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.

Faculty Changes

The McGovern Institute welcomed one new faculty member in FY2013. Mehrdad Jazayeri joined the institute in January 2013 with a faculty appointment as assistant professor in the Department of Brain and Cognitive Sciences. He was previously a postdoctoral researcher with Michael Shadlen at the University of Washington, Seattle. Professor Jazayeri studies the brain's timekeeping mechanisms at the levels of neurons, circuits, and behavior. He uses theoretical models, electrophysiological recording, and optogenetic manipulations to understand how the brain controls behavior with flexible timing.

Resource Development

Fundraising from individuals and private foundations remains a priority at the McGovern Institute. 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.

More than $1.1 million in cash from 154 individuals and companies was donated to the McGovern Institute in FY2013.

Annual Symposium

The 2013 McGovern Institute annual symposium, held on May 8, 2013, was titled Neural Control of Movement: Models, Representations, and Brain-Machine Interfaces. The organizer was Institute Professor Emilio Bizzi. The event featured nine speakers from the US and Israel, who explored the question of how the brain controls muscles: what computations does it perform, how and where in the brain does this happen, and how can this knowledge be exploited for rehabilitation and for the development of neural prosthetics.

Other Major Events

The 2013 Scolnick Prize was awarded to Thomas Jessell, of Columbia University, a leading expert on the development and function of the spinal cord. Jessell's lecture, given on April 1, 2013, was titled "Sifting Circuits for Motor Control."

The annual Phillip A. Sharp Lecture in Neural Circuits (endowed by Biogen Idec in honor of the McGovern Institute's founding director, Phillip Sharp) was given by Karel Svoboda of the Howard Hughes Medical Institute, on March 14, 2013, and was titled "The Cortical Circuits and Neural Codes Underlying Tactile Sensation."

Annual Retreat

The McGovern Institute's annual retreat was held at Seacrest Resort, in Falmouth, MA, in June 2013. The two-day event was attended by over 150 people. The keynote presentation was given by new faculty member Mehrdad Jazayeri, and there were 16 talks and numerous poster presentations from McGovern Institute laboratories.

McGovern Institutes in China

Following the April 2011 announcement of the International Data Group/McGovern Institute for Brain Research at Tsinghua University, two more such institutes have been initiated, at Peking University and Beijing Normal University.

Board of Directors and Leadership Board

The McGovern Institute board of directors meets quarterly, in July, October, January, and April. The membership of the board remains unchanged since last year, and includes Patrick McGovern; Lore McGovern; Elizabeth McGovern; Marc Kastner, MIT; Robert Langer, MIT; Edward Scolnick, Broad Institute; Sheila Widnall, MIT; and James Poitras, Avalon Mining, Inc.

The McGovern Institute Leadership Board meets twice per year. The Leadership 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 McGovern 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 Center provides access to neuroimaging technologies, including a 3 Tesla (3T) magnetic resonance imaging (MRI) scanner for human brain imaging, a 9.4T MRI scanner for small animal imaging, a magnetoencephalography scanner, and an electroencephalography system. There is also a coil fabrication laboratory and a mock MRI scanner to help subjects (especially children) adapt to the scanning environment. A second human MRI scanner was purchased recently and is expected to become operational by fall 2013. The center recently recruited a new assistant director and MRI physicist, Atsushi Takahashi, formerly a senior scientist at General Electric and an affiliate of Stanford University.

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 is currently being upgraded to include an electrophysiology system.

McGovern Institute Neurotechnology Program

The McGovern Institute Neurotechnology Program (MINT) provides seed funding for collaborations between McGovern Institute laboratories and researchers from other disciplines within and beyond MIT, with a focus on developing new technologies for brain research. Since its establishment in 2006, MINT has supported over 25 projects, including five new projects initiated within the reporting period. 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

Robert Desimone and Edward Boyden were invited to the White House on April 2, 2013, for President Obama's BRAIN (Brain Research through Advancing Innovative Neurotechnologies) Initiative announcement. Two other MIT faculty members, Emery Brown and Sebastian Seung, also attended the event.

In a separate event at the White House, Ann Graybiel was invited to a private meeting with President Obama on March 28, 2013, along with the other US-based winners of the 2012 Kavli Prize (including Jane Luu and Mildred Dresselhaus, of MIT).

Martha Constantine-Paton was elected to the American Academy of Arts and Sciences. The induction ceremony is scheduled for October 12, 2013. She also won a lifetime achievement award from the Society for Neuroscience, and the Dean's Medal from Tufts University, her alma mater.

Edward Boyden was among six scientists who shared the 2013 Grete Lundbeck European Brain Research Prize, the world's largest prize for neuroscience, with a value of one million euros. The award was given for the development of optogenetics, a technology that makes it possible to control brain activity using light. In announcing the prize, the chairman of the selection committee described optogenetics as "arguably the most important technical advance in neuroscience in the past 40 years."

