. Today, however, each of the six departments in the School of Science is ranked at the top of its field. Faculty and students produce a constant stream of important discoveries in 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 past 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.

At this landmark moment in the history of MIT, the School of Science again finds itself at a critical juncture, not only for building on its past successes but for making investments in new and exciting fields of research. Humankind now faces some of the greatest challenges to its innovation and creativity—challenges that the School of Science is uniquely poised to meet. 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. Moreover, new and promising fields, such as the drive to make computers intelligent, are opening up, but they demand new ways of integrating knowledge and organizing research to unlock their potential. This year, the School of Science has made significant advances toward meeting those challenges, both through the founding of new programs such as the Intelligence Initiative and the Lorenz Center, and through the accomplishments of our outstanding faculty and staff.

Initiatives and Programs

Intelligence Initiative

In cooperation with all five Schools and spearheaded by professors Joshua Tenenbaum (Brain and Cognitive Sciences) and Tomaso Poggio (Brain and Cognitive Sciences and Computer Science and Artificial Intelligence Laboratory), the School of Science has launched the Intelligence Initiative (I^2). I^2 reintegrates cognitive science, computer science, and artificial intelligence, which flourished together in the 1950s and 1960s at MIT under the auspices of scholars such as Claude Shannon, Norbert Weiner, Noam Chomsky, and Marvin Minsky. Research supported by I^2 is organized around questions

of physical, molecular, and collective intelligence, such as: How is human knowledge stored, represented, and organized? How can we design machine perception, learning, and planning algorithms with more human-like intelligence? How does collective intelligence arise in social and economic systems? I^2 is designed to target research and education in an integrated way, developing faculty, graduate students, and postdoctoral fellows who can carry out highly interdisciplinary and collaborative work. The initiative supports 11 I^2 seed projects, spanning the Department of Computer Science, the Sloan School of Management, the Department of Mechanical Engineering, the Media Laboratory, and the Department of Linguistics.

Lorenz Center

In September 2010, the School of Science launched the Lorenz Center, a new climate think tank devoted to fundamental inquiry. By emphasizing high-risk, curiosity-driven research, the Lorenz Center aims to attract an interdisciplinary group of top scientists who will focus on the enormous scientific challenge of understanding the physics, biology, and chemistry of Earth's climate system. Earth, Atmospheric, and Planetary Sciences professors Kerry Emanuel and Daniel H. Rothman are leading this effort, which is named after their late colleague Edward N. Lorenz, founder of modern chaos theory and an early contributor to climate science.

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 join our ranks. As part of these efforts, the School of Science continues to focus its 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.

MIT Report on the Status of Women Faculty

In cooperation with the School of Engineering, the School of Science published *A Report on the Status of Women Faculty in the Schools of Science and Engineering at MIT, 2011*. This new study follows up two reports, published in 1999 and 2002, that identified several areas in gender parity that needed to be addressed, including the low number of women faculty, the exclusion of women faculty from administrative decisions, and the difficulty women faculty faced in combining work and family responsibilities. The 1999 report became a national model for addressing gender inequities and, as the latest study shows, both reports had remarkable impact on the Institute.

The new study reveals significant gains achieved since 1999: an increase in the number of women faculty (from 30 to 52 in Science and 32 to 60 in Engineering), an increase in women holding senior administrative positions, and a more equitable distribution of salary and resources. However, efforts to achieve an environment more friendly and supportive of women have led to new problems and tensions. In the School of Science, attempts to identify and eliminate bias in the faculty search and promotion processes

have led to the perception that women faculty are unfairly hired and held to lower standards for advancement. Moreover, although study participants viewed MIT's family-friendly policies positively, they generally expressed concern that childcare issues are still perceived as "women's" issues rather than "family" issues. The report concludes that efforts within the Schools and the Institute should continue, building on previous gains and addressing persisting and newly arising issues.

