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 the greatest challenges to our innovation and creativity. Several 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 resources of renewable energy and understanding disorders that affect the lives of millions, such as cancer, autism, and Alzheimer's disease.

With our 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 topics ranging from the formation of planets, to the emergence of animal life on earth, to the intricacies of memory in the human brain. The significance of their work is well recognized: in the last two decades, our faculty have 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 graduate students now hold faculty positions at the world's best universities, and 16 of them have also won Nobel Prizes.

Often the most profound and important questions require collaborations between groups with different expertise, sometimes in different departments or different schools. At the School of Science, such boundaries do not prevent people from working together; interest in interdisciplinary work across department and school lines is increasing. In recent years, the establishment of the Koch Institute for Integrative Cancer Research and a graduate program in microbiology have enhanced this productive trend. This year, the School of Science joins with the School of Engineering and researchers at Harvard University and Massachusetts General Hospital to form the Ragon Institute, dedicated to the development of an AIDS vaccine.

Building and Strengthening a Diverse Community

One of the highest priorities of the School's 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 has made an especially strong effort to recruit female and minority faculty. Individual departments have used 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. For example, in the past year CLE Moore instructor Mia Minnes and professors Gigliola Staffilani and Katrin Wehrheim have organized the Women in Mathematics Lecture Series, which brings in leading female mathematicians from important institutions and companies around the country to give lectures intended for advanced undergraduates and beginning graduate students of all genders. The lectures are meant to celebrate women's success in mathematics and encourage more young women to pursue careers in the discipline.

This year, the School has done particularly well with hiring new women faculty. Of the 10 faculty members hired, five were women: Wendy Gilbert in Biology, Yingxi Lin and Weifeng Xu in Brain and Cognitive Sciences (BCS), and Janet Conrad and Jocelyn Monroe in Physics.

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 an 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 School helps support, for example, the Experimental Study Group, which offers 50 freshmen small classes with increased interaction and flexible pacing and scheduling, as well as six pass/fail hands-on and innovative seminars available to all students in the Institute. The d'Arbeloff Interactive Mathematics Project and the Technology-Enabled Active Learning program, in which the Department of Physics participates, 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. Some professors participate in the Howard Hughes Medical Institute (HHMI) Master Education Group, an educational collaborative between several scientists at research universities committed to developing and implementing student-centered, active learning strategies to teach biology at the university level. See reports from individual departments for more details about these programs.

Research

As always, School of Science faculty have made significant contributions in research this year, achieving discoveries in diverse areas such as evolutionary theory, genetics, brain and neurological disorders, quantum mechanics, and many others. Though more complete accounts of research accomplishments will be given by each department, a few are highlighted here.

Physics professor Adam Burgasser discovered the two faintest star-like objects ever found, a pair of twin "brown dwarfs," each only a millionth as bright as the sun. This type of brown dwarf is thought to be the most common kind, but, because they are so faint, none had been identified before. This year, Professor Burgasser also announced the discovery that, rather than the nearly circular orbits most stars take more or less in tandem with the sun, ultracool subdwarfs have irregular orbits, traveling much faster than other stars and possibly arriving from other galaxies.

Professor of mathematics John Bush published a milestone study building on the late Edward Lorenz's pioneering work on chaos theory, demonstrating that the "fluid trampoline" is the simplest fluid example of chaos theory ever explored. Professor Bush showed that a water drop placed on a soap film that vibrates up and down may be

accurately described with a single simple equation. Bush's work explores the problem of identifying the simplest physical system that still displays chaotic behavior.

A team of MIT and Harvard scientists, including BCS professor John Gabrieli, has overturned the previous theory that schizophrenia was the result of disconnection between brain regions; rather, the team showed that schizophrenia is the result of excessive connectivity between default brain regions. These regions are active during self-reflection or when the brain is thinking of nothing in particular. Because close relatives of schizophrenia patients who do not have the disorder also exhibit elevated activity in default brain regions, it is likely that the increased activity in schizophrenia patients is associated with genetic causes rather than a consequence of the disease.

