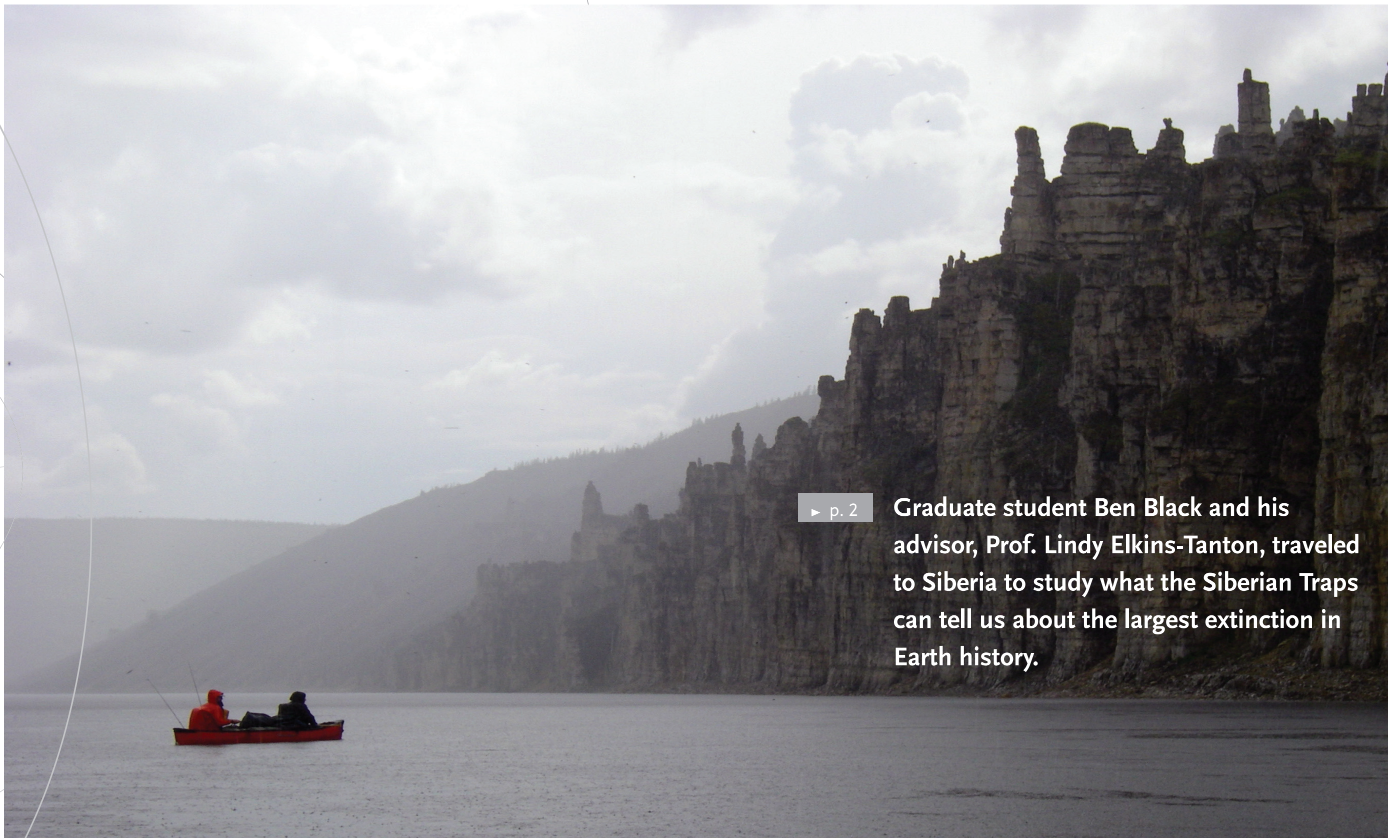
MIT School of Science

Massachusetts Institute of Technology

Science @ MIT

Fall 2009

Published twice yearly



▸ p. 2 Graduate student Ben Black and his advisor, Prof. Lindy Elkins-Tanton, traveled to Siberia to study what the Siberian Traps can tell us about the largest extinction in Earth history.

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Letter from Marc Kastner

Dear Friends,

Marc Kastner,
Dean, MIT School of Science
Donner Professor of Physics

I am pleased to inform you that MIT is handling the economic downturn reasonably well. Our endowment has declined less than we had expected—and less than many of our peer institutions. We still must make dramatic cuts in our operating budget, but they will not be as deep as we had estimated last year. The stimulus funds from the federal government have helped to increase the support of graduate students and post-doctoral associates, especially those working in fields related to energy and health.

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Letter from Marc Kastner

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Our faculty and students continue to do great things. In these pages, you will read about some of the School's forefront research. You will learn about graduate student Ben Black's expedition with his thesis advisor, Professor Lindy Elkins-Tanton, to study a massive lava flow that occurred in Siberia 250 million years ago and may have caused a mass extinction. And you will read about Professor Ron Prinn's world-leading research on climate change.

Despite the budget cuts, we have managed to hire ten outstanding new faculty members, almost all of whom are at the assistant professor level. I am continually impressed at how our investments in young faculty members pay off. Last year, we promoted six of our junior faculty members to tenure, and their accomplishments are truly exceptional.

However, our students and faculty members cannot do their extraordinary work without funds for research—and not all funding can come from the federal government. I encourage you to read about two of the School's donors: Paul Newton, who has created a chaired professorship in the Department of Brain and Cognitive Sciences; and Tom Peterson, who has supported the McGovern Institute for Brain Research and has recently made an important gift to support the new Koch Institute for Integrative Cancer Research. The Koch Institute, which will occupy a new building in December 2010, is the most visible evidence of MIT President Susan Hockfield's initiative to foster the convergence of life sciences with the physical sciences and engineering. It brings together 13 School of Science faculty members and an equivalent number from the School of Engineering to find new ways of diagnosing and treating cancer. I encourage you to follow the examples of both these generous men. Now, more than ever, we need your help.

Sincerely,
Marc Kastner
Marc Kastner
Dean, MIT School of Science

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Become a Geologist and Eat Mosquito Soup

Ben Black

Graduate Student, Department of Earth, Atmospheric and Planetary Sciences

In Siberia, you get used to vast numbers. The vast number of trees that recede in every direction. The vast number of mosquitoes, bees, biting flies, and biting bee flies that crawl into your ears and drown themselves in your soup. And the vast number of parts that appear to be missing from the ancient Soviet helicopter that lurches over the taiga and then drops you off in a place so wild that landslides have been known to unearth frozen woolly mammoths.

Last summer, on the morning of my tenth full day of graduate school at MIT, just such a helicopter deposited me, my advisor Professor Lindy Elkins-Tanton, and the rest of our team of Russian and American geologists on the banks of the Kotuy River in Arctic Siberia. After the helicopter left, we were on our own. For food, we had dried pasta, cracked wheat, oatmeal, and tins of *gushonka* (condensed milk) and *tushonka* (canned meat with plenty of lard). For water, we had the river. We packed our gear onto little rafts that cheerfully deflated almost as quickly as we could pump them up.

We had traveled thousands of miles by plane and helicopter. Now, we were about to paddle down the Kotuy on rafts, to study the rocks of the Siberian Traps—the largest known continental flood basalt province to erupt in the past 542 million years. The total volume of igneous rock related to the Siberian Traps has been estimated at about 4 million cubic kilometers—enough to cover the entire continental United States in more than a kilometer of lava. Of all the numbers in Siberia, that one may be the greatest of all.

Roughly 252 million years ago, at close to the same time as the eruption of the Siberian Traps, the end-Permian extinction occurred. This was likely the largest mass extinction in the Earth's history, even more devastating than the one that killed the dinosaurs. One of the major questions of the Siberian Traps is whether the extinction and the volcanism may have been linked; and if so, what the precise relationship was. But there are many other

Graduate Student Ben Black in August 2009 on his second trip to Siberia.

fundamental questions. For example, how was such a large volume of magma produced? Why did the Siberian Traps occur when and where they did? And what was the precise timing of the eruption?