B^3: Biology and Biotechnology Bridge Program

This past fall semester, the Biology and Biotechnology Bridge (B^3) postbaccalaureate program welcomed its first four students. The program is designed to prepare individuals from underrepresented minority groups or economically disadvantaged backgrounds to pursue PhDs in biological and biomedical fields, tapping a pool of talented science students who are disproportionately unlikely to apply to graduate school at MIT or elsewhere. B^3 students split their time between tuition-free coursework at MIT and a paid internship at the local biotech company Novartis. B^3 students will have access to models for scientific careers as well as the research experience that is necessary to be competitive for top graduate programs but often unavailable at schools without large research programs. As B^3 grows, the program will add new industrial partners and, it is hoped, become a model for programs in other departments at MIT and at other institutions.

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 project, which integrate technology into coursework to help students engage with concepts. The Undergraduate Research-Inspired Experimental Chemistry Alternatives curriculum integrates cutting-edge research with core chemistry concepts.

Bachelor's of Science Degree in Computer Science and Molecular Biology

In fall of 2011, the Department of Biology and the Department of Electrical Engineering and Computer Science will inaugurate a new interdisciplinary major combining biology and computer science. The degree in computer science and molecular biology will prepare students for careers in pharmaceuticals, bioinformatics, computational molecular biology, or medicine, and for graduate school in computer science, biology, and computational biology.

Research

The School of Science faculty made significant advances in research this year, with discoveries in such diverse areas as the biology of cancer, the early stages of Earth formation, and the physics of subatomic particles. More complete accounts of research accomplishments will be provided in each department's report to the president, but a few are featured here.

Biology professor Angelika Amon identified three compounds that induce cell death in aneuploidic cancer cells. Since most human cancers are aneuploid (i.e., have an abnormal number of chromosomes), compounds that target aneuploidy may allow researchers to develop drugs that are effective for a broad range of cancer types and yet selectively kill cancerous cells. Amon's work further showed that combining 17-AAG, a protein-folding inhibitor, and AICAR, a stress-inducing agent, produced the best results in mouse and human cancer cell cultures.

A team of scientists that included physics professor Janet Conrad observed one of the first violations of CP symmetry in work at the Booster Neutrino Experiment at the Fermi National Accelerator Laboratory. CP symmetry theorizes that matter and antimatter particles should behave in the same way, yet the Booster Neutrino Experiment research showed that antineutrinos may switch between "flavors" (muon, electron, and tau) differently than neutrinos do. Should their findings be confirmed by further data collection, the Standard Model may need to be revised to include new flavors of neutrinos.

Chemistry professor Christopher Cummins developed a means of processing phosphorous that uses ultraviolet light rather than chlorine, as is most commonly used in industry. In Cummins's study, UV light was applied to tetrahedral phosphorous in the presence of organic molecules with unsaturated carbon-carbon bonds to form tetra-organo diphosphane. Because chlorine methods are costly and pose considerable dangers to the environment and to phosphorous-processing workers, Cummins's new process promises substantial benefits if it can be adapted to large-scale production.

Mathematics professor Jonathan Kelner introduced one of the first significant improvements in about a decade in the efficiency of solutions to the max-flow problem. The max-flow problem, a basic problem of computer science first solved in World War II, calculates the maximum amount of "stuff" that can be moved from one end of network to the other, taking a system's capacity limitations into account. Max-flow can be applied to a range of problems, from airline scheduling to DNA sequence alignment. Max-flow algorithms usually consider only one pathway at a time, but Kelner found that an algorithm that employs a matrix could solve the max-flow problem hundreds of times faster.

Chemistry professor Stephen Lippard and a team of researchers at MIT and Brigham and Women's Hospital developed nanoparticles capable of delivering, and then activating, the common cancer drug cisplatin to targeted prostate tumor cells. In a mouse study, Lippard's methods were able to shrink tumors with one-third the standard dose of cisplatin, improving the drug's efficiency while reducing the potential for cisplatin's severe side effects. This work not only promises significant improvement in

the effectiveness of cisplatin treatment, but also is adaptable for the selective delivery other drugs and even multiple drugs at once.

Mathematics professor Gilbert Strang developed a method of separating a banded matrix into simpler matrices that are easier to identify as banded when inverted. Banded matrices are grids where most numbers equal zero except for a diagonal band at or near the center. In processing video or audio signals, banded matrices are easily multiplied with other matrices because of their many zeros; however, in dividing matrices back out, losses of speed may occur because inverted banded matrices are almost always full. Strang's new method could help engineers determine which processing techniques are practical and, moreover, may help process a signal even faster than the discrete Fourier transform.

