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. Established in 2000 by Lore Harp McGovern and the late Patrick J. McGovern, the McGovern Institute aims to improve human welfare, communication, and understanding through neuroscience research.

Faculty

For the period July 1, 2016–June 30, 2017, the McGovern Institute had 17 faculty and two associate members.

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 Massachusetts, New York, Florida, and California.

The McGovern Institute raised over $21 million in outright cash gifts and $23 million in new pledges from individuals, companies, and small family foundations in FY2017. Twenty million dollars of this was a pledge from Hock Tan and Lisa Yang to create the Hock E. Tan and K. Lisa Tan Center for Autism Research.

Major Events

The Edward M. Scolnick Prize in Neuroscience

The 2017 Scolnick Prize (endowed by Merck in honor of Edward M. Scolnick) was awarded to Dr. Catherine Dulac from Harvard University. Her lecture, presented on March 13, 2017, was titled, "The Neurobiology of Social Behavior Circuits."

The Phillip A. Sharp Lecture in Neural Circuits

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 Larry Abbott from Columbia University on March 20, 2017, and was titled, "Un-Marring the Perceptron: Lessons in Cerebellar Computing from Fish and Flies."

The Poitras Center and Stanley Center Translational Neuroscience Joint Seminar Series

The Poitras Center and Stanley Center continued to jointly sponsor a monthly seminar series featuring leading researchers in psychiatric disorders. The series continued in AY2017 and featured the following speakers: John Gabrieli (October 11, 2016), Alvaro Pascual-Leone (December 13, 2016), Joseph Buxbaum (January 3, 2017), Michael Ehlers (February 7, 2017), Amit Etkin (March 28, 2017), Carrie Bearden (April 11, 2017), Angela Roberts (April 28, 2017), Suzanne Haber (May 23, 2017), and Patricia Janak (June 13, 2017). Talks were held in Singleton Auditorium in Building 46.

Symposium with the Chinese McGovern Institutes

On November 8, 2016, there was a symposium with the three Chinese McGovern Institutes (Tsinghua University [TSU], Beijing Normal University [BNU], and Peking University [PKU]). More than 70 scientists from the Chinese McGovern Institutes attended. Speakers were: Bailong Xiao (TSU), Jing Yang (PKU), Jun Yao (TSU), Yong Zhang (PKU), Guoping Feng (MIT McGovern Institute), Huan Luo (PKU), Xiaohong Wan (BNU), Yina Ma (BNU), and Bo Hong (TSU). In addition, the McGovern Institute hosted a poster session during lunch featuring over 50 posters from both the McGovern Institutes in China and MIT's McGovern Institute. The poster session gave students and postdocs a chance to interact on a personal level.

The McGovern Institute at MIT continues to collaborate and interact with these three Chinese universities, and also has a burgeoning collaboration with Shenzhen Institutes of Advanced Technology.

McGovern Institute Spring Symposium

The McGovern Institute Spring Symposium was organized by Gloria Choi and focused on the topic of neuromodulators. It took place on May 16, 2017, and featured nine speakers: Yang Dan (University of California, Berkeley), Susan Dymecki (Harvard University), Tal Kimchi (Weizmann Institute of Science), Jeffrey Friedman (The Rockefeller University), Jonathan Kipnis (University of Virginia), Minmin Luo (Tsinghua University), Richard Palmiter (University of Washington), Gerald Rubin (Howard Hughes Medical Institute, Janelia Research Campus), and Naoshige Uchida (Harvard University).

McGovern Institute Retreat

The McGovern Institute Retreat was held in Newport, RI, at Gurney's Goat Island Resort and Marina. The two-day event, from June 5 to 6, 2017, was attended by 150 McGovern Institute researchers, faculty, and staff members. There were nine talks, a poster session, and many opportunities to interact and get to know fellow researchers.

Board of Directors

The McGovern Board of Directors meets quarterly, in July, October, January, and April. The membership of the board for FY2017 included: Lore McGovern; Elizabeth McGovern; Michelle Bethel; Michael Sipser, MIT; Robert Langer, MIT; James Poitras; and Lisa Yang. Sheila Widnall, MIT, rotated off the Board in January 2017.