With scientists at MIT, the Albert Einstein College of Medicine, and the Weill Cornell Medical School, biology professor Frank Gertler developed a test that could help doctors precisely identify which breast cancer patients should receive aggressive therapy, thereby sparing many women at low risk for metastatic disease from undergoing unnecessary and potentially dangerous treatment. A blood test may become available, depending on the results of a two-year large population study of breast cancer patients.

Professor of geology Timothy Grove and a team of scientists in the Department of Earth, Atmospheric and Planetary Sciences (EAPS) solved the problem of how arc volcanoes are formed. Grove found that the stability of the mineral chlorite is the key factor that controls when, how, and at what depth fluids and molten rock from subducting plates are released, giving rise to the molten magma that erupts from the Earth's mantle. Understanding the process could lead to a model for the thermal structures underneath arc volcanoes as well as better methods for locating deposits of metals such as silver, copper, and molybdenum that occur in these formations.

A team of MIT physicists led by professor Eric Hudson discovered that several high-temperature superconductors display a patchwork of variations at the atomic scale called a Fermi surface, which has never been seen before in any kind of material. The phenomenon could serve as an important clue for physicists working to unravel the mystery of why a broad new class of materials known as strongly correlated electronic material exhibits unusual properties from high-temperature superconductivity to colossal magneto-resistance.

Researchers in the lab of biology professor Susan Lindquist have isolated the first links between genetic and environmental factors in the pathology of Parkinson's disease. Using a yeast model, they found the *PARK9* gene protected cells against misfolded alpha-synuclein on exposure to manganese. Misfolded alpha-synuclein is the hallmark of Parkinson's disease. A very early step in mapping out the biopathology of the disease, this discovery may eventually lead to treatments that target the causes rather than just the symptoms of Parkinson's.

BCS professor Elly Nedivi found that a type of neuron implicated in autism spectrum disorder remodels itself in a strip of brain tissue at the upper border of cortical layer 2. The discovery reveals the potential flexibility of cerebral cortex circuitry and architecture

in brain regions that contribute to perception and cognition. Nedivi's goal is to explore how structural remodeling contributes to long-term adult brain plasticity and what allows or limits this plasticity.

Sarah O'Connor's lab in the Department of Chemistry genetically engineered periwinkle plants to produce new compounds, some of which may be useful in the treatment of cancer and other diseases. Periwinkle produces alkaloids that exhibit pharmacologic activity, but some are too toxic for human use. O'Connor and her team induced an enzyme active in alkaloid synthesis to accept tryptamines modified with halogens, which often serve as points of attachments for chemical groups. Their discovery may allow biosynthetic pathways to be modified to reduce the toxicity or increase the effectiveness of alkaloid compounds.

While RNA transcription has long been thought to proceed in one direction across the DNA sequence to be copied, Phillip Sharp's lab in the Department of Biology has discovered that two RNA polymerases often start at the same site and move in opposite directions. The researchers believe that upstream and downstream RNA polymerases, or divergent polymerases, are paused on the DNA and keep the transcription start site open so that the gene can be easily accessed and transcribed.

Studying an unusually well preserved long sequence of strata found in Oman, a research team led by EAPS professor Roger Summons and including Samuel Bowring was able to produce strong evidence from chemical fossils that sponges were the first multicellular animals to evolve. Previously, multicellular animals were thought to originate in the Ediacarian period, but this new work places the emergence of sponges as much as 80 million years earlier, confirming hypotheses based on genetic evidence.

Professor Joshua Tenenbaum in BCS developed a model that can help computers recognize patterns in large sets of data more like humans do. Tenenbaum's algorithm can analyze a set of data and determine the most suitable organizational structure (e.g., a hierarchy, a linear order, or a set of clusters). The algorithm could help scientists in many fields analyze large amounts of data and could also illuminate pattern discovery in human brains.

