McGovern Institute for Brain Research

The McGovern Institute for Brain Research at MIT (MIBR) is 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 based on a gift from Lore Harp McGovern and the late Patrick J. McGovern.

Faculty

For the period July 1, 2020–June 30, 2021, the McGovern Institute had 15 faculty and six associate members.

Coved-19 and the McGovern Institute

Although MIBR is a brain research institute, our researchers rose to the coronavirus challenge, and we conducted a large amount of research relevant to the coronavirus crisis. Investigator Feng Zhang collaborated with our McGovern Fellows Omar Abudayyeh and Jonathan Gootenberg. Professor Zhang also released the How We Feel app with Ben Silbermann, CEO of Pinterest, and a global team of researchers. This app allows tracking of symptoms and progress of the virus by researchers as well as allowing researchers to ask pressing questions.

Other researchers mobilized to bring their knowledge and skills to bear on mitigating some of the unexpected shortages. Jill Crittenden, a research scientist in Institute Professor Ann Graybiel's lab and scientific advisor for the McGovern Institute, worked with a consortium to gather and curate information about the three main approaches for decontaminating N95 face masks. Shortages of these masks were causing health workers to resort to reusing them. The consortium put together a website and a document that helped hospitals and other frontline organizations to quickly and easily examine the effectiveness and use of different decontamination protocols. Crittenden also started a project to identify potential gene expression differences in the nasal epithelium of older adults versus children to better understand why older adults are more vulnerable to infection.

Y. Eva Tan Professor in Neurotechnology Edward Boyden and Edward Hood Professor of Medical Engineering and Computational Neuroscience Emery Brown worked together to develop a low-cost ventilator for coronavirus patients. They believe their design is superior to some of the other low-cost ventilators in development elsewhere.

Principal Research Scientist Ian Wickersham, head of our viral research core, worked to develop the basic viral elements for new vaccines as a backup to the worldwide efforts to develop a coronavirus vaccine. Concern that many of the vaccines under current development may not elicit a strong enough immune response to be effective prompted him to create new constructs that could potentially help in that case.

McGovern Institute labs also looked at the effects of the response to Covid-19. John W. Jarve (1978) Professor, Brain and Cognitive Sciences Rebecca Saxe worked to understand some effects of social isolation. Her lab's findings indicated that loneliness in social isolation leads to neural craving responses similar to hunger.

Finally, MIBR created a new page on our website that features stories from members of the McGovern community who rose to the challenge during the pandemic.

Resource Development

Fundraising from individuals and private foundations remains a priority at the McGovern Institute. Although our staff were unable to host in-person donor cultivation events during the fiscal year and travel was halted, MIBR continued to raise significant gifts and pledges to fund our research.

Plans to Increase Diversity

The McGovern Institute partnered with the Department of Brain and Cognitive Sciences (BCS) and the Picower Institute for Learning and Memory (PILM) to address serious concerns about diversity in all parts of the department. To improve the pipeline of underrepresented minorities in neuroscience, we participated in several new initiatives with BCS and PILM. These included expanding the departmental diversity committee, hiring a contractor to help with the department's diversity efforts, and expanding the BCS post-baccalaureate program, which gives minority students research experience to prepare for graduate school. We also hired a shared diversity, equity, inclusion, and justice program officer to work on our goals. In addition to these joint initiatives, the McGovern Institute and three of its centers—the Poitras Center for Psychiatric Disorders Research, the Hock E. Tan and K. Lisa Yang Center for Autism Research, and the new K. Lisa Yang and Hock E. Tan Center for Molecular Therapeutics—each offered fellowships with a preference for underrepresented minorities. With donor funding, we were able to create a post-baccalaureate program for disadvantaged young scientists within the Tan and Yang Center and the Yang and Tan Center for Molecular Therapeutics, and to begin a neurodiversity initiative.

McGovern Institute Post-Baccalaureate Program

As part of our efforts to build a more diverse pipeline of people in brain science and neuroengineering, a donor funded an expansion of our post-baccalaureate program to give recent college graduates from disadvantaged backgrounds an opportunity to earn up to two years of research experience and mentorship from McGovern Institute faculty and postdoctoral scholars. The goal of the program is to give the individuals the research experience they need to successfully apply for graduate school in neuroscience, for example in MIT's Brain and Cognitive Sciencs or Biological Engineering programs.

Our initial recruitment focus was on recent college graduates from disadvantaged backgrounds, which includes individuals who are underrepresented minorities, individuals with disabilities, and first-generation college students. The program's first two post-bacs will be placed in research labs within the K. Lisa Yang and Hock E. Tan Center for Molecular Therapeutics and the Hock E. Tan and K. Lisa Yang Center for Autism Research.