The McGovern Institute Leadership Board

The McGovern Institute Leadership Board meets once a 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.

James and Patricia Poitras Neuroscience Chair

Feng Zhang, who was awarded tenure in 2016, was named the inaugural chair holder of the James and Patricia Poitras (1963) Professorship in Neuroscience. This new, endowed professorship was made possible through a generous gift by Patricia and James Poitras '63.

The Hock E. Tan and K. Lisa Yang Center for Autism Research

In spring 2017, Lisa Yang and MIT alumnus Hock Tan '75, established the Hock E. Tan and K. Lisa Yang Center for Autism Research, with a kick-off commitment of $20 million. This gift presents a tremendous opportunity to advance autism research within and beyond the McGovern Institute. We expect that this initial investment will stimulate additional support and foster collaborative research efforts. An advisory board for the Center has been formed. Members include Michael Greenberg, chair of neurobiology at Harvard Medical School (and former Scolnick Prize winner); Steven Hyman, former director of the National Institute of Mental Health, former provost at Harvard, and current director of the Stanley Center at the Broad Institute; Story Landis, former director of the National Institute of Brain Disorders and Stroke; and Matthew State, the current chair of psychiatry at the University of California, San Francisco. The board will meet once a year.

The Tan-Yang Center will be highly collaborative. Key partners will include the Simons Center for the Social Brain at MIT, headed by Mriganka Sur, and the Stanley Center for Psychiatric Research at the Broad Institute, headed by Steven Hyman. One key area of collaboration will be the development of marmoset genetic models, which have great potential for the study of autism and other brain disorders. This work is still in an early stage and has been, until now, supported by the Poitras Center, the Stanley Center, Roche Pharmaceuticals, Massachusetts Life Sciences Center, and by private philanthropic donations to the McGovern Institute.

Another early priority for the Tan-Yang Center will be the development of new approaches to gene therapy, which could eventually form the basis for new treatments for autism in children and adults. The center will also support research into the role of the immune system in autism, including the maternal immune system and its possible link to risk factors during pregnancy. Lastly, the Tan-Yang Center will support novel applications of human brain imaging research in autism. The center anticipates developing collaborations with autism researchers at other institutions in all four research directions over the next several years.

Core Facilities

The McGovern Institute operates several core laboratories serving the local neuroscience community, including, but not limited to, members of the McGovern Institute. These include:

- The Martinos Imaging Center at MIT: The Martinos Center provides access to neuroimaging technologies, including two 3 Tesla (3T) MRI scanners 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 lab and a mock MRI scanner to help subjects (especially children) adapt to the scanning environment.

- The viral gene transfer core: The viral core was a joint project of the McGovern and Picower Institutes. Established in 2009, it operated on a fee-for-service basis to provide viral vector technologies to neuroscience researchers inside and outside of MIT. As of June 30, 2017, the core has been relocated to Massachusetts General Hospital (MGH), and will no longer be affiliated with the McGovern Institute.
- The 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. The core is managed by Mark Harnett and is provided free-of-charge to those in the neuroscience building (Building 46).
- The OpenMind computing cluster: This cluster was established in 2014 to provide the MIT brain research community with access to state-of-art computing resources. The cluster is housed at the Massachusetts Green High Performance Computing Center in Holyoke, MA, with a 10G link to the MIT campus.

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 37 projects. Collaborating principal investigators are from multiple departments and schools at MIT and from other institutions, including the Broad Institute, MGH, and McLean Hospital.

Awards and Honors

Edward Boyden has been elected to the American Academy of Arts and Sciences.

The Howard Hughes Medical Institute, the Simons Foundation, and the Bill and Melinda Gates Foundation announced that McGovern faculty members Ed Boyden and Feng Zhang have been selected as Faculty Scholars. They are among 84 early career scientists from 43 institutions across the US recognized for their “great potential to make unique contributions to their field.”

Mark Harnett has been named a Fred and Carole Middleton Career Development Professor in the Department of Brain and Cognitive Sciences. Harnett, who joined the McGovern Institute in 2015, studies how the physical processes within neurons give rise to the computational power of the brain.

