Dear Friends,

Never has the excitement of basic science been greater than it is today. Here is a list of just a few of the opportunities made possible by new technologies and new ideas developed recently:

- What are the origins of life on earth and does it exist on extrasolar planets? Genomics can help us answer the former and advanced space telescopes the latter.
- Are the prime numbers randomly distributed? If you can prove this, the Riemann hypothesis, you will win the $1M Clay Millennium Prize.
- Can we understand and control matter and energy far from equilibrium? While we have predictive theories for the physics and chemistry of material in equilibrium, non-equilibrium phenomena, which dominate in life, for example, are poorly understood. New technologies from nanoscience and femtosecond laser spectroscopy will allow us to address these problems for the first time.

Marc Kastner
Dean, MIT School of Science and Donner Professor of Science.
• How does the interconnected network of billions of neurons lead to memory, consciousness, intelligence, and all the other miraculous things we do in what we call our minds? Advances in every level of analysis—genes, neurons, circuits, algorithms—give us the opportunity to make great progress in understanding how the mind works.

• What are the dark matter and dark energy that make up more than 95% of all matter and energy in the universe? Satellite measurements of the cosmic microwave background have made cosmology quantitative for the first time in human history, and infrared astronomy is allowing us to study the earliest stars in the universe.

In these pages you can read about progress in some of these and other areas of basic science. We held “An Astronomical Event,” at which our alumni and friends learned about progress in many areas of astrophysics and astronomy. We have an article about the identification of the Higgs boson at the Large Hadron Collider, in which MIT played a major role; we have an article about RNA interference, a basic science discovery that is already being used for disease therapies; and we have an article about a colloquium by Susan Solomon, who recently joined MIT and is a world leader in the science of climate.

It is a tragedy that at the very moment when the opportunities are greatest, the United States is reducing its support of basic science at the steepest rate in our history. I have been called the Cassandra of MIT, because I have been forecasting a decline in federal funding for research for many years, but few believed me. Indeed, the stimulus funding after the crash of 2008 put off the downturn in funding. But under sequestration, funding for research at MIT is now going down by about 10% immediately. And new budgets proposed by the Congress will not reverse that.

Most of the research-funding agencies will maintain their current commitments, but there will be much less money for new grants. We are already seeing distinguished faculty members, some members of the National Academy of Sciences, failing to have their grants renewed. Some of the agencies are reserving funds for the youngest investigators, but this is exacerbating the hardship for mid-career faculty members, who are at the peak of their productivity.

What will be the consequences of these cuts in funding? I predict that there will be a large decrease in the number of graduate students and postdoctoral researchers. The commitments to postdocs are typically no more than 1 year at a time, so they can be terminated relatively quickly. We can reduce the number of graduate students by admitting fewer into our programs, and that is already happening. This is enormously painful for the individuals involved, and it means that we will lose a generation of promising scientists.

Some tell me that this has happened before, and MIT has always weathered the storm. I believe that this time is different. When the physical sciences saw reductions in the early 1990’s, because of the end of the Cold War, the life sciences saw dramatic increases. The overall federal spending on research and development remained about 13% of the discretionary budget. But if the entire discretionary budget is cut, basic science will be cut too. We have some of the most talented researchers in the world, and if the funds were distributed completely by merit, places other than MIT would be cut and we would not. But politics always plays a role, and the cuts will be distributed over all the states—Massachusetts cannot be protected just because we have better universities than Mississippi.

The only way in which we are different from most of the universities in the United States is that we have you, our alumni. We need your help, and we need it now. We need you to invest in basic research at MIT. You can do this by giving to support graduate students, faculty chairs, or research funds. If you want to speak with me about making a gift to the School of Science, contact me directly, or contact my Assistant Dean for development, Elizabeth Chadis at echadis@mit.edu or (617) 253-8903.
Two thousand twelve will be remembered as the year of the Higgs boson discovery. Hypothesized more than 40 years ago, the Higgs boson is the key to the question of how fundamental particles acquire their mass and how the weak force is broken. Its observation by the ATLAS and CMS experiments at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland, completes the Standard Model (SM) of particle physics. Named breakthrough of the year by Science magazine, the Higgs discovery is the experimental confirmation of a theoretical prediction and an incredible triumph of science.

Only 3 years ago, on March 30, 2010, the first collisions took place at CERN between two 3.5 TeV proton beams, setting the world record for the highest-energy particle collisions, about a factor 4 larger than previously achieved. Thus, the LHC research program and the hunt for the Higgs boson began. Based on previous experimental data and theoretical input, the LHC experiments were bound to make a major discovery. The observation of a new particle was first presented on July 4, 2012, by ATLAS and CMS teams using final states with photons and Z bosons. The complete dataset collected by ATLAS and CMS during the first 3 years of LHC operation is now 2.5 times larger than what was available when the observation was made in July 2012. Further analysis of this data now also shows evidence of decays to a pair of W bosons and strong indication for couplings to taus.