Neurodiversity in the Workforce Initiative

The McGovern Institute partnered with Neurodiversity in the Workplace (NITW) to create an internship program for neurodiverse individuals, including but not limited to individuals on the autism spectrum. We also identified faculty interested in participating

in the pilot program. The program identified a group of qualified neurodiverse candidates, and NITW provided weekly coaching for the paid interns and training support for supervisors. During the pilot, the candidates selected for the program were hired as temporary workers for six-month periods.

Neurodiversity in the Workplace is an initiative that emerged in 2013 as a part of SpArc Philadelphia, a nonprofit organization. Stemming from its work with German software company SAP, NITW provides companies with guidance on how to use a person-centered approach to identify, prepare, and support both neurodiverse candidates and existing managers and staff.

Addiction Initiative

With the recruitment of Professor Fan Wang this year and the commitment of McGovern Institute co-founder Lore Harp McGovern, we developed a new addiction science program. This collaborative initiative launched with nine major research projects (both existing and new) that examine critical questions about addiction across six McGovern laboratories: Professor Wang, Professor Graybiel, Associate Investigator and Matoula S. Salapatas Professor in Materials Science and Engineering Polina Anikeeva, Investigator and Grover Hermann Professor John Gabrieli, Associate Investigator Alan Jasanoff, and Professor Boyden. Key research questions include: Why do some people become addicted while others do not? Can science help predict who will benefit from rehab programs? Can we develop a non-addictive alternative to opiates? With additional funding, we may be able to expand the program to include other laboratories within and outside of MIT.

McGovern Institute Centers

K. Lisa Yang and Hock E. Tan Center for Molecular Therapeutics in Neuroscience

The center, established at the McGovern Institute at MIT through a $28 million gift from K. Lisa Yang and Hock Tan, aims to change how we treat brain disorders by developing innovative molecular tools that precisely target dysfunctional genetic, molecular, and circuit pathways.

Research at the center will initially focus on three major lines of investigation: genetic engineering using CRISPR tools, delivery of genetic and molecular cargo across the blood-brain barrier, and the translation of basic research into the clinical setting. The center will serve as a hub for researchers with backgrounds ranging from biological engineering and genetics to computer science and medicine.

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

This center, founded by Hock E. Tan and K. Lisa Yang, was created to support and catalyze new research approaches and potential treatments for individuals affected by autism spectrum disorder (ASD). The center emphasizes novel projects that are difficult to fund through traditional grants. By concentrating research efforts on new models, therapeutic approaches, and a push toward understanding changes in the human brain, the center aims to better detect, treat, and potentially prevent the most severe forms of ASD.

Poitras Center for Psychiatric Disorders Research

In the years since the Poitras Center for Psychiatric Disorders Research was established in 2007, research into psychiatric illness has surged. The invention of optogenetics, first reported in 2005, has allowed our scientists to control and study the activity of neural circuits with a precision previously unimaginable. New imaging methods provide us with ever-more detailed pictures of brain activity in humans and in animal models. Advances in microscopy are revolutionizing our view of the brain's fine structure. New methods for genome editing will allow us to create animal models of neurogenetic disease faster and more precisely than ever before. The Poitras Center has enabled numerous discoveries and technical advances, many of which have been published in top scientific journals including *Nature*, *Science*, and *Cell*. As a result of these advances, the center has leveraged millions of dollars in federal grants and private funding. Poitras Center support has made possible national and international collaborations with renowned researchers and clinicians and provided a vital source of support for the next generation of neuroscientists and biological engineers. The Poitras Center has cemented MIT's position as one of the world's leading institutions for psychiatric disorders research.

The Poitras Center has enabled us to appoint two of our faculty as endowed faculty. The James W. (1963) and Patricia T. Poitras Professor of Neuroscience, established in 2003, is currently held by Guoping Feng. The James and Patricia Poitras Professorship in Neuroscience, created in 2017, is an endowed professorship held by CRISPR pioneer Feng Zhang.

The Center for Brains, Minds and Machines

Funded by the National Science Foundation, the Center for Brains, Minds and Machines is dedicated to the study of intelligence—how the brain produces intelligent behavior and how we may be able to replicate intelligence in machines. This effort is a multi-institutional collaboration headquartered at the McGovern Institute, with managing partners at Harvard University.

