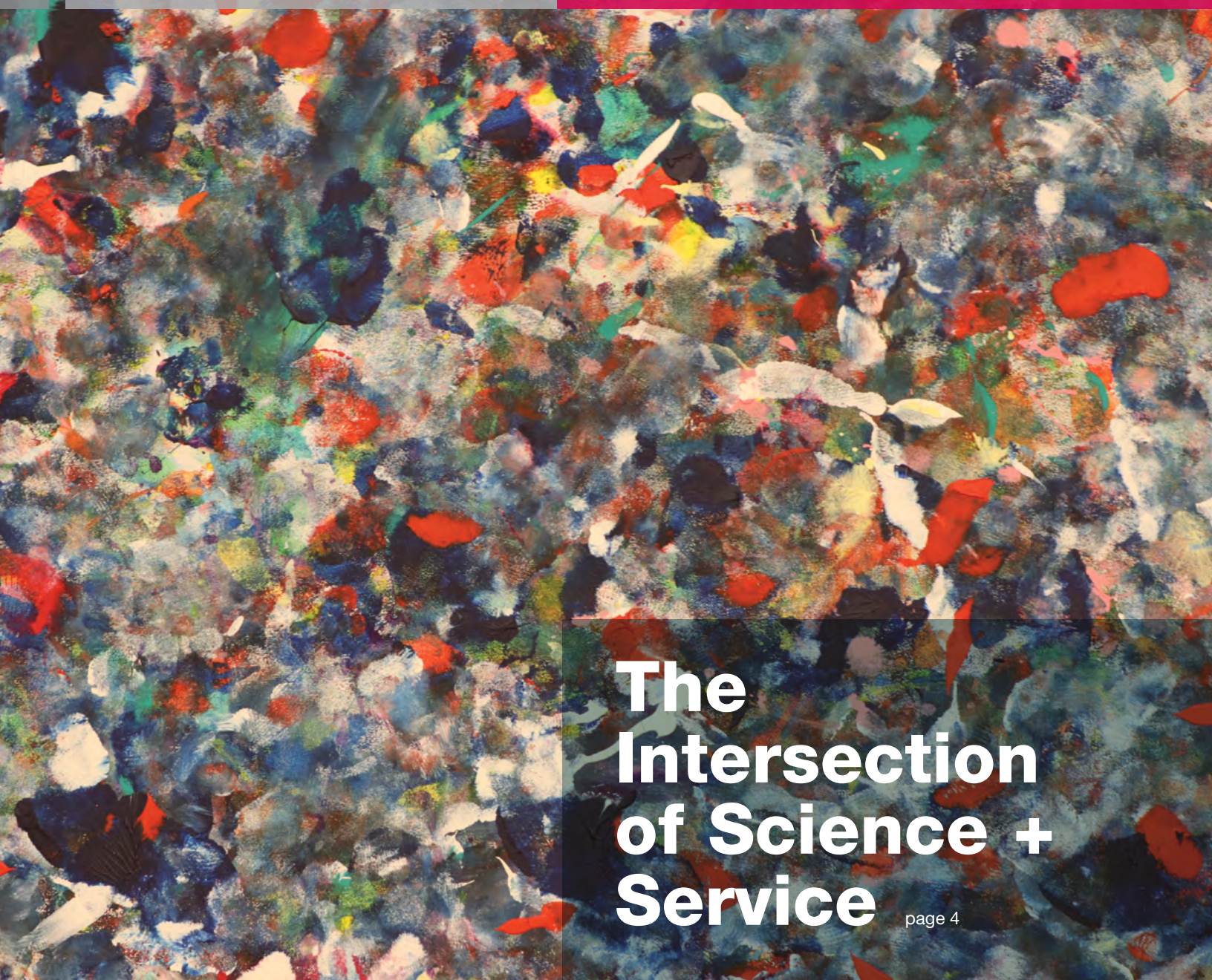




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bcsnews



The Intersection of Science + Service

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 **brain+cognitive
sciences**

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A Message from the Department Head

Jim DiCarlo



In this Department, we are champions of science. For some members of our community, you are Champions in a literal sense — please see the story facing this page about how some of our closest friends support our research by enabling our graduate students to pursue their scientific dreams. Our community is driven by arguably the biggest science question of all time: how does the brain create the mind?

