Dear Friends,

As you read these words, I will be finishing my first official year as Dean of Science at MIT. In my new role, I have been so fortunate to meet many of the extraordinary scientists in the School of Science and to experience firsthand their passion for their work. Last fall, I was particularly struck by a meeting with Li-Huei Tsai, Picower Professor of Neuroscience and Director of the Picower Institute for Learning and Memory, and her work on Alzheimer’s disease. Surprisingly little progress has been made thus far on treating this terrible affliction, but tools have recently become available that may lead to significant advances. The annual cost of caring for people with dementia – now estimated at over $200 billion nationally and over $600 billion worldwide – is growing faster than the number of sufferers. It threatens to bankrupt our healthcare systems. We need a War on Alzheimer’s.
LETTER FROM THE DEAN

I believe that MIT can play a leading role by expanding our research efforts in this area.

A few months and two scientific workshops later, the Aging Brain Effort was born. Spearheaded by Professor Tsai, and bringing together researchers and clinicians from all over MIT as well as the greater Boston clinical centers, this effort will consolidate and organize our efforts to understand what causes some people to age with dementia and some people to age without. I am greatly excited that so many MIT researchers are eager to join this effort, which you can read about on page 5 of this issue. Most of all, I hope those of you who are as concerned as I am will join this effort by providing the resources needed to really make headway in our understanding of AD and other dementias.

Aging research isn’t new to MIT. The Paul E. Glenn Laboratory for the Science of Aging has been working on aging for many years. In fact, in this issue you can read how Christin Glorioso, a postdoc in the laboratory of Professor Lenny Guarente, believes that with lifespan-extending genetic and environmental interventions, scientists can extend life and reduce the rate of dementia. Already, scientists have created worms that live up to six times longer than worms without interventions and mice that can live 50% longer.

As I mentioned in the last newsletter, MIT life scientists have played an instrumental role in the biotech explosion in Kendall Square. Paul Schimmel Ph.D. ’67 (VII) probably understands this better than anyone: For 30 years he was a member of the Biology faculty, and together with former students and colleagues he founded many of the biotech companies found in Kendall Square. I am absolutely delighted and so thankful that Paul has agreed to work closely with Department Head Alan Grossman to raise funds to endow the graduate program for biology. He and his wife, Cleo, have been longtime supporters of MIT and wonderful friends to the School of Science. You can read about his efforts starting on page 10.

This issue is filled with inspiring stories about new companies being started by our students, exciting techniques for visualizing fine brain structures by our faculty, and a satellite that, when it launches in 2017, will monitor over 200,000 stars in search of exoplanets capable of supporting life. What an incredible time to be doing science. As always, I would love to know your thoughts. You can reach me at Sipser@mit.edu.

“We need a War on Alzheimer’s. I believe that MIT can play a leading role by expanding our research efforts in this area.”

– Mike Sipser

continued from page 1
Using Science to Disrupt Industry

A student with a dream, a faculty member who questions authority, and a serial entrepreneur join forces

Written by Jessica Boyle

Nevada Sanchez grew up in New Mexico with dreams of someday starting a technology company. His parents, a florist and a drywaller, told him that the place to go to make that happen was the Massachusetts Institute of Technology. Years later Sanchez enrolled at MIT, and in 2011 with the support and encouragement of his physics professor, Max Tegmark, he fulfilled his dream.

Sanchez was just 23 years old when he cofounded Butterfly Network alongside serial entrepreneur Jonathan Rothberg. At 26, he appeared on Forbes’ “30 Under 30” list for his contributions to science. His story is an easy-to-find example of the ways our graduates are spurring innovation and solving humanity’s greatest challenges, and is a true demonstration of how students, faculty, and friends of MIT can join forces to change our world in just a matter of years.

Butterfly Network is developing a new kind of medical imaging device described by MIT’s Technology Review as “a scanner the size of an iPhone that you could hold up to a person’s chest and see a vivid, moving, 3-D image of what’s inside…. The technology, which according to patent documents relies on a new kind of ultrasound chip, could eventually lead to new ways to destroy cancer cells with heat, or deliver information to brain cells.” The final product, Butterfly hopes, will be “nearly as cheap as a stethoscope” and will “make doctors 100 times as effective.” A portable, cheap, and high-quality ultrasound could make medicine’s most commonly used imaging technique accessible to more people, thereby having a significant impact on healthcare across the globe.

A New Way of Thinking

As an undergraduate, Sanchez enrolled in Professor Max Tegmark’s class on Special Relativity and was wowed by Tegmark’s work and his insights into Sanchez’s preconceptions about the world. Tegmark explained, “Special relativity is a great lesson in what I view as the core principle of science: Question authority, even when that authority is your own personal preconception as to how the world works. [For example], the idea that time flows at the same rate for all observers was so deeply engrained that it took the genius of Einstein to challenge it.” This philosophy, when applied to industry, can easily spur innovation. Shedding deeply engrained preconceptions and processes provides the opportunity to rethink traditional approaches. And, if nothing else, MIT students are taught how to tackle hard problems.

Tegmark is a proponent of this approach and is using this philosophy to reimagine radioastronomy. It was during a presentation about the subject – about how radioastronomy would be completely different if it were completed from scratch – that he attracted the attention of Jonathan Rothberg, an entrepreneur whose experience with the semiconductor industry and understanding of biology and biotechnology has led him to a path of regularly disrupting healthcare with novel approaches that are often better, more efficient, and more cost-effective than what currently exists. Recognizing a kindred spirit, Rothberg approached Tegmark after his presentation and told him he agreed with his philosophy but couldn’t come up with a business plan to use Tegmark’s techniques in astronomy. However, Rothberg did see a way forward in medicine. He was (and is) passionate about developing technology for good causes and was eager to support a startup. What was missing, though, was someone with whom to cofound his next venture.

“Suddenly a lightbulb went off in my head, and I knew I had the perfect match,” said Tegmark. The person he referred to, of course, was Nevada Sanchez, who was so impressed with Professor Tegmark’s work that he stayed at MIT to finish his
master’s in Tegmark’s laboratory. “Nevada wanted to defer his Ph.D. to support his family, and Facebook and Microsoft got into a bidding war over him. I felt that such a brilliant guy full of creative ideas would bring more good into the world if he started his own company where he was in charge rather than just a small cog in a big machine.” Tegmark made the introduction.

When asked about his decision to give up competitive job offers to instead found a startup, Sanchez shared his thought process: “I studied a lot of subjects at MIT, ranging from computer science and electrical engineering to physics and mathematics. This startup was a unique opportunity where I could exercise just about everything I learned at MIT. I had spent my whole life preparing for entrepreneurship and I had the perfect opportunity unfolding right in front of me.

“We knew that we could change the way that we image the human body in much the same way that Max’s lab was changing the way that we image the universe. Now we’re 3 years in, a year away from launch, and have $100 million to push us into production with a game changing product.”