Harnett was also named by the Allen Institute as one of its 2016 Next Generation Leaders, “a group of six esteemed young scientists who will provide feedback in both formal and informal settings to researchers at the Allen Institute.”

Nancy Kanwisher has received the 2016 National Institutes of Health (NIH) Director's Pioneer Award. The Pioneer Award is one of the four awards in the NIH Common Fund's High-Risk, High-Reward Research program, and supports individual scientists of "exceptional creativity, who propose pioneering and transforming approaches to major challenges in biomedical and behavioral research."

Feng Zhang received several awards and recognitions for his work on CRISPR (clustered regularly interspaced short palindromic repeats), as well as his earlier work on optogenetics. He was among four CRISPR scientists named to *TIME* magazine's short list for 2016 Person of the Year, and he was named a 2017 Young Global Leader by the World Economic Forum. Zhang was also among the winners of the John Scott Medal, awarded by the Franklin Institute and the Philadelphia City Council. The medal recognizes scientists whose inventions improve the "comfort, welfare, and happiness of human kind." In June 2017, Zhang was named a Blavatnik National Award winner "for his role in developing the CRISPR-Cas9 gene-editing system and demonstrating pioneering uses in mammalian cells, and for his development of revolutionary technologies in neuroscience."

Summary of Selected Research

Divide and Conquer

July 28, 2016: Traditionally, researchers have taken an "en masse" approach to studying gene expression, extracting an averaged measurement derived from an entire cell population. But over the past few years, single-cell sequencing has emerged as a transformative tool, enabling scientists to look at gene expression within cells at an unprecedented resolution. In *Science*, a team of researchers led by Feng Zhang and Aviv Regev report on their newest contribution to this field: Div-Seq, a method that enables the study of previously intractable and rare cell types in the brain.

Study Finds Brain Connections Key to Learning

August 8, 2016: A team led by Nancy Kanwisher and John Gabrieli has studied a part of the brain known as the visual word form area (VWFA), which is thought to be specialized for reading. In five-year-olds who have not yet learned to read, the VWFA does not respond to written words, but the researchers found that they could predict its future location based on its connections to other language areas of the brain—suggesting that the word form area is anatomically wired to support reading even in pre-reading children.

How the Brain Builds Panoramic Memory

September 8, 2016: When asked to visualize your childhood home, you can probably picture not only the house you lived in, but also the buildings next door and across the street. Researchers in Nancy Kanwisher's lab have now identified two brain regions that are involved in creating these panoramic memories. These brain regions help us to merge fleeting views of our surroundings into a seamless, 360-degree panorama, the researchers say.

Newly Discovered Neural Connections May Be Linked to Emotional Decision Making

September 20, 2016: A team led by Ann Graybiel and Ed Boyden has discovered connections deep within the brain that appear to form a communication pathway between areas that control emotion, decision making, and movement. The researchers suspect that these connections, which they call "striosome-dendron bouquets," may be involved in controlling how the brain makes decisions that are influenced by emotion or anxiety.

Reading the Rules of Gene Regulation

September 30, 2016: Researchers have a reasonable understanding of the rules behind the genome's protein-coding components, but by comparison, scientists have barely begun to crack open the rulebook for the vast non-coding regions of the genome. In a paper in Science, Feng Zhang and colleagues show how methods leveraging CRISPR gene editing could help researchers grasp those rules.

A New Player in Appetite Control

October 18, 2016: Guoping Feng and colleagues have discovered that brain cells called glial cells play a critical role in controlling appetite and feeding behavior. In a study of mice, the researchers found that activating these cells stimulates overeating, and suppressing the cells leads to a suppressed appetite.

Mapping Serotonin Dynamics in the Living Brain

October 20, 2016: Serotonin is a neurotransmitter that is involved in mood regulation in humans, and many antidepressants work by blocking the removal of serotonin—thereby increasing its concentration and prolonging its effects on the brain. Researchers in Alan Jasanoff's lab have developed an imaging technique that, for the first time, enables three-dimensional mapping of serotonin as it is reabsorbed into neurons. This technique gives an unprecedented view of serotonin dynamics in the living brain, and could be a powerful tool for the development of new antidepressants.