Four days after the helicopter dropped us off, we followed the Kotuy River downstream past towering limestone hoodoos and high candy-striped cliffs of Ordovician marls. Hemmed in on both sides by cliffs that were promisingly black, we tied down our rafts on the bank and climbed up into the trees. Damp branches snapped us in the face, knocking away some of the swarming mosquitoes. After we had climbed 100 meters, the thick underbrush gave way to soft yellow moss. At our feet were thin layers of dark gray sediments: Upper-Permian shale, coal, and mudstone. Just above them, the black cliffs began—the lowermost units of the thousands of meters of lava, tuff, and related rocks that compose the Siberian Traps. We could reach out and put our hands on

A helicopter drops off the team on the bank of the Kotuy River. From there, they journey by raft downstream.

"Ben is a fantastic student and scientist. He owns his work, and now oversees a small army of UROPs who are helping to process the 400 kg of samples. This winter, we will present his first results. We are so fortunate at MIT to get students like Ben!"

– Prof. Lindy Elkins-Tanton

the beginning of one of the greatest cataclysms in Earth's history.

The story goes on. I could tell you about the woolly mammoths stored in a permafrost cave underneath a small Siberian town, or about composing haikus that expressed our mental serenity as we took off aboard a rickety cargo plane full of frozen, skinless caribou. I could even tell you about the summer of 2009, when we returned to Siberia to do fieldwork along the Maymecha River. But I am running out of space.

Instead, I will just say that we now have more than 300 kilos of Siberian rocks in our lab on the eighth floor of MIT's Green Building. Pieces of those rocks have already started traveling around the world to laboratories where they are analyzed by scientists seeking to understand the origins of the Siberian Traps, the timing and eruption rates, or the explosivity of the eruption. My own job is to use small droplets of melt trapped inside crystal grains to investigate the concentrations of volatile gases carried by the magma as it erupted and the potential consequences for the end-Permian environment. As I peer through the microscope at a tiny grain of pyroxene, I like to think of the strange story of that crystal. Erupted hundreds of millions of years ago in Siberia, the crystal was left alone for all that time, until one summer a group of geologists came along and collected it. They carried the crystal to Cambridge, Massachusetts, of all places, where a graduate student picked and polished it. In return, he hoped that the crystal would help him understand that long-ago moment when the Siberian Traps erupted.

RESEARCH

The Climate Conundrum: Challenging Science, Economics, Technology, and Policy

Ronald G. Prinn ScD '71
TEPCO Professor of Atmospheric Science
Department of Earth, Atmospheric and Planetary Sciences

I must confess that my views have evolved over the many years that I have worked in climate science. Twelve years ago, at the 1997 "Countdown to Kyoto" hearings in the U.S. House of Representatives, I testified that I was not convinced that human activity had yet made a detectable impact on the natural variations of the climate. But in the ten years that followed—amid the observations of continued overall warming, and the recent improvements in climate theory and modeling—I had good reason to change my conclusions. By the time I was invited to appear before the U.S. House Ways and Means Committee in 2007, I could confirm that human activity was indeed affecting the Earth's climate.

That we are experiencing a change of climate is well documented: An examination of the actual temperature records since 1860 shows some ups and a few downs, but an overall warming of about 0.8°C—a seemingly small, but yet significant increase. However, the crux of the intense debates on climate change is not about whether warming has occurred; rather, it is about whether warming is the result of human activity or is simply part of the naturally occurring fluctuations in temperature observed over the Earth's history.

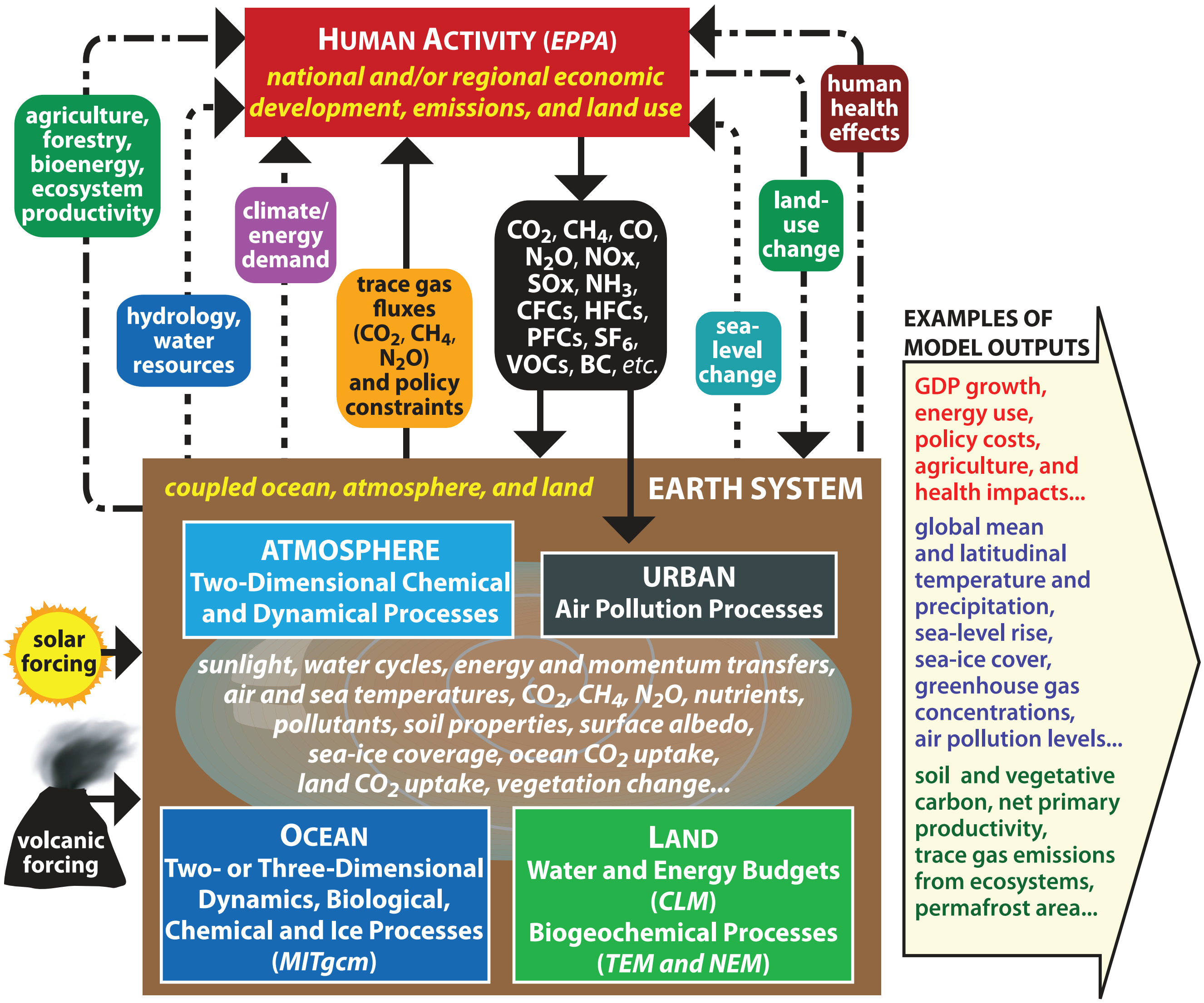
Central to these debates is the influence of greenhouse gases on global warming. Any global imbalance between the energy the Earth receives as visible light from the Sun and the energy it radiates back to space as infrared radiation will drive global warming or cooling. The greenhouse effect is one driver of climatic warming, where clouds and gases absorb outgoing infrared radiation and re-emit it back toward the Earth's surface, causing temperatures to rise. A significant portion of the greenhouse effect occurs naturally through quickly dissipating water vapor, and is countered by the cooling properties of snow, desert sand, clouds, and colorless sulfate aerosols that reflect sunlight back to space.

However, concerns that human activity is propelling global warming arise from the accumulation of long-lived greenhouse gases, notably carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and lower atmospheric ozone. The concentrations of these gases have increased substantially over the past two centuries, due in large part to human activity that can upset the long-term balance between global warming and cooling mechanisms.

When I first testified at the U.S. House of Representatives in 1997, there were not enough powerful observations, theories, and models to sort out how much of the climate change we had experienced could be attributed to a natural warming phenomenon and how much could be attributed to human activity. But since then, the Intergovernmental Panel on Climate Change (IPCC) has combined multiple models to separate the "noise" of natural variability in climate from the "signal" of human-caused changes. Model runs that include human influences and those that exclude them were compared. If human activity has a negligible effect on the climate, then models that exclude human influence should be able to simulate the patterns of climate change already observed over the past 50 to 100 years. The reverse is also true: If human activity has a significant impact on the climate, then those models that account for human influence should match observed patterns. The IPCC concluded in 2007 that the latter case was correct: There is a greater than 90 percent chance that most of the observed increase in globally averaged temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas levels.

Given this human influence, integrating and understanding the diverse human and natural components of the problem is essential if we are to objectively address uncertainty in forecasts and inform policy development and implementation. Toward this end, over the past 15 years at MIT, we have developed the Integrated Global System Model (IGSM). To make effective forecasts of climate change, the IGSM combines models not only of natural biogeochemical cycles, climate dynamics, and natural ecosystems, but also urban air pollution and the increase in emissions from such essential human activities as energy and food production linked with economic growth.

Figure 1. This schematic depicts the current framework and processes of the MIT Integrated Global System Model. Feedback between the component models under development is shown as dashed lines.



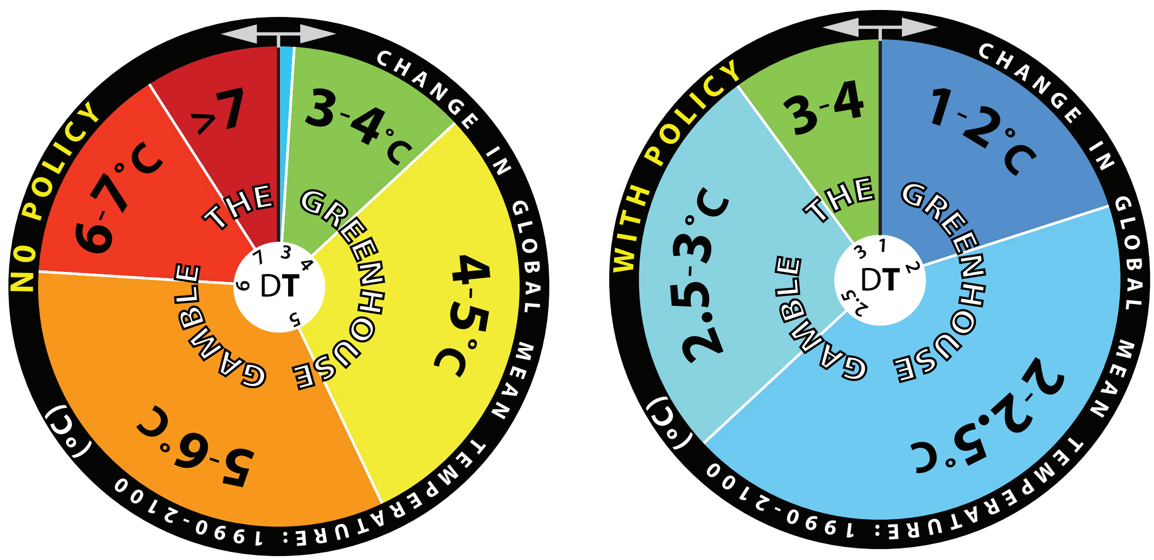
RESEARCH

Though the IGSM accounts for numerous variables affecting climate change, there is still some amount of uncertainty associated with climate forecasts—a model, after all, can only give us probable outcomes. Toward this end, we have used thousands of IGSM runs applying different assumptions to quantify the uncertainty of future climate change forecasts. We can provide the probability range of outcomes expected for proposed policies and account for important feedback relationships between submodels, the sensitivities of certain policy-relevant variables (such as rainfall, temperature, and ecosystem state) to the accuracy of assumptions built in the submodels, structural uncertainties present in existing models, and uncertainties in economic parameters such as labor productivity and efficiency growth.

No matter how persuasive comprehensive models like the IGSM are to the scientific community, the results of such an uncertainty study must be communicated with force and clarity to the public and policymakers to be useful. My colleagues and I have found our "greenhouse gamble" wheels to be effective in communicating the value of climate policy despite the uncertainties. The probabilities of various amounts of warming from the above IGSM runs are projected onto two exemplary wheels. One represents the range of probable results when implementing no policy, and the other reflects the results from implementing a stringent policy that keeps total long-lived atmospheric greenhouse gas levels in the year 2100 just below the equivalent of 660 parts per million (ppm) of CO_2. If there are no significant efforts to curb greenhouse gas emissions, the "no policy" wheel shows about a 1-in-4 chance of greater than 6 °C warming between now and 2100. Most climate scientists regard such an amount of warming as undeniably dangerous. The "policy" wheel indicates that the odds of exceeding a 6°C warming drop to less than 1 in 400, clearly showing the value of the policy in lowering the risks. Therefore, the exact odds of various amounts of warming depicted in the two wheels are not as important as the differences between them.

To illustrate the dangers of a 6°C warming, I note that the warming of the Arctic and Antarctic regions is predicted to be about twice that of the global average warming shown on these wheels. A 12°C polar warming would undoubtedly lead to total loss of the Greenland and West

Figure 2. The probabilities for various amounts of global average warming between 1980 and 2000 and between 2090 and 2100 calculated from two 400-member sets of IGSM forecasts are projected onto two wheels. The left-hand wheel is for "no policy," and the right-hand wheel is for "with policy."



Antarctic ice sheets that together contain the equivalent of 12 meters (39 feet) of sea-level rise. The last time the polar latitudes were only a few to several degrees warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 meters of sea-level rise. Arctic tundra and frozen soils (which contain the equivalent of over 200 years of current fossil fuel carbon emissions that would be released on melting) and Arctic summer sea ice cover (an already diminishing polar cooling mechanism) are also vulnerable.

We cannot wait for perfection in either climate forecasts or impact assessments before taking action. The long-lived greenhouse gases emitted today will last from decades to centuries in the atmosphere. Added to this is the multi-decade period needed to change the global infrastructure for energy and agricultural production and utilization without serious economic impacts.

How You Can Help...

As long-time backpackers in the Sierras and the Rockies, Audrey Buryn '58, PhD '66 and Alan Phillips '57, PhD '61 have seen firsthand the impact humankind has had upon nature in the form of shrinking glaciers and warmer temperatures. By establishing the Ally of Nature Fund in the School of Science, they are seeking partners to help reverse this unfortunate trend.

One way you can support a sustainable Earth is by contributing to the Ally of Nature Fund. All gifts to this fund will be matched up to $500,000—this means that your gift will have twice the impact!

Professor Ron Prinn was the first grant recipient from this fund.

The Ally of Nature Fund	**3120150**

If you happen to be in New York City's Penn Station or Madison Square Garden, you cannot fail to see the 70-foot-high sign called the "Carbon Counter." This is a bold new experiment in communicating climate science to the public. The number on the Carbon Counter is provided by Ron Prinn's Advanced Global Atmospheric Gases Experiment (AGAGE) group at MIT for Deutsche Bank, the sponsor of the sign, based on global measurements from the AGAGE and the National Oceanic and Atmospheric Administration (NOAA) networks. It shows the total amounts of all these gases expressed as their equivalent in metric tons of carbon dioxide, with seasonal and other neutral cyclical variations removed to more clearly reveal the underlying long-term trends driven by human and other activity. It is indeed a number to watch.

DONOR PROFILE

Making a Difference… From Ohio to Hollywood to MIT

Thomas F. Peterson Jr. '57

Tom Peterson spent only two years at MIT before he was called home to run the family company—but those four semesters shaped his interests and career for life.

As a result, the man who would go on to lead two successful and very different businesses decided to give back to the Institute by becoming an active member of the MIT Club of Cleveland, Ohio, and by supporting—and regularly meeting with—MIT professors across a range of fields, from cancer research to earth sciences.

Peterson came to the Institute as a first-year student in 1953 knowing that he would return to his hometown of Cleveland to work at his father's company, Preformed Line Products (PLP), a manufacturer of equipment and systems for telecommunication and energy applications. Unfortunately, his father's deteriorating health precipitated his son's return. But MIT had already made an impact.

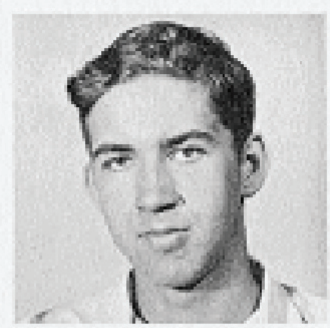
During first-year rush week, Peterson had to choose between a lecture by MIT's Harold "Doc" Edgerton and one by Timothy Leary (then a psychology lecturer at Harvard). He chose Edgerton, whose work with photography inspired Peterson to explore photography and video. After returning to Cleveland, Peterson continued to pursue his interest in those subjects, eventually concentrating on scripts, editing, and sound—all in his free time after coming home from PLP. That ultimately led Peterson to start Motion Picture Sound, Inc., a company that produced sophisticated audio for Hollywood, the Public Broadcasting Service, and the Department of Defense. Peterson eventually left PLP to focus full time on Motion Picture Sound.

Peterson speculates that he may have chosen a very different path had he attended Leary's lecture instead!

Calculus with Norbert Wiener, known as the founder of cybernetics, was Peterson's most memorable class at MIT. There, he "learned a lot about life," Peterson says, "and not very much about calculus." Wiener reviewed the homework problems in the first few minutes of class, only to spend the remaining hour brainstorming and bouncing ideas off his students. Peterson adopted Wiener's strategy of brainstorming ideas—it is one of the things he enjoys doing today with current MIT faculty.

Return to MIT

At the urging of local alumni, Peterson decided to join the MIT Club of Cleveland in 2000. Peterson was hesitant at first because he was not an MIT graduate. When he contacted the Registrar's Office, they could not locate his files. A friend pointed out that Peterson's freshman yearbook photo was on the Class of '57 website, which Peterson shared with the Registrar's Office. A short time later, the office did indeed find his file—it was in offsite storage marked "waiting for return."


Thomas F. Peterson, Jr.
Shaker Heights High School
Shaker Heights, Ohio

Tom Peterson's photo and information from the entering Class of '57 yearbook.

And return to MIT he did. Peterson is now actively involved in many things MIT, from supporting graduate students in engineering and the conservation of rare and antique books at the MIT Libraries to serving on the McGovern Institute Leadership Board and the Corporation Development Committee. But it's the personal connections that matter most to Peterson, especially his regular visits to professors on campus.

During these visits, Peterson likes to sit with researchers and brainstorm, much as he did in Wiener's calculus class, with often exciting results. For example, Peterson

> "...I *can* make a difference. There is definitely research at MIT that would not happen without my support."
>
> —Tom Peterson

formed an instant bond with Christopher Moore, an assistant professor in the Department of Brain and Cognitive Sciences and a principal investigator at the McGovern Institute for Brain Research at MIT. He was interested in Moore's groundbreaking work on human perception. After getting to know Moore, Peterson shared the professor's frustration over a lack of access to equipment. Once a month, Moore had been borrowing equipment at Massachusetts General Hospital, but he wasn't allowed to fine-tune it to his specifications. Shortly after learning of the problem, Peterson gave Moore a two-photon microscope and an accompanying set of lasers for optical control of brain circuits. Within three months, Moore published an article in the journal *Nature* highlighting his results from using these instruments. Peterson was so pleased that he then contributed to the purchase of a magnetoencephalography (MEG) machine for the McGovern Institute. The MEG provides a different, yet complementary set of data from a two-photon microscope. Peterson is eager to learn about the results from these studies in the coming months.

A proponent of interdepartmental collaboration, Peterson remarks that "some of the greatest breakthroughs in history were made by people who were not experts in that field." Such people are uninhibited because they don't know what "can't" be done, he says. At the Koch Institute, for example, Peterson supports Institute Professor Robert Langer's work. He likes that Langer's background is in chemical engineering and not in cancer research. Plus, he adds, Langer's track record—which now stands at more than 1,000 articles, over 500 issued and pending patents, and around 170 prestigious awards for his pioneering work in drug delivery systems and tissue engineering—is unbeatable.

Tom Peterson at home in Cleveland, Ohio, with his collection of antique scientific instruments and books, some dating back to Galileo's time. Photo Credit: Sandra Kay.

Peterson also introduced Moore to Benjamin Weiss, an associate professor in the Department of Earth, Atmospheric and Planetary Sciences (EAPS). Recently, Peterson began supporting Weiss's research, which uses state-of-the-art imaging technology, in this case SQUID microscopy, to conduct laboratory magnetic studies on rocks from Mars, the Moon, Earth, and asteroids to understand the development of planetary evolution and magnetism. Peterson has a longstanding interest in geophysics, which began with an MIT course on the subject.

Peterson's varied interests in MIT include the Koch Institute, EAPS, the McGovern Institute, and the MIT Libraries. "I know that I can't make the same impact as Bill Gates," he says, "but I can make a difference. There is definitely research at MIT that would not happen without my support." Through his gifts and the resulting discoveries, Peterson hopes to create a catalytic response, generating more support than his own gift.

At a Gray House dinner, Peterson remembers hearing MIT President Susan Hockfield remark, "Some of MIT's best friends are not graduates; some were not even students." Peterson is pleased that he can give back to MIT—a place that gave him many things, if not a diploma.

Biology

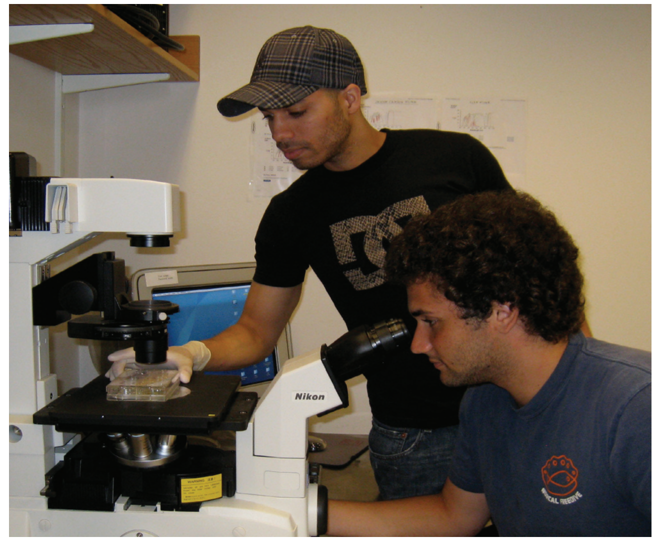
Attracting the Best and Brightest from Around the World

Since joining Professor Jacqueline Lees' lab in 2007, Eliezer Calo has flourished as a graduate student: Besides mentoring undergraduates and younger graduate students, he has authored two scientific publications, and is just about to submit a first-author manuscript. While growing up in Puerto Rico, however, graduate work at MIT wasn't something that Eliezer would have imagined for himself. The oldest of five boys, he is the first of his family to go to college. When he decided to attend the University of Puerto Rico (UPR), Eliezer says that everyone told him, "University is hard. I don't know if you can handle it." But on the very first test, he was the only student to score 100 percent. Eliezer knew then that he could handle it.

His success led to other opportunities, including the MIT Summer Research Program (MSRP). During this HHMI-funded summer program at MIT, Eliezer was encouraged to apply to the graduate program in biology—and, of course, he was accepted. The MSRP provides a unique opportunity for students who lack access to top-notch research facilities at their own institution to conduct supervised research. It is designed to encourage students, like Eliezer, to attend graduate school and pursue a career in research.

Financial constraints and a lack of information keep many of the brightest students from attending top universities. Because many undergraduates don't attend the most prestigious universities, they are often too intimidated by MIT's reputation to consider applying. Mandana Sassanfar, director of outreach for the Biology Department, is dedicated to making sure that students from underserved and underrepresented communities know they can succeed at MIT. Through Sassanfar's work, the Department has built strong relationships that help recruit top students from UPR's huge undergraduate population. In 2004, the Biology Department had zero students from Puerto Rico; today there are nine.

There is a national need for underrepresented or underserved students to achieve success in science and engineering, and the challenge falls to departments to attract competitive students from non-traditional backgrounds. Puerto Rico is only one of the places the Department targets: Similar efforts are under way around the country. Eliezer Calo sees how important those efforts are to MIT. "You can just walk around and see people from all different cultural backgrounds," he says. "And that makes me feel comfortable."



Graduate student Eliezer Calo mentoring an MSRP student.

Annual Sackler Lecture

On April 7, 2009, Professor Phillip Sharp and the Biology Department hosted the annual Sackler Lecture. Raymond and Beverly Sackler are international philanthropists with a deep, longstanding commitment to supporting scientific research. Although their interests are varied, the Sacklers are dedicated sponsors of basic biomedical research.

This year's speaker was Kari Stefansson, president, CEO, director, and co-founder of deCODE Genetics. Headquartered in Reykjavik, Iceland, deCODE is a biopharmaceutical company applying its discoveries in human genetics to the development of drugs and diagnostics for common diseases. deCODE is a global leader in gene discovery, having isolated key genes contributing to major public health challenges, from cardiovascular disease to cancer.

Brain and Cognitive Sciences, The McGovern Institute for Brain Research, and The Picower Institute for Learning and Memory

"An Afternoon with MIT's Brains on Brains"

MIT has long been at the forefront of brain research—from its early days of descriptive observation and speculation in "psychology" to the recent discoveries of "neuroscience" enabled by genomics, molecular and cellular biology, neurophysiology, brain imaging, and cognitive testing. Now, we are poised not only to illuminate the emergence of the mind from the complexities of gene, molecule, and physiology, but also to create rationally designed therapies for some of the most devastating disorders of the brain.

Last May, a mini-symposium, "An Afternoon with MIT's Brains on Brains," celebrated the role MIT researchers in the Department of Brain and Cognitive Sciences (BCS), the McGovern Institute for Brain Research, and the Picower Institute for Learning and Memory played in the stunning advancement of this field. The symposium featured talks by three leading neuroscientists at MIT and several breakout panels on psychiatric disorders and diseases related to aging and development, outlining the most promising directions at this crucial moment in brain research.

A few of Building 46's top brains: BCS Department Head Professor Mriganka Sur, Picower Professor of Neuroscience Mark Bear, and Director of the McGovern Institute Professor Robert Desimone.

Understanding the Autistic Neuron

In his talk, Picower Professor of Neuroscience Mark Bear explained that, while autism is a widespread disorder—about one in every 150 births—its pathology is still poorly understood. There is no single "autism" to target for study, but rather numerous "autisms" with multiple genetic factors and a range of expression—from the severe mental retardation and lack of language and social skills of classical autism to high-functioning Asperger's syndrome. Bear emphasized the need to classify disorders on the autism spectrum and to map out their genetics and brain physiology. He believes the payoff will be "tangible and huge." Already, research at MIT has led to promising experimental drugs for the autism spectrum disorders fragile X syndrome and Rett syndrome. However, these two syndromes only account for a tiny fraction of individuals with autism overall. If we expand our understanding to the whole spectrum of autism disorders, we can develop early therapeutic interventions that not only ameliorate symptoms of autism, but also, as Bear said, "actually correct the course of brain development and let these children grow up normally."

Anne and Paul Marcus '81 with Larry Hilibrand.

"At MIT, we love bold experiments—the kind that change rules... That fearless experimental spirit... will bring us to the next level of brain research."

— Susan Hockfield, MIT President

Li-Huei Tsai and Marc Kastner at a School of Science Breakfast in May. Tsai presented a similar talk to one she gave at the Brains on Brains event.

Alzheimer's Disease: Current State and Hope for the Future

Picower Director Li-Huei Tsai addressed the need to expand research approaches for Alzheimer's disease, a disorder afflicting 5.3 million in the United States and 25–30 million worldwide. Currently, no treatment can prevent or reverse the deterioration of memory, speech, and function that characterizes Alzheimer's; available medications only delay the development of the disease by a few months. Drug development has mostly targeted amyloid peptides, which play an early role in the development of the disease. Since all clinical trials of those drugs have been halted or have failed, the need to investigate other aspects of Alzheimer's pathology is critical. Tsai has taken a valuable new approach, exploring the role of histone deacetylase (HDAC) in memory. She demonstrated that HDAC2-deficient mice displayed increased learning and memory, synaptic plasticity, and, significantly, increased expression of genes associated with memory formation. Tsai is taking early steps toward drug development, searching for compounds that selectively inhibit HDAC2.

New Frontiers in Schizophrenia and Bipolar Disorder Research

Ed Scolnick, director of the Psychiatric Disease Program and the Stanley Center for Psychiatric Research at the Broad Institute, sketched out the unprecedented research opportunities in the field of schizophrenia and bipolar disorder. Until now, the knowledge base was so poor that few neuroscientists were willing to work in the field. But with the completion of the genetic sequence in 2001 and a map of human genetic variants in 2007,

Debbie Hilibrand, Prisca Marvin '85, Lori Ireland, and Ilene Lainer at the Brains on Brains reception.


Jerry Goldstein '64, SM '65, MET '67 and Art Goldstein at the School of Science Breakfast with Prof. Li-Huei Tsai in May.

as well as improvements in brain imaging and disease modeling, advances in the field promise to come quickly. Already, the first steps toward understanding the pathology of schizophrenia and bipolar disorder have been made at MIT through the development of several mouse models. Work in Tsai's lab has made progress toward drug development by targeting the DISC1 (short for "disrupted in schizophrenia 1") gene which, when functioning normally, inhibits the activity of a particular brain enzyme—behaving much like the mood-stabilizing drug lithium. With this signaling pathway identified, researchers now have many new targets to aim for as they develop drugs to treat schizophrenia. Scolnick believes that technology no longer limits the study of psychiatric diseases, concluding that "science's ability to unravel the underlying causes of severe mental illness is upon us."

MIT is uniquely positioned to take advantage of this exciting moment in brain research. The talented scientists at BCS, the McGovern Institute, and the Picower Institute are encouraged to take the kind of risks that accelerate progress—to take on difficult, multifaceted disorders like autism, to guide Alzheimer's research in productive new directions, and to open up new fields of inquiry like schizophrenia.

As MIT President Susan Hockfield explains, "At MIT, we love bold experiments—the kind that change rules. And we have an impressive record of making bets that win. That fearless experimental spirit, coupled with intense collaboration among investigators and the support of our philanthropic friends, is exactly what will bring us to the next level of brain research."

A Great Adrenaline Rush

Paul E. Newton '65, SM '67

Like so many members of the MIT family, Paul Newton was fascinated by computers ever since programming them in his first year at MIT. But now, nearly 50 years later, it is the human computer—the brain—that captivates Newton and brings him back to MIT.

Everyone becomes interested in the brain when it malfunctions, and both Newton and his wife, Lilah, have witnessed that firsthand. Each had a parent who suffered many years from Alzheimer's disease, but Newton also became interested in how the brain normally functions. He began to understand that the brain was "neither totally pre-programmed (by nature) nor a blank slate (arranged by nurture), but rather an amalgam of the two."

Newton also became fascinated with the brain's plasticity because of Lilah, who had a congenital cataract in one eye that was not corrected until she was an adult. Though her eye now sees perfectly, her brain did not learn how to process what that eye saw because it had become "hardwired" to process the input from only one eye. Newton found out that an infant's brain easily learns to understand visual information; but after a critical period of development, the brain loses its plasticity in that area. Newton grew more intrigued by the brain's limited window of plasticity when he tried learning to speak Japanese and to play the piano as an adult, but found that neither came naturally as they would have before puberty.

Newton read books and papers but found some areas unexplored. So he developed his own hypotheses on how the brain directs its attention, makes decisions, and handles deductive versus inferential thinking. Newton found that MIT's BCS expertise made the Department most likely to achieve breakthroughs in the areas that interested him. "When we know enough about the way the brain works to cure related diseases and perhaps

DONOR PROFILE

enhance the way we use our brains," Newton says, "that will mean wonders for progress in every field."
Talking to faculty individually about their latest work is one thing that really excites Newton. "Hearing about new research as it's developing, even before it's published, gives me a great adrenaline rush," he says. Recently, for example, Mriganka Sur, BCS Department Head and the Newton Professor of Neuroscience, told Newton about the promising development of a treatment for Rett syndrome, one of the autism-like disorders.

The Newtons began their support of BCS shortly after selling the last of three software companies he headed. As Newton tells it, he had just decided to fund a career development (CD) chair and was trying to reach the dean of Science with whom he had previously met. Coincidentally, a "dialing-for-dollars" student called him at home. The student caller was a bit of a wiseacre and said that since Newton was a CEO, he should contribute a million dollars or more. "Fine," Newton said, "have the dean call me and I will!" The student didn't know whether he was joking, and it became a big story among student fund-raisers.

The CD chair, established in 2000, was the Newtons' first significant gift. They have since helped the Department by funding research projects and equipment purchases. They continue to fund their CD chair, recently bringing it to the level of a full professorship.

Lilah and Paul Newton hiking in Switzerland.

For the last eight years, Newton has served on the BCS Visiting Committee. "Half the meeting involves the research. It's a fascinating experience. Although I have spent some time studying neuroscience and have even written a book on the subject, I still struggle to understand," he says. "The other half of the meeting, we discuss budget, staffing, facilities, and other management issues. Here, I am in my comfort zone and hope I am occasionally contributing something of value."

Some of his favorite MIT experiences have been hosting events where a small group of alumni get together to hear from a key MIT professor. "I get five minutes to kick off the meeting and get a bunch of engineers and physicists to relate their knowledge to some cutting-edge brain science research. If MIT staff and alumni can get others really interested in what's going on, that's the best gift we can give."

Chemistry

Faculty Committed to Graduate Student Support

Jeffrey Steinfeld '62, emeritus professor of Chemistry, appreciates the importance of graduate students. As an MIT professor since 1966, Steinfeld has worked with many graduate students in his lab and in the classroom. Furthermore, he is committed to the importance of education and sustainable science.

Steinfeld has decided to leave a legacy in the Department of Chemistry by establishing an annuity that will provide him with an annual income—and that will support graduate students in the future. This year, Steinfeld has provided additional funds to endow a summer fellowship in honor of his parents. Gifts from our faculty are especially meaningful because they show how much our faculty members value MIT. The Chemistry Department looks forward to announcing the first Ann and Paul Steinfeld Fellow for the summer of 2010.

“I remember spending most of my time fighting with the Pentagon, who kept saying they needed him.”
— Irwin Oppenheim, professor emeritus, on keeping John Deutch at MIT to finish his thesis

As an emeritus professor, Steinfeld's principal activities focus on Education for Sustainable Development—through the Energy Education Task Force within MIT and through outside collaborations such as the Sustainable Energy Education and Training Program. Steinfeld is currently the education program director of the Laboratory for Energy and the Environment (LFEE). Bringing together collaborating faculty and staff in 13 departments, LFEE serves as a focal point of research and innovation for energy and the environment at MIT.

John Deutch '61, PhD '66: Celebrating 40 Years of Research and Service

Even before he had completed his PhD work at MIT in the early 1960s, Institute Professor John Deutch was already getting calls from Washington asking him to step away from academia and enter government service, says his former thesis advisor Irwin Oppenheim, a professor emeritus in the Department of Chemistry.

“While he was writing his thesis, I remember spending most of my time fighting with the Pentagon, who kept saying they needed him,” Oppenheim said after the symposium. The celebration of Deutch's 70th birthday featured several high-profile speakers from government service, academia, and industry.

Deutch had attracted the attention of national leaders by doing a study that questioned—“quite correctly,” Oppenheim said—the value of the Skybolt missile system then under development. The Skybolt project was cancelled as a result.

Deutch was eventually called to Washington service, both in the 1970s and the 1990s, serving four presidents in a variety of posts in the Departments of Defense and Energy and as director of Central Intelligence—but only after he had already achieved tenure on the MIT faculty.

In addition to his government service and his teaching and research duties, which include 140 published papers in chemistry, Deutch has held important administrative

Patricia and John Deutch at the symposium in honor of his 70th birthday.

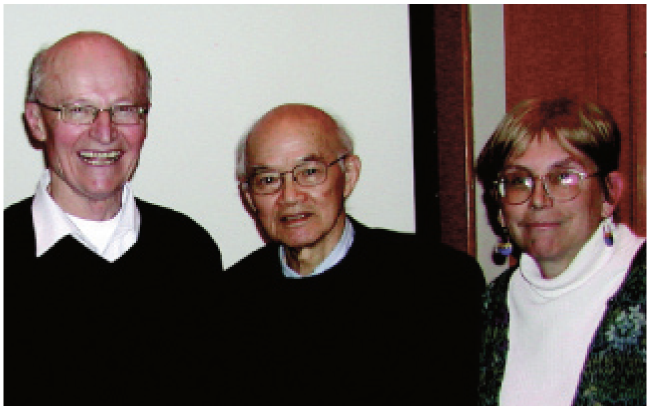
posts at MIT. He served as head of the Department of Chemistry, dean of Science, and provost under former MIT President Paul Gray. In 1993, he was selected as an Institute Professor, the highest honor bestowed upon MIT professors.

Speaking at the celebration were longtime friends and colleagues, including Professor George Whitesides of Harvard, former Secretary of Defense and Secretary of Energy James R. Schlesinger, former Secretary of Defense Harold Brown, former National Security Advisor Brent Scowcroft, former Assistant Secretary of Defense Richard Perle, former White House Chief of Staff John Podesta, former U.S. Congressman Philip Sharp, Washington-based lawyer Linda Stutz, and Deutch's son Philip, who described himself as “Deutch 2.0” and whose talk featured a picture of his own two children, or “Deutch 3.0.”

In addition to several talks, the symposium featured two panel discussions on subjects related to Deutch's government positions: energy and national security.

Commenting at the end of the symposium, Deutch alluded to comments Schlesinger made during the energy discussion on the limitations of solar and wind power. “The wind does not blow all the time, and the sun does not shine all the time,” Deutch said. “But the wind always blows and the sun always shines on me here at MIT.”

Excerpted from “A life of research and service,” David Chandler, MIT News Office April 17, 2009.



Prof. Vern L. Schramm, T.Y. Shen, and Prof. JoAnne Stubbe.

T.Y. Shen Lecture Attracts Top Biological Chemist to MIT

Professor JoAnne Stubbe, Novartis Professor of Chemistry and Professor of Biology, hosted the annual T.Y. Shen Lectures in Biological Chemistry on February 17 and 18, 2009. This year's speaker was Professor Vern L. Schramm from the Albert Einstein College of Medicine in New York.

Throughout his career, Schramm has conducted groundbreaking research into the mechanisms involved in enzymatic reactions. This work has led to promising drugs now being tested in clinical trials for treating autoimmune diseases and several types of cancer. Schramm studies the "transition-state structure" of enzyme-catalyzed reactions—the shapes that reacting molecules assume when enzymes catalyze chemical reactions.

T.Y. Shen, namesake of the lecture series, came to MIT in the 1950s for his post-doctoral work with Arthur Cope. Shen enjoyed his time in Course V so much that he encouraged his children to study here. He is the father of Theodore Shen '78 and Evelyn Shen SM '90.

The Shen family recently made a gift to fully endow this lecture series, ensuring that the Department of Chemistry will continue attracting the top minds in biological chemistry from around the world. These lectures are a great asset to the Department, and are widely attended by both students and faculty.

Earth, Atmospheric and Planetary Sciences

Inspiring the Next Generation of Scientists

Scientists are the ultimate detectives—they search for answers to the world's mysteries. From solving mathematical equations to exploring the history of the Earth, the intellectual curiosity of our scientists is the driving force of discovery.

Now the big question is: How can we stimulate this kind of curiosity in the next generation?

At MIT, we celebrate science every day, sharing our enthusiasm with the greater community. In April, Kurt and Therese Melden invited Professor Lindy Elkins-Tanton, EAPS Mitsui Career Development Professor, and

Prof. Lindy Elkins-Tanton and Norman Gaut PhD '67, a member of the EAPS Visiting Committee.

Joseph Alsop '67, Christiane Alsop PhD, and Bob Metcalfe '68.

Marc Kastner with Therese and Kurt Melden.

her husband, Dr. Jim Tanton from St. Mark's School, to share why they love science and how they inspire future scientists.

In 2008, Lindy Elkins-Tanton '87, SM '87, PhD '02, traveled to Siberia to study "the biggest unsolved murder mystery in the history of the world"—the extinction of 90 percent of the Earth's species 250 million years ago. This mass extinction occurred at the same time as the largest volcanic eruptions in the Earth's history. For more on her trip and subsequent findings, read graduate student Ben Black's trip report on page 3. Ben returned to Siberia this summer to further explore this mysterious event and its possible implications for global warming today.

Jim Tanton believes in the power of a good high school education. As a high school teacher and founder of the St. Marks Institute of Mathematics in Southborough, Massachusetts, he strives to bring fun and creativity into his classroom—a challenging notion when math is most often presented as a list of equations. Tanton is a dedicated proponent of outreach programs like the Research Science Institute (RSI) in MIT's Department of Mathematics, where 75 high school juniors explore mathematical problems under the mentorship of MIT graduate students and professors—many going on to win prizes in the nation's most prestigious math and science competitions.

Mary Puma SM '81 and Evivind Lange SM '81 at the Meldens.

Mathematics

"The Best of the Institute"—Is Singer's 85th Birthday Celebration

Colleagues, friends, and students celebrated Institute Professor Isadore "Is" Singer's 85th birthday and his legendary contributions to mathematics and physics with a two-day conference, "Perspectives in Mathematics and Physics," held May 22–24 at MIT and Harvard.

"Is Singer represents the very best of the Institute," said MIT President Susan Hockfield in her introductory remarks. "As both scholar and teacher, he combines the highest rigor with a spirit of boldness, experimentation, and fearlessness in reaching across disciplines." She went on to say that Singer's work has altered the very landscape of his profession.

Is Singer and Marc Kastner enjoying the lectures at the "Perspectives in Mathematics and Physics" Conference.

> “Is Singer represents the very best of the Institute. As both scholar and teacher, he combines the highest rigor with a spirit of boldness, experimentation, and fearlessness in reaching across disciplines.”
>
> — Susan Hockfield, MIT President

Singer, a specialist in differential geometry, partial differential equations, and mathematical physics, first joined the MIT Mathematics faculty in 1950. A 1983 winner of the National Medal of Science, Singer shared the 2004 Abel Prize, the highest distinction for a senior mathematician, with Sir Michael Atiyah, University of Edinburgh, for their discovery and proof in 1962 of the Atiyah-Singer Index Theorem. The two were praised for bringing together topology, geometry, and analysis, and for their outstanding role in building new bridges between mathematics and theoretical physics.

The celebratory weekend included a birthday dinner held at the American Academy of Arts and Sciences. In a brief speech, Singer described himself as age 60, not 85, sparking a recurring joke that the honoree’s true age was “60 mod 25.”

Professor John Bush Shares the Secret to Walking on Water

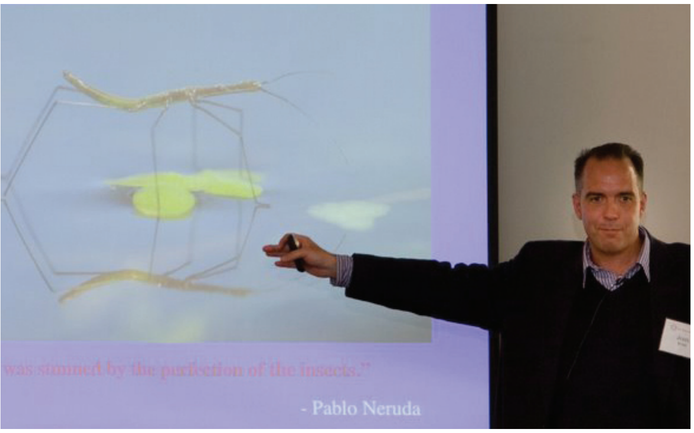
Alumni and friends learned how to walk on water at the March School of Science Breakfast in Cambridge. One catch: It only works for certain species—and a specially constructed soda can. John Bush, associate professor of Applied Mathematics, explained the science behind walking on water.

Bush’s research began in geophysics, but then shifted toward the effects of surface tension. As an applied mathematician, Bush seeks to understand and rationalize nature’s design. There are over 300 creatures that can skim effortlessly across the surface of ponds, rivers, and oceans with several distinct water-walking styles. The hydrodynamics underlying the surface locomotion of these semiaquatic creatures has been, until recently, poorly understood.

Using high-speed photography and a variety of flow visualization techniques, Bush and his lab demonstrated that waves are not a prerequisite for walking on water. Rather, the insects propel themselves by using the

Jim Simons ’58, PD ’61 and MIT President Susan Hockfield at Is Singer’s birthday celebration.

Mike Sipser with Ellen Gaffney and Lou Odette EE ’78, PhD ’81 at the John Bush Breakfast.



John Bush showing a water-walking insect and a favorite quote by Pablo Neruda, “I was stunned by the perfection of the insects.”

trampoline-like nature of where the air and water interface. This inference was confirmed by a supporting theoretical model, and guided them in constructing Robostrider, the first mechanical water-walking device.

This first study prompted Bush and his students to rationalize a number of less common water-walking techniques. For example, a number of creatures are able to defy gravity, climbing menisci simply by deforming the interface. Others alter the surface tension by ejecting chemicals that serve as fuel to propel them forward. Most recently, his group has examined the subtle dynamic role of the water-repellent surface of water-walking insects.

The result of this series of studies is a classification of all dynamic modes of interfacial propulsion. Certain insects and spiders can reside at rest at the interface, where their weight is supported by the surface tension. Their propulsion also relies critically on surface tension. Larger creatures, such as the basilisk lizard, can sustain themselves at the interface only by vigorous leg motions that create jets of fluid downward.

The Applied Mathematics faculty at MIT look for important connections with other disciplines that may inspire interesting and useful mathematics, and where innovative mathematical reasoning may lead to new insights and applications.

Reid Weedon ’41 and Paddy Wade ’45 in Cambridge.

Mike Sipser on One of the World’s Most Complex Math Problems

After the success of his School of Science Breakfast talk in 2008, Department Head Mike Sipser traveled to the West Coast to explain the P versus NP problem to a group of friends and alumni in Menlo Park, California. The morning was hosted by Satomi Okazaki PhD ’96. Sipser’s talk, “Beyond Computation: The P versus NP Problem,” describes one of the world’s most famously unsolved problems in mathematics. It is so intractable that the Clay Mathematics Institute has offered one million dollars to anyone who can solve this problem. This was a very lively breakfast talk with many questions on the topic—but alas, there were no solutions to the problem.

Mike Sipser with Satomi Okazaki PhD ’96 in California.

Physics

Patrons of Physics Fellows Dinner

The Department celebrated its fourth annual Patrons of Physics Fellows Dinner on April 10, 2009. More than 75 guests gathered for a dinner in the Green Center's Pappalardo Room. Rebecca Trobel and Sarah Trowbridge, both Whiteman Fellows, and John Barrett, a Frank Fellow, were student presenters. George Elbaum '59, SM '63, PhD '67 and his wife, Mimi, are founding members of the Patrons of Physics Fellows Society. At dinner, he shared his reasons for creating the Whiteman Fellows (named for his mother) and why giving back to the Department means so much to him. "Having a fellowship for my doctoral studies at MIT gave me the freedom to choose a program, a direction, and a thesis advisor," he said. "I want our fellowships to provide the same freedom to other students."

> "Having a fellowship for my doctoral studies at MIT gave me the freedom to choose a program, a direction, and a thesis advisor. I want our fellowships to provide the same freedom to other students."
>
> — George Elbaum

The Patrons of Physics Fellows Society was created to recognize the generosity of those friends and alumni who make it possible for first-year physics graduate students to explore their dreams—to determine the right area of specialization, find a mentor, and have the freedom of

Marc Kastner and Tom Frank '77, PhD '85 at the Patrons of Physics Fellows Society Dinner.

George '59, SM '63, PhD '67 and Mimi Elbaum.

Phyllis Buchsbaum and Janet Polansky with graduate students Leslie Rogers and Phillip Zukin.

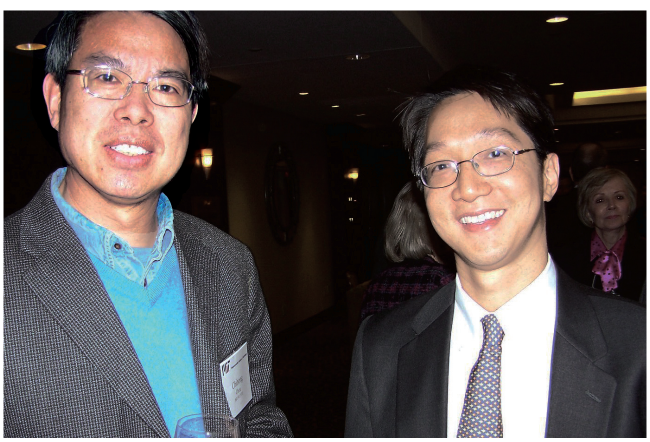
Nan Lower SM '84 and Doug Bailey '72, SM '74, ME '75 at the Physics reception in Greenwich, Connecticut.

time to develop new insights and ideas—just as George Elbaum did.

Probing the Small- and Large-Scale Structure of the Universe

On May 11, 2009, Tom Frank, another member of the Patrons of Physics Fellows Society, hosted Nobel Laureate and Institute Professor Jerome Friedman and Physics Department Head Ed Bertschinger for an evening lecture and reception in Greenwich, Connecticut. Friedman's talk, "Probing the Small- and Large-Scale Structure of the Universe," detailed his Nobel Prize-winning research on quarks.

Chihong Chou PhD '92 and Emmin Shung '91 at the reception in Greenwich, Connecticut.



Elizabeth Monrad SM '80, Eric Shuman, and Michael Lawler '93.

The David H. Koch Institute for Integrative Cancer Research

Koch Institute Construction Proceeds on Time, on Budget

Since the groundbreaking ceremony in March 2008, the new Koch Institute building has risen eight stories above Main Street. The structure is now mostly enclosed against the weather with two kinds of limestone, metal panels, and glass curtain walls. The signature exterior staircases at the east and west ends of the building have been installed and will soon be enclosed in glass. Faculty and staff will begin installing their specialized research equipment that will, in part, define the excellence of this facility.

MIT President Susan Hockfield with Alice and Nick Galakatos PhD '84 in her home, Gray House, for a Koch Institute Leadership Dinner.

David H. Koch at Gray House with Tyler Jacks, director of the Koch Institute.

SCIENCE NEWS & EVENTS

> "We're poised with more drugs, more insights, and more new ways of dealing with disease than ever before."
>
> — Prof. Phillip A. Sharp

For the past 40 years, cancer research at MIT has focused on identifying the molecular mechanisms that cause the disease.

While that is still a hot research field, the focus is now expanding. MIT researchers are trying to "not only understand how cancer develops and how it undergoes metastatic spread, but also to use our knowledge in new ways to diagnose and treat the disease," says Institute Professor Phillip Sharp, a member of MIT's Koch Institute for Integrative Cancer Research.

Pat McGovern '59, namesake of the McGovern Institute for Brain Research at MIT, with Marc Kastner at the Koch Institute Breakfast.

Prof. Robert Langer SCD '74 with John Shaw, William Haseltine, and Kiran Mazumdar-Shaw at the Koch Institute Gray House Dinner.

Fran Brown '79 and Tyler Jacks at the Koch Institute Breakfast in April.

Tuan Ha-Ngoc and John Alam '82 at the Koch Institute Breakfast.

Cancer biologists like Sharp are working with their engineering colleagues at the Koch Institute to develop a new arsenal of powerful weapons, including tiny strands of RNA that can shut off cancer genes, and new types of homing nanoparticles that can deliver drugs directly to tumors. In effect, MIT cancer researchers have reached a possible turning point in the long struggle against the disease. Through the use of new technologies, ideas, and ways of working, they hope to turn as many types of cancer as possible from a death sentence to a chronic but controllable illness.

"We're poised with more drugs, more insights, and more new ways of dealing with disease than ever before," says Sharp.

Support the MIT School of Science

Building the Koch Institute

Koch Institute construction progress as of September 2009.

> “The Koch Institute is the most visible evidence of President Hockfield’s initiative to foster the convergence of life sciences with the physical sciences and engineering.”
> – Marc Kastner

Join the fight against cancer by considering a gift to the building fund. MIT borrowed the money to create the world’s first fully collaborative, multidisciplinary institute dedicated to cancer research before the crisis in the financial markets. Now, we are paying back the principal and interest out of our general budget at the same time as that budget has been diminished by 15 percent. With this new facility, MIT is creating an environment of innovation that will foster the collaborations needed to advance new discoveries and technologies that will benefit cancer patients in the near term. All gifts in support of the building fund are deeply appreciated. Many naming opportunities still exist, including the ground-level gallery, state-of-the-art laboratories, and small meeting spaces.

- Name the ground-level gallery — $25 million
- Name one of the state-of-the-art laboratories — $2.5 million
- Name a small meeting space — $250,000

Koch Institute Building Fund	3703400

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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, as well as problems with obvious practical implications. Supporting these brilliant and creative minds will take more effort and resources than ever before. We encourage you to get involved.

Mosquito soup: one of the many perils of field research. Learn more on page 2.

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