The Origins of Innovation

Many people think of engineering or business school if their goal is to create game-changing technologies and products. Some even make the mistake of thinking that science has little impact on our daily lives and imagine scientists to be isolated in their laboratories, pursuing highly theoretical and arcane questions – particularly in the fields of physics and mathematics. Tegmark couldn’t disagree more: “We owe most of our technology and most of our GDP to physics research.”

He goes on to explain that, often, the research investments with the highest payoffs are ones that seemed most irrelevant to our everyday lives. “For example, the curiosity-driven quest to understand the fundamental building blocks of matter seemed to have little practical relevance, but gave us quantum mechanics, lasers, transistors, computers, and smartphones.”

So what, exactly, is the connection between basic research, innovation, and disruptive technology? According to Rothberg, basic research gives you the theoretical foundation to solve a problem, which is then realized as a new, disruptive technology which can then be brought to market. “If you are creating something that hasn’t been done before, it’s critical to go back to first principles and often take an approach not taken before. At 4Catalyzer [Rothberg’s startup accelerator], we are always doing something that has never been done before – something that often requires fundamental science. Peter Thiel calls this going from Zero to One. Engineering is great once you have something working – the engineers then make sure you can scale and manufacture the products.”

For Sanchez and the Butterfly Network, this means reinventing medical technology to replace $6 million of slow, imprecise equipment – an MRI machine and high intensity focused ultrasound (HIFU) – with a semiconductor chip.

Now a graduate of MIT, where he triple-majored in physics, mathematics, and electrical engineering, Sanchez is doing just that. After turning down several competing offers from top technology companies, Sanchez seized an opportunity to play a role in revolutionizing the healthcare industry; in 2011, Butterfly Network was born.

A kidney imaged with Butterfly’s technology.
Faculty Mount an Aging Brain Effort to Tackle Neuro-Degenerative Disease

“Where is the war on Alzheimer’s disease?” asks Michael Sipser, Dean of Science, and he is not alone. There is clearly a tremendous need – and great urgency – to address the burdens of the aging brain and the co-morbidities it spawns, from cognitive decline to Alzheimer’s disease (AD) and other dementias of aging.

This is a global health challenge. Dementias of aging now claim 35 million victims worldwide, and the numbers will double every 20 years as life expectancy rises and the population ages. In our lifetimes, one in three of us will fall victim to AD or a dementia of aging. The annual cost of dementias worldwide – now estimated at $604 billion – is growing faster than the number of sufferers.

And while other causes of death have declined in the past decade, AD has risen an alarming 46%. 5.2 million Americans now have AD, and by 2050 the number will rise to 13.8 million. AD-related Medicare and Medicaid expenses were $150 billion in 2014, making it our greatest healthcare cost – greater than cancer or heart disease.

Without breakthrough treatments, in 30 years AD threatens not only to bankrupt Medicare, but also to impoverish healthcare systems worldwide. Of the annual worldwide cost of AD care, 70% is spent on informal social and direct medical care. These social and economic challenges will only intensify as life expectancy rises across the globe.

The Knowledge Gap

Great strides have been made in diagnosing and treating other morbidities of aging, like diabetes, cancer, and heart disease. However, those strides have yet to come in AD and dementias because we know so little about their basic biology and what causes brain functions to change with age. No patient diagnosed with AD has ever recovered, and no effective disease-modifying therapies have been developed.

Dementia is not a normal or inevitable part of the aging process. We do know that the brain is the control center of the systemic aging process and is highly vulnerable to damage over time. We also know that some of us are protected from these degenerative processes while others are not.

Lead Investigator Li-Huei Tsai, Picower Professor of Neuroscience and Director of the Picower Institute for Learning and Memory, insists that “in order to conquer AD and dementias, we need to understand both what causes these degenerative processes and also why some of us are protected from them. We need to understand the genetic, biochemical, cellular, circuit, behavioral, and environmental factors behind cognitive decline and how these components function, interact, and overlap to regulate aging and neurodegeneration. Finally, we need to know which pathways and biological targets are amenable to diagnostic, prognostic, or therapeutic intervention.”

continued on page 6
its rapid integration into the clinical setting, and to establish an investment platform for long-term commitments to address this global health imperative.”

The Aging Brain Effort at MIT would be the first collaborative effort focused exclusively on researching the aging brain. Though there are academic departments of neuroscience which are invested in AD research, aging institutes dedicated to general lifespan issues (including the Buck Institute for Research on Aging, Glenn Centers for Aging Research, and the National Institute on Aging), and even comprehensive clinical care facilities like Harvard Medical School’s Aging Brain Center and Albert Einstein College’s translational program for clinical care of dementia – there is currently no center devoted to fundamental research on the aging brain.

We hope to bring together today’s leading researchers in health, aging, and Alzheimer’s disease in an integrated, multidisciplinary, highly collaborative group that includes the neurosciences, biology, engineering, computer science, artificial intelligence, and the clinical environment, as well as healthcare economics, manufacturing, and technology transfer. The result would be the first multidisciplinary, multi-institutional basic research group for the study of the neurological mechanisms that underlie brain aging. Its focus would be on aging brain research not previously attempted, and its mission would be to integrate core sciences and technologies across a wide range of fields and apply them to the field of aging, building from multiple domains to create a comprehensive understanding of the aging brain in health and cognitive decline.

Building on MIT’s Strengths

The founders of the initiative include renowned MIT researchers Li-Huei Tsai, Edward Boyden ’99 (VI-2, VIII), MNG ’99 (VI P), Emery N. Brown, Leonard Guarente, H. Robert Horvitz, and Susan Lindquist. They are joined by distinguished collaborators at MIT, the Whitehead Institute, the Broad Institute, Massachusetts General Hospital, Harvard Medical School, the greater Boston medical research community, and other leaders in the national and global scientific community. The Aging Brain Effort would be ideally positioned to leverage MIT’s exceptional laboratory and educational infrastructure, its leadership in hard sciences and engineering, its intellectual capital and

Lack of Sufficient Funding and No Cure

These are formidable challenges. Making them more difficult is the fact that government funding for dementia research lags far behind other diseases: this year, we will spend $5.4 billion on cancer research, $3 billion on HIV/AIDS research, and $1.2 billion on heart disease research, but just $566 million on AD.

Meanwhile, in the past two years the FDA has approved 19 new cancer drugs, with more in the pipeline. In contrast, not a single new AD drug has been approved in the past decade. The reason is simple: More than 40 years of investment in basic cancer research has made the disease much better understood than AD, and this understanding has led to successful translational research. Today’s oncology drugs could not have been developed without this foundational knowledge. But this fundamental information is largely missing in AD, so it’s not surprising that inadequate research investment has yielded no effective treatment. The clinical landscape is littered with more than a hundred failed attempts to develop effective treatments; the success rate among independent trials is just 5%.

The Need for Basic Research

The disappointing performance of almost every drug in Phase III clinical trials points to an urgent need to increase both the amount of basic research taking place and the speed with which we conduct it. It has become clear that there are likely many causes of AD and many different genetic mutations that increase the risk for the disease, yet almost all the clinical trials of potential AD drugs have focused on just a single biological pathway that leads to amyloid deposition while other causes remain largely unexplored.