With the discovery of the Higgs boson, the next big question is whether or not it marks the beginning of a new age of discovery in particle physics. We can shed light on this question by measuring the properties of the Higgs boson with high precision. The accumulated data allows the measurement of the Higgs mass to about 125 GeV with a precision of better than 1% (Figure i). Thus, with the knowledge of its mass, all other properties of the Higgs boson can be predicted by the SM. The precise measurements of couplings, spin, and parity challenge the theory and may well lead to the next discovery.

Through analysis of the kinematic, angles, and masses of Higgs decay products, we have sensitivity to the spin and parity of the new particle. We observe signatures consistent with the hypothesis of a Standard-Model Higgs boson, a spin-0 particle with even parity, and can exclude pure alternative models with a pseudoscalar (odd parity) or spin-2 particle (Figure ii). The final distinguishing characteristic of the Higgs field is the form of its interactions with the other particles and the coupling to itself. So far we have confirmed, with still limited precision, that elementary particles couple as expected with a strength proportional to their mass (Figure iii).

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The figure shows the test statistic versus the boson mass mX. The Higgs boson mass measurement yields mH = 125.7 +/- 0.4 GeV. (Syst. stands for “systematic uncertainty.”)
Combining all available information on the Higgs boson, the data shows no significant sign of physics beyond the SM, and the newly-discovered Higgs boson is truly Standard Model-like. However, our understanding of all this is not yet complete. Although the SM requires only one Higgs field, we are not sure how many kinds of Higgs fields there are. In fact, we suspect that the SM will be superseded by a more complete theory. For example, we already know that the SM is incomplete through the observation of dark matter (the SM does not provide a candidate for 85% of the matter content of the universe, a severe shortcoming). Leading contenders for a more complete theory are extensions of the SM known as supersymmetric models, which would require a minimum of two Higgs fields.

Even more data will be required to explore these exciting questions. To upgrade the LHC to higher collision energies and intensities, it was shut down in February 2013. When the LHC comes back online in Spring 2015, the center-of-mass energy will be increased from 8 to 13 TeV, and intensities will be doubled. The LHC upgrade will again open a new window in the search for new physics beyond the Standard Model.

“ If it looks like a Higgs, swims like a Higgs, and quacks like a Higgs, then it’s probably a Higgs.”
– Markus Klute

Distribution of the test statistics for the SM Higgs (yellow histogram) and a pseudoscalar hypothesis (blue histogram). The arrow indicates the observed value. The data disfavor the pseudoscalar hypothesis with more than three standard deviations.

The 68% confidence level contours for individual Higgs search channels (colored area) and for the overall combination (black solid line) for scaling parameter \( (k_V, k_f) \) for the coupling to the Higgs boson. The cross indicates the best-fit values. The thin contour shows the 95% CL range for the combination. The yellow diamond shows the SM point \( (k_V, k_f) = (1, 1) \).
Hearing the word “yeast” often conjures up the smell of freshly baked bread or the taste of an ice-cold beer. But this single-celled microbe is also a major workhorse in biological research. The budding yeast *Saccharomyces cerevisiae* is a model organism for the study of a variety of conserved biological processes, including the cell cycle, gene regulation, and even aging. The short generation time, ease of genetic manipulation, and small genome make yeast particularly amenable to experimental analysis. However, despite its usefulness in many areas of biological interest, *S. cerevisiae* is missing some key biological pathways that are present in humans. One such example is the gene-silencing pathway known as RNA interference, or RNAi.

In the Bartel Laboratory, we study RNAi and related RNA-silencing pathways that all use small snippets of RNA to regulate gene expression. RNAi is triggered by long molecules of double-stranded RNA (dsRNA), which get processed by the Dicer enzyme into smaller pieces termed short interfering RNAs (siRNAs). These siRNAs are then loaded into the effector protein Argonaute (named for the squid-like appearance of plants bearing mutations in the gene) to guide the cleavage of target RNAs. The RNAi pathway plays an important role in defending the genome against parasitic DNA elements known as transposons, as well as protecting cells against viral invasion. Beyond its natural role in biology, RNAi has become an indispensable research tool due to its ability to potently reduce the levels of any gene of interest by simply introducing a corresponding piece of RNA. There has also been considerable interest in exploiting the RNAi pathway to treat human disease by reducing protein production from disease-promoting genes. A thorough understanding of the biochemistry of the RNAi pathway will be essential for harnessing the potential of RNAi in the laboratory and the clinic.