An MIT team led by Brain and Cognitive Sciences professor Li-Huei Tsai found that sirtuins, usually associated with longevity, metabolism, and genome stability, also play a role in synaptic plasticity. Tsai's work builds on her 2007 study, in which researchers found that sirtuins protect neurons from degeneration and observed improvements in learning and memory. Though initially concluding that such improvements were a byproduct of sirtuins' protective function, Tsai's latest study uncovered a pathway in which sirtuins prevent the microRNA miR-134 from inhibiting the production of plasticity-inducing proteins. Tsai's finding may have useful applications in Alzheimer's, Parkinson's, and Huntington's research, though any potential drugs will require brain-specific targeting for human use, because sirtuins are involved in a diverse range of pathways.

Biology professor Matthew Vander Heiden identified a difference in the metabolism of normal and cancerous cells that identifies a promising drug target for cancer therapy. Conventional wisdom has held that cancer cell glycolysis follows the same nine-step process that occurs in normal cells, in which the last step employs PKM1 and PKM2 to convert a compound called PEP into pyruvate. Vander Heiden discovered that PKM2 is less active in cancer cells, leading to an accumulation of PEP. Excess PEP causes a positive feedback loop that produces compounds necessary for DNA production and other synthetic pathways, which supports the proliferation of cancer cells. Therefore, drugs that activate PKM2 may circumvent the positive feedback loop and slow the growth of cancer cells.

Earth, Atmospheric, and Planetary Sciences professor Benjamin Weiss developed a new technique for dating seafloor rocks that relies on the alternating bands of magnetism in rock layers created by re-orientations in Earth's magnetic field at random intervals. Weiss's scanning SQUID (superconducting quantum interference device) builds on work dating bands of fast-growing igneous rocks in mid-ocean ridges, but applies them to the microscale. Rather than collecting hundreds of oriented rock cores and analyzing each, dating can now be done on a single 5 cm sample. SQUID has the potential to extend the climate record well past the last few 100,000 years measured in ice core sampling, and could also be applicable to astronomical phenomena.

Physics professor Martin Zwierlein created clouds of impenetrable ultracold gas by cooling a fermionic isotope of lithium to nearly absolute zero and tuning the gas with a magnetic field to maximize collisions between atoms. The result was that particles were separated into spin-up and spin-down clouds; rather than passing through one another like normal gases, these clouds repelled one another. Zwierlein's "bouncing" gas clouds can serve as a model for high-temperature superconductors and quark-gluon plasma, the mix of elementary particles formed immediately after the Big Bang.

Events

Koch Institute Dedication

The David H. Koch Institute for Integrative Cancer Research building was dedicated on March 4, 2011. The seven-story, 365,000-square-foot building, stretching along Main Street between Ames and Vassar streets, houses 25 faculty labs and about 600 researchers. Scientists and engineers work side-by-side in the building, fostering collaborations among disciplines such as biology, chemical engineering, computer science, and materials science. All of the building's common areas—meeting rooms, tea rooms, elevators—are clustered in the center of the building to help promote chance encounters that could lead to new research collaborations.

Dean's Colloquium

Entering its third year, the Dean's Colloquium is a series of lectures designed to recognize scientists who began careers in science but have outstanding accomplishments outside of scientific research. In October, Charles Zhang PhD '94 gave a talk, titled "From Experimental Physics to Internet Entrepreneurship: One Scientist's Journey," describing his evolution from humble beginnings in rural China to MIT physics graduate student, to founder, chairman, and CEO of Sohu.com (a leading Internet service provider in China). In December, James Simons '58 described his path from mathematician to founder and CEO of a successful hedge fund and, now, philanthropist, in his talk, "Mathematics, Common Sense, and Good Luck: My Life and Careers."

School of Science Breakfast Series

This year, the School of Science continued its successful Breakfast Series. The series featured talks from around the School, including biology professor Laurie Boyer's discussion of stem cells and applied mathematics professor Tom Leighton's address on the Akamai Technologies story and the challenge of internet security.