Basic research in brain aging is one of the most cost-effective approaches to fighting age-related disease. Recent calculations by Andrew Lo, Charles E. and Susan T. Harris Professor of Finance at MIT, suggest that a new therapy resulting from this research – a therapy which delays the onset of AD by 5 years – could save Medicare/Medicaid $200 billion over the next decade and $1.5 trillion over the next 30 years.

According to Susan Lindquist, Professor of Biology and member of the Whitehead Institute, “The Aging Brain Effort is a proposal to begin this process of foundational research and
entrepreneurial culture, and its proximity to the Kendall Square commercialization corridor, which acts as a unique vehicle for pharmaceutical development and technology transfer.

We Need Your Help

We have the talent and the tools and we know what must be done to win the war against Alzheimer’s disease and the dementias of aging. The Aging Brain Effort at MIT would focus a unique range of scientific talent on a single goal: improving our future through a thorough understanding of the aging brain. Our greatest challenge is to fund this future. We must find the resources to execute groundbreaking basic research despite the paucity of government funding. Private philanthropy can make a significant difference in this critical problem of our lifetimes. Please consider a gift in support of this effort. If you would like to receive further information about this project, please contact Elizabeth Chadis, Assistant Dean, at 617.253.8903 or echadis@mit.edu.

“ I can think of no other condition that places such a heavy burden on society, families, communities, and economies. I can think of no other condition where innovation, including breakthrough discoveries, is so badly needed.”

– Dr. Margaret Chan
Director-General of the World Health Organization,
Address to the 2013 G8 Dementia Summit

About Our Founding Investigators

Edward Boyden, Ph.D.
Associate Professor of Biological Engineering and Brain and Cognitive Sciences, MIT Media Lab and the McGovern Institute for Brain Research. Boyden ’99 (VI-2, VIII), MNG ’99 (VI P) engineers tools for mapping, controlling, observing, and building dynamic circuits of the brain. He has developed “optogenetic” tools to activate and silence neurons with light. In 2010 his approach was recognized as the “Method of the Year” by Nature Methods and is now in worldwide use.

Emery N. Brown, M.D., Ph.D.
Edward Hood Taplin Professor of Medical Engineering, Institute for Medical Engineering and Science and Professor of Computational Neuroscience, Department of Brain and Cognitive Sciences, MIT and Massachusetts General Hospital. An anesthesiologist-statistician, Brown has developed signal processing algorithms that characterize how the brain represents and transmits information. He has made important contributions to understanding how anesthetics act in the brain and how their impact changes with age.

Leonard Guarente, Ph.D.
Novartis Professor of Biology, MIT. Guarente is an expert in the longevity of species from yeast to mammals and has identified potent anti-aging regimens. He found sirtuin proteins central to diet and stress adaptation and to combating diseases of aging, like cancer and neurodegenerative disease.

H. Robert Horvitz, Ph.D.
David H. Koch Professor of Biology, MIT. Horvitz uses the genetics of the nematode worm (C. Elegans) to understand neurodevelopment, behavior, and neurodegenerative disease. He received the 2002 Nobel Prize in Physiology or Medicine for his discoveries concerning the genetic regulation of organ development and programmed cell death.

Susan Lindquist, Ph.D.
Professor, Department of Biology, MIT and the Whitehead Institute. Lindquist has pioneered studies of protein homeostasis and protein folding, particularly as it pertains to heat-shock proteins and prions. She has discovered processes in the rapid evolution of new traits, cancer, neurodegenerative disease, and microbial drug resistance. She was awarded the President’s National Medal of Science in 2010.

Li-Huei Tsai, Ph.D.
Lead Investigator, Aging Brain Effort. Director, The Picower Institute for Learning and Memory and Picower Professor of Neuroscience, Department of Brain and Cognitive Sciences, MIT. Tsai combines molecular, genetic, and circuit approaches to understanding the pathophysiology of neurological disorders affecting cognition as we age. Her discoveries in Alzheimer’s-like disease research, including therapeutic reversal strategies for cognitive defects, have been highlighted in Nature, Cell, and Neuron.
What if, at 80 years old, you could choose to restore your brain to its 20-year-old level of functioning? You could have your optimal ability to remember facts, learn information, react, and balance, and be in no danger of Alzheimer’s disease. This sounds fantastical but it may be possible. This possibility is what piqued my interest in studying human brain aging and is the long-term goal of my research project.

People are living longer because of advances in medicine for common diseases such as cancer and heart disease, among other factors. But this longevity is leaving an increasing proportion of people suffering from late life neurodegenerative diseases such as Alzheimer’s and Parkinson’s disease. In fact, by the time individuals in the U.S. reach 95 years of age, they have a 50/50 chance of having Alzheimer’s disease. Treatment options for Alzheimer’s disease are poor, at most delaying decline by a few months. This leads many people to wonder why they would want to live to very old age if it means that they have a good chance of suffering from a devastating incurable disease, will lack the balance to avoid falling and breaking bones, or will lack the cognition to do the things that they enjoy.

We study aging of the human brain because if we can understand what happens within aging neurons, then we can create drugs that specifically slow down or reverse brain aging. We believe that this is possible due to the work of many laboratories that have shown that lifespan-extending genetic and environmental interventions in animals can also extend health span, that is, years of disease-free living. Scientists have now created worms that live up to six times longer and mice that live up to 50% longer, and many of these animals also suffer from diseases of aging – including Alzheimer’s – later and at a slower rate. This research tells us that lifespan-extending interventions in people should also extend health span and improve quality of life.

Our approach is to directly study the genetics and molecular processes in human brains across the lifespan. Specifically, people donate their brains to science and we study tissue samples from them. What we have begun to understand is that the molecular state of the brain is a surprisingly accurate clock. Just as we can fairly accurately tell how old a person is by looking at them, we can also tell how old a person’s brain is by looking at its molecular signature (Figure i). But just as some people look older or younger than their chronological age, some people’s brains look older or younger than their chronological age.

We think that this may be in part because they have genetic factors that result in their brains aging faster or slower than the average person’s. If we can identify what those genetic factors are, then we can figure out how they work and ultimately design drugs to target those pathways. In practice, a lot of what we do is computational: We create computer programs that sift through and model vast amounts of data on the genetic differences and molecular states of brain cells. This allows us to predict which genes are the key master regulators governing the rate of brain aging.

We have begun to have success with these computations. Figure ii contains preliminary data showing an example of a gene we have identified that has a slightly different sequence between people whose brains age quickly and those whose brains age slowly. These results have been replicated in two separate studies. This gene’s function is to repair environmental damage that neurons undergo over time. People with slower brain aging...
have a version of this gene that is more abundant, so having more of this gene appears to cascade down to slow overall brain aging.