While the impacts of our science are far-reaching, in this issue you will learn about when a pursuit of basic science directly intersects with service to improve people's lives. BCS Prof. Pawan Sinha founded Project Prakash more than a decade ago to tackle the pervasive issue of childhood blindness in India. In addressing this humanitarian need, Pawan also saw an unprecedented opportunity to facilitate our scientific understanding of visual development in the brain. I encourage you to read the full story on page 4, and to view the corresponding video on the BCS website to see for yourself the incredible impact that our science and our scientists have on society.

Next, you may have noticed some familiar faces joining me on this page. As the Associate Department Head for Education, Michale Fee develops and maintains our undergraduate and graduate curricula, and is leading the next phase of upgrades in our educational programs. I am also thrilled to have Rebecca Saxe join us as an Associate Department Head to further advance our core research and educational missions. Though her role will evolve over time, she will initially focus on identifying new ways to help our graduate students, our mentoring programs, and our 360 reviews to help faculty. I am very excited to collaborate with Rebecca in this new capacity.



Michale Fee, PhD
Glen V. and Phyllis F. Dorflinger
Professor of Neuroscience
Associate Department Head of
Education, BCS

In this issue, I am also thrilled to introduce Ila Fiete, our newest associate professor who joined the BCS faculty this semester. Ila is a world-leading computational neuroscientist, and her research aims to understand how neural circuits support algorithms that underlie behavior and cognition. Her recent work advances our understanding of neural 'grid' codes in the medial entorhinal cortex of rodents during spatial navigation — sometimes referred to as the "brain's GPS." Computation is a key area of expansion for our department and our field and a skill area of high demand in industry. We are fortunate to have such a rising superstar in this area join our faculty ranks. Please join me in welcoming Ila!



Rebecca Saxe, PhD
John W. Jarve (1978) Professor in
Brain and Cognitive Sciences
Associate Department Head, BCS

As I read the latest issue of our newsletter, I am struck, as always, by the accomplishments of our BCS community — our faculty, postdoc and scientist colleagues spanning BCS, the McGovern Institute for Brain Research (MIBR), the Picower Institute for Learning and Memory (PILM) and our affiliated labs and centers, our talented graduate and undergraduate students, our generous friends and alumni and our incredible administrative staff who work tirelessly behind the scenes to make sure the proverbial trains run on time all day, every day — I am so proud, grateful, and humbled by the opportunity to work with all of you.

James J. DiCarlo MD, PhD
Peter de Florez Professor of Neuroscience
Head, Department of Brain and Cognitive Sciences

On the Cover

As part of their community outreach efforts, Project Prakash offers an art program, "Unruly Art," to children with developmental and physical disabilities in local communities. The program celebrates the philosophy of "art without rules," and students use tennis balls, brushes and their own hands to make their own colorful creations. Learn more on page 7.

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Annual Champions of the Brain Fellows Celebrates the Best of BCS

By Sara Cody

On Oct. 25, 2018, the Department of Brain and Cognitive Sciences held its fifth annual *Champions of the Brain Fellows*. The event celebrates BCS graduate students and the generosity of donors who enable their exciting scientific research.

The event kicked off with a colloquium by BCS Prof. Feng Zhang, who presented “Exploration of Microbial Diversity to Discover Novel Molecular Technologies.” Zhang discussed his research exploring this microbial diversity through bioinformatics, biochemical, and molecular techniques to better understand the fundamental ways in which living organisms sense and respond to their environment and ultimately to harness these systems to improve human health.

