McGovern Institute for Brain Research

The McGovern Institute for Brain Research at MIT is led by a team of world-renowned neuroscientists committed to meeting two great challenges of modern science: understanding how the brain works and discovering new ways to prevent or treat brain disorders. The McGovern Institute was established in 2000 by Patrick J. McGovern and Lore Harp McGovern, who are committed to improving human welfare, communication, and understanding through their support for neuroscience research. Patrick McGovern passed away March 2014.

Faculty Changes

The McGovern Institute welcomed one new faculty member, Gloria Choi, in FY2014, as assistant professor in MIT's Department of Brain and Cognitive Sciences. She was previously a postdoctoral researcher with Richard Axel at Columbia University in New York.

Professor Choi's current research is focused on neural circuits underlying motivated behaviors in the olfactory systems, using a combination of anatomy, imaging behavior, optogenetics, and molecular manipulations. She is interested in bringing modern molecular tools to bear on systems-level questions.

Resource Development

Fundraising from individuals and private foundations remains a priority at the McGovern Institute. Staff hosted multiple donor cultivation events during the fiscal year, and faculty and staff met with more than 50 donors and prospects in Cambridge, New York, Florida, and California.

The institute raised over $2 million in cash gifts and pledge payments from individuals, companies, and small family foundations in FY2014. This figure includes new commitments of $625,000 in planned gifts.

Annual Symposium

Our 2014 symposium, Disruptive Innovations in Neuroscience, was held on May 2 and was organized by professor Feng Zhang. The ten speakers discussed ways in which technological advances in genomics, proteomics, microscopy, and nanotechnology are enabling new discoveries in neuroscience.

Other Events

The 2014 Scolnick Prize was awarded to Huda Zoghbi, a Howard Hughes Investigator, director of the Jan and Dan Duncan Neurological Research Institute at Texas Children's Hospital, and professor at Baylor College of Medicine. Dr. Zoghbi uses genetic, biochemical, and cell biological approaches to explore the pathogenesis of polyglutamine neurodegenerative diseases and Rett syndrome and to study genes essential for normal neurodevelopment. Her lecture, given on April 30, was titled "Tipping Point: MeCP2 and Neuropsychiatric Disorders."

The annual Phillip A. Sharp Lecture in Neural Circuits (endowed by Biogen Idec in honor of the McGovern Institute's founding director) was given by May-Britt Moser from the Norwegian University of Science and Technology on February 5 and was titled "Grid Cells, Place Cells and Neural Maps for Space."

Annual Retreat

The McGovern Institute joined with the Picower Institute for Learning and Memory and the Department of Brain and Cognitive Sciences at MIT to hold a joint retreat at the Sea Crest Beach Hotel in Falmouth, MA. The two-day event held in June was attended by over 300 people studying brain science. It provided a tremendous opportunity for scientists to share highlights of their work and to get to know fellow researchers they may not have met before. There were 15 talks, a very large poster session, and many opportunities to interact.

McGovern Institutes in China

There are now three International Data Group (IDG)-McGovern Institutes in China—at Tsinghua University, Beijing Normal University, and Peking University. The McGovern Institute at MIT hosted a joint symposium in Cambridge with the three IDG-McGovern Institutes in the spring of 2014 that featured speakers from the Chinese institutes. In 2015 there will be a similar event held in China.

Board of Directors

The McGovern Institute Board of Directors meets quarterly—in July, October, January, and April. The membership of the board changed during FY2014. The current board includes: Lore McGovern; Elizabeth McGovern; Michael Sipser, MIT; Robert Langer, MIT; Edward Scolnick, Broad Institute; Sheila Widnall, MIT; and James Poitras, Avalon Mining, Inc. In January 2014, Marc Kastner stepped down as dean of the School of Science and was replaced by Michael Sipser, who also joined the board. The sudden death of Pat McGovern in March 2014 left the board with an empty seat, to be filled by a member of the McGovern Foundation.

The McGovern Institute Leadership Board meets twice per year. The board participates in programming at the McGovern Institute and interacts with the director and faculty members throughout the year, providing critical funding and strategic advice to the institute.

Core Laboratories

The McGovern Institute operates several core laboratories that serve the local neuroscience community, including but not confined to members of the McGovern Institute.

Martinos Imaging Center at MIT

The Martinos Imaging Center provides access to neuroimaging technologies, including two 3Tesla magnetic resonance imaging (MRI) scanners for human brain imaging, a 9.4Tesla MRI scanner for small animal imaging, a magnetoencephalography scanner, and an electroencephalography system. There is also a coil fabrication lab and a mock MRI scanner to help subjects (especially children) adapt to the scanning environment.

Viral Gene Transfer Core

The viral core is a joint project of the McGovern and Picower Institutes. It operates on a fee-for-service basis to provide viral vector technologies to neuroscience researchers inside and outside MIT.

Two-photon Microscopy Core

This core features a sophisticated two-photon system with four lasers to support two-color imaging and uncaging. The system includes two workstations configured for slice physiology and whole animal work. It was upgraded to include an electrophysiology system.

McGovern Institute Neurotechnology Program

The McGovern Institute Neurotechnology (MINT) Program provides seed funding for collaborations between McGovern labs and researchers from other disciplines within and beyond MIT, with a focus on developing new technologies for brain research. Since its establishment in 2006, the MINT program has supported over 30 projects. Collaborating principal investigators are from multiple departments and schools at MIT and from other institutions, including the Broad Institute, Massachusetts General Hospital, and Mclean Hospital.

Awards and Honors

Martha Constantine-Paton was inducted into the American Academy of Arts and Sciences on October 12, 2013.

Mehrdad Jazayeri and Gloria Choi were among nine MIT researchers to be named 2014 Sloan Research Fellows. These fellowships are awarded each year to early-career scientists "in recognition of distinguished performance and a unique potential to make substantial contributions to their field."

Rebecca Saxe received a Troland Research Award from the National Academy of Sciences. The Troland Award "recognizes unusual achievements and further empirical research in psychology regarding the relationships of consciousness and the physical world."

Zeynep Saygin, a postdoc in Nancy Kanwisher's lab, has been named a winner of the 2014 Wellcome Image Awards for her work visualizing connections in the human brain. The awards recognize the "most informative, striking and technically excellent images" recently acquired by the Wellcome Image Gallery.

Feng Zhang was named the winner of the 2014 National Science Foundation (NSF) Alan T. Waterman Award. The award is NSF's highest honor for outstanding researchers under the age of 35, across all areas of science and engineering. The Waterman Award was presented to Dr. Zhang at a ceremony at the US Department of State in Washington, DC.

Feng Zhang was listed by MIT Technology Review as a key player in the field of genome editing, one of the magazine's 10 Breakthrough Technologies for 2014.

Gloria Choi and Feng Zhang have been named among Cell's "40 Under 40."

Feng Zhang is the co-recipient of the 2014 Gabbay Award in biotechnology and medicine from Brandeis University.

Summary of Recent Published Scientific Advances

Evelina Fedorenko and Nancy Kanwisher collaborated with John Duncan in Cambridge, UK to map for the first time a network of brain regions important for many demanding different executive control tasks. They have discovered that these "multi-purpose" regions are interspersed between other brain regions that are highly specialized for particular functions such as language, number processing, or face recognition.

John Gabrieli's lab, in collaboration with Boston Children's Hospital, has used brain imaging to identify young children who are at risk for dyslexia. In a study of 40 kindergarteners, poor pre-reading skills—a known predictor of dyslexia—were correlated with structural differences in the left arcuate fasciculus, a large bundle of fibers that connect different brain areas involved in speech production and comprehension.

John Gabrieli and colleagues—including his brother Chris Gabrieli, a prominent advocate for education reform—have examined the relationship between test scores and cognitive skills in a large sample of disadvantaged eighth grade students. The authors found that schools that raise state test scores do not also influence a set of cognitive skills, like abstract reasoning, that are typically associated with achievement in many areas of life. These findings raise questions about the relative roles of school learning and cognitive skills in life success, and also suggest opportunities for schools to focus new efforts directly on raising cognitive skills.

John Gabrieli and colleagues examined the phenomenon of letter reversal in children, based on the observation that young children frequently write letters in mirror image. By comparing brain responses to normal versus mirror-reversed letters in children and adults, they showed that the distinction between correct and reversed letters emerges slowly during development.

John Gabrieli's lab has examined adults who were diagnosed with Attention Deficit Hyperactivity Disorder during childhood, and compared those who did or did not recover by adulthood. The groups show different patterns of activity within a brain system known as the default network. Understanding these differences may eventually make it possible to predict which therapeutic approaches are likely to work for a given patient.

Using new technology for tracking dopamine concentrations in real time, Ann Graybiel and colleagues found that dopamine is released gradually as rats navigate a maze in search of reward. Dopamine is known to be important for reward-motivated behaviors. A similar mechanism in humans could explain our ability to remain focused on distant goals in the face of distraction, and it may also explain why patients with Parkinson's disease, in which dopamine signaling is impaired, often have difficulty in sustaining motivation to finish tasks.

Ann Graybiel's lab also described two populations of neurons in the ventral striatum that can signal both positive and negatives outcomes as animals learn to perform a task for a reward. The authors suggest that dysfunction in this neural signaling process may contribute to the apathy of mood that is often seen in depression.

Feng Zhang previously described a new method for genome editing based on a bacterial nuclease system called Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR). Zhang's group has now modified the method to make it up to 1,500 times more accurate, potentially removing one key barrier to future clinical applications.

Feng Zhang, in collaboration with researchers at the University of Tokyo, described the structure of the cas9 complex, which is the central component of the CRISPR genome editing technology. The structure reveals how cas9 can make precisely targeted cuts in a sequence of DNA, and is expected to lead to further improvements in the technology in future. In a separate study, Feng Zhang collaborated with Phil Sharp to examine the molecular mechanism by which the CRISPR complex finds its DNA targets.

Feng Zhang's lab has developed a way to control gene expression with light. The method exploits a light-sensing mechanism from plants, which can be targeted to any gene of interest using customized DNA-binding proteins. This versatile method is likely to have many applications in basic and disease research.

Ki Goosens's lab has discovered that the hormone ghrelin, known as the "hunger hormone," may also be a key to post-traumatic stress disorder. Ghrelin released during chronic stress makes the brain more susceptible to fearful memories, suggesting that drugs that block ghrelin may lessen the effects of chronic stress.

Tomaso Poggio's group has used magnetoencephalography (MEG) to track the flow of visual information through a succession of human brain regions that are responsible for object recognition. This is the first publication to emerge based on data from the group's new MEG scanner.

Martha Constantine-Paton and colleagues report that the amino acid homocysteine, whose levels are elevated in patients with schizophrenia, can alter the activity of NMDA-type glutamate receptors. Disruption of glutamate signaling has been implicated in schizophrenia, and the newly discovered effect may contribute to the pathophysiology of the disease.

Martha Constantine-Paton collaborated with Ed Boyden to develop a new optogenetic method that allows researchers to control the activity of two separate populations of neurons simultaneously, using two different colors of light.

James DiCarlo and colleagues screened a large number of computer models for the ability to recognize visual objects. The best model performs as well as human observers on a range of visual tasks, and it also shows many resemblances to the known properties of the brain's visual system, even though it was not specifically constrained to do so.

Alan Jasanoff's group developed a molecular sensor for the neurotransmitter dopamine, and showed that it can be used to image dopamine signals in the living brain.

In a separate study, Alan Jasanoff and colleagues described a new MRI-based method for imaging gene expression in the brains of living animals. The technique is expected to enable new ways to study brain plasticity and learning, and it may also have applications in many other areas of biology.

Robert Desimone's lab used MEG to identify a human brain circuit that directs visual attention to different categories of objects.

Rebecca Saxe and colleagues identified patterns of brain activity associated with willingness of group members to harm individuals from a competing group. People in such situations show reduced activation of brain regions implicated in moral self-scrutiny. In this laboratory-based study the "harm" consisted of posting unflattering photos, but the findings may also be applicable to real-world group conflicts.

Rebecca Saxe has previously identified a brain region involved in understanding the mental states (such as beliefs) of other people. In a new study, her group shows that this region represents the source of those beliefs (for example, whether the subject's belief was based on what they saw or what they heard), and that this distinction exists even in congenitally blind individuals who have no direct experience of what it means to see.

Previous work from Nancy Kanwisher's lab has demonstrated the existence of a brain system for language that is separate from the "multiple demand network" that is involved in many types of cognitively demanding tasks. A new study from Kanwisher and colleagues shows that activity is strongly correlated within the components of each network, but only weakly or negatively between the two networks, supporting the view that these two systems are functionally distinct.

Many groups have reported differences in brain structure in children with autism. But a new study by Nancy Kanwisher and colleagues casts doubt on some of these claims, showing that they may simply reflect the fact that subjects with Autism Spectrum Disorder often find it hard to lie still in the MRI scanner. One result that does appear conclusive, however, is that autistic individuals show differences in a bundle of fibers thought to underlie the processing of visual objects such as faces.

Dimitrios Pantazis, director of the magnetoencephalograpy lab, collaborated with Computer Science and Artificial Intelligence Laboratory researchers to study how the human brain recognizes and classifies visual objects. Their study uses a novel method to align MEG and MRI scans, allowing researchers to localize brain activity with a level of precision not previously possible.

Ed Boyden's lab and the University of Vienna have created an imaging system that reveals neural activity throughout the brains of living animals. This technique, the first that can generate 3-D movies of entire brains at the millisecond timescale, could help scientists discover how neuronal networks process sensory information and generate behavior.

Ed Boyden's team developed a light-sensitive molecule that enables neurons to be silenced noninvasively, using a light source outside the skull. The engineered protein, known as Jaws, makes it possible to do long-term studies without the need for a surgically implanted light source. This paper will publish on July 6.

Emilio Bizzi's lab showed for the first time that muscle movements can be controlled by applying optogenetics to the spinal cords of animals that are awake and alert. This work opens the door to a detailed understanding of the spinal circuits that control movement with a level of precision not previously possible.

A new computational model developed by the Bizzi Lab explains how the brain maintains the balance between plasticity and stability, and how it can learn very similar tasks without interference between them.

Robert Desimone
Director
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