Department of Brain and Cognitive Sciences

Mission

For more than 40 years, the mission of the people of Brain and Cognitive Sciences (BCS) has remained constant: to understand the brain and how it gives rise to the mind. In the pursuit of this objective, BCS has created a diverse, multidisciplinary environment of interrelated areas and levels of investigation providing the greatest opportunities for significant insight into key questions.

The Department is complemented and strengthened by association with the Picower Institute for Learning and Memory and the McGovern Institute for Brain Research; 18 of the 36 BCS primary faculty members are also investigators in these centers. With the brain and cognitive sciences complex bringing researchers from all three entities together in the same building, BCS plays a special role, acting as an umbrella and providing an academic home for all teaching and research of the brain and mind at MIT.

Faculty

The faculty of BCS number 36, with 11 current members having joined the Department in the last five years. Of the 36, nine hold appointments in the Picower Institute for Learning and Memory and nine in the McGovern Institute for Brain Research. Two faculty have dual appointments in Harvard-MIT Division of Health Sciences and Technology. BCS faculty are widely recognized as being among the most noteworthy leaders in their respective fields. Four are Howard Hughes investigators, eight are members of the National Academy of Sciences, and 10 have been welcomed into the American Academy of Arts and Sciences.

The interdisciplinary nature of neuroscience and cognitive science is highlighted by the nature and number of the joint appointments held by BCS faculty members as well as those granted to faculty of other departments. BCS has welcomed eight jointly appointed faculty from the departments of Linguistics and Philosophy, Mechanical Engineering, Nuclear Science and Engineering, Biology, Electrical Engineering and Computer Science, and the Media Lab. BCS faculty members hold joint appointments in many of these groups, as well as in the Physics Department, the Computer Science and Artificial Intelligence Laboratory, and the Clinical Research Center.

During the last year, BCS faculty welcomed two new colleagues. Ki Goosens was appointed assistant professor of neuroscience in BCS and the McGovern Institute, and Rebecca Saxe joined the faculty as assistant professor of cognitive science. Effective July 1, 2006, faculty members Elly Nedivi and Pawan Sinha were promoted to the rank of associate professor with tenure. Also during the last year, Joshua Tenenbaum was promoted to associate professor with tenure, and James DiCarlo was appointed associate professor—these appointments are effective July 1, 2007.

Graduate Program

Thirteen students joined the BCS graduate program in September 2006, bringing the size of the student body at the time to 83. During AY2007, six students graduated with

the doctorate, four of them assuming postdoctoral positions in universities or research institutions (one in the Picower Institute, one in the McGovern Institute, one in the Psychology Department at the University of Minnesota, and one in the Neurology Department at the University of California, San Francisco). Of the remaining two, one is a software development engineer at Amazon.com and the other a clinical fellow in pediatrics at Children's Hospital Boston and Harvard Medical School.

Two students were honored for excellence in undergraduate teaching; two were received awards for excellence in graduate teaching; and two students were commended for continuing dedication to teaching.

Course 9 Major

The Department's undergraduate population remained near record highs, with a total of 156 students this year. Fifty BCS seniors graduated this year and a further 50 freshmen declared as Course 9 majors at the end of the 2007 spring term.

At the annual spring BCS Undergraduate Awards dinner, six seniors were honored for outstanding scholarship or research, while 13 seniors were commended for outstanding academic records, leadership in the Department, or outstanding work in a particular course, and an additional 13 juniors were also acknowledged for both research and academic accomplishments. Two students were inducted into Phi Beta Kappa. Thirty-eight undergraduates had perfect grade point averages this past term and were acknowledged by the Department for their achievements. The first BCS Award for Excellence in Undergraduate Teaching by Faculty was given to Carlos Lois and Yasunori Hayashi for their work in 9.12 Experimental Molecular Neurobiology.

Some Research Highlights

Professor Matthew Wilson found evidence that memories of life stories may be reinforced during sleep. Wilson and a colleague looked at what happens in rats' brains when they dream about the mazes they ran while they were awake. Wilson had previously showed that rats formed complex memories for sequences of events experienced while they were awake, and that these memories were replayed while they slept—perhaps reflecting the animal equivalent of dreaming. Because these replayed memories were detected in the hippocampus, the memory center of the brain, the researchers were not able to determine whether they were accompanied by the type of sensory experience associated with dreams, in particular, the presence of visual imagery. By recording brain activity simultaneously in the hippocampus and the visual cortex, Wilson was able to demonstrate that replayed memories did, in fact, contain the visual images that were present during the running experience.

BCS professor and Howard Hughes investigator Li-Huei Tsai has made a number of important advances in Alzheimer's disease research. Her lab recently introduced an innovative new mouse model which allows the expression of p25—a protein implicated in several neurodegenerative diseases—to be switched on or off with a simple change in diet. Tsai also demonstrated that mice whose brains had atrophied like those of Alzheimer's patients were able to regain learning and memory function after exposure

to a stimuli-enriched environment. This finding opens the possibility of the recovery of cognitive function, even in advanced stages of dementia.