Given its absence from *S. cerevisiae*, RNAi had been presumed lost in all budding yeasts. When I joined the Bartel Laboratory in the summer of 2008, there were hints that some closely related yeast species might contain a functional RNAi pathway because their recently sequenced genomes appeared to contain Argonaute. One of these yeasts was *Saccharomyces castellii*, a poorly studied species originally isolated from soil in Finland and later found on fermenting cucumbers in the United States. To follow up on this lead, we assembled a team in the Bartel Laboratory that included me, another graduate student, a UROP, and Professor Gerry Fink (an expert in yeast genetics) to investigate RNAi in budding yeast. Our results collectively demonstrated that RNAi and its core components Dicer, Argonaute, and siRNAs are present in some budding yeasts, including *S. castellii* and the human fungal pathogen *Candida albicans*. I also made the surprising discovery that RNAi can be restored to *S. cerevisiae* by introducing the genes encoding *S. castellii* Dicer and Argonaute and that the reconstituted pathway

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functions in genome defense. Our establishment of *S. castellii* as a model system for RNAi now enables budding-yeast tools to be used to interrogate the mechanism of RNAi, which will yield insights that also apply to humans. The portability of the budding-yeast RNAi system is also now being used to construct synthetic biological circuits, to engineer industrial yeast strains, and even as a possible experimental tool for malaria research (as an example, Figure i shows how RNAi can effectively silence a gene of interest in *S. cerevisiae*).

A notable feature of the budding-yeast RNAi pathway is that the Dicer looks nothing like other Dicers. Indeed, it was the absence of a canonical Dicer that allowed the budding-yeast pathway to go unnoticed for many years. To generate fragments of a particular length, canonical Dicers act as "molecular rulers" by binding to the end of the long RNA and cleaving at a specific distance from the end. However, budding-yeast Dicer lacks end-binding activity, raising the question of how it can generate precisely sized siRNAs.

To understand how budding-yeast Dicer works, I characterized the biochemical properties of the purified enzyme, and we collaborated with Dinshaw Patel's laboratory at Memorial Sloan-Kettering Cancer Center to determine the three-dimensional structure of the protein. My analyses revealed that multiple Dicer molecules bind along the length of the dsRNA substrate, with neighboring molecules tightly packed next to each other. When these molecules cleave the dsRNA, the result is small fragments with a length that corresponds to the distance between the neighboring molecules (see Figure ii for an illustration of this). Knowing the structure of budding-yeast Dicer allowed us to model how Dicer molecules would coat dsRNA and precisely define

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The image shows a mixture of *S. cerevisiae* cells with and without the RNAi pathway. Yeast cells expressing a green-fluorescent-protein (GFP) reporter gene normally glow green under fluorescent light. However, when the RNAi pathway is used to silence GFP, the cells no longer contain the fluorescent protein and therefore appear dark.
When I interviewed for Ph.D. programs in biology, I was drawn to MIT because of the unique structure of the first-year curriculum and the highly collaborative environment. Both aspects of the MIT biology program have been instrumental in facilitating my research over the past 5 years. This summer, I’ll begin my independent research career as a Faculty Fellow at the University of California, San Francisco. Unlike traditional postdoctoral training, this fellow position provides me with the opportunity to manage my own laboratory as a principal investigator. At UCSF, I’ll be embarking on a new research direction: understanding how messenger RNA templates are converted into proteins during the process of translation (which even S. cerevisiae can’t survive without). Just as my past studies in S. castellii have provided new insights into the RNAi pathway, I hope that my future studies in S. cerevisiae have will reveal new details about the essential cellular process of translation. 🍒
Jonathan Rothberg
What fascinates Jonathan Rothberg about science is the ability to learn something no one knew before or to create an instrument that enables the discovery of something new. He is a serial entrepreneur best known for inventing high-speed, massively parallel DNA sequencing. The company he founded, 454 Life Sciences, brought to market a new method for sequencing genomes. After creating the next generation sequencing, he went on to develop the first sequencing on a semiconductor chip enabling the $1,000 genome. With this discovery he founded Ion Torrent where they actually sequenced the genome of Intel co-founder Gordon Moore.

The idea for the high-speed sequencing came to him when his infant son was rushed to intensive care and he realized how critical personal genomes were to human health. That invention is now in use at major pharmaceutical companies, universities, genome centers, and medical centers around the world and his son, Noah, lived to inspire yet another company.