BCS professor Li-Huei Tsai and her colleagues made several discoveries related to Alzheimer's and schizophrenia. Tsai found drugs that work on the gene *HDAC2* reverse the effects of Alzheimer's and boost cognitive function in mice. She also found that increasing levels of *HDAC1* prevent neurons from reentering the cell cycle, losing genomic integrity, and dying in mice genetically engineered to exhibit Alzheimer's-like symptoms. Both *HDAC1* and *HDAC2* are possible therapeutic targets. In her research on schizophrenia, Tsai and other MIT researchers used optogenetics, a technology combining genetic engineering with light to manipulate the activity of individual nerve cells, to induce gamma oscillations. Gamma oscillations are crucial to consciousness, attention, learning, and memory. Tsai and her colleagues also discovered that the protein DISC1 directly inhibits an enzyme associated with schizophrenia that causes cells to stop dividing and prematurely turn into neurons. Her research on DISC1 could lead to a better understanding of the relationship between genetic and environmental factors in schizophrenia.

EAPS professor Benjamin Weiss made a major step toward understanding why meteorites exhibit magnetism and overturned the prevailing theory that planetesimals, chunks of rock that came together to build planets, lacked any large-scale structure. Weiss's analysis shows that planetesimals were more like miniplanets themselves, with crusts and mantles and molten cores. On collision, they melted completely, causing their constituents to separate out, with lighter materials including silicates floating to the surface and eventually forming a crust, while heavier iron-rich material sank down to the core, producing a magnetic dynamo.

Space

Construction progresses on the building destined to house the new David H. Koch Institute for Integrative Cancer Research, and it is projected to open on time and on budget in December 2010. The building is designed to encourage close interaction between various MIT-affiliated researchers in biology and engineering, 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 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

Symposia and Lectures

Faculty and friends gathered at the American Academy of Arts and Sciences in September 2008 to celebrate the life of Edward Lorenz '48. Lorenz was an MIT meteorologist who began by attempting to explain why it is so hard to make good weather forecasts and ended by unleashing a scientific revolution called chaos theory. The event featured scientific talks by three of Dr. Lorenz's colleagues: Dr. Timothy Palmer of the European Centre for Medium-Range Weather Forecasts spoke on "A Lorenzian Perspective on Weather and Climate Prediction: Towards the Probabilistic Earth-System Model"; EAPS professor Richard Lindzen spoke on "Ed Lorenz's Contributions to Our Understanding of the General Circulation"; and professor Mitchell Feigenbaum of Rockefeller University spoke on "Edward Lorenz and Chaotic Dynamics." The event included personal reminiscences by friends and colleagues and concluded with an evening concert.

In February 2009, the Department of Biology hosted the 10th anniversary of the Francis Otto Schmitt Memorial Lecture. The annual Schmitt Lecture commemorates Francis Schmitt's significant contributions to the formation of the intellectual community within the biological sciences at MIT. Picower Scholar Matthew A. Wilson, the Sherman Fairchild professor of neuroscience and the associate department head for education of Brain and Cognitive Sciences, spoke on "Hippocampal Memory: Moving at the Speed of Thought." Dr. Wilson and his laboratory team work on how memories of places and events are encoded across networks of cells within the hippocampus, a region of the brain long implicated in the processes underlying learning and memory.

Last May, the major advances and new challenges in brain research were profiled at "An Afternoon with MIT's Brains on Brains," presented by the Department of Brain and Cognitive Sciences, the McGovern Institute for Brain Research, and the Picower Institute for Learning and Memory. As MIT president Susan Hockfield explained in her opening remarks, "After a few decades of simply stunning acceleration, the field of neuroscience is poised for the first time in human history to deliver scientifically designed, rational therapies for some crippling disorders of the brain." Professors Mark Bear and Li-Huei Tsai gave talks on "The Autistic Neuron" and "Alzheimer's Disease: Current State and Hope for the Future," respectively. The talks were followed by break-out panels on developmental and psychiatric disorders and diseases of aging.