This is one example of an anti-brain-aging drug target. Perhaps one day we could create a drug that would increase the levels of this gene in elderly people who have the inferior version of it. We still have a long way to go in narrowing down the best anti-aging drug targets and proving that they do what we think they do experimentally, but we believe that we may get there soon. I think that the future of treating neurodegenerative disease will be in slowing down and reversing brain aging itself, which will have the wonderful side effect of restoring our thinking and moving abilities to their youthful peak. We are optimistic that this may be a reality within our lifetimes.

“...but we believe that we may get there soon.”
– Christin Glorioso

Figure ii. Rate of biological brain aging in subjects with different genetic versions of a potential master brain aging regulator in two studies (A, B). Each point is a subject. Red subjects have the two copies of the good version of the gene and slower aging, green points have one good version and one bad version (intermediate rates of aging), and blue subjects have two copies of the bad version of the gene (fast aging).
Paul Schimmel Spearheads Campaign to Sustain Life Sciences at MIT

Written by Elizabeth Chadis

The Department of Biology at MIT has been an incubator of unparalleled excellence for decades. It is considered by many to be the best in the world, and that recognition comes from the presence of extraordinary faculty who, in turn, attract outstanding graduates from both MIT and other schools. These students have gone on to build our nation’s science and technology enterprises by doing groundbreaking research, spawning new companies, developing life-saving medicines, and providing high-level government service. Many of the new institutes that have sprung up across Kendall Square trace their roots to MIT’s Biology Department, from Professor David Baltimore and philanthropist Jack Whitehead’s creation of the Whitehead Institute in 1982, to Professor Eric Lander’s teaming with Eli and Edythe Broad to create the Broad Institute in 2003. The Koch, Picower, and McGovern Institutes have also sprung up with the help of the department. Companies ranging from small startups to global pharmaceuticals have opened their doors in Cambridge to take advantage of the local talent.

Paul Schimmel Ph.D. ’67 (VII), MacArthur Professor Emeritus, was a member of the faculty in the Department of Biology for 30 years and was involved in starting several companies. According to his former student, Eric Schmidt Ph.D. ’96 (VII D), “Paul always exhibited a keen interest in translating biomedical innovation to the commercial setting, and beginning in the 1980s he became one of biotech’s few serial academic entrepreneurs. Somehow, despite any formal training in business, Paul was able to start multiple, highly successful companies.” Local Cambridge companies with Schimmel’s imprimatur include RepliGen, Alkermes, Cubist, and Alnylam, among several others in San Diego and Seattle.

“None of the robust economic impact would have occurred [in Kendall] if it hadn’t been for MIT’s life sciences. It helps everyone, and now they need our help.”

– Paul Schimmel

Schimmel left MIT for The Scripps Research Institute in 1997. Every time he returns to campus, he looks around and asks himself, “What would Kendall Square and Boston be like if there were no MIT? More specifically, what would they be like if there were no life sciences at MIT?” It’s hard to imagine a world without the biotechnology that has spun out of MIT, and nearly impossible to imagine Kendall Square without the new life it breathed into the area. “What makes the Biology Department and the life sciences at MIT so extraordinary,” said Schimmel, “is the singular ability to transfer knowledge and inventions to society for its benefit. That is much of why Kendall Square and Boston are what they are.”

As a member of the Biology Visiting Committee, Schimmel has seen firsthand the decline in federal funding and its impact on the department. Federal support, specifically for training graduate students, has steadily declined. Exacerbating the problem is the fact that the costs of research and training increase every year. According to Department Head Alan Grossman, the department has historically relied extensively on government funds to train its students and to support research.
Grossman stated, “The good news is that we have a healthy research and training enterprise that has largely been supported by federal funds, and we have not had to ask for help in the past. The bad news is that we can no longer rely on this source of support, and we now need to turn to our alumni and friends to help support our research and training missions. With the Biology Department having no real history or experience in fundraising and asking for support, I am tremendously appreciative that Paul Schimmel has agreed to help us build the endowment for our Graduate Training Initiative (GTI).”

While at MIT, Schimmel and his wife, Cleo, anonymously contributed to the construction of Building 68. Shortly after leaving MIT, they endowed four 4-year graduate fellowships for outstanding women in life sciences (“Cleo and Paul Schimmel Scholars”). Later, in addition to more gifts to life science, they sold their home in La Jolla and turned the proceeds over to MIT for the purpose of training the next generation of graduates. Schimmel said, “I’ve been talking to the people that I’ve started companies with, pointing out that the life science educational enterprise spreads across five departments at MIT and reminding them that none of the extensive commercial and residential real estate development, restaurants, hotels, and the founding and locating of major biopharmaceutical enterprises would have happened without the MIT life science enterprise. MIT’s Kendall Square is to biopharma what Silicon Valley is to technology. None of the robust economic impact would have occurred if it hadn’t been for MIT’s life sciences. It helps everyone, and now they need our help.”

Schimmel has been soliciting the CEOs of the companies he founded as well as the venture capitalists who made these endeavors possible – many of whom have no official connection to the Institute. “What pleases me greatly is the response from people who never attended MIT. They get it. And they have matured in their thinking to understand that there is no depth to happiness unless you are grateful, and they express that by making a personal sacrifice and letting go of personal resources for the future of society. I feel giving in this way is a cogent test of maturity and the state of one’s own heart.”

Among the first people to heed Schimmel’s call were Eric Schmidt Ph.D. ’96 (VII D) and his wife, Tracy Smith Ph.D. ’96 (VII D), who met as graduate students at MIT. They were motivated to make their gift not only because Paul asked them, but because “science has played a large role in our lives, and we have tremendous confidence in the value it brings to society.”

– Eric Schmidt and Tracy Smith

“Science has played a large role in our lives, and we have tremendous confidence in the value it brings to society.”

According to Grossman, “The country’s life science enterprise is built on the foundation of basic research and our understanding of how living systems function. In order to understand, cure, and prevent disease, we need to know about the non-disease state. It is this basic research, combined with research focused on disease states, and the collaborative and entrepreneurial spirit at MIT, that makes our Biology Department such a special place and a unique incubator for research, discovery, and education in the life sciences.”

To watch Schimmel’s talk, visit sciencem.it/schimmeltalk.
Biology

Workshop on Quantitative Methods in Biology Draws Diverse Students from Across the Country


The first week of the new year brought smatterings of undergraduates returning to the MIT campus after the holidays – and 54 new faces were among them. These students traveled from across the country to attend the annual Quantitative Methods Workshop, a weeklong event with lectures and classes for undergraduates from partner institutions, including Howard University, Hunter College, and the University of Puerto Rico.

The workshop, sponsored by the Department of Biology and the National Science Foundation-funded Center for Brains, Minds, and Machines, focused on how computer programming can apply to problems in biology and neuroscience. Amy Keating, Co-Director of MIT’s graduate program in biology, has taught at the workshop for the past five years. “The workshop gives students with a broad range of backgrounds exposure to the exciting ways in which quantitative tools are applied in modern biological research,” Keating said. “Some math and computer science students don’t realize that they can make important contributions to biology research until [this workshop].”