Researchers Create Synthetic Cells to Isolate Genetic Circuits

November 14, 2016: Synthetic biology allows scientists to design genetic circuits that can be placed in cells, giving them new functions such as producing drugs or other useful molecules. Ed Boyden and colleagues have demonstrated that these circuits can be isolated within individual synthetic "cells," preventing them from disrupting each other. The researchers can also control communication between these cells, allowing for circuits or their products to be combined at specific times.

Machine-learning System Spontaneously Reproduces Aspects of Human Neurology

December 1, 2016: Tomaso Poggio and colleagues have developed a new computational model for how the brain learns to recognize faces. Their model, which is based on known properties of neurons, takes account of the symmetry of faces and, like real brains, learns to recognize faces as they turn to either the left or the right.

A Radiation-free Approach to Imaging Molecules in the Brain

December 2, 2016: The Jasanoff lab has devised a new probe that allows scientists to image brain molecules without using any chemical or radioactive labels. The new sensors consist of proteins designed to detect a particular target, which causes them to dilate blood vessels in the immediate area. This produces a change in blood flow that can be imaged with magnetic resonance imaging (MRI) or other imaging techniques.

Distinctive Brain Pattern May Underlie Dyslexia

December 21, 2016: John Gabrieli and colleagues have used MRI to identify brain differences that may underlie dyslexia. When a stimulus is presented repeatedly, the brain response decreases with each repetition, a phenomenon known as neural adaptation. Gabrieli's team found that this effect was diminished in people with dyslexia, including both adults and children. The difference was seen in multiple brain regions, suggesting that the deficit responsible for dyslexia affects many different brain functions. The authors speculate that reading may be especially sensitive to subtle deficits, because it involves so many brain processes.

A Glimpse into the Workings of the Baby Brain

January 10, 2017: In adults, certain regions of the brain's visual cortex respond preferentially to specific types of input, such as faces or objects—but how and when those preferences arise has long puzzled neuroscientists. One way to help answer that question is to study the brains of very young infants and compare them to adult brains. However, scanning the brains of babies while they are awake in an MRI machine has proven difficult—until now. Rebecca Saxe's lab has overcome that obstacle, adapting their MRI scanner to make it easier to scan infants' brains as the babies watch movies featuring different types of visual input. Using these data, the team found that in some ways, the organization of infants' brains is surprisingly like that of adults.

Sensors Traces Dopamine Released by Single Cells

February 6, 2017: Another approach to measuring dopamine has been developed by Ed Boyden in collaboration with MIT chemist Michael Strano. Strano previously showed that single-walled carbon nanotubes (SWCNT) can be converted into fluorescent sensors by wrapping them in DNA or other polymers. Working with Boyden, Strano has now developed a SWCNT-based sensor that serves as a sensitive indicator of dopamine. Although not yet tested in intact brains, the new sensor makes it possible to image dopamine release from cultured neurons with very high spatial and temporal resolution.

Tiny Fibers Open New Windows into the Brain

February 21, 2017: For the first time ever, a single flexible fiber no bigger than a human hair has successfully delivered a combination of optical, electrical, and chemical signals back and forth into the brain, putting into practice an idea first proposed two years ago. With some tweaking to further improve its biocompatibility, the new approach could provide a dramatically improved way to learn about the functions and interconnections of different brain regions. The new fibers were developed through a collaboration among materials scientists, chemists, biologists, and other specialists (including McGovern Investigator Gloria Choi).

Precise Technique Tracks Dopamine in the Brain

March 3, 2017: Ann Graybiel has collaborated with MIT bioengineers Michael Cima and Robert Langer to develop a new device for measuring the neurotransmitter dopamine in the living brain. The method involves a dense array of tiny carbon electrodes, which can measure the distribution of dopamine with a precision that was previously unachievable. The researchers have used the device to track dopamine levels in the rat striatum, a structure that in humans is a primary target for dopamine therapy in Parkinson's disease.

