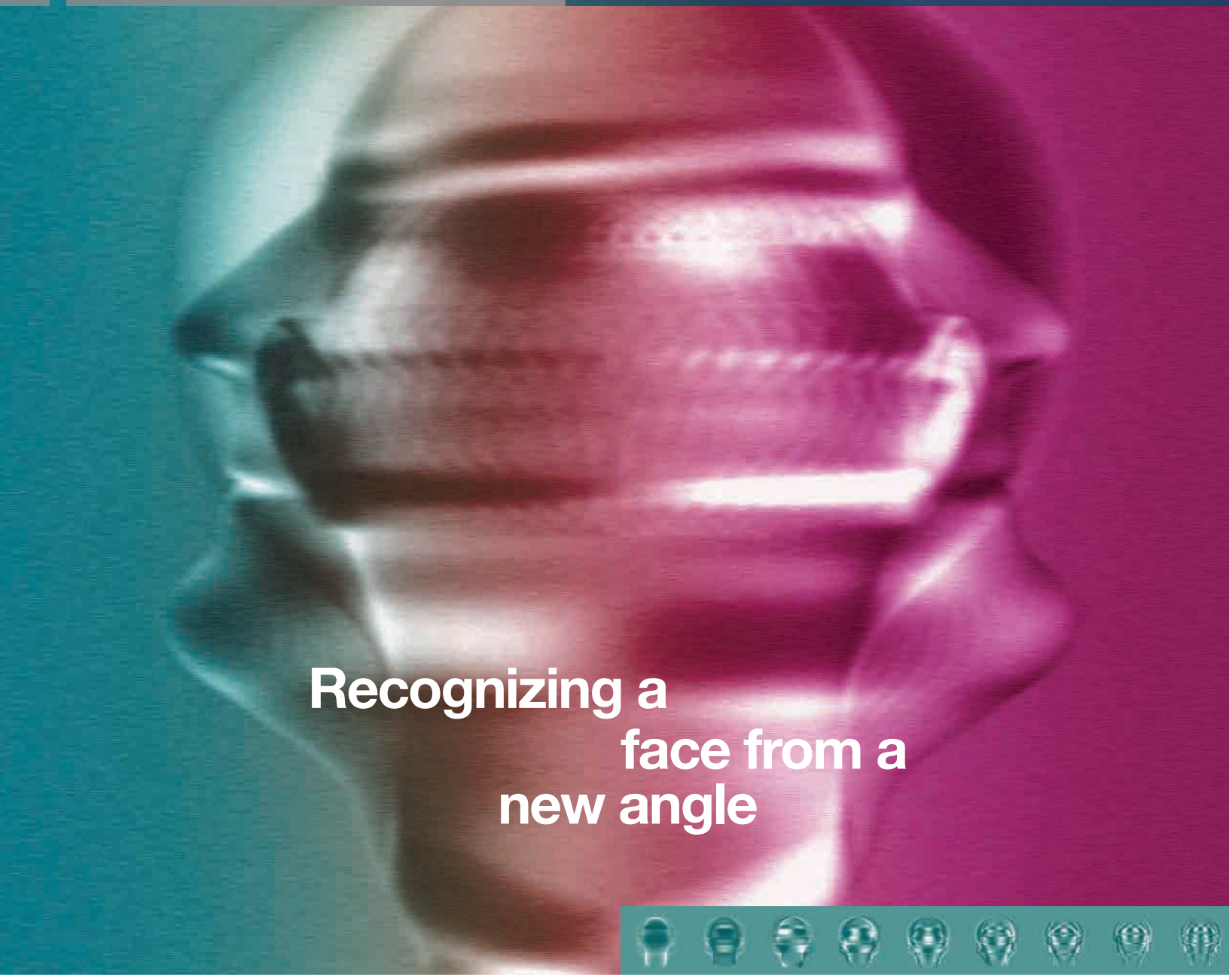
Massachusetts Institute of Technology

fall / winter 2013

bcsnews



Recognizing a face from a new angle

brain+cognitive sciences

contents

A Message from the Department Head
Jim DiCarlo

One of the many exciting aspects of working here together to understand how the brain gives rise to the mind is the fascination that our work holds for our colleagues in nearly every part of academia, as well as the general public. Since becoming Department Head, I have received many inquires from researchers, journalists and others looking to understand the cutting edge of our research, with an expectation that it will inform or inspire our work.