Potential for Two New Centers

We have begun planning for two new centers. The K. Lisa Yang Integrative Computational Neuroscience Center will support cutting-edge computational neuroscience in several major project areas, including a collaboration with the Children's Hospital of Philadelphia, to improve the automated analysis and diagnosis of behavioral disorders in children. Ila Fiete, McGovern Institute associate member and international leader in computational neuroscience, will head up that center. The center will develop strictly neural and behavioral models, and while it may use tools from machine learning, it will not pursue research in artificial intelligence per se.

The K. Lisa Yang Bionics Center will develop and implement new technologies for prosthetic limbs, including artificial sensory stimulation and optogenetic control. Hugh Herr, professor of media arts and sciences, and Professor Boyden will head up that center. Professor Herr is a double amputee himself and is widely recognized for his innovative research in prosthetics. The research will be truly unique, as will be the center itself.

McGovern Institutes in China

The McGovern Institute at MIT continues to collaborate and interact with the three IDG-McGovern Institutes in China, at Tsinghua University, at Beijing Normal University, and at Peking University. We also have a continuing collaboration with Shenzhen Institutes of Advanced Technology.

Board of Directors

The McGovern Board of Directors meets quarterly, in July, October, January, and April. The membership of the board for FY2021 consisted of Lore Harp McGovern, Elizabeth McGovern, Michelle Bethel, Curtis and Kathleen Marble Professor of Astrophysics Nergis Mavalvala, David H. Koch Institute Professor Robert Langer, James Poitras, and K. Lisa Yang.

The McGovern Institute Leadership Board

The McGovern Institute Leadership Board meets once 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. The leadership board met virtually during FY2021 due to COVID restrictions.

Major Events

2020 Anniversary Events

In lieu of our expected 2020 gala anniversary event, we instead held three one-hour Zoom events and published a special 20th-anniversary edition of our newsletter BrainScan. Our first event, in September, focused on addiction. Our October event was on the future of molecular therapeutics. Our final event, in November, was Story Slam: Tales from the Bench and Beyond, which featured students, postdocs, and faculty sharing short stories.

Neurotech 2020 Symposium

In November, we co-hosted the Neurotech 2020 symposium, with virtual talks by neurotechnology pioneers whose cutting-edge innovations are changing the face of neurobiological research from molecules to cognition. Speakers were Todd Coleman (University of California San Diego), Guosong Hong (Stanford University), Xin Jin (Harvard University and Broad Institute), Nancy Kopell (Boston University), Rosalind Picard (MIT), and Mikhail Shapiro (California Institute of Technology).

Phillip A. Sharp Lecture in Neural Circuits

Eve Marder of Brandeis University was the 2020 speaker of this named lecture. She gave her talk, “Differential Resilience of Neurons and Networks to Perturbation,” virtually in March 2021.

Scolnick Prize in Neuroscience

Joshua Sanes of Harvard—the Scolnick Prize in Neuroscience 2020 winner—presented his talk, “Cell Types as Building Blocks of Neural Circuits,” virtually in April 2021.

Building 46 Colloquium Series

This longstanding series supported by the McGovern Institute, the Picower Institute, and the Department of Brain and Cognitive Sciences continued virtually during AY2021. MIT's Director of Libraries Chris Bourg gave the seminar "Open Science: Challenges, Opportunities, and Assumptions," Samy and Ruth Cohn Professor of Computer Science Shimon Ullman—hosted by McGovern Institute Investigator Tomaso Poggio—presented "Scene Understanding by Bottom-Up Top-Down Visual Routines," and Marc Fuccillo gave the lecture "Exploring the Molecular and Neural Circuit Architecture of Goal-Directed Behavior."

Core Facilities

The McGovern Institute operates several core laboratories that serve the local neuroscience community, including members of the McGovern Institute.

- The Athinoula A. Martinos Imaging Center provides access to neuroimaging technologies, including two 3T magnetic resonance imaging (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. This center was closed for the better part of the 2021 academic year due to Covid restrictions, but opened up in the spring for those internal to the MIT community.
- The Two-Photon Microscopy 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 McGovern Institute Investigator Mark Harnett and is provided free of charge to those in Building 46.
- The OpenMind computing 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 Program (MINT) continues to provide seed funding for collaborations between McGovern labs and researchers from other disciplines within MIT, with a focus on developing new technologies for brain research. Since its establishment in 2006, the MINT program has supported more than 40 projects. Collaborating principal investigators are from multiple departments and schools at MIT.

Awards and Honors

- James DiCarlo, the Peter de Florez Professor of Neuroscience, was named director of the MIT Quest for Intelligence.
- Robert Desimone, the Doris and Don Berkey Professor in Brain and Cognitive Sciences at MIT and director of the McGovern Institute, received the 2020

Goldman-Rakic Prize for Outstanding Achievement in Cognitive Neuroscience Research. Professor Desimone also received the Fred Kavli Distinguished Career Contributions Award.