Boyden was also the inaugural winner of the A. F. Harvey Engineering Research Prize. The prize, awarded by the London-based Institute of Engineering and Technology, is worth £300,000 and recognizes outstanding contributions to research in the field of medical engineering. In addition, Boyden shared the Gabbay Award in Biotechnology and Medicine from Brandeis University, along with two other pioneers in optogenetics: Karl Deisseroth of Stanford University, and Gero Miesenbock of the University of Oxford. Finally, Boyden was invited for the second year in succession to speak at the World Economic Forum held in Davos on Jan 23-27, 2013.

Suhasa Kodandaramaiah, a postdoctoral researcher in Professor Boyden's laboratory, was named by *Forbes Magazine* to their "30 Under 30" list of rising stars in the field of science and healthcare.

Guoping Feng was the recipient of the 2012 Gill Young Investigator Award from Indiana University. The award recognizes "exceptional scientists who have emerged as international leaders in cellular, membrane, or molecular neuroscience."

Major Research Publications

Robert Horvitz and colleagues identified a genetic pathway in nematode worms that controls the response to re-oxygenation following oxygen deprivation. A similar mechanism in humans may be important in reperfusion injury. *Science*: http://www.ncbi.nlm.nih.gov/pubmed/23811225

Ann Graybiel's laboratory used optogenetics to block compulsive behavior in mice—a result that could help researchers develop new treatments for diseases such as obsessive-compulsive disorder and Tourette's syndrome. *Science*: http://www.ncbi.nlm.nih.gov/pubmed/23744950

Graybiel and colleagues examined brain activity as a learned behavior that is initially goal-directed and becomes habitual through repetition. Using optogenetics to disrupt this activity, they were able to prevent habit formation without blocking goal-directed learning. *Neuron*: http://www.ncbi.nlm.nih.gov/pubmed/23810540

Graybiel's lab showed that habits can be rapidly switched on or off. By using optogenetics to disrupt a specific region of cortex in rats, they could reversibly suppress a recently formed habit, revealing a previous habit that had been "overwritten" by the more recent one. The results are potentially relevant to human habitual behaviors, suggesting that bad habits, including addiction, are potentially reversible. *PNAS*: http://www.ncbi.nlm.nih.gov/pubmed/23112197

Feng Zhang collaborated with Rudolf Jaenisch at the Whitehead Institute to show that the Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) DNA-editing system, which Professor Zhang pioneered, can be used to generate mice with multiple targeted gene mutations in a single step. The new method has the potential to greatly accelerate many types of genetic studies. *Cell*: http://www.ncbi.nlm.nih.gov/pubmed/23643243

Zhang and colleagues developed a new method for editing genomic sequences, based on a naturally occurring bacterial nuclease system known as CRISPR. The method is fast, simple, and cheap compared to existing technologies, and should enable genetic manipulations in a wide range of species. *Science*: http://www.ncbi.nlm.nih.gov/pubmed/23287718

John Gabrieli and colleagues cast doubt on the widely publicized claim that memory training can raise human intelligence. In an attempt to replicate the original finding, the MIT researchers confirmed that practice improves performance on the specific task, known as dual n-back; however, the effect did not generalize to other standardized measures of intelligence. *PLOS [Public Library of Science] One*: http://www.ncbi.nlm.nih.gov/pubmed/23717453

Martha Constantine-Paton and colleagues studied a mutant mouse strain known as Flailer, showing that it has a defect in a cellular motor that is needed to transport synaptic proteins to their proper sites. Flailer mice show many behavioral abnormalities and may be a useful model for studying the neural circuits affected by psychiatric disorders. *Journal of Neuroscience*: http://www.ncbi.nlm.nih.gov/pubmed/23658184

Rebecca Saxe and colleagues studied the patterns of brain activity that underlie moral judgments about other people's actions. Compared to neurotypical individuals, people with autism give less weight to the beliefs and intentions of actors, relative to the consequences of their actions, when assigning moral responsibility. Using functional MRI (fMRI), the researchers identified patterns of neural activity that may underlie these differences in judgment. *Proceedings of the National Academy of Sciences (PNAS)*: http://www.ncbi.nlm.nih.gov/pubmed/23479657

Nancy Kanwisher and colleagues used transcranial magnetic stimulation to identify a human brain region that underlies our ability to recognize scenes. The existence of this area (which they call the occipital place area) had been suggested from brain imaging studies, but never proved until now. *Journal of Neuroscience*: http://www.ncbi.nlm.nih.gov/pubmed/23345209