Mandana Sassanfar, a Lecturer in the Biology Department, organizes the workshop. “We want to give them a spark, provide them the tools and the basic knowledge,” Sassanfar said. “When they go back to school, they can try to do something with what they have learned.”

An Intense and Rewarding Experience

Each morning during the workshop, students attended a lecture on a range of relevant topics, such as modeling activated neurons, machine learning in neuroscience, and gene-sequencing technology.

“We take this deep dive into the problems of their field,” explained Talmo Pereira, a bioinformatics and computational biology major at the University of Maryland, Baltimore County. “Then in the afternoons, we learn some computational method for how to approach those problems. And so it really does reinforce this notion that, no matter what field of biology you’re in, you need these computational methods in order to solve these very basic and essentially biological problems.” This was Pereira’s second year at the workshop; Like many of the students there, he first found out about it when he attended the MIT Summer Research Program (MSRP; see page 13 for details), working in a research laboratory on campus. This year, he helped out during the week as a teaching assistant.

Throughout the workshop, students completed assignments through an online course module on the MITx website, where they could submit work and check their code. MITx also offers an eight-week online version of the course – known as “Quantitative Biology Workshop” – through edX.

The workshop welcomed students with a wide range of backgrounds; some participants had never programmed before, while others were new to biology. “I didn’t realize how important it is, as a bio and chemistry major, to also have a background in programming,” said Sheena Vasquez, a junior at Georgia Perimeter College.
“I have no formal background in biology,” added Alejandro Vientos, a computer science major at the University of Puerto Rico. “This has done a lot to push me in that direction – biology has a lot of interesting problems.”

For several students, the time they spent at MIT through the MSRP and the Quantitative Methods Workshop provided an unexpected boost of confidence. “One of the things I really love about this program is the collaboration and the high caliber of everyone here,” said Kevin White, a biology and neuroscience major at Howard University. “It inspires you to do your best and go to the top, and not be afraid to do what you didn’t think you could do.”

“The idea of applying to a top school became more attainable,” added Candace Ross, a computer engineering major at Howard.

Cassandra Schaening, who attended the workshop two years ago, felt the same way. “It was sort of that whole thing where you don’t think you’re competitive enough, but it was after I came here that I was actually more encouraged to apply,” she said. Now, Schaening is a graduate student in computational and systems biology at MIT.

“Even in such a short workshop, you work at a really intense pace. The workshop is seven days, 10-hour days; you’re just working constantly and absorbing new information every minute,” Schaening recalled. “It’s just so much more than you’re used to doing, and you realize – this is something I can do. I can work at this level. And you want more of it.”

About MSRP – Biology

One of the most powerful tools for increasing diversity in the life sciences has been the MIT Summer Research Program (MSRP) in biology. A spinoff of the more centralized MSRP, this program was initiated in 2003. Coordinated by Mandana Sassanfar, it helps the department’s efforts in minority recruiting and retention.

The MIT Summer Research Program in biology is designed to encourage students from underrepresented minority groups, first-generation college students, and students from economically-disadvantaged backgrounds to attend graduate school and pursue a career in basic research by providing them with the opportunity to conduct supervised research in a top-notch research institution in a supportive learning environment featuring plenty of interaction with graduate students and faculty. Students selected for the program have demonstrated academic excellence, a strong interest in research, and financial need and typically attend institutions with limited research opportunities.

Over 85% of past participants have enrolled in top graduate programs within 2 years of completing this summer program. A number of our summer interns were also awarded Goldwater Scholarships, 3-year pre-doctoral NSF fellowships, or 5-year Gilliam Fellowships for Advanced Study.

“We want to give them a spark, provide them the tools and the basic knowledge. When they go back to school, they can try to do something with what they have learned.”

– Mandana Sassanfar
Brain and Cognitive Sciences

McGovern Institute for Brain Research: Creating New Techniques to Image Brain Activity

Written by Kara Flyg and Charles Jennings, Ph.D.

The human brain is an incredibly complex and densely wired network of almost 100 billion neurons. Driving our progress in understanding the brain’s inner workings is the development of novel technologies to help scientists map, record, image, and manipulate the brain. Designing new ways to enable neuroscientists to observe individual neurons – or large networks of neurons at once – is a critical step in accelerating our understanding of the brain and probing the origins of diseases such as schizophrenia, autism, bipolar, and Alzheimer’s. By bringing together expertise in neuroscience, chemistry, physics, biology, and other fields, scientists at the McGovern Institute for Brain Research at MIT are at the forefront of creating novel techniques to image brain activity at many levels.

To understand how the brain perceives sensory information, encodes memories, and generates behavior, it is important to measure the activity of many neurons simultaneously. Until recently, this was not possible, and researchers were limited to monitoring single neurons or small groups of nearby neurons – an approach that has been compared to trying to understand a movie by watching a few pixels on a TV screen.

An important priority for the field, therefore, is to develop methods for monitoring activities of larger numbers of neurons. The laboratory of Guoping Feng, Poitras Professor of Neuroscience, has tackled this challenge by using fluorescent proteins to reveal how neurons coordinate with each other to control specific behaviors such as initiating movement or detecting an odor. The technique is based on an engineered protein, known as GCaMP, whose fluorescent properties change in the presence of calcium ions. The concentration of calcium increases when a neuron fires an electrical impulse, and the resulting fluorescent signal can be observed using a microscopic method known as two-photon imaging. Feng and colleagues have engineered strains of mice that express GCaMP in specific subsets of neurons, and have used a powerful 2-photon microscope to monitor the activities of hundreds or even thousands of neurons in parallel, at high speed and with single-cell resolution. This system is now being used to study brain activity during many types of behavior and promises to provide new insights into how neural activity is disrupted in conditions such as autism, schizophrenia, and other psychiatric diseases.

Two-photon microscopy provides an impressively detailed view of brain activity, but Ed Boyden ’99 (VI-II, VIII), MNG ’99 (VI P), Associate Professor of Brain and Cognitive Sciences, is working to push the limits of technology even further. In 2014 his group, along with collaborators in Vienna, Austria, developed a technique that allows scientists to simultaneously image every active neuron in small living creatures, offering a more complete picture of brain activity than anything achieved previously. This new method is based on a method known as light-field imaging, which creates 3-D images by measuring the angles of rays of light emitted from a single object. An array of lenses enables each neuron to generate about 400 different points of light, which can then be recombined using a computer algorithm to create a 3-D image of activity across the entire nervous system.

Thus far, Boyden’s team has successfully imaged the nervous system of the C.elegans worm and the brain of a zebrafish larva. Next, they plan to image the brain of a living Etruscan shrew, the world’s smallest mammal. This technique has the potential to help neuroscientists understand how neural activity is coordinated across the entire brain and to pinpoint individual neural circuits that are involved in complex behaviors and disorders.

“These techniques... pinpoint individual neural circuits that are involved in complex behaviors and disorders.”