That widespread interest was in evidence at our "Day with MIT's Brains on Brains" event this past spring, when around 200 MIT community members joined us in building 46 for a full day of presentations. In my introductory talk entitled "Why Study the Brain?", I explained our shared mission of understanding how the brain gives rise to the mind, the importance of the distinctive BCS approach of bridging levels of analysis to accomplish that mission, and why this is such an exciting time in human history to be on this mission. In this issue of our newsletter, you'll find a recap of that event, along with a link to online videos of the talks – I highly encourage you to check them out.

One of the reasons for the widespread interest in our work is a sense that we are entering a key moment for our field, a period in which powerful new technologies are allowing neurosciences and cognitive scientists to join forces with computer scientists and engineers to accelerate progress on what is arguably the most important endeavor humans will ever undertake: reverse-engineering the brain. This fall, MIT launched two new interdisciplinary centers, spearheaded by BCS faculty, that represent major steps forward in that synergy. In this issue, we are excited to introduce you to both the Center for Neurobiological Engineering and the Center for Brains, Minds and Machines.

One of the best ways we can prepare for a potentially bright future is by insuring that our students are participating in building the future and are being well prepared to take over our lead. In this issue, we'll summarize some changes we are making to our undergraduate curriculum. They include a new introductory class that will give our students a strong foundation in computational and quantitative approaches to neuroscience, along with a commitment to build on those skills in our intermediate classes. These changes are the culmination of many discussions with our students and alumni and hard work by our faculty and staff, so I am very excited to see them roll out. Not only will they allow us to continue to meet our students' expectations of a world class education, but they will also keep our Department at the center of a field whose potential is evident to so many at MIT and throughout the world.

"Recognizing a face from a new angle" – Domain-specific regions, like the Fusiform Face Area, discovered by BCS faculty member Nancy Kanwisher, are a prominent feature of the brain's visual recognition system. Despite decades of interest from a large number of investigators in diverse fields – including medicine and psychology in addition to neurophysiology – employing methods ranging from human behavior and neuroimaging to electrophysiology, there has been surprisingly little theoretical work on "why" the visual recognition system may adopt this modular organization. A recent theory developed in the laboratory of BCS faculty member Tomaso Poggio may answer this question. The activity of a neuron can be thought of as measuring the similarity of its current input to the orbit (in the group theoretical sense) of a stored "template". Shown here is pictorial representation of the corresponding neural tuning of a cell in a brain region specialized for processing faces. Courtesy of the Center for Brains, Minds and Machines: Joel Z. Leibo.

MIT's Brains on Brains

A day exploring the minds and research of building 46

By Rachel Traughber, BCS

On April 30, 2013, the Department once again hosted its biennial symposium, **A Day with MIT's Brains on Brains**. Expanding this year from a half day symposium to a full day schedule offered attendees an even greater opportunity to experience the Department's wide variety of brain research topics and interact with faculty, students and researchers here in building 46.

"In creating the agenda for this year's Brains on Brains, we really wanted to expose our guests to a cross section of the research initiatives here in the brain and cognitive science community," explains BCS Department Head Jim DiCarlo.

Attendees were treated to a morning of short talks by BCS Professors Josh Tenenbaum, John Gabrieli, Rebecca Saxe, Feng Zhang and Mriganka Sur, ranging from presentations on technologies for engineering the brain and the study of intelligence to autism and dyslexia. A lunch with Department faculty, students and researchers allowed for plenty of one on one interaction at brain-themed tables to help guide conversation.