Nucleic Acid Detection with CRISPR-Cas13a/C2c2

April 12, 2017: Feng Zhang and his collaborators have engineered a CRISPR-associated enzyme known as Cas13a as a rapid, inexpensive, and highly sensitive diagnostic tool for detecting tiny quantities of DNA or RNA. The method can be used to detect Zika virus in blood or urine samples, and can also be applied to many other viral and bacterial pathogens. The CRISPR reagents can be incorporated into a paper-based test with no need for refrigeration, meaning that it could be deployed in rural clinics or other settings that lack access to high-tech equipment.

Press Mentions

TEDSummit
"Ed Boyden: A new way to study the brain's invisible secrets" (July 2016)
Neuroengineer Ed Boyden wants to know how the tiny biomolecules in our brains generate emotions, thoughts and feelings—and he wants to find the molecular changes that lead to disorders like epilepsy and Alzheimer's. Rather than magnify these invisible structures with a microscope, he wondered: what if we physically enlarge them and make them easier to see? Learn how the same polymers used to make baby diapers swell could be a key to better understanding our brains.

Huffington Post
"How to think, according to this winner of the Brain Prize – MIT's Ed Boyden on thinking, taking notes and rebooting from our failures" (September 13, 2016)
"Synthesize new ideas constantly. Never read passively. Annotate, model, think, and synthesize while you read, even when you're reading what you conceive to be introductory stuff. That way, you will always aim towards understanding things at a resolution fine enough for you to be creative."

Taiwan Today
"Giants in four fields honored at Tang Prize ceremony" (September 26, 2016)
The recipients of the 2016 Tang Prize, including Feng Zhang of the McGovern Institute, were honored at an awards ceremony September 25 at National Sun Yat-sen Memorial Hall in Taipei City before an audience of more than 2,000 guests from home and abroad, including several of the 2014 laureates.

The Scientist
"Targeting the noncoding genome with CRISPR" (September 29, 2016)
Two independent groups demonstrate the utility of CRISPR-based techniques to identify regulatory elements that govern disease-linked genes.

Vanity Fair
"The 2016 New Establishment List" (October 2016)
"The Gene-iuses" Emmanuelle Charpentier, Feng Zhang, and Jennifer Doudna rank #59 on *Vanity Fair's* New Establishment list for discovering the revolutionary genome-editing technology known as CRISPR.

Forbes, TIME, The Boston Globe
(December 2016)
Various publications reported on John Gabrieli's dyslexia study, which found that reading difficulties could be caused by reduced plasticity in the brain.

TIME
(December 2016)
A feature story about Feng Zhang and the other "CRISPR Pioneers" who made the magazine's shortlist for 2016 Person of the Year, stating, "Their breakthrough work could change the world."

Forbes
"What Warren Buffett and Ann Graybiel Advise on Habits" (January 2017)
Graybiel's advice for the new year is that it is never too late to break bad habits or form new (good) ones.

The Atlantic
"Are babies wired to understand the world from birth?" (January 13, 2017)
Research out of Rebecca Saxe's lab reveals surprising similarities between baby and adult brains.

The Boston Globe
"IDG, tech publisher founded by Patrick McGovern, to be bought by Chinese conglomerate" (January 19, 2017).

Fortune, Philadelphia Inquirer, Inside Philanthropy, MIT News
(February 9, 2017)
Various news outlets reported on the newly established Hock E. Tan and K. Lisa Yang Center for Autism Research at the McGovern Institute

Washington Post
"CRISPR pioneer muses about long journey from China to pinnacle of American science" (February 17, 2017)
An in-depth Profile of Feng Zhang by *Washington Post* reporter Joel Aschenbach. The article was also republished in the South China Morning Post.

STAT News
"Scouring the brain for clues to new treatments for mental illness" (February 15, 2017)
"It took literally decades of work in the cancer field before we got to a level of mechanistic understanding," said Robert Desimone, director of MIT's McGovern Institute for Brain Research. "That's vital to achieve in psychiatry," he added. And, "that's what the field has been missing all this time."

Medscape
(April 4, 2017)
"Feng Zhang: The most transformative biologist of our era?"

Robert Desimone
Director
Doris and Don Berkey Professor of Brain and Cognitive Sciences