Rothberg has made gifts to MIT in support of projects led by Max Tegmark of the Physics Department and Maria Zuber of the Department of Earth, Atmospheric and Planetary Sciences. He decided to get involved because of the tremendous scope of the projects these scientists are pursuing and the vision behind them. About Professor Zuber, Rothberg says, “she really thinks big,” and he notes that “Max Tegmark is one of those people who, as Steve Jobs was fond of saying, is actually putting a dent in the universe.” Professor Tegmark intends to map the universe at a resolution never before obtainable, and Professor Zuber is using sequencing technology to detect life on Mars.

Although his undergraduate degree in chemical engineering is from Carnegie Mellon and his Ph.D. in biology from Yale, Jonathan Rothberg encourages others to support science at MIT. “Ultimately it is research that raises the quality of life, and if you love science and discovery and people then you should support basic research.”

Ion Torrent was acquired in 2010 by Life Technologies. Rothberg also founded CuraGen Corporation, a company dedicated to using genome technologies in drug development; RainDance Technology, a company developing general droplet microfluidic lab-on-chip technologies; and Clarifi Corporation, an analytical software company. Rothberg is inspired to create companies that impact the quality of life, and he is always looking for like-minded people to join him.
The World’s Chemistry in Our Hands: Global Environmental Challenges Past and Future

Susan Solomon
Ellen Swallow Richards Professor of Atmospheric Chemistry & Climate Science

Atmospheric science pioneer Susan Solomon spoke on past environmental accomplishments, technology’s role, and how history should be our guide to meeting today’s global challenges at the fall Dean’s Colloquium.


Few can speak with as much authority on the topic of environmental success as Susan Solomon. An MIT Professor of Atmospheric Chemistry and Climate Science, Solomon was the first to identify the chemical process that causes the ozone hole, and she made some of the first measurements in Antarctica demonstrating that chlorine-containing chemicals that used to be in refrigerators and spray cans are the cause of ozone depletion. On September 13, 2012, at the fall Dean’s Colloquium, Solomon used the phasing out of these chemicals, known as chlorofluorocarbons (CFCs), as well as the phasing out of lead in indoor paint and gasoline, as successful examples from which the world could learn how to meet today’s most critical global challenge: climate change.

CFCs and lead were phased out mainly because of the clear evidence of their danger and strong public understanding of personal health impacts, explained Solomon, who came to MIT’s Department of Earth, Atmospheric and Planetary Sciences last year from the U.S. National Oceanic and Atmospheric Administration and the University of Colorado. In the case of CFCs, the real reason they were able to be phased out “was because of us,” Solomon said. “Most of these CFCs came from spray cans everyone was using for hairspray and deodorant, so one of the primary sources was literally in your medicine cabinet at home.”

When two chemists found that CFCs might deplete the ozone layer and increase risks of skin cancer, “that was enough to get people concerned … [and] it wasn’t that difficult to make the change. All you had to do was ‘get on the stick,’” Solomon said, parodying a well-known advertisement from that era. “The key thing that this did was take something that had been very good business and turn it into bad business,” Solomon said. To meet the shifting consumer demand, “technological successes were achieved in sector after sector where chlorofluorocarbons were used.” Public understanding and action spurred the technological advancements that paved the way to success. But gaining that broad public support isn’t always easy.

Lessons from past environmental challenges

In the case of lead, the trail of scientific evidence warning of health impacts went back as far as the Roman Empire, and perhaps even further. Yet it took many centuries before real action was taken. “One of the reasons we were slow in doing something about lead was because of scientists who were skeptics,” Solomon said, displaying a clear parallel to the climate change issue. In the end, it was civil rights that spurred public engagement, as poor African American children living in deteriorating housing and near highways were found to have higher levels of lead in their blood, Solomon said.

Solomon also pointed out that the developed world had the infrastructure and institutions to make these changes possible. “It’s easy to knock the EPA these days, but the EPA, FDA, Consumer Product Safety Commission, those are all organizations that we have to thank.”

Many of the underlying health and human rights concerns from the past are alive today, as the world confronts climate change. The ethical dimension is especially disturbing, and it’s making the problem even more complex and difficult to address. Solomon explained that the average person in the developed world emits 1,000 times more emissions than the average person in Chad, 200 times more than those in Ethiopia, 80 times more than those in Kenya, and 20 times more than those in India. “Six billion people live in the developing world, and they emit about five times less CO2 per person than the one billion of us in the developed world,” Solomon said.

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At the same time, those countries want to grow and develop. If they choose to grow using fossil fuels like the developed world, global emissions will go up significantly. “So the key question, the key sustainability issue is, what about those peoples’ future?” she asked. “Should China pay more to develop than we did? Should Africa?” Such questions aren’t sparking the same level of public engagement the world saw before phasing out lead and CFCs, but Solomon thinks they should. “We’re in the developed world, we have air conditioning, we have comfortable lives, we have to think beyond us.” While Solomon notes that she personally takes the bus and does what she can to reduce the amount she emits, she’s not fooling herself into believing that such actions from everyone will be enough. “This issue will not be solved by giving up your spray deodorant, this issue won’t be solved by taking the bus,” Solomon said. “The problem is much bigger.”