By using cutting-edge technologies such as CRISPR and looking to nature for inspiration, he hopes to leverage basic research and identify new therapeutic opportunities. At the end of his presentation, Zhang spoke about the importance of team work in his lab, and the important role that graduate students have in research.

“When you do research, you want to work with graduate students because they are open-minded, willing to take risks and willing to work on things that are challenging because they don’t know something is hard yet,” said Zhang. “For any given project, you might use computation, programming, chemistry, biochemistry, animal behavior to approach the same problem. Sometimes it’s hard to embody all of that in someone who is just starting out on a project. By training more of these multidisciplinary individuals, they can then go out into their respective disciplines and do more collaborative work.”

Following the colloquium, attendees were treated to a reception and dinner in the Simons Center Reading Room. BCS Department Head James DiCarlo provided opening remarks, echoing Zhang’s sentiments about the importance of graduate students.

“Our graduate students are incredibly talented individuals in an early stage of their career, where they are able to take the scientific risks that often lead to exciting discoveries and breakthroughs. They are critical to attracting and retaining exceptional faculty members in our Department, and that’s not all!” said DiCarlo. “Our graduate students also provide mentorship to our undergraduates doing research in BCS labs and they contribute to the vibrancy in our department by interconnecting our labs and community.”



Photo credit: Steph Stevens Photo

DiCarlo then introduced a video presentation in which fellows spoke about their respective experiences as fellowship recipients, and how the generosity of donors not only enables their research but also enhances their overall experience as graduate students at MIT. (To view this video, visit the link below.)

The evening concluded with remarks from Barrie R. Zesiger HM, MIT Corporation Life Member, founding Champion of the Brain Fellows and longtime supporter of MIT. In her remarks, Barrie noted her and her husband Al’s plan to continue that tradition through a bequest, part of which will support the Department.

The annual *Champions of the Brain Fellows* event honors donors who commit \$70,000 or more through an endowed, expendable or corporate gift to support graduate students at the forefront of cutting-edge research in BCS. ■■

To view the Champions video and to learn more about supporting BCS, visit bcs.mit.edu/give-bcs

The Gift of Light

Pawan Sinha combines science and service to address a humanitarian need and to advance our understanding of visual development in the brain.

By: Stephanie M. McPherson | BCS Contributing Writer

Edited by: Sara Cody | Photos provided by Project Prakash



Poonam was 13 years old and blind from cataracts when Project Prakash provided her with surgery to restore her sight.

When Pawan Sinha, professor of vision and computational neuroscience in the Department of Brain and Cognitive Sciences at MIT, first met Poonam, she was 13 years old. Poonam lived in a remote village far from the urban bustle of Delhi, the second most-populous city in India. She had grown up among lush trees, straw-thatched roofs and white cows with pointy horns grazing languidly along the dirt-packed road. But she had never seen any of it. Like many of the patients Sinha has worked with since he began Project Prakash, Poonam had been blind since birth due to dense cataracts, a treatable form of blindness more often seen in elderly patients.

Project Prakash, from the Sanskrit word for light, is a nonprofit organization that provides surgeries to congenitally blind children in India, and observes them during recovery to track the development of sight in the brain. Volunteers from Project Prakash travel to remote villages with limited access to health care to screen blind children and if they are eligible, enroll them in the program. Sinha first conceived of Project Prakash in 2002 while visiting his father in Delhi. He encountered two young siblings, living in poverty on the city streets, both blinded by treatable cataracts.

“This opened my eyes to the pervasiveness of childhood blindness in India, and more broadly in the developing world. Many children have treatable forms of blindness, but they stay blind because of lack of access to medical facilities, lack of knowledge of treatment options, and lack of financial resources to pursue medical care,” says

Sinha. “These children languish in their blindness and lead difficult lives with little education, almost no prospects for employment and sadly, in many cases they die very young.”