- Associate Professor Evelina Fedorenko was named a Frederick A. (1971) and Carole J. Middleton Career Development Associate Professor of Neuroscience.
- Michale Fee, the Glen V. and Phyllis F. Dorflinger Professor of Brain and Cognitive Sciences, was named head of the Department of Brain and Cognitive Sciences.
- Jonathan Gootenberg was named as one of the MIT Technology Review Innovators Under 35.
- Investigator H. Robert Horvitz was named an American Society for Cell Biology 2020 Fellow.
- Alan Jasanoff received a grant from the G. Harold and Leila Y. Mathers Foundation.
- Investigator Mehrdad Jazayeri earned tenure from the Department of Brain and Cognitive Sciences.
- Associate Investigator Josh McDermott earned tenure from the Department of Brain and Coginitive Sciences.
- Archana Poudry in the Boyden Lab received a 2021 Paul and Daisy Soros Fellowship for New Americans.
- Quique Toloza in the Harnett Lab) received a 2021 Paul and Daisy Soros Fellowship for New Americans.
- Feng Zhang was named a Fellow of the National Academy of Inventors. Zhang also received the Richard Lounsbery Award from the National Academy of Science.

Summary of Research Advances

Signs of Covid-19 May Be Hidden in Speech Signals

It's often easy to tell when colleagues are struggling with a cold—they sound sick, maybe their voices are lower or have a nasally tone. Infections change the quality of our voices in various ways, but MIT Lincoln Laboratory researchers are detecting these changes in Covid-19 patients even when these changes are too subtle for people to hear or notice in themselves. A partnership is under way with Principal Research Scientist Satra Ghosh to integrate vocal screening for Covid-19 into Lincoln Lab's VoiceUp app, which was initially developed to study the link between voice and depression. (July 8, 2020)

A Mechanical Way to Stimulate Neurons

In addition to responding to electrical and chemical stimuli, many of the body's neural cells can respond to mechanical effects, such as pressure or vibration. These responses have been difficult for researchers to study because there has been no easily controllable method for inducing such mechanical stimulation of the cells. Now, researchers in the Anikeeva lab and elsewhere have found a new method for doing just that. The finding might offer a step toward new kinds of therapeutic treatments, similar to electrically based neurostimulation that has been used to treat Parkinson's disease and other conditions. (July 19, 2020)

Mapping the Brain's Sensory Gatekeeper

Many people with autism experience sensory hypersensitivity, attention deficits, and sleep disruption. One brain region that has been implicated in these symptoms is the thalamic reticular nucleus (TRN), which is believed to act as a gatekeeper for sensory information flowing to the cortex. A team of researchers including Associate Professor Mike Halassa and Guoping Feng have mapped the TRN in unprecedented detail, revealing that the region contains two distinct subnetworks of neurons with different functions. The findings could offer researchers more specific targets for designing drugs that could alleviate some of the sensory, sleep, and attention symptoms of autism. (July 22, 2020)

Looking Into the Black Box of Deep Learning Networks

Deep learning systems are revolutionizing technology around us, from voice recognition that pairs you with your phone to autonomous vehicles that are increasingly able to see and recognize obstacles ahead. But much of this success involves trial and error when it comes to the deep learning networks themselves. A group of MIT researchers led by Tomaso Poggio recently reviewed their contributions to a better theoretical understanding of deep learning networks, providing direction for the field moving forward. (July 27, 2020)

Key Brain Region Was "Recycled" as Humans Developed the Ability to Read

Humans began to develop systems of reading and writing only within the past few thousand years. Our reading abilities set us apart from other animal species, but a few thousand years is much too short a timeframe for our brains to have evolved new areas specifically devoted to reading. To account for the development of this skill, some scientists have hypothesized that parts of the brain that originally evolved for other purposes have been "recycled" for reading. A new study out of the DiCarlo lab offers evidence for this hypothesis. The findings suggest that even in nonhuman primates, who do not know how to read, a part of the brain called the inferotemporal cortex is capable of performing tasks such as distinguishing words from nonsense words or picking out specific letters from a word. (August 4, 2020)

Viral Manipulation of Functionally Distinct Interneurons in Mice, Nonhuman Primates, and Humans