Recently published work by Professor Earl Miller and graduate student Timothy Buschman presented evidence that two different regions—the prefrontal cortex and the parietal cortex—are each responsible for originating a different mode of attention. The researchers also reported for the first time that activity in the two regions operates at different frequencies depending on whether the attention is based on sensory input or on experience and memory. Using an innovative technique, Miller and Buschman conducted a series of experiments in which monkeys were engaged in different kinds of visual tasks. The researchers looked simultaneously at the prefrontal cortex and the parietal cortex allowing, for the first time, a direct comparison of the activity in these regions. The results support the idea that in the bottom-up mode, sensory cortical areas like the parietal cortex direct our eyes toward the stimulus. When we purposefully look for something, the prefrontal cortex seems to originate and coordinate attention. Taken together, these data suggest two modes of operation: When a stimulus pops out, a bottom-up, fast target selection occurs first in the posterior visual cortex; while in search mode, a top-down, longer latency target selection is reflected first in the prefrontal cortex. This is believed to be the first direct demonstration that these areas may have different contributions to different modes of attention.

Associate professor Pawan Sinha is exploring questions of how the human brain learns to see by studying people who were born blind, or blinded very young, and later had their sight restored. It has long been believed that children who were blind during a "critical period" early in life had little hope of learning how to see even if vision were later restored. However, in a recent case study originated by Sinha, it was found that a woman who had her vision restored at the age of 12 performed almost normally on a battery of high-level vision tests when studied at age 32. This suggests that the brain is still malleable in older children, a finding that could benefit thousands of blind children around the world who were previously thought to be too old to receive eye treatment. The research was carried out in conjunction with Project Prakash ("light" in Sanskrit), a National Science Foundation–funded initiative begun by Sinha that takes as a primary purpose a humanitarian mission to help bring eye care to those in India who have never had access to advanced medical resources.

Professor Mark Bear and colleagues were the first to directly confirm, after more than 30 years of speculation, that long-term potentiation (LTP) is a real and important mechanism in memory and learning. Originally proposed in the late 1960s, LTP—the reinforcement of synaptic connections among neurons involved in memory and learning—has long been assumed to be true, but the evidence supporting this hypothesis has never been conclusive. In an elegant set of experiments, Bear began by identifying molecular changes in protein expression related to LTP. Then, by using biochemical probes to mark synapses that had recently been modified by learning, the researchers were able to confirm that learning induced the same molecular changes as LTP.

Professor Jerry Schneider and research scientist Rutledge Ellis-Behnke recently reported several findings that illustrate the potential of nanotechnology in research and medicine. In work performed in conjunction with University of Hong Kong, they have shown

that a self-assembling peptide solution can stop bleeding in wounded rodents within seconds. Earlier, Schneider and Ellis-Behnke had reported that a similar material was able to partially restore sight in hamsters that had had their visual tract severed. In this instance, the peptide served as a structural matrix on which brain cells could regrow.

Selected Faculty Awards and Honors

Edward Adelson was named John and Dorothy Wilson professor of visual sciences.

Mark Bear was awarded the William and Enid Rosen Research Award for outstanding contributions to the understanding of Fragile X by the National Fragile X Foundation.

Emilio Bizzi was elected president of the American Academy of Arts and Sciences.

Emery Brown was elected fellow of the American Institute of Medical and Biological Engineering and fellow of the American Statistical Association.

Earl Miller won the Mathilde Solowey Award in the Neurosciences from the National Institutes of Health.

Aude Oliva and Laura Schulz received the School of Science Prize for Excellence in Undergraduate Teaching.

Tomaso Poggio was appointed to the Scientific Advisory Board of the Institute for Scientific Interchange (ISI) Foundation, in Turin, Italy. He was also appointed to the Expert Committee of the Institute of Advanced Studies in Information and Communication Technologies (ISICT), in Genoa, Italy.

Molly Potter delivered the keynote speech at the annual meeting of the Psychonomic Society in Houston, TX.

Rebecca Saxe was the recipient of a 2007 John Merck Scholars Award in the Biology of Developmental Disabilities in Children.

Morgan Sheng was elected fellow of the Royal Society.

Pawan Sinha received the Troland Research Award from the National Academy of Sciences as well as a James S. McDonnell Foundation Scholar Award.

Josh Tenenbaum was elected to membership in the Society of Experimental Psychologists, and received their Young Investigator Award.

Mriganka Sur
Department Head
Sherman Fairchild Professor of Neuroscience

More information about the Department of Brain and Cognitive Sciences can be found at http://www.mit.edu/bcs/.