Volunteers transported Poonam from her village to Dr. Shroff’s Charity Eye Hospital in Delhi, where, after a full examination, she received cataract removal surgery. The very next day, the bandages came off. During Poonam’s post-operative check-up, the caregiver held up her fingers and asked how many — and she answered correctly, both up close and from a distance. Poonam could see.

“The name Prakash reflects our immediate goal to bring light into the lives of children who suffer from blindness,” says Sinha. “In meeting this humanitarian need, as a neuroscientist I realized we had an scientific opportunity. With surgery, we can transition a child from blindness to sight in less than an hour and from the very moment the child’s bandages are removed, you have a ringside seat into the process of visual development.”

THE CALL TO ACTION

According to the World Health Organization, current estimates suggest between 200,000 and 700,000 children suffer from potentially treatable forms of blindness, such as cataracts or corneal opacities. Only 50 percent of these children are expected to survive into adulthood and many suffer physical or sexual abuse at some point in their lives.

Compelled to act, Sinha quickly realized he wanted to create a lasting impact beyond a one-time donation to cover the cost of cataract surgeries for individual children. From the perspective of a vision researcher, Sinha felt he was in a unique position to tackle this problem on a larger scale. He could also address a common problem that arises when studying visual development.

Sinha (pictured) led Prakash volunteers to remote villages with limited access to health care to screen blind children and, if eligible, enroll them in the program.



BCS Prof. Pawan Sinha



“Until now, almost all the approaches we had to observe visual development happening in real time was by working with infants, and they are notoriously difficult experimentally,” says Sinha. “Not only are they unable to follow instructions or report out, their brains have many developmental processes progressing simultaneously, so it is hard to isolate one from the others. Visual development proceeds rapidly, so we have a short window to work with before infants become very sophisticated visual perceivers.”

And that is one of the key scientific benefits of Project Prakash. Older blind children, like Poonam and the kids Sinha met while visiting with his father, have physiologically mature brains, but have not yet been exposed to patterns in the visual world. This makes it much easier to identify the processes of visual development as they unfold during follow-up care. Using functional MRI data acquired from post-operative Prakash patients imaged at various points throughout their recovery, Sinha and the rest of the Project Prakash team observe how a child’s brain incorporates new information into existing structural and functional organization. These studies then inform Sinha’s MIT lab work on computational models of visual learning.

Prakash patients range from children as young as six to young adults in their mid-twenties — if a young person presents to the Project Prakash team with a treatable form of blindness, they won’t be turned away. A few days after surgery, children begin visual acuity tests using the standard eye charts anyone with glasses would be familiar with. While no child winds up with perfect vision, patients gain significant functional vision, and Project Prakash provides glasses to correct their sight further.

After securing an initial round of funding from the National Institutes of Health, Sinha officially launched Project Prakash with three of his students in 2004. Since then, Sinha has added 20 team members and together they have provided 500 surgeries and 43,000 ophthalmic screenings to children in need.

A RINGSIDE SEAT

Since Sinha established Project Prakash, the humanitarian work has become inextricably linked to the work in his research laboratory at MIT. Many of his lab members are also involved with Project Prakash and pursue a number of research questions related to data gathered from its patients. Typically, the research team travels to India twice a year to volunteer with the program, interact with the patients, and of course, to gather data.



Since it was founded in 2004, Project Prakash has provided 500 surgeries and 43,000 ophthalmic screenings to children in need.

Conventional wisdom in childhood blindness suggests that older children should not see significant gains post-surgery, since their brain’s visual machinery should be set. However, in one of his first key scientific findings enabled by Project Prakash, Sinha found that even young adults can make significant gains in visual function after surgical intervention.

Members of the Sinha laboratory at MIT have also found new avenues of research probing the development of different visual skills in the Prakash children. For example Sruji Raja, a research associate in the Sinha laboratory, is working on a project that looks at sensitivity to visual motion before and after surgery. Another ongoing study, led by Sharon Gilad-Gutnick, a staff research scientist in Sinha’s lab and a Project Prakash team member, looks at how patients learn to translate what they see into drawings.