With no one silver bullet on the horizon, Solomon believes that research on many different approaches is critical. That could include research on reducing deforestation, increasing wind and solar power, using more efficient cars and building techniques, expanding nuclear, gas, and biofuel energy, or employing carbon capture and storage techniques. To gain this fundamental research and development will require a “bottoms-up technology policy where we start as consumers saying we need a space race for energy technology,” Solomon said. “That’s what I think we need because engineering and technology has to pave the way. That’s why I’m at MIT.”

The Dean’s Colloquium series recognizes and celebrates scientists who have chosen innovative, non-traditional career paths and have been unusually successful. Past speakers have included Edward Scolnick, former President of Merck Research Laboratories, Jim Simons of Renaissance Technologies, and Paul Schimmel of the Scripts Research Institute. Following the colloquium, Dean Kastner hosted a dinner in Professor Solomon’s honor at the Liberty Hotel.
SCIENCE NEWS & EVENTS

Biology

The Malvin and Eleanor Mayer Lectureship

The Malvin and Eleanor Mayer Lectureship in the Life Sciences took place Wednesday, November 7, 2012. The speaker was Dr. Claudia Bagni from VIB, a life science research institute in Flanders, Belgium. She spoke on “Synaptic Plasticity in the Context of Fragile X Syndrome.”

The Mayers’ goal in creating this lectureship was to bring unusually distinguished scholars in the field of the life sciences to campus, and to foster true scholarship and intellectual exchange between these scholars and MIT faculty and students. In the mid-1960’s, the Mayers established this lecture at both MIT and Wellesley College.

Repligen Corporation Honors Dr. Alexander Rich

On Thursday, November 29, 2012, the Biology Department hosted a luncheon in recognition of Repligen Corporation’s generous gift for the creation of the Alexander Rich Scholarship. Professor Tania A. Baker welcomed Dr. and Mrs. Rich and members of the extended Rich family, as well as Walter C. Herlihy Jr., President and CEO of Repligen, who received his Ph.D. in Chemistry from MIT in 1979. Also in attendance was the first recipient of the Rich Scholarship, biology major Meghan O’Dell, class of 2015.

The Alexander Rich Scholarship was established to honor Alexander Rich, M.D., for his significant contributions to the field of life sciences, both in his business and academic endeavors. Rich is a co-founder of Repligen and a former chairperson of the company’s board of directors. He is now chairperson emeritus and an emeritus member of Repligen’s science and technology committee. He is internationally recognized for his role in elucidating the molecular biology of nucleic acids, including the three-dimensional structure of transfer RNA (tRNA), and for his discovery of a novel, left-handed form of DNA (Z-DNA). Rich has been on the faculty of MIT since 1958 and is the Sedgwick Professor of Biophysics.

Left to right: Faculty host and Assistant Professor of Biology Wendy Gilbert, Dr. Claudia Bagni, and Christoper Mayer, grandson of Malvin and Eleanor Mayer.

Left to right: Meghan O’Dell ’15, Walter Herlihy Ph.D ’79 (V), and Alexander Rich, Sedgwick Professor of Biophysics.
Picower 10th Anniversary

Top researchers in the field of neuroscience joined MIT faculty, students, and postdoctoral fellows on November 6, 2012, to celebrate the 10th Anniversary of The Picower Institute for Learning and Memory. A full-day symposium featured Picower Institute faculty members Myriam Hyman and Weifing Xu along with noted researchers Richard Axel (Columbia University), Karl Deisseroth (Stanford University), Cornelia Bargmann (Rockefeller University), Robert Knight (University of California, Berkeley), and others. Talks highlighted novel technologies and methods for exploring how we learn, think, and remember, as well as the latest investigations into brain function from molecules to synapses and from circuits to behavior. Dean Marc Kastner praised the exciting research The Picower Institute has pioneered over the past decade and the tremendous generosity and vision of founders Barbara and Jeffry Picower. The day was capped with dinner and dancing at Boston’s Mandarin Oriental.

Brain and Cognitive Sciences

Dr. David Holtzman (left), Li-Huei Tsai, Picower Professor of Neuroscience and Director of The Picower Institute for Learning and Memory (middle), and Lonarto Liong (right). Holtzman was a speaker for The Picower Institute’s 10th Anniversary Symposium that took place on November 6th.