After lunch, guests attended their choice of two out of six breakout sessions featuring an hour of panel-led

continued on back cover

Interested in learning more about Brains on Brains? Visit **brains.mit.edu** for more information, including videos of this year's symposium.

MIT President Rafael Reif greets MIT Alumnus Paul Newton '65 (VIII), SM '67 (XV) at the Brains on Brains reception.

MRI Research Technician Steve Shannon leads a tour of the Martinos Center's MRI machine. Guests were allowed to select two breakout sessions during the afternoon.

School of Science Dean Marc Kastner chats with guests during lunch at the "Dean's Brain" table.

Brains on Brains 2013 breakout sessions

- Reverse Engineering the Brain: the World's Most Powerful Computer
- Transforming Education with a Science of Learning
- New Developments in Psychiatric Disease Research
- Advances in Autism: Reasons for Optimism
- Technologies for Understanding and Fixing the Brain
- A Tour of the Martinos Imaging Center

Undergraduate Education Reform at BCS

BCS community takes a close look at the undergraduate academic structure and culture

By Rachel Traughber, BCS

It's no secret that the Department of Brain and Cognitive Sciences at MIT is the home of one of the top neuroscience and cognitive science programs in the country – as recently as 2010, the National Research Council ranked it as the number one program for PhDs in neuroscience, and in the top five for cognitive science. BCS' world renowned faculty teach a breadth of subjects that touch on everything from psychology and biology to neuroscience.

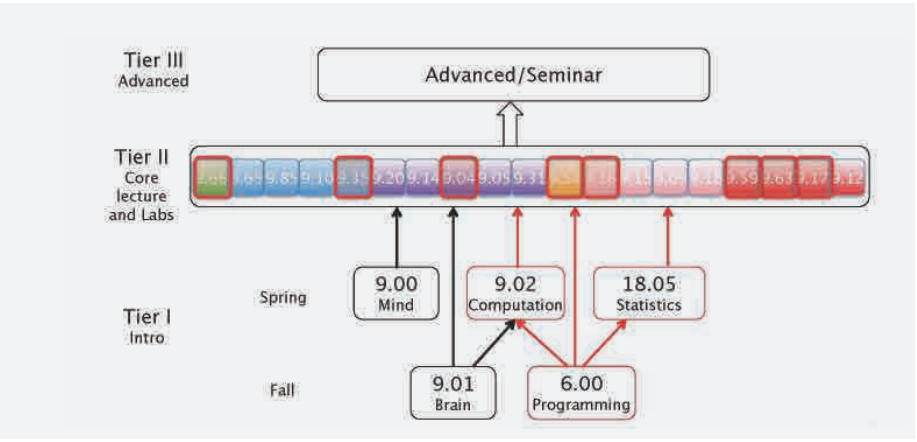
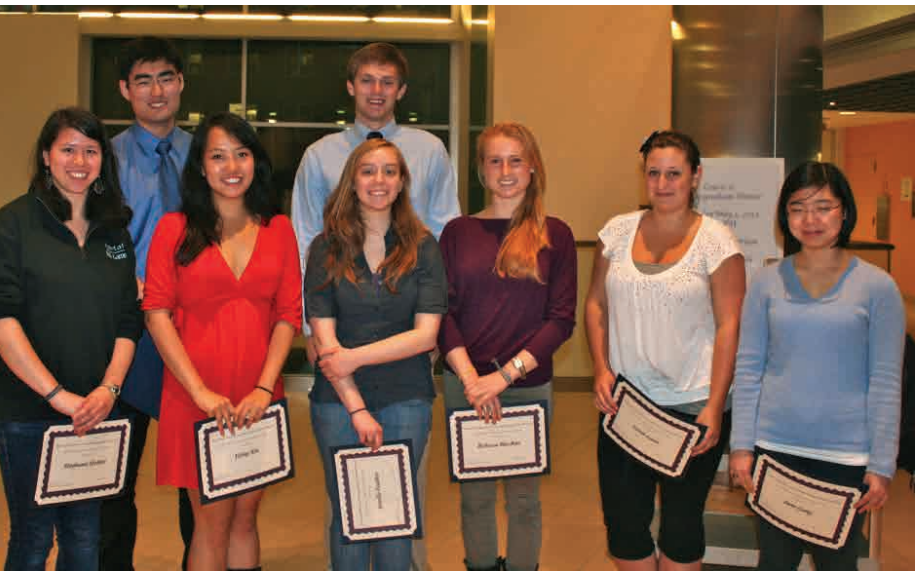