This June's annual summer symposium at the Koch Institute for Integrative Cancer Research, Understanding Metastasis, returned to the 2002 theme of invasion and metastasis to trace the progress that has been made and to outline new questions and directions for research. Given that 90% of cancer deaths are due to metastasis rather than benign tumors that retain positional control, the symposium explored which changes make cancer cells malignant, how metastasized cells reach distant sites, and what those cells require to survive and grow. The conference was attended by scientists from companies and research institutions in Greater Boston and New England, and the presenters hailed from around the United States and the world at large.

School of Science Breakfast Series

This year, the School of Science expanded its successful breakfast series, taking two of its speakers on the road. At the first breakfast outside Cambridge, Pawan Sinha gave an illuminating explanation of how we acquire the ability to make sense of visual information. Addressing friends and alumni in Palo Alto, CA, Sinha showed that understanding visual information is not only a fundamental challenge in neuroscience but also is extremely useful in developmental studies and in creating theoretical models. In January, Dr. Leonard P. Guarente, the Novartis professor of biology, shared his recent findings in his talk on "Sirtuins: The Biological Fountain of Youth?" in La Jolla, CA. These findings include his discovery of genes, called SIR2-related genes, which regulate many processes related to aging and disease. He demonstrated the relationship of SIR2 gene function to calorie restriction, which is known to extend life span in many species.

Talks in Cambridge included "Imaging Earth's Deep Interior with Seismic Waves: From Hydrocarbon to the Core (and Back)" by EAPS professor Robert van der Hilst, "Walking on Water" by associate professor of applied mathematics John Bush, "Prospecting for Water on Mars" by department head and E. A. Griswold professor Maria Zuber, and "Alzheimer's Disease: Current State and Hope for the Future" by Picower professor of neuroscience Li-Huei Tsai.

Communication

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

Awards and Honors

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 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. During the 2009 academic year, a total of 10 awards were given in the categories of Infinite Mile Awards, the Dean's Education and Student Advising Awards, and the Dean's Recognition Award. Lastly, the School continues its Spot Awards, which reward employees "on the spot" for going beyond the requirements of their normal duties.

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.

Four professors in the Chemistry Department won awards from the American Chemical Society this past year: Stephen Lippard was given the Linus Pauling Medal, Mohammad Movassaghi received the Arthur C. Cope Scholar Award, Daniel Nocera won the ACS Award in Inorganic Chemistry, and JoAnne Stubbe won the Nakanishi Prize.

James McKernan from the Department of Mathematics was awarded the Frank Nelson Cole Prize in Algebra by the American Mathematical Society.

BCS professor Rebecca Saxe was named a David and Lucile Packard Fellow. She will use the five-year grant to study the circuits in the human brain that give rise to the high-level aspects of human thought.

B. Clark Burchfiel, a professor in EAPS, was awarded the Penrose Medal by the Geological Society of America.

Professor of physics Janet Conrad was named a Guggenheim Fellow. Conrad will use her fellowship to work on a new detector for large liquid argon experiments at MIT and Fermilab in Batavia, IL.

Wolfgang Ketterle of the Department of Physics received the Humboldt Research Award in recognition of his lifetime achievements in research.

Physics professor Marin Soljacic was awarded the MacArthur Fellowship for his influential work on several aspects of electromagnetic waves.

Professor of biology Stephen Bell received the National Academy of Sciences Award in Molecular Biology for his groundbreaking studies illuminating the mechanisms of DNA replication in eukaryotic cells.

Leonard Guarente from the Department of Biology was honored as a "Pioneer in Biomedical Research" along with two other scientists at the Biotechnology Study Center at New York University. Guarente was honored for the discovery of sirtuins, key regulators of longevity in living creatures.