Awards and Honors

Faculty Awards and Honors

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

Professor of biology Susan Lindquist was awarded the 2009 National Medal of Science (presented November 2010) for "her studies of protein folding, demonstrating that alternative protein conformations and aggregations can have profound and unexpected biological influences, facilitating insights in fields as wide-ranging as human disease, evolution, and biomaterials."

Nergis Mavalvala, professor of physics, won a 2010 MacArthur Fellowship, also known as the "genius" grant, which she will use to further her work on optics, condensed matter, and quantum mechanics.

Mathematics professor Tomasz Mrowka was awarded the 2011 American Mathematical Society Joseph L. Doob Prize, honoring him for his book *Monopoles and Three-Manifolds*, cowritten with Harvard University professor Peter Kronheimer.

David Page, director of the Whitehead Institute and professor of biology, received the 2011 March of Dimes Prize in Developmental Biology for his work on the human Y chromosome.

Mathematics professor Bjorn Poonen was named a 2011 Guggenheim Fellow. Poonen will use the fellowship to study Selmer groups of elliptic curves.

Professor of computational cognitive science Joshua Tenenbaum (Brain and Cognitive Sciences and Computer Science and Artificial Intelligence Laboratory) was a recipient of the 2011 National Academy of Sciences Troland Research Award.

Matthew Vander Heiden, assistant professor of biology, received a 2011 Damon Runyon-Rachleff Innovation Award.

Mathematics professor David Vogan was awarded the 2011 American Mathematical Society Levi L. Conant Prize for his work on the character table for E_8.

Martin Zwierlein, assistant professor of physics, won a 2010 David and Lucile Packard Fellowship, which will be used to support his work on ultracold atomic gases and models of high-temperature superconductivity.

Four professors won the Presidential Early Career Award for Scientists and Engineers: Michael Laub (Biology), Laura Schulz (Brain and Cognitive Sciences), Katrin Wehrheim (Mathematics), and Martin Zwierlein (Physics).

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

- David Page (Biology) and Peter Shor (Mathematics), fellows, American Academy of Arts and Sciences
- Chris Kaiser (Biology), Terry Orr-Weaver (Biology), and Li-Huei Tsai (Brain and Cognitive Sciences), fellows, American Association for the Advancement of Science

- Physics professors Jan Egedal-Pedersen and Nergis Mavalvala, fellows, American Physical Society
- David Bartel (Biology), member, 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 and Infinite Kilometer Awards recognize School of Science employees for their dedication to the School and their willingness to go far beyond the extra mile to accomplish everything that needs to be done.

Personnel

Appointments and Promotions

Promotions to full professor: Jianshu Cao (Chemistry), J. Troy Littleton (Biology), Gunther Roland (Physics), Pawan Sinha (Brain and Cognitive Sciences), Marin Soljačić (Physics), Joshua Tenenbaum (Brain and Cognitive Sciences), Senthil Todadri (Physics), and Vladan Vuletic (Physics)

Tenure: Steven Johnson (Mathematics), Amy Keating (Biology), Aviv Regev (Biology), Rebecca Saxe (Brain and Cognitive Sciences), and Thomas Schwartz (Biology)

Promotions to associate professor: Mark Behrens (Mathematics), Benjamin Brubaker (Mathematics), Michael Hemann (Biology), Michael Laub (Biology), John McGreevy (Physics), Robert Simcoe (Physics), and Joshua Winn (Physics)

Appointments to assistant professor: Clark Barwick (Mathematics), Mircea Dinča (Chemistry), Jacob Fox (Mathematics), Mary Gehring (Biology), Piyush Gupta (Biology), Myriam Heiman (Brain and Cognitive Sciences), Adam Martin (Biology), Noelle Eckley Selin (Earth, Atmospheric, and Planetary Sciences), and Feng Zhang (Brain and Cognitive Sciences)

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. This year, several faculty members presented their research, while other meetings covered topics such as current events and initiatives at MIT, postdoctoral considerations, and harassment policies and issues.

School of Science Learn@Lunch Series

To provide administrative staff with the support they need to do their jobs as effectively as possible, the School of Science holds a monthly lunch series for staff members on a variety of subjects. Topics for this year included the fundamentals of finance, improving communication between staff and supervisors, and positive psychology.

Marc A. Kastner
Dean
Donner Professor of Physics