Figure 1.0
New undergraduate education curriculum model



BCS Undergraduates display recently won departmental academic awards. From left to right: Stephanie Holden, Daniel Han, Yijing Xin, William Watkins, Jenelle Feather, Rebecca MacRae, Sara Lund, June Geng

Making sure that BCS undergraduates have the opportunity to immerse themselves in this intellectual richness is a top priority for the Department.

"BCS undergraduates are the future of our fields," says Associate Department Head of Education and BCS Professor Michale Fee. "Within a decade or two, many will be our colleagues. A commitment to their education is a commitment to the future of neuroscience."

With this mission in mind, the Department's Education Committee began a full scale evaluation of the undergraduate curriculum during the 2011-2012 academic year. Through a series of meetings with students, faculty, and academic staff, the Committee developed a new curriculum model based on a tiered system that builds upon the expertise learned at each level over the course of a student's four years at MIT.

Tier I provides an introduction to the fields of cognitive science and neuroscience. Students moving on to Tier II experience the Department's core lectures and laboratory work, including cellular and molecular neuroscience, systems neuroscience, computation, cognitive neuroscience and cognitive science. In Tier III, students use the research skills gained during Tiers I and II to engage deeply in a topic. **(Figure 1.0)**

In addition to creating the tiered system, the Education Committee also recommended that the Department incorporate quantitative material early across the curriculum.

"To support the inclusion of more rigorous material in Tier II courses, we needed to provide students with a more solid mathematical, statistical and computer programming foundation," says Fee.

The Department will also offer a new Tier I course focusing on quantitative approaches to neural and cognitive science. Introduction to Programming (6.00) is now also a required course.

A phased rollout of the curriculum changes is planned over the next few academic years.

BCS Community News

Innovation, visibility and student achievements

Redesigning the content and structure of the curriculum is only the beginning. Last November, the Department applied for and received a grant from MIT's d'Arbeloff Fund for Excellence in Education. The Fund, established through a generous $10 million grant from Brit, SM '61, and the late Alex, '49, d'Arbeloff, supports undergraduate education innovation across MIT.

The Department's plans for the funds include helping faculty develop pedagogically inventive courses and raising the profile of undergraduate successes, from awards won by students to creating a space in the building where undergraduate academics are prominently displayed.

"The d'Arbeloff grant gives us a chance to really focus on raising the profile of undergraduate education at BCS," says BCS Undergraduate Officer and Associate Professor Laura Schulz. "Our students are so incredibly talented. I am very excited about sharing that talent with the wider MIT community."

Highlighting the teaching skills of BCS professors is another important part of the BCS use of the d'Arbeloff funds. Plans for a public display of teaching awards garnered by faculty are currently underway, along with the creation of short, 2-3 minute videos of faculty members teaching classes that will be displayed on the BCS website.

"BCS faculty are amazing teachers – we want to make sure that their skills do not go unrecognized," says Schulz.