Viral vectors are key reagents for controlling gene expression in specific cell types. However, identifying the genomic elements that direct the spatial and temporal expression of genes has been difficult to define, so researchers typically resorted to using large genomic regions surrounding a given gene in order to replicate its expression. Viral vectors can only package small amounts of genetic material, which limited their utility for controlling gene expression. In this study, Guoping Feng and colleagues combined single-cell RNA and DNA sequencing to identify short DNA sequences that can drive gene expression in specific neuronal cell types. They confirmed that these short sequences can be successfully used in viral vectors to direct cell-type specific expression for a selected gene for therapeutics or technical utility, for example. (August 17, 2020)

How General Anesthesia Reduces Pain

General anesthesia is a medication that suppresses pain and renders patients unconscious during surgery, but whether pain suppression is simply a side effect of loss

of consciousness has been unclear. Fan Wang and colleagues have now identified the circuits linked to pain suppression under anesthesia in mouse models, showing that this effect is separable from the unconscious state itself. (August 31, 2020)

Rapid Test for Covid-19 Shows Improved Sensitivity

Since the start of the Covid-19 pandemic, Feng Zhang, Omar Abudayyeh, and Jonathan Gootenberg, and their collaborators have been working on a CRISPR-based diagnostic for Covid-19 that can produce results in 30 minutes to an hour with similar accuracy as the standard PCR diagnostics now used. The new test, known as STOPCovid, is still in the research stage but, in principle, could be made cheaply enough that people could test themselves every day. In a new study, the researchers showed that on a set of patient samples, their test detected 93% of the positive cases as determined by PCR tests for Covid-19. (September 17, 2020)

Tool Reveals New Clues About Parkinson's Disease

As the brain processes information, electrical charges zip through its circuits and neurotransmitters pass molecular messages from cell to cell. Both forms of communication are vital, but because they are usually studied separately, little is known about how they work together to control our actions, regulate mood, and perform the other functions of a healthy brain. Ann Graybiel has developed new tools so that chemical and electrical signals can for the first time be measured simultaneously in the brains of primates. The tools revealed an unexpectedly complex relationship between two types of signals that are disrupted in patients with Parkinson's disease—dopamine signaling and coordinated waves of electrical activity known as beta-band oscillations. (September 25, 2020)

New Neuron Type Discovered Only in Primate Brains

Guoping Feng and colleagues report several key differences in the brains of ferrets, mice, nonhuman primates, and humans, all focused on a type of neuron called an interneuron. Most surprisingly, the team found a new type of interneuron only in primates, located in a part of the brain called the striatum, which is associated with Huntington's disease and potentially schizophrenia. The findings could help accelerate research into causes of and treatments for neuropsychiatric illnesses by helping scientists choose the lab model that best mimics features of the human brain that may be involved in these diseases. (September 30, 2020)

Researchers Identify Crucial Brain Pathway Involved in Object Recognition

The DiCarlo lab has identified a brain pathway critical for enabling primates to effortlessly identify objects in their field of vision. The findings enrich existing models of the neural circuitry involved in visual perception and help to further unravel the computational code for solving object recognition in the primate brain. The study looked at an area called the ventrolateral prefrontal cortex, which sends feedback signals to the inferior temporal cortex via a network of neurons. The main goal of this study was to test how the back-and-forth information processing of this circuitry, that is, this recurrent neural network, is essential to rapid object identification in primates. (October 19, 2020)

RNA "Ticker Tape" Records Gene Activity Over Time

As cells grow, divide, and respond to their environment, their gene expression changes; one gene may be transcribed into more RNA at one time point and less at another time when it's no longer needed. Now, Ed Boyden and colleagues at Harvard University and the Broad Institute have developed a way to determine when specific RNA molecules are produced in cells. The method allows scientists to more easily study how a cell's gene expression fluctuates over time. (October 19, 2020)

Study Helps Explain Why Motivation to Learn Declines With Age

As people age, they often lose their motivation to learn new things or engage in everyday activities. In a study of mice, neuroscientists in Ann Graybiel's lab have identified a brain circuit that is critical for maintaining this kind of motivation. This circuit is particularly important for learning to make decisions that require evaluating the cost and reward that come with a particular action. The researchers showed that they could boost older mice's motivation to engage in this type of learning by reactivating this circuit, and they could also decrease motivation by suppressing the circuit. (October 27, 2020)

Identifying the Structure and Function of a Brain Hub

Our ability to pay attention, plan, and troubleshoot involves cognitive processing by the brain's prefrontal cortex. The balance of activity among excitatory and inhibitory neurons in the cortex, based on local neural circuits and distant inputs, is key to these cognitive functions. A recent study from the Halassa lab shows that excitatory inputs from the thalamus activate a local inhibitory circuit in the prefrontal cortex, revealing new insights into how these cognitive circuits may be controlled. (October 30, 2020)