“How are they able to recognize and then copy or draw from memory basic shapes and objects?” says Gilad-Gutnick, who has worked with Sinha since she was an undergraduate. “What does that tell us about their internal representation of these shapes, and of objects in general? We are looking at that as a function of time after sight onset.”

Another study, published in *PNAS* on Oct. 30, details how some Prakash patients struggle with the task of recognizing faces. Newborn babies have notoriously bad eyesight, with an average visual acuity of 20/600 (see *below*.) In this paper, the researchers hypothesize that

What is visual acuity?

According to the American Optometric Association, good visual acuity refers to the ability to see sharply and clearly. Normal visual acuity is referred to as 20/20 vision, which means that you can see patterns as clearly at 20 feet as an average person at the same distance. Different fractions refer to different levels of acuity. For instance, 20/100 acuity indicates that in order to see an object clearly, you must be as close as 20 feet to resolve what a person with normal visual acuity can see at 100 feet.

poor eyesight has an important function in infant visual development, acting as a visual low-pass filter. The filter induces the brain to develop visual processing strategies that emphasize the gestalt rather than local details, or as Sinha describes it, the “forest from the trees.” Project Prakash patients miss out on this benefit of poor initial acuity, which leads to difficulty organizing and recognizing the spatial relationships of distinct faces. In the paper, Sinha and the team refer to this as the **high initial acuity (HIA) hypothesis**.

To test this hypothesis, Sinha’s research team used a deep learning algorithm designed to mimic the many layers of the human visual system. They fed the algorithm series of images simulating different visual learning scenarios, from only blurred images to only high resolution images to a mix of the two. The series that led to the most robust recognition performance began with blurred images and progressively increased in resolution—echoing the progression in normal human development and consistent with the HIA hypothesis.

These results have significant clinical implications. Post-operative outcomes for cases of congenital cataracts can potentially be improved by blurring visual stimuli to mimic the poor acuity of a newborn. By gradually increasing the resolution of visual stimuli, the regimen may provide the Prakash children’s brains the inducement to encode larger scale structures in images and improve subsequent recognition performance.

While the Project Prakash children are a unique subset of individuals, lessons learned from them can be applied to brain development in general. The work reported in the *PNAS* paper illustrates how studies of newly sighted children can inform our thinking of normal visual development, and also guide the creation of more powerful computational strategies for visual recognition.

“We are essentially providing a possible answer to why normal visual development unfolds in the way that it does — it’s not just a limitation imposed upon us by immaturity of the retina, but it might actually have adaptive value,” says Sinha. Looking beyond vision, this idea could potentially provide insight into auditory development as well; the muffling of sound by the amniotic sac may have adaptive significance akin to the blurring of images in early development.

LOOKING AHEAD

While Sinha appreciates the opportunity to tackle these scientific questions, he doesn’t lose sight of the transformative impact Project Prakash has on real lives.



In the days following Poonam’s surgery, Project Prakash staff watched her blossom as she healed. She created artwork, she made up dance moves with her caregiving team (*above*), and she even took it upon herself to lead another blind patient receiving care at the hospital around the hallways. In addition to this newfound sense of independence and self-confidence, Poonam’s follow-up exams showed a marked improvement in visual abilities.

Poonam’s outcome was not an outlier for Project Prakash participants. Even though the speed of healing and level of visual acuity varies from patient to patient, most report significant improvement to their vision and their quality of life. Sinha and his team surveyed a group of 60 patients and their families to gauge how their experience participating in Project Prakash improved their sense of independence, their ability to perform in school, and their relationships with friends, family and their communities.

“Across all of these dimensions, they reported big gains, and both patients and their families are uniformly ecstatic about the outcomes of the treatment, says Sinha. “When you take a step back to look at the whole picture, we have made a relatively small contribution by providing this routine surgery. But the consequence of that surgery is so profound that the families think of us as more. It’s incredibly rewarding.”