A study from Nancy Kanwisher challenged the common view that people with autism are less able to process global information relative to local information. The study found that autistic children are equally able to process global patterns when so instructed, but prefer to focus on local information when given the choice. This suggests that other features of autism might also reflect disinclination rather than disability, which could have important implications for remediation therapies. *Journal of Autism and Developmental Disorders*: http://www.ncbi.nlm.nih.gov/pubmed/23378063

Martha Constantine-Paton and colleagues studied a postsynaptic scaffolding protein known as SAP102 that has been previously implicated in X-linked mental retardation. They used virally delivered siRNA to show that SAP102 is required for proper localization of glutamate receptors at synapses, and identified some of the downstream signals that mediate these effects. *Journal of Neuroscience*: http://www.ncbi.nlm.nih.gov/pubmed/23486974

John Gabrieli's group used real-time fMRI to identify brain states associated with faster or slower reaction times. (The task is to press a button as fast as possible in response to a visual stimulus.) By controlling the time of stimulus presentation relative to brain states, they were able to manipulate the speed of their subjects' reactions. *Journal of Neurophysiology*: http://www.ncbi.nlm.nih.gov/pubmed/23236006

Ann Graybiel's lab studied how the activity of the striatum is disrupted by loss of dopamine (a key feature of Parkinson's disease) and how these changes are reversed by the drug L-DOPA, commonly used to treat Parkinson's disease. They showed in a rat model that L-DOPA treatment normalizes the activity of striatal projection neurons but not local interneurons. *Journal of Neuroscience*: http://www.ncbi.nlm.nih.gov/pubmed/23486949

Emilio Bizzi studied how the motor cortex controls hand movements. By applying microstimulation to the motor cortex of monkeys, Professor Bizzi and colleagues could evoke naturalistic reaching movements toward imaginary targets whose position varied with the site of stimulation. The evoked movements are assembled from "synergies," patterns of muscle activation that are thought to represent fundamental "building blocks" by which the brain controls complex natural movements. *Neuron*: http://www.ncbi.nlm.nih.gov/pubmed/23259944

Nancy Kanwisher and colleagues identified human brain regions that respond specifically to musical structure, including both pitch and rhythm, but not to language or other non-musical sounds. This supports the idea of specialized brain mechanisms for music that are distinct from the language system. *Journal of Neurophysiology*: http://www.ncbi.nlm.nih.gov/pubmed/23019005

Nancy Kanwisher and colleagues reexamined Broca's area, a classic language area that is cited as a preeminent example of the brain's functional specialization. They found that Broca's area in fact has two subdivisions, only one of which is specialized for language. The other subregion appears to be part of the so-called multiple demand network, a set of brain structures that are activated by a wide variety of cognitively demanding tasks. *Current Biology*: http://www.ncbi.nlm.nih.gov/pubmed/23063434

Guoping Feng's laboratory developed a new way to monitor the activity of large numbers of neurons in parallel. The method uses a protein engineered to emit light in response to neural activity, and which can be expressed in specific types of neurons within the mouse brain. *Neuron*: http://www.ncbi.nlm.nih.gov/pubmed/23083733

Rebecca Saxe and colleagues used brain imaging to study the plasticity of visual brain regions in people who were born blind or who lost their sight at a later age. The results suggest that there is a sensitive period in early childhood, with different patterns of plasticity depending on whether vision was lost before or after this period. *Brain and Language*: http://www.ncbi.nlm.nih.gov/pubmed/22154509

Observing that the ability to remember scenes increases from childhood through adolescence to young adulthood, John Gabrieli and colleagues examined the brain changes that accompany this growth. *Journal of Neuroscience*: http://www.ncbi.nlm.nih.gov/pubmed/22815515

John Gabrieli and colleagues used brain imaging to study patients undergoing treatment for social anxiety disorder and to predict in advance which patients will respond best to cognitive-behavioral therapy. *Journal of the American Medical Association Psychiatry* http://www.ncbi.nlm.nih.gov/pubmed/22945462

James DiCarlo and former postdoctoral researcher Nicole Rust examined how the brain decodes visual stimuli in a step-wise manner as signals pass from lower to higher parts of the visual cortex. *Journal of Neuroscience*: http://www.ncbi.nlm.nih.gov/pubmed/22836252

Emilio Bizzi and colleagues found that after a stroke, the brain's ability to coordinate muscle activity is disrupted in specific ways. The pattern of disruptions depends on the severity of the stroke and the length of time since its occurrence. *PNAS*: http://www.ncbi.nlm.nih.gov/pubmed/22908288

Rebecca Saxe and colleagues examined how children develop a "theory of mind" (ToM), the ability to understand the mental states of other people. By scanning children aged 5–11, they showed that the brain's response to ToM tasks develops gradually over this period, in parallel with the children's ability to make inferences about other minds. *Child Development*: http://www.ncbi.nlm.nih.gov/pubmed/22849953

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