To find out more about undergraduate education at BCS, please visit our website at **bcs.mit.edu/academics/undergrad.html**


1


2


3

1. **BCS welcomes new graduate students** Bottom row from left to right: Mike Reed, Chris Leppla, Tuan Le Mau, Josh Rule, Rosa Lafer-Sousa

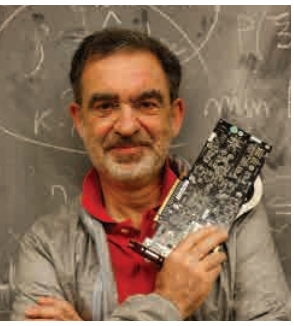
   Top row from left to right: Hongyi Zhang, Chen Sun, Jake Donoghue, Julia Leonard, Deniz Atabay, Alex Kell

2. **BCS's new graduate students welcomed** with high fives on the Department's annual boat cruise

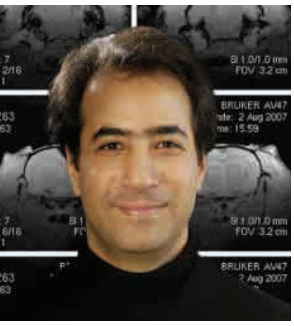
3. **BCS Professors Ann Graybiel, Guoping Feng and Mehrdad Jazayeri** serve ice cream to hungry postdocs in honor of National Postdoc Appreciation Week

Two New Neuro Centers Launch at MIT

By Rachel Traughber, BCS



Director of the Center for Brains, Minds and Machines Tomaso Poggio



Director of the Center for Neurobiological Engineering Alan Jasanoff

Photo credit: Oliviero Toscani

BCS News (BCSN) sits down with Tomaso Poggio, Director of the Center for Brains, Minds and Machines, and Alan Jasanoff, Director of the Center for Neurobiological Engineering

Mission: Center for Brains, Minds and Machines
"The vision of the Center for Brains, Minds and Machines is to develop a deep understanding of intelligence, and the ability to engineer it; to train the next generation of scientists and engineers in an emerging new field - the Science and Engineering of Intelligence; to catalyze continuing progress in and cross-fertilization between computer science, math and statistics, robotics, neuroscience, and cognitive science."

BCSN: Tell us a bit about the genesis of your Center.
Poggio: In 2009, then Provost Rafael Reif challenged the MIT faculty to come up with a grand research vision. [BCS Professor] Josh Tenenbaum suggested an initiative to combine cognitive science with computer science; at about the same time I suggested an effort to combine neuroscience with computer science. School of Science Dean Marc Kastner and then BCS Department Head Mriganka Sur encouraged Josh and me to join forces in a collaboration which became the Intelligence Initiative, which in its first workshop at the American Academy of Arts and Sciences attracted more than 50 MIT faculty from all Schools of the Institute. We later decided to apply for a more focused NSF grant project which is at the foundation of the new CBMM.

BCSN: What are the Center's most pressing goals over the next few years?
Poggio: Of all the great problems of science, I believe intelligence is the greatest. If we can make progress on the problem of intelligence, we can then make smarter machines, perhaps make ourselves smarter, and thereby solve more easily some of the other great problems in science, technology and society. I think the next few decades will be a golden age for narrowly intelligent systems; but machines which are intelligent as we are will require basic science efforts such as ours.

While our main goal is to develop a science of intelligence that spans several disciplines – mainly neuroscience, cognitive science and computer science – I also believe that our Center can shape a new approach towards understanding brains and computers. As importantly, we will be training a new generation of students and postdocs in these new scientific fields between cognitive neuroscience and computer science.

The initial NSF grant is for five years, with a good chance of an extension for another five, giving us ten years to work on this ambitious set of research and educational goals.

BCSN: How much student involvement do you anticipate?
Poggio: One of the important components of our NSF grant is building courses for both graduate and undergraduate students. Several CBMM faculty at MIT and at Harvard are already teaching courses that quite naturally fit as part of the Center. For example, Josh Tenenbaum currently teaches a course on computational cognitive science, I teach on the mathematics of machine learning – these also fit under the CBMM umbrella. We also plan on organizing a summer school at Woodshole and a few technical workshops each year.

Learn more about the Center for Brains, Minds and Machines by visiting their website http://cbmm.mit.edu/

Mission: Center for Neurobiological Engineering
"Reverse engineering the brain will require tremendous innovation in the technologies for measuring, manipulating, and analyzing processes and functions of the nervous system. The Center for Neurobiological Engineering brings together MIT's unique, transdisciplinary set of engineers and scientists to tackle the challenges of this field."