Using Machine Learning to Track the Pandemic's Impact on Mental Health

Dealing with a global pandemic has taken a toll on the mental health of millions of people. A team of MIT and Harvard University researchers, including the lab of Satrajit Ghosh, has shown that those effects can be measured by analyzing the language that people use to express their anxiety online. (November 5, 2020)

Controlling Drug Activity With Light

Hormones and nutrients bind to receptors on cell surfaces by a lock-and-key mechanism that triggers intracellular events linked to that specific receptor. Drugs that mimic natural molecules are widely used to control these intracellular signaling mechanisms for therapy and in research. Polina Anikeeva and colleagues have introduced a microfiber technology to deliver and activate a drug that can be induced to bind its receptor by exposure to light. (November 18, 2020)

Imaging Method Reveals a Symphony of Cellular Activities

Within a single cell, thousands of molecules work together to perform all kinds of functions—absorbing nutrients, storing memories, and differentiating into specific tissues, among many others. Deciphering these molecules and all their interactions is a monumental task. Over the past 20 years, scientists have developed fluorescent reporters to read out the dynamics of individual molecules within cells. However, typically

only one or two such signals can be observed at a time, because a microscope cannot distinguish between many fluorescent colors. Ed Boyden has developed a way to image up to five different molecule types at a time by measuring each signal from random, distinct locations throughout a cell. (November 23, 2020)

A Hunger for Social Contact

Since the coronavirus pandemic began in the spring, many people have only seen their close friends and loved ones during video calls, if at all. A new study from the Saxe lab finds that the longings we feel during this kind of social isolation share a neural basis with the food cravings we feel when hungry. The researchers found that after one day of total isolation, the sight of people having fun together activates the same brain region that lights up when someone who hasn't eaten all day sees a picture of a plate of cheesy pasta. (November 23, 2020)

A Large-Scale Tool to Investigate the Function of Genes Associated With Autism Spectrum Disorder

Feng Zhang and colleagues at Harvard University and the Broad Institute have developed a technology to investigate the function of many different genes in many different cell types at once in a living organism. They applied the large-scale method to study dozens of genes associated with autism spectrum disorder, identifying how specific cell types in the developing mouse brain are impacted by mutations. The "Perturb-Seq" method is an efficient way to identify potential biological mechanisms underlying autism spectrum disorder, which is an important first step toward developing treatments for the complex disease. (December 1, 2020)

Neuroscientists Find a Way to Make Object-Recognition Models Perform Better

Computer vision models known as convolutional neural networks can be trained to recognize objects nearly as accurately as humans do. However, these models have one significant flaw: Very small changes to an image, which would be nearly imperceptible to a human viewer, can trick them into making egregious errors such as classifying a cat as a tree. Professor DiCarlo and colleagues have developed a way to alleviate this vulnerability by adding to these models a new layer designed to mimic the earliest stage of the brain's visual processing system. In a new study, they showed that this layer greatly improved the models' robustness against this type of mistake. (December 3, 2020)

New Clues to Brain Changes in Huntington's Disease

Huntington's disease is a fatal inherited disorder that strikes most often in middle age with mood disturbances, uncontrollable limb movements, and cognitive decline. Years before symptom onset, brain imaging shows degeneration of the striatum, a brain region important for the rapid selection of behavioral actions. As the striatal neurons degenerate, their "identity" proteins, the building blocks that give particular cell types their unique function, are gradually turned off. A new study from the Graybiel lab has found a surprising exception to this rule. (December 10, 2020)

To the Brain, Reading Computer Code Is Not the Same as Reading Language

In some ways, learning to program a computer is similar to learning a new language. It requires learning new symbols and terms, which must be organized correctly to instruct the computer what to do. In spite of those similarities, Professor Fedorenko has found that reading computer code does not activate the regions of the brain that are involved in language processing. Instead, it activates a distributed network called the multiple demand network, which is also recruited for complex cognitive tasks such as solving math problems or crossword puzzles. (December 15, 2020)

Sequencing Inside Cells

By bringing DNA sequencing out of the sequencer and directly to cells, Ed Boyden and colleagues have revealed an entirely new view of the genome. With a new method for in situ genome sequencing reported in the journal *Science*, researchers can for the first time see exactly how DNA sequences are organized and packed inside cells. (December 31, 2020)