Mriganka Sur, Paul E. & Lilah Newton Professor of Neuroscience and Director of the Simons Center for the Social Brain (right), and his wife Abha Sur (middle), chat with Mayumi Tonegawa ’92 (IX) at the Symposium.

Jeff Hoch shares a laugh with Earl Miller, Picower Professor of Neuroscience and Associate Director of The Picower Institute for Learning and Memory.

Symposium speaker Dr. Richard Axel has a conversation with MIT President L. Rafael Reif and his wife, Chris Reif.
Leventhal Student Fellowship Luncheon

On October 21, 2012, current and former Norman B. Leventhal Student Fellows attended a BCS sponsored luncheon celebrating the continuation of the Leventhal Fellowship program. The luncheon, which was attended by Norman B. Leventhal ’38 (I), son Alan, and Paul ’81 (I) and Anne Marcus, was an opportunity for the students to meet Leventhal, share their research, and express appreciation for his support over the years.

Chemistry Career Panel

The first annual MIT Chemistry Career Panel series was held as part of this year’s independent activities period (IAP). IAP is a special four-week term at MIT that runs from the first week of January until the end of the month. The Chemistry Career Panel series was developed and run by members of the Chemistry Graduate Student Committee (CGSC) as well as student and post-doc volunteers. Principal organizers were graduate students Peter Goldman, Drennan Laboratory; Alyssa Larson, Klibanov Laboratory; and Jeremy Setser, Drennan Laboratory.

The panels were organized into the themes of Non-Traditional Postdocs, Science Policy, Biotech/Pharma, Computing, Materials/Energy/Environment, Intellectual Property, Consulting, Academia, Education, Outreach, and Science Writing, and consisted mainly of MIT Course V doctoral alumni who came and spoke to current graduate students and postdocs about their career paths and what it’s like to work in their chosen professions. These alumni were working at the National Institutes of Health, Dow Chemical, McKinsey & Company, and Amherst College, to name just a few.

The response to the panels was overwhelmingly positive, and students were very excited to hear from alumni and network. Graduate students hope to continue the panel series in the years to come. Alumni interested in participating in a career panel in the future should contact cgsc-board@mit.edu.

Left to right: Course V alumni Marta Fernandez Suarez Ph.D. ’08, Kathy Lee Ph.D. ’96, and Stuart Licht Ph.D. ’98 pose for a picture after the Biotech and Pharma panel.

Graduate student Rebecca Canter meets Norman B. Leventhal ’38 (I). Over the years, many BCS students have benefitted from the Leventhal Fellowships at MIT.

Left to right: Paul Marcus ’81 (I), Norman B. Leventhal ’38 (I), and Anne Marcus.
Predicting Climate in a Chaotic World: Second John Carlson Lecture Featuring Timothy Palmer

“Can we have any confidence at all in long-range predictions of weather? Should we believe estimates of human-induced climate change? Is the whole notion of predicting long-term changes in climate misguided and unscientific?”

These were just some of the questions raised by Professor Timothy Palmer at the Lorenz Center’s second annual John Carlson Lecture on November 1, 2012. The lecture was held at the New England Aquarium (NEAQ), which co-sponsored the event.

The John Carlson Lecture Series, generously funded by John Carlson, aims to communicate new results in climate science to the general public. The Lorenz Center and the NEAQ joined forces after realizing that both were committed to promoting understanding of climate change.

More than 350 people filled the Simons IMAX Theater to hear Palmer, the Royal Society Professor of Climate Physics, discuss “Predicting Climate in a Chaotic World: How Certain Can We Be?” Palmer used his dry English wit to illustrate that predictions with properly quantified estimates of uncertainty can, in fact, be meaningful. “Uncertainty is not a reason for inaction,” Palmer said. “We can still make rational decisions even with uncertainty.”

Palmer explained that climate change predictions must be couched in probabilistic terms because of uncertainties about the magnitude of some of its natural amplifiers, such as water vapor. Climate change is not about belief or denial, he emphasized. Instead, it’s about the risk involved in not taking action. “If we want to reduce the risk of living in a world which will be as different from today as today is from the last ice age, is it worth taking mitigating actions?” he asked. “That’s the fundamental question.”

To watch Palmer’s lecture, please visit http://web.mit.edu/lorenzcenter/activities/past-events.html.
Of Rivers and Ripples: Reading Patterns in Landscapes

“Always choose the window seat.” That was the advice given by Taylor Perron, Cecil and Ida Green Assistant Professor of Geology, and the featured speaker at the October 15, 2012, School of Science breakfast at MIT’s Faculty Club. A geomorphologist, Perron studies the processes that create landscapes on Earth, other planets, and moons. More than most, he is keenly interested in the amazing diversity of landscapes that can be seen from an airplane window.