But Prakash patients and their families are not the only ones who have been impacted by this work.

“In general, scientific research can be ambiguous and frustrating. But when you get to work so closely with patients, and in particular children, and you get to have that real-world impact in addition to pursuing these interesting questions, the motivation is huge,” says Gilad-Gutnick. “As scientists, I think we need to find more ways to work at this intersection of basic science and humanitarian need, and I think that neuroscience and the

study of behavior presents a lot of unique opportunities to do that.”

Looking ahead, Project Prakash aims to improve patient outcomes even further through their newest initiative: a year-long residential educational program. Patients who have fallen behind in school due to their visual impairment can receive specialized instruction, bringing them to an age-appropriate grade level before integrating them in local schools. They also intend to track how learning and education affects brain structure.

For Sinha, though his experience with Project Prakash has led to many immeasurably meaningful moments, meeting the Prakash patient named Poonam and following her success through the program hit especially close to home. His older sister was a doctor before her untimely death at age 25 and she was one of Sinha’s main sources of inspiration when he established Project Prakash. Her name was also Poonam.



Sinha says goodbye to Poonam when she is discharged from Dr. Shroff’s Charity Eye Hospital in Delhi.

“We are all shaped by the people we meet, and especially by the ones we admire,” says Sinha. “Seeing my sister’s devotion as a doctor to helping those in need, even at great cost to her own health, affected me greatly. Project Prakash is a small tribute to her memory, and the future of many more Poonams.”



Art Without Rules

The purpose of Unruly Art, the art program led by Project Prakash, is to empower children in local communities with developmental disabilities to become creators. Volunteers transform a local classroom into an art studio, and participants are encouraged to get messy as they discover new textures, colors and sound. Working with paint and canvas, the artists will use tennis balls, brushes and their bare hands to make their own colorful creations, all while strengthening their social skills and self-confidence.

“We provide them with the resources and materials to experience art in whatever form they want, whether they want to work together or individually” says Sharon Gilad-Gutnick, staff research scientist in the Sinha lab at MIT. “It’s amazing to see them experiencing color and the texture of materials to produce something they are really proud of.”

To learn more about Project Prakash, visit www.projectprakash.org. To support research in BCS, visit bcs.mit.edu/give-bcs.

Research Bytes

Here is a snapshot of the latest research discoveries from BCS faculty and their research teams. To read the stories in full and to get the latest research news, visit bcs.mit.edu.

A glimpse of conversation

Study reveals the impact of harmonic sound on the cocktail party problem

One of the biggest mysteries of the brain is the cocktail party problem, or how we are able to carry on a one-on-one conversation in a crowded room, tuning out the noisy background to focus on a single voice. BCS Prof. Joshua McDermott published a study describing a new method to manipulate the frequencies of voice recordings to help us understand how the harmonic sound frequencies contained in speech impact our ability to understand natural sound in the real world. McDermott and his team presented participants with whispered words and phrases as well as speech samples rendered harmonic or inharmonic by a signal processing methodology developed by their collaborators. In some cases, participants heard one speech sample at a time, and in others, a speech sample was superimposed on another speech sample or noise, to simulate the sound of multiple people talking. The biggest impact on what participants heard occurred when the researchers instead simulated whispered speech. Unlike either harmonic or inharmonic speech, concurrent samples of whispered speech were reported to be nearly impossible to understand. The findings provide some explanation of why speech is voiced rather than whispered. With this insight, McDermott sees potential application to develop better hearing aid algorithms that will improve the device's ability to tune out background noise.

- Sara Cody | MIT Department of Brain & Cognitive Sciences

Want to hear the experimental sound samples for yourself? Visit the full story online:

bcs.mit.edu/news-events/newsletter

How the brain switches between different sets of rules

Cognitive flexibility — the brain's ability to switch between different