Individual Neurons Responsible for Complex Social Reasoning in Humans Identified

The ability to understand others' hidden thoughts and beliefs is an essential component of human social behavior. Now, Professors Saxe and Fedorenko have for the first time identified specific neurons critical for social reasoning, a cognitive process that requires individuals to acknowledge and predict others' hidden beliefs and thoughts. The findings open new avenues of study into disorders that affect social behavior. (January 27, 2021)

A High-Resolution Glimpse of Gene Expression in Cells

Using a novel technique for expanding tissue, Ed Boyden and colleagues at Harvard Medical School have devised a way to label individual molecules of messenger RNA within a tissue sample and then sequence the RNA. This approach offers a unique snapshot of which genes are being expressed in different parts of a cell, and it could allow scientists to learn much more about how gene expression is influenced by a cell's location or its interactions with nearby cells. The technique could also be useful for mapping cells in the brain or other tissues and classifying them according to their function. (January 28, 2021)

Eyeless Roundworms Sense Color

Roundworms don't have eyes or the light-absorbing molecules required to see. Yet new research out of the Horvitz lab shows they can somehow sense color. The study suggests worms use this ability to assess the risk of feasting on potentially dangerous bacteria that secrete blue toxins. The researchers pinpointed two genes that contribute to this spectral sensitivity, which are conserved across many organisms, including humans. (March 4, 2021)

Gene Changes Linked to Severe Repetitive Behaviors Seen in Autism, Addiction

Extreme repetitive behaviors such as hand-flapping, body-rocking, skin-picking, and sniffing are common to a number of brain disorders including autism, schizophrenia, Huntington's disease, and drug addiction. These behaviors, termed stereotypies, are also

apparent in animal models of drug addiction and autism. Graybiel lab researchers, led by Jill Crittenden, have identified genes that are activated in the brain prior to the initiation of these severe repetitive behaviors. This finding might help to understand the biological basis of repetitive, stereotypic behaviors as seen in a range of neurologic and neuropsychiatric disorders and in otherwise "typical" people under stress. (March 24, 2021)

What's Happening in Your Brain When You're Spacing Out?

Principal Research Scientist Susan Whitfield-Gabrieli and colleagues at Northeastern University identify dynamic brain activity associated with mind-wandering. Identifying circuits in the so-called default mode network will help reveal new targets and better treatment options for people suffering from ADHD, depression, and anxiety. (March 25, 2021)

Method Offers Inexpensive Imaging at the Scale of Virus Particles

Using an ordinary light microscope, engineers in the Boyden lab have devised a technique for imaging biological samples with accuracy at the scale of 10 nanometers—which should enable them to image viruses and potentially even single biomolecules. The new technique builds on expansion microscopy, an approach that involves embedding biological samples in a hydrogel and expanding them before imaging them with a microscope. For the latest version of the technique, the researchers developed a new type of hydrogel that maintains a more uniform configuration, allowing for greater accuracy in imaging tiny structures. (March 29, 2021)

Biologists Discover Trigger for Cell Extrusion

One way that organisms get rid of unneeded cells is through a process called extrusion, which allows cells to be squeezed out of a layer of tissue without disrupting the layer of cells left behind. MIT biologists led by H. Robert Horvitz have discovered that this process is triggered when cells are unable to replicate their DNA during cell division. The researchers discovered this mechanism in the worm *C. elegans*, and they showed that the same process can be driven by mammalian cells. They believe extrusion may serve as a way for the body to eliminate cancerous or precancerous cells. (May 5, 2021)

New Technique Corrects Disease Causing Mutations

Gene editing, or purposefully changing a gene's DNA sequence, is a powerful tool for studying how mutations cause disease and for making changes in an individual's DNA for therapeutic purposes. A novel method of gene editing that can be used for both purposes has now been developed by a team led by Guoping Feng. This technical advance can accelerate the production of disease models in animals and, critically, opens up a brand-new methodology for correcting disease-causing mutations. (May 26, 2021)

Abnormal Brain Connectivity May Precede Schizophrenia Onset

Although the cerebellum was long considered only for its role in maintaining the balance and timing of movements, it has become evident that it is also important for balanced thoughts and emotions. Susan Whitfield-Gabrieli shows for the first time that cerebellar dysfunction actually precedes the onset of psychosis in schizophrenia, a brain disorder characterized by severe thought and emotional imbalances. (May 28, 2021)

Squishy, Stealthy Research Probes

Slender probes equipped with electrodes, optical channels, and other tools are widely used by neuroscientists to monitor and manipulate brain activity in animal studies. Polina Anikeeva has devised a way to make these usually rigid devices become as soft and pliable as their surroundings when they are implanted in the brain. The new multifunctional devices are less intrusive than traditional neuroscience probes and remain functional for months after implantation, enabling long-term studies of neural circuits in animal models. (June 8, 2021)