That morning, Perron’s stated goal was to help his audience see familiar landscapes in a different way. “We are all geomorphologists,” he said. In his talk, Perron explored the origin of two common landscapes, river networks and sand ripples, that often contain organized, repeating patterns. Despite their abundance and uniformity, there is no underlying theory to explain how either of these landscapes form.

Using a combination of mathematical models, high-resolution topography, and field measurements, Perron and his research team have discovered that branching river networks arise from an instability in the erosional mechanisms that shape Earth’s surface and that the size of the smallest branches depends on rainfall, the strength of the underlying rock, and the gradual downhill movement of the soil.

Sand ripples generated by water waves are a familiar feature of beaches; however, we know remarkably little about how their patterns adjust as waves and tides shift. Perron and his research team have conducted laboratory wave tank experiments and numerical simulations to discover the meaning of “irregularities” or “defects” in wave ripples that have been observed in modern environments and in ancient rocks. They have found that some defects are unique signatures of changes in wave height or water depth, whereas others are similar to patterns observed in many settings with approximately parallel features, such as animal stripes and optical wave fronts.
Mathematics

Another Putnam Record

Word just arrived with results of the 2012 William Lowell Putnam Mathematical Competition: the MIT Team ranked second among 402 teams. Three of our students were designated Putnam Fellows for scoring in the top five test takers. In addition, nine of our students ranked in the next 20, followed by 22 who received Honorable Mention (out of a total of 59). Overall, this represents fully 40.5% of the top 84 scorers in the competition, beating MIT’s previous record performance of 36% last year.

On December 1, 2012, over 4,200 students took the exam from 578 colleges and universities in the United States and Canada. Established in 1938, the William Lowell Putnam Mathematical Competition annually administers the exam on the first Saturday of December. The exam consists of 12 problems and lasts six hours, over two equal sessions. The median score this year was 0 out of 120.

PRIMES (Program for Research In Mathematics, Engineering, and Science)

PRIMES is a year-long research program for top high school students from Greater Boston. Unlike summer programs, PRIMES gives students the opportunity to conduct mathematical research at a natural pace, over the period of 1 year, facilitated by weekly meetings with graduate student mentors. About 50 students work with MIT researchers on exciting unsolved problems in mathematics, computer science, and computational biology, offered by MIT faculty. PRIMES students have won major awards at national science competitions, including Rohil Prasad and Jonathan Tidor, who won the 5th Prize at the 2012 Siemens Competition in Math, Science, & Technology, and Sahana Vasudevan, who won the 10th Prize at the 2013 Intel Science Talent Search.

PRIMES has now opened two new sections: PRIMES-USA, for exceptional out-of-state students, and PRIMES Circle, a math enrichment program for talented students with disadvantaged backgrounds from local urban public high schools.

These programs comprise a coordinated system for nurturing mathematical talent. They deepen the understanding of mathematics and help talented students discover the beauty of mathematical research.

PRIMES student Fengning Ding giving a talk at the annual PRIMES conference at MIT in May 2012.
An Astronomical Event

On October 9, 2012, the MIT Department of Physics and the Kavli Institute for Astrophysics and Space Research hosted “An Astronomical Event” on campus. This was the second Astronomical Event, a full day symposium celebrating astrophysics and the work that is being done in this exciting field. Among the goals of MIT researchers are to detect the waves in space-time predicted by Einstein’s theory, discover Earth-like planets in other solar systems, identify the “dark matter” that binds galaxies together, and observe the ancient epoch when the first stars began to shine.

During the morning attendees heard talks from MIT faculty on their research, and in the afternoon they were able to tour laboratories and see the work that is happening up close. There was also an opportunity for small group interactive sessions with faculty and research scientists. The event concluded with a special colloquium by Professor of Physics, Emeritus Walter Lewin on “The Pioneering Decade of X-ray Astronomy.”

If you’d like to watch the faculty talks from the Astronomical Event, please visit: http://techtv.mit.edu/genres/32-science/videos/21298-astrophysics-colloquium-morning-sessions.