In the 2009 academic year, five School of Science faculty were elected fellows of the American Academy of Arts and Sciences: Bradford Hager, EAPS; Nancy Kanwisher, BCS; Mehran Kardar, Physics; Michael Sipser, Mathematics; and Mriganka Sur, BCS. In addition, five were elected to the National Academy of Sciences: Tyler Jacks, Biology; John Joannopoulos, Physics; Monty Krieger, Biology; Daniel Nocera, Chemistry; and Gilbert Strang, Mathematics.

In the same period, five School of Science faculty were elected fellows of the American Association for the Advancement of Science: Arup Chakraborty, Chemistry; John Gabrieli, BCS; Mriganka Sur, BCS; Li-Huei Tsai, BCS; and Graham Walker, Biology.

Lastly, Department of Biology professor H. Robert Horvitz was named a Foreign Member of Great Britain's Royal Society and David C. Page, also of Biology, was elected to the Institute of Medicine.

Personnel

School of Science Learn@Lunch Series

To help 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 the past academic year included MIT benefits and resources, nonprofit accounting, business writing, Adobe Illustrator basics, active bystander training, organization, stress management, and improving sleep habits.

Tenure-track Faculty Lunch Program

These new 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 discuss key topics of particular interest to junior faculty. Meetings for this academic year included research presentations and a workshop on "Managing Research and Everything Else."

Appointments and Promotions

Li-Huei Tsai, a Picower professor of neuroscience and a Howard Hughes Medical Institute investigator, was appointed director of the Picower Institute for Brain Research. Professor Tsai succeeded director Mark Bear on July 1, 2009.

Ann Graybiel, the Walter A. Rosenblith professor of neuroscience in BCS, was named Institute Professor in November 2008.

Professors Michael Yaffe (Biology), Michale Fee (BCS), Timothy Jamison (Chemistry), Raffaele Ferrari (EAPS), John Bush, Bjorn Poonen, and Scott Sheffield (Mathematics), and Janet Conrad and Max Tegmark (Physics) were appointed to full professorships.

The following professors were granted tenure in the past academic year: James DiCarlo (BCS), Alice Y. Ting (Chemistry), Benjamin Weiss (EAPS), Kiran Kedlaya (Mathematics), Denis Auroux (Mathematics), Nergis Mavalvala (Physics), and Iain Stewart (Physics).

Thomas Schwartz (Biology), Steven Johnson (Mathematics), Adam Burgasser (Physics), and Bernd Surrow (Physics) were promoted to associate professor.

Wendy Gilbert (Biology), Yingxi Lin (BCS), Weifeng Xu (BCS), J. Taylor Perron (EAPS), Lie Wang (Mathematics), Allan Adams (Physics), and Jocelyn Monroe (Physics) were all appointed assistant professor in the past academic year.

Paul Chang was appointed to the Howard S. and Linda B. Stern career development professorship. Iain Cheeseman was named the Thomas D. and Virginia W. Cabot career development professor. Linda Elkins-Tanton obtained the Mitsui career development professorship. Joseph Formaggio will hold the Class of 1956 career development professorship. Oliver Jagoutz was named the Kerr-McKee career development professor. Kiran Kedlaya was named the Cecil and Ida Green career development associate professor of mathematics. Jonathan Kelner was appointed as the KDD career development assistant professor of applied mathematics. James McKernan obtained the Norbert Weiner professorship of mathematics. Bjorn Poonen will hold the Claude Shannon professorship of mathematics. Peter Reddien was named the Thomas D. and Virginia W. Cabot career development professor. Rebecca Saxe was appointed to the Fred and Carole Middleton career development professorship. Mriganka Sur was named the Paul E. Newton professor in neuroscience. Matthew Wilson was appointed to the Sherman Fairchild professorship in neurobiology.

Marc A. Kastner
Dean
Donner Professor of Physics

More information about the School of Science can be found at http://web.mit.edu/science/.