– Kara Flyg and Charles Jennings
More recently, the Boyden Laboratory has developed another exciting technique for visualizing fine brain structures such as synaptic connections that are too small to be seen by conventional optical microscopy because they are below the diffraction limit. Such details can be seen by so-called super-resolution microscopy, but this requires specialized equipment and reagents and is not easily accessible to most laboratories. Boyden and colleagues have developed an alternative approach called expansion microscopy, in which the specimen is physically enlarged to render small structures more easily visible. The technique involves infusing the fixed brain tissue with the same polymer substance that is used in baby diapers, which expands dramatically when it absorbs water. As with conventional microscopy, the tissue is labeled with fluorescent probes, but these are then linked to the polymer matrix, anchoring them in place during the subsequent expansion step. When water is added, the specimen expands uniformly by up to five times in every direction, while preserving the shape of even very small subcellular structures. The new technique will enable researchers to image large volumes of brain tissue with nano-scale precision and will be useful for a wide range of applications both in neuroscience and other areas of biology.

i  McGovern Institute Investigator Guoping Feng (right) and graduate student Michael Wells are studying how the disruption of synaptic connections can lead to behavioral disorders such as autism. Photo by Justin Knight.

ii  McGovern Institute Investigator Ed Boyden holds an ontogenetic device created in his laboratory. Photo by Justin Knight.

iii  McGovern neuroscientist Ed Boyden created this image of neurons in the hippocampus using a new technique called expansion microscopy. Image by Ed Boyden, Fei Chen, and Paul Tillberg.

iv  The Boyden Laboratory at MIT is developing new tools to analyze and engineer the brain. Photo by Justin Knight.

To watch short videos about these new brain imaging techniques and other technologies that enable scientists to observe and control the brain, visit the McGovern Institute for Brain Research video gallery at mcgovern.mit.edu.
Chemistry

Intracellular Delivery of Peptides and Proteins Using Anthrax Toxin

Written by Amy E. Rabideau

Delivery of proteins into the cytosol of cells is a challenge due to their large size, structural complexity, and charge. The cell membrane not only provides a physical barrier from outside elements, but also maintains the inner contents of the cell. For this reason, the cell membrane poses a major obstacle for the delivery of protein therapeutics.

Nature has found a way to deliver proteins into cells in the form of protein toxins. Pathogenic bacteria such as Bacillus anthracis and Corynebacterium diphtheriae express and secrete protein toxins like anthrax and diphtheria toxin, respectively, that infect host organisms and often cause cell death. These protein toxins take advantage of the host cells’ machinery to gain access inside the cells by hijacking ubiquitous cellular receptors and utilizing the endocytic pathway.

Anthrax lethal toxin is one example of a potent toxin that utilizes host cells receptors and is taken up into the cell through endocytosis in order to deliver toxic proteins into the cell cytosol. Anthrax lethal toxin is a two-component protein toxin consisting of a pore-forming protein, protective antigen (PA), and an effector protein, lethal factor (LF). PA first recognizes an anthrax receptor on the surface of a host cell (Figure i, step 1). After receptor binding, protease cleavage of the N-terminal domain leads to PA pre-pore formation (Figure i, step 2). Up to three molecules of LF can then bind to the surface of the PA pre-pore (Figure i, step 3). The entire complex is endocytosed into the cell (Figure i, step 4), where acidification triggers PA pore formation and subsequent delivery of LF into the cell cytosol (Figure i, step 5). In the cytosol, LF acts as a protease to cleave mitogen activated protein kinase kinases (MAPKK), thereby interrupting the MAPK signaling pathway and inducing apoptosis.

We looked to anthrax toxin to develop a platform for delivering complex biomolecules such as peptides and proteins into the cytosol of cells. To accomplish this we removed the enzymatic domain of LF and worked with only the PA-binding domain (LFₜₐₜ) to avoid any associated toxicity. We designed a modular platform to ligate our cargos to the C-terminus of LFₜₐₜ using Sortase A (SrtA) ligation chemistry. As depicted in Figure ii, LFₜₐₜ containing the Sortase A (SrtA) recognition motif LPSTGG (LFₜₐₜ-LPSTGG) can be ligated to any cargo with an N-terminal oligo-glycine tag (G₅-cargo). After devising the ligation strategy, we set out to investigate the promiscuity of the PA pore and determine if it could accommodate more than just its native protein cargo (i.e., LF), as shown in to Figure iib.

Our delivery studies began with a small peptide library containing assorted peptides with slight modifications to the peptide backbone and side-chain residues. All peptides were ligated to a protein fusion, LFₜₐₜ-NTA, in which NTA is the A chain of diphtheria toxin and was used as a method of detecting delivery into the cytosol through western blot immunostaining. As depicted in Figure iiia, LFₜₐₜ-NTA conjugates 2-6 contain modifications at one amino acid position with respect to LFₜₐₜ-NTA conjugate 1; and all conjugates contain a biotinylated C-terminus for detection of the intact conjugate after cytosolic delivery. LFₜₐₜ-NTA conjugate 7 contains the small molecule, doxorubicin, and conjugate 8 contains the peptidomimetic, monomethyl auristatin F (MMAF). According to the DTA immunostaining in the western blot in Figure iiib, each LFₐ₉-NTA conjugate 1-8 was delivered efficiently into the cytosol of Chinese hamster ovary (CHO-K1) cells. The Erk1/2 (cytosolic marker) and Rab5 (early endosome marker) staining indicates that the mild lysis conditions used for extracting the cytosolic fraction were sufficient. Furthermore, streptavidin staining of the C-terminal biotin indicated that the conjugates were intact after delivery into the cytosol. These results indicate that slight modifications

Amy E. Rabideau, Chemistry Graduate Student.
to the peptide backbone or amino acid side chain as well as the addition of certain small molecules or peptidomimetics do not perturb delivery through the PA pore.

Given these promising results and initial indication of the promiscuity of the PA pore, the scope of the study was expanded to include delivery of protein cargos in the form of antibody mimics. As represented in Figure iva, delivery of the following antibody mimics was analyzed: B1 domain of protein G containing a mixture of \( \alpha \)-helix and \( \beta \)-sheet secondary structures (GB1; 6 kDa), all \( \alpha \)-helical designed ankyrin protein repeats (DARPin; 13 kDa), and all \( \beta \)-sheet tenth type 3 human fibronectin domain (10FN3; 11 kDa). These antibody mimics were ligated to LFN to form LFN-cargo conjugates 9-11, respectively. According to the LF immunostaining in the western blot in Figure ivb, each LFN conjugate 9-11 was delivered efficiently into the cytosol of CHO-K1 cells. These results indicate that proteins of varying size, charge, and secondary structure could be delivered through the PA pore.