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i Sara Seager, Professor of Planetary Science and Physics, engages in discussion with Howard Messing ’73 (VI), who is a member of the Patrons of Physics Fellows Society.

ii Dr. Robert Hart ’72 (XII) and his wife Beth chat with Ed Bertschinger, Head of the Department of Physics.

iii Ann Kreis and Neil Pappalardo ’64 (VI) have a conversation during the Astronomical Event.
LETTER FROM THE ASSOCIATE DEAN

An Important Group: Our Postdoctoral Researchers

After students complete the Ph.D., a postdoctoral period has become the norm. This period allows the graduate to gather new expertise, even to completely change fields. Historically, the postdoctoral period began as a month or few of extra training, but now extends considerably longer. For example, in the Chemistry Department a “postdoc” is about 2 years, but can stretch to more than 6 years in Biology. Concomitant with the stretched period, the postdoc population at MIT has grown to ~1200, with about half in the School of Science. Postdoctoral training has lengthened for several reasons. One is that research success is measured by productivity, and more research time → more publications → more success in finding a next position. A related reason is increasing competition for jobs, the outcome of training many graduate students and a shrinking job pool coupled with challenges affecting the United States economy. Thus, a wait time may be necessary before job openings appear. Even so, the majority of MIT postdocs will not enter academia as new professors, since the number of openings has become relatively small. Some will enter the private sector, for example, in energy, computational, or pharmaceutical industries, while others will join biotech “startup” companies or enter the consulting, teaching, financial, or management professions. Many of our postdocs (~60%) are international, and go home to make use of the excellent skills learned at MIT.

Some time ago, we decided it was important to improve the formal mentoring and feedback that School of Science postdoctoral researchers receive. An annual review mechanism was therefore introduced and later adopted across MIT (see http://web.mit.edu/mitpostdocs/toolkit/). Review discussions help the postdoc properly plan training and define a career trajectory that fits expertise and goals. Over the past 2 years additional improvements have been made to postdoctoral training at MIT, largely under the oversight of former Vice President for Research (VPR) Professor Claude Canizares (Physics). These include setting a minimal recommended postdoc salary, granting (Associate) Alumni status to postdocs, and giving access to the Career Office and Writing Center, as well as a reduced gym membership. The recently formed MIT Postdoctoral Association awards travel grants, hosts career development events, and builds community. A Faculty Postdoctoral Advisory Committee chaired by myself interfaces between faculty and postdocs to advise the VPR, now previous Head of EAPS Professor Maria Zuber. Postdoctoral training at MIT still faces multiple challenges that relate to compensation and career trajectory. In the School of Science, we plan to put in place a mechanism that helps guide our postdocs towards employment opportunities. Together, these leadership efforts acknowledge the important mission of the Institute and School of Science in the postdoctoral training period. They also acknowledge the pivotal role that postdocs play in research success at MIT and the ways MIT postdoctoral training is used around the world to good effect.

Hazel Sive, Associate Dean of the School of Science, Professor of Biology, and Member of the Whitehead Institute for Biomedical Research.
Support basic scientific research by endowing a graduate fellowship or a professorship, and demonstrate your deep and lasting investment with the MIT School of Science.

**Endowed Professorships and Fellowships for Graduate Students Provide an Enduring Legacy**

It is the intellectual vision of the remarkable and amazing people who constitute the School of Science faculty, and the enthusiasm and creativity of our graduate students, that will no doubt help us all to tackle and solve the problems of our times. Providing the resources to enable these scientists to pursue their research is becoming more and more challenging. You can help by considering the gift of a named fellowship or professorship.

The gift of endowment fuels MIT to its very core. Endowed chairs enhance the life of the chair holder by providing discretionary income and prestige. Named chairs enable the School of Science to retain stellar faculty and recruit brilliant young stars. Friends and alumni who endow professorships endorse the ideals and goals of MIT, and many nourish mutually beneficial relationships. The same can be said of the donors who endow graduate fellowships. Year after year, donors enjoy meeting their graduate students and then watching as each student pursues his or her scientific career. These relationships provide enjoyment today before ultimately transcending the life of all individuals by providing a legacy for your family and support for MIT in perpetuity.

- $1 million to name a fellowship to support one graduate student every year in perpetuity
- $2 million to name a career development chair to be given to a young rising star
- $3 million to name a chair in the School of Science for a tenured member of the faculty

For more information on endowment, contact Elizabeth Chadis, Assistant Dean for Development, echadis@mit.edu or (617) 253-8903
Support the MIT School of Science

MIT’s School of Science is an amazing enterprise conducting research at the most exciting frontiers of science. By constantly pushing the limits, we are discovering answers to deep philosophical questions and problems with obvious practical implications. Supporting these brilliant and creative minds will take more effort and resources than ever before. We encourage your engagement.

To get involved in the School of Science or for information about establishing a fund in support of our faculty and students and their research, please contact:

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Tell us what you think! What would you like to see featured in Science@MIT? Send all comments to jboyle@mit.edu.

George Elbaum ’59 (XVI), S.M. ’63 (XVI), Ph.D. ’67 (XXII) and his wife Mimi Jensen with this year’s Whiteman Fellows at the annual Patrons of Physics Fellows dinner. The Whiteman Fellows are named in memory of George’s mother, Pauline Whiteman.