Some Brain Disorders Exhibit Similar Circuit Malfunctions

Many neurodevelopmental disorders share similar symptoms, such as learning disabilities or attention deficits. A new study from the Feng lab has uncovered a common neural mechanism for a type of cognitive impairment seen in some people with autism and schizophrenia, even though the genetic variations that produce the impairments are different for each condition. In a study of mice, researchers found that certain genes that are mutated or missing in some people with those disorders cause similar dysfunctions in a neural circuit in the thalamus. If scientists could develop drugs that target this circuit, they could be used to treat people who have different disorders with common behavioral symptoms. (June 30, 2021)

Press Mentions

- "Does a 'Recycled' Brain Region Let Us Read?," *Cosmos Magazine*, August 5, 2020
- "Face Selectivity in the Blind Brain," *Discover Magazine*, August 30, 2020
- "Broadcom CEO Donates $28 Million to MIT, Fueling Research for Brain Disorders," *Forbes*, September 15, 2020
- "New MIT Labs to Study Brain Disorders Thanks to $28M Gift From Broadcom CEO," *Boston Business Journal*, September 15, 2020
- "New MIT Research Center Seeks Precise Treatments for Brain Disorders," *The Boston Globe*, September 15, 2020
- "A Power Couple in Autism Philanthropy Goes After Elusive Treatments," *Inside Philanthropy*, September 17, 2020
- "Broadcom CEO Hock Tan and Wife, Lisa Yang, Give MIT $27 Million," *The Chronicle of Philanthropy*, September 18, 2020
- "MIT, Harvard Researchers Say They're Close to a New Rapid Covid Test," *WBUR*, September 18, 2020
- "This Company Wants to Help Your Boss Monitor Your Brainwaves at Work," *VICE*, September 21, 2020
- "Modeling a Visionary Future," *MIT Spectrum*, Fall 2020
- "Feng Zhang Interview: CRISPR Can Fight Covid-19 and Climate Change," *New Scientist*, October 14, 2020
- "Face Value," *Technology Review*, October 20, 2020
- "Fast, Cheap Accurate: Researches Pin Hopes on Nobel Prize–Winning CRISPR Technology to Detect Coronavirus," *USA Today*, October 24, 2020

- "Deep Neural Networks Help Explain Living Brains," *Quanta*, October 30, 2020
- "Loneliness and Hunger Light Up Brain Activity in Similar Ways," *Inverse*, November 23, 2020
- "Hunger and Loneliness Activate the Same Part of the Brain," *Smithsonian Magazine*, November 24, 2020
- "You're Not Crazy—You Really Hunger for Social Contact," *Fortune Magazine*, November 24, 2020
- "Do Math Geeks or Linguists Make Better Programmers?," *Psychology Today*, December 29, 2020
- "CRISPR Rivals Put Patents Aside to Help in Fight Against Covid-19," *STAT*, March 3, 2021
- "Eyeless *C. elegans* Perceives Colors," *Scientist*, March 4, 2021
- "How Do Blind Worms See Color?," *The New York Times*, March 4, 2021
- "These Worms Have No Eyes, but They Avoid the Color Blue," *Smithsonian Magazine*, March 8, 2021
- "On-the-Spot Gene Readouts Offer Clues to How Cells Work," *NIH Director's Blog*, March 11, 2021
- "Missing Your Spark? Pandemic Stress Can Interfere With Your Ability to Focus," *The Washington Post*, March 13, 2021
- "STATMadness Twitter Chat with Xin Jin on 'Perturb-Seq' Tool," *STAT*, March 25, 2021
- "CRISPR Versus Covid," Science Clear+Vivid Podcast, March 31, 2021
- "Cracking the Code: The Neural Basis of Computer Code Comprehension," *Science Rehashed Podcast*, April 28, 2021
- "Investigating the Embattled Brain," *MIT News*, April 29, 2021
- "Josh McDermott Seeks to Replicate the Human Auditory System," *MIT News*, May 3, 2021
- "The Benefits of Special Interests in Autism," *Spectrum News*, May 12, 2021
- "How Your Mind Creates Language," *Science Clear+Vivid Podcast*, May 12, 2021
- "Four CRISPR Scientists on the Future of Gene Editing," The Future of Everything Festival, May 13, 2021
- "Partial Sight Restored for Man Who Is Blind Thanks to Optogenetics," *New Scientist*, May 24, 2021
- "Scientists Partially Restored a Blind Man's Sight With New Gene Therapy," *The New York Times*, May 24, 2021

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