With the LFN/PA delivery system, we have found a way to efficiently access the cell cytosol to deliver a variety of complex biomolecules. These exciting results have been published in three publications: *ChemBioChem*, *Chemical Science*, and *Scientific Reports*. Currently, we are investigating the delivery of bioactive cargo into the cytosol of cells and measuring the associated response. Additionally, we are working toward targeting PA to specific types of cells such as cancer cells that overexpress the epidermal growth factor receptor (EGFR).
Earth, Atmospheric and Planetary Sciences

Big Cats, Panama, and Armadillos: A Story of Climate and Life
Written by Genevieve Wanucha

Approximately 3 million years ago, an enormous ice sheet pushed southward from the arctic, covered what is now Canada, and stretched down to modern day Missouri, becoming the first ice age to occur in hundreds of millions of years. Ever since, Earth’s climate has passed in and out of ice ages roughly every 40,000 years with the last ice sheet retreating about 20,000 years ago.

What triggered this enormous shift in climate? A commonly accepted explanation relies on the assumption that the Isthmus of Panama closed at that time, creating a land bridge between North and South America that blocked the essential ocean currents keeping the ice ages at bay.

At the MIT Lorenz Center’s 4th John Carlson Lecture, prominent geophysicist Peter Molnar dismantled this long accepted explanation for why Earth’s ice ages began when they did. Molnar pulled up Wikipedia’s entry for the Isthmus of Panama, which presents a dramatic sequence of geological events: As continental plates collided 3 million years ago, a thin rib of land emerged, closing the gap between the North and South American continents. This major event separated the Atlantic and Pacific Oceans, and as a consequence, transformed ocean circulation in a way that allowed ice sheets to grow on the North American continent and to give us recurring ice ages.

Around that same time in Earth’s history, fauna began to migrate across the continents in an event called the Great American Biotic Interchange. The emergence of the Isthmus of Panama, as accepted scientific theory goes, created a land bridge that allowed the animals to cross the continents. Fossil evidence shows that North American natives such as bears, mastodons, ancestors of big cats, camels, and horses traveled into South America, while ancestors of modern day armadillos, porcupines, sloths, anteaters, and opossums migrated into North America.

Molnar then proceeded to tear down this elaborate interpretation in minutes. “We can reject it,” he said. “It has no foundation.” He presented fossil findings that frogs, salamanders, and snakes crossed the continents between 6 and 19 million years ago, as well as new geological evidence that the Isthmus of Panama actually emerged 20 million years ago – far before the commonly cited 3 million. That’s one hole in the story that the emergence of a land bridge directly enabled the Great American Biotic Interchange – it was already there.

Molnar’s alternative explanation hinges on the slow global cooling that eventually sustained an ice sheet briefly, for no more than 20,000 years, on Canada 3 million years ago. During this ice age, the climate in Panama shifted from the hot, wet, mosquito-infested jungle we know today to a drier, cooler savannah grassland environment favorable to the migration of animals such as armadillos and saber-toothed cats. This change in Panama alone would have allowed animals to cross between continents.

“Did the emergence of the Isthmus of Panama, whenever it occurred, have anything to do with ice ages? I think it had nothing to do with it.”

– Peter Molnar

Molnar admitted that he did not answer the larger motivating question about what geological processes transformed Earth’s climate from one with no ice ages to another with recurring ice ages. He will be working on that one for a long time. Rather, his talk proved the importance of challenging core assumptions in science. “The most important part of science is asking good questions,” he told the young scientists and high schoolers in the audience.
Before the lecture, MIT and the New England Aquarium hosted an exhibition of the iGlobe, a new tool for Earth science education. By projecting scientific data such as weather patterns, ocean circulation, and land temperature on a sphere, the iGlobe provides an intuitive, accurate, and fun way to represent the interconnectedness of Earth’s systems. Researchers from MIT, led by Glenn Flierl, Professor of Oceanography in MIT’s Department of Earth, Atmospheric and Planetary Sciences, recently partnered with iGlobe Inc. to educate students and the general public and improve the presentation of spatial information and computer model results on the iGlobe.

The John Carlson Lecture communicates exciting new results in climate science to the general public. The lecture is made possible by a generous gift from John H. Carlson to the Lorenz Center in the MIT Department of Earth, Atmospheric and Planetary Sciences. The next lecture will take place in Boston on October 15, 2015. If you are interested in attending, please contact Angela Ellis at aellis@mit.edu.

To watch Molnar’s lecture, visit science.mit.edu/molnarvideo
Tomasz S. Mrowka '83 (XVIII), the Singer Professor of Mathematics, has been named Head of the Department of Mathematics, effective December 10, 2014.

“Mathematics holds a unique place at MIT,” Mrowka said. “Much of the community uses it on a daily basis and in an ever-growing and sophisticated manner. The Mathematics Department is the nexus of this activity. Its health and strength are crucial for MIT’s future.”

Mrowka has served as the Interim Department Head since June 2014. Mrowka takes over the role from Michael Sipser, the Barton L. Weller Professor of Mathematics. Sipser was named Dean of the School of Science after serving since last December as Interim Dean and since 2004 as Head of the Department of Mathematics.

“I am delighted that Tom has agreed to be Head of mathematics,” said Sipser. “From working with him closely for many of the past 10 years while I was in that role, I know of his deep dedication to the department, to mathematics, and to MIT. He is a stellar mathematician and we are fortunate to have him in this position of leadership.”

Mrowka brings substantial experience as a researcher, educator, and administrator to his role as Department Head. A 1983 graduate of MIT, he received a Ph.D. from the University of California at Berkeley in 1988 under the direction of Clifford Taubes and Robin Kirby. He taught at Stanford University, Caltech, and Harvard University before returning to MIT in 1996. He served as chair of the Graduate Student Committee from 1999 to 2002 and has chaired the Pure Mathematics Committee since 2004, with a one-year pause in 2009-2010.

Mrowka’s work combines analysis, geometry, and topology, specializing in the use of partial differential equations such as the Yang-Mills equations from particle physics to analyze low-dimensional mathematical objects. Among his results is the discovery (jointly with Robert Gompf of the University of Texas at Austin) of surprising four-dimensional models of space-time topology, going far beyond the expected examples envisaged by Kunihiko Kodaira and others.

In joint work with Peter Kronheimer of Harvard, Mrowka settled many long-standing conjectures, including ones posed by John Milnor on the complexity of knots in three space and another posed by Rene Thom on surfaces in four space. Mrowka and Kronheimer also revealed a deep structure underlying the Donaldson invariants of four-dimensional manifolds, which was an avatar of the Seiberg-Witten invariants. In further recent work with Kronheimer, Mrowka used these tools to show that a certain subtle combinatorially-defined knot invariant introduced by Mikhail Khovanov can detect “knottedness.”