BCSN: How did the idea for your Center come about?
Jasanoff: Around a year ago I was preparing a presentation with other faculty members on various Centers belonging to the Institute. During the course of our discussion, it became evident that while there were a number of excellent Centers at MIT, none of them focus broadly on the interface between neuroscience and engineering. We realized there was a real need to create a "base" for the many faculty, students and postdocs from across the Institute who are pioneering innovative engineering-based approaches to study the brain – and the planning for CNBE began.

BCSN: CNBE faculty hail from a broad range of Departments across campus. How did you find them all, and do you see the Center expanding beyond MIT?
Jasanoff: One of the major goals of CNBE is to bring together people across the Institute whose research interests span an array of technologies that can advance brain research. Fortunately, the richness of MIT's intellectual diversity naturally lends itself to this type of interdisciplinary study. We searched the Institute for people

continued on back cover

Noteworthy News

Faculty

Profs. Bob Desimone, Ed Boyden, Emery Brown and **Sebastian Seung** were invited to the White House for President Obama's announcement of the BRAIN Initiative.

Associate Professor Ed Boyden also received both a Pioneer Award for his project "Millisecond-Timescale Whole-Brain Neural Activity Mapping in Health and Disease" as well as a Transformative R01 Award for his project "Recording neural activities onto DNA."

Prof. Martha Constantine-Paton was elected to the American Academy of Arts and Sciences.

Institute **Prof. Ann Graybiel** was invited to the White House to meet President Obama in recognition of her Kavli Award.

Assistant Prof. Myriam Heiman and her laboratory received an "On-the-Spot" Award for establishing and maintaining a high level of safety.

Prof. Sebastian Seung was selected by MIT to hold the Dorothy W. Poitras Professorship for the next five years, a chair previously held by **BCS Prof. Emeritus Peter Schiller.**

Prof. Josh Tenenbaum was elected a Fellow of the Cognitive Science Society.

Assistant Prof. Kay Tye was selected by the Esther A. and Joseph Klingenstein Fund to receive a Klingenstein Fellowship. She was also selected by MIT to receive the Whitehead Career Development Chair, and awarded the Director's New Innovator Award from NIH for her project "A Novel Strategy for Combating Obesity: Reprogramming Neural Circuits."

Prof. Feng Zhang was selected by MIT to receive the Keck Career Development Chair. He also received a Vallee Foundation Young Investigator Award, was selected as one of *MIT Technology Review's* 2013 list of "Innovators under 35" and named one of Popular Science's yearly "Brilliant Ten" for his work on open-source genetic engineering techniques.

Postdocs and students

Dr. Suhasa Kodandaramaiah, a postdoc in Prof. Ed Boyden's lab, has been named by Forbes Magazine to their "30 Under 30" list of rising stars in the field of science and healthcare.

Grad student **Steve Ramirez** was selected as one of *MIT Technology Review's* 2013 list of "Innovators under 35."

The following Course 9 students were inducted into Phi Beta Kappa:

Hamsika Chandrasekar
June Geng
Elia Harmatz

The following students received their PhDs from our department:

Dr. Ben Auerbach
Dr. Krista Ehinger
Dr. Hyowon Gweon
Dr. Mark Howe
Dr. Ni Ji
Dr. Li-Wei King
Dr. Stuart Layton
Dr. Retsina Meyer
Dr. David Osher
Dr. Zeynep Saygin
Dr. Susan Su
Dr. Nathaniel Twarog
Dr. Veronica Weiner

The following students graduated from MIT with Bachelor's degrees in Brain and Cognitive Sciences:

Heather E. Acuff
Shivani Agarwal
Jennifer Bustamante
Hamsika Chandrasekar
Camila Caballero
Elizabeth Cain
Ian Cinnamon
Beverly G. Cope
Margaret Mary Cunniff
Jeremy Dalcin
Kathryn Dere
Swethasri Dravida
Joy Ekuta
Margarita Esteban
Jenelle Feather
June Geng
Chelsi Green
Sahar Hakim-Hashemi
Elia S. Harmatz
Connor Kirschbaum
Arooshi Kumar
Smriti Kumar
Allison Lee
Margaret Lee
Eugenia Luo
Carine Moezinia
Claire O'Connell
Victoria Okuneye
Catherine Olsson
Jessica Pourian
Carolina Roque
Alireza Samiei
Soraya Shehata
Elise Stave
Aparna Sud
Alissa Totman
Adrienne Tran
Lily Tran
Huaiying Wang
Shawn Wen
Phyllis Yan
Jeanne Yu
Fangheng Zhou

Alumni

BCS alumnus and McGill **Professor Emeritus Ronald Chase** recently published a book entitled *Schizophrenia: A Brother Finds Answers in Biological Science*. The book tells the story of his brother's life and explores the scientific challenges presented by schizophrenia. Chase studied at MIT to learn how the brain works so that he might better understand mental illness.

brain+cognitive sciences

Massachusetts Institute of Technology
77 Massachusetts Ave
Cambridge, MA 02139

NON PROFIT ORG.
U.S. Postage
Paid
Cambridge, MA
Permit No. 54016

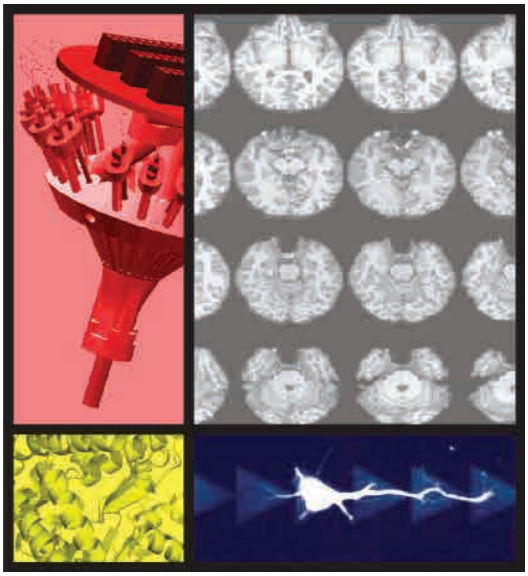
continued from p.03

BCS Associate Professor Rebecca Saxe during her presentation "It's the thought that counts: how our brains think about other people's thoughts" at Brains on Brains 2013.

discussion. Institute Professor Ann Graybiel provided the symposium with its first keynote address in a special colloquium entitled "Making and Breaking Habits: The Basal Ganglia in Action." Special guest MIT President Rafael Reif brought the symposium to a close, thanking both guests and presenters and kicking off the reception.

continued from p.06

working on cutting-edge neurobiological technologies, many of whom make up our initial core group of 20 investigators and their associated laboratories. Today, the Center is exclusive to MIT, but long term, we envision collaborations with hospitals as a natural fit. Because we create and research technologies, developing relationships with local and international industry partners also makes sense.



Snapshots illustrating some of the neurotechnologies being developed and used by CNBE laboratories.

BCSN: Do you plan on offering any coursework for students?

Jasanoff: Yes! Many of the courses our faculty currently teach contribute directly to the Center's mission. We are also developing a capstone graduate course that will be modeled around a rotation concept – small modules where graduate students and senior undergraduates can be exposed to a variety of cutting edge brain technology research in MIT labs.

BCSN: Where do you see CNBE in the next five to ten years?

Jasanoff: Well, in ten to fifteen years the major research questions about the brain won't be solved, so there will be plenty for us to do. One of our major tasks is to push forward the field of neuroscience by partnering the people who are neuro-tool makers with those who will use them. We are also working on training grant applications for NIH and NSF, funding for core facilities, and possibly resources for a seed grant program.

Learn more about the Center for Neurobiological Engineering on their website http://web.mit.edu/cnbe/