Mrowka’s joint work with Kronheimer has been honored by the American Mathematical Society with the 2007 Oswald Veblen Prize in Geometry as well as the 2010 Joseph L. Doob Prize for their monograph, “Monopoles and Three-Manifolds” (Cambridge University Press, 2007). In addition, Mrowka was elected a fellow of the American Academy of Arts and Sciences in 2007 and was named a Guggenheim Fellow in 2010 and Fellow of the Radcliffe Institute for Advanced Studies in 2013.
Physics

MIT in Space:
The Transiting Exoplanet Survey Satellite  
Written by Bendta Schroeder

At last September’s School of Science Breakfast, Jacqueline Hewitt Ph.D. ’86 (VIII), the Director of the MIT Kavli Institute, introduced the audience to an exciting MIT-led NASA mission: the Transiting Exoplanet Survey Satellite (TESS).

Hewitt outlined the long history of the TESS project, which began as a small private mission at the MIT Kavli Institute for Astrophysics and Space Research (MKI), supported by the Kavli Foundation, Google seed funding, and MIT donors. After being restructured and proposed as a Small Explorer Class Mission in 2008 and again as an Explorer Class Mission in 2010, it was greenlighted for development in 2013. TESS has grown into a $200 million mission with a team that includes the NASA Goddard Space Flight Center, the NASA Ames Research Center, the Harvard-Smithsonian Center for Astrophysics, the Space Telescope Science Institute, and several universities and observatories. George Ricker, a senior research scientist at MKI, is the mission’s Principal Investigator.

When TESS launches in 2017, it will monitor over 200,000 stars in search of exoplanets capable of supporting life. One of the leaders of MIT’s science effort and Class of 1941 Professor of Planetary Science and Physics, Sara Seager, outlined the conditions needed for a habitable planet in a paper published in Science in 2013. These conditions included having an orbit within a habitable zone around a “quiet” star that doesn’t produce a lot of radiation, and a greenhouse effect that increases the likelihood of water.

In order to find habitable exoplanet candidates, TESS will use the same method of detecting exoplanets as the Kepler mission, looking for the minute but measurable dips in a star’s light intensity caused by a planet passing in front of – or “transiting” – the star.

The Kepler mission not only found 1,000 exoplanets, but revealed that Earth-sized and “Super Earth” planets of up to twice Earth’s radius were far more common than previously thought. While these results were encouraging, most of the exoplanets Kepler found orbit stars that are too faint and distant to allow scientists to determine whether relatively small Earths and Super Earths possess characteristics necessary for life.

continued on page 22
In contrast, TESS will focus on the bright stars in Earth’s more immediate neighborhood. The mission is expected to identify 3,000 new planets ranging from small rock and ice planets to gas giants, including 500 Earth-sized and Super Earth exoplanets to be targeted for detailed study by the James Webb Space Telescope after it launches in 2018.

TESS will employ a number of innovations developed at MIT, including a unique high-Earth orbit that is both close enough for high data-downlink rates and far enough away to avoid Earth’s harmful radiation belts. The orbit is highly stable and keeps TESS’s sensitive instrumentation within a steady temperature range during long periods of observation. Once TESS is in orbit, the all-sky survey will be carried out by cameras designed at the Lincoln Laboratory, containing novel CCD detectors with high signal-handling capacity and photometric accuracy and speed, also developed and fabricated at the Lincoln Laboratory.

Hewitt believes that the TESS mission will provide extraordinary opportunities for MIT to raise its international profile, expand its educational and research mission, and make MIT a credible center for space exploration missions to a risk-averse NASA. Because the mission’s Science Operations Center will be based in Building 37, MKI will have an opportunity to rebuild its infrastructure and to pave the way for future space exploration projects. MIT students will also have more mission-building training available to them: Kerry Cahoy, an Assistant Professor in the AeroAstro and EAPS Departments, is already using TESS as a test case in a graduate course in satellite engineering. TESS is helping MKI and MIT to attract some of the best scholars in planetary science: When the first MIT Torres Postdoctoral Fellowship for Research on Exoplanets was offered at MKI, 160 applications were submitted. The four postdoctorates that fellowship currently supports helped to tip the balance toward MIT in the NASA selection process.
SUPPORT THE SCHOOL OF SCIENCE

The Graduate Training Initiative for Biology

The Department of Biology at MIT is an internationally recognized pioneer in research and education. For over 50 years, the department has played a central role in the growth of molecular life sciences and the revolution in molecular and cellular biology, genetics, genomics, and computational biology, while simultaneously training thousands of postdoctoral Fellows, graduate students, and undergraduates – many of whom now enjoy notable scientific careers. It has been the incubator for growth of the life sciences at MIT, contributing significantly to the creation of the Koch, Broad, McGovern, and Picower Institutes, as well as the ever-increasing number of biotechnology companies in Kendall Square and beyond.

Now, the department needs help. Because of reductions in the number of NIH Training Grants we’ve received over the last few years, we are actively engaged in a fundraising campaign to give our renowned graduate program financial security and enhance its research activities. With the help of Paul Schimmel Ph.D. ’67 (VII), MacArthur Professor Emeritus, the Graduate Training Initiative for the Department of Biology has begun (for more details, see page 10).

Gifts of any and all amounts are greatly appreciated and can be made online by visiting giving.mit.edu/biology and choosing the following:

**Biology Graduate Support Fund (2740100)**
Supports Biology’s Graduate Training Initiative, which hopes to alleviate the burden of government cuts to basic science funding and keep MIT the #1 graduate school in the world for biology.

Gifts to fund a named Fellow begin at $70,000 and can be fully endowed at the $1 million level. For more details or if you have any questions about making a gift to the School of Science, please contact:

**Elizabeth Chadis**
Assistant Dean for Development
MIT School of Science 6-131
77 Massachusetts Avenue
Cambridge, MA 02139
Tel: 617-253-8903
Email: echadis@mit.edu

Peter Fisher Visits California

Physics Department Head Peter Fisher gave a breakfast talk on October 17, 2014 at the Rosewood Sand Hill Hotel in Menlo Park, CA. Over a hundred alumni and friends, and many former students of Fisher’s, attended his talk titled “Big Bangs and Little Bumps: The Story of Dark Matter.” John Tsai ’83 (VIII), Ph.D. ’92 (VIII) introduced Fisher and welcomed everyone.

Starting from the Big Bang, dark matter has shaped our universe. Despite 80 years of study, we still know very little about dark matter. Fisher discussed what we do know about dark matter and the experiments to find out more. Fisher also gave attendees a dark matter box that he created (for more information, visit dark-matter.mit.edu). Fisher’s research is in particle physics in the areas of dark matter detection and the development of new kinds of particle detectors. He also has an interest in compact energy supplies and wireless energy transmission.

Peter Fisher, Head of the Department of Physics

To learn more about Peter Fisher and his research, visit sciencem.it/1ctktI3
On April 27, 2015, MIT released a report in which faculty and other researchers detail the specific impacts of declining federal investment in basic research. The report examines how funding cutbacks will affect the future of scientific studies in the U.S. and highlights opportunities in basic research that could help shape and maintain U.S. economic power and benefit society. The participants discuss 15 discrete areas in which government support is needed, including the need to expand research in neurobiology, brain chemistry, and the science of aging to develop new treatments for Alzheimer’s disease.

To read the report, visit sciencem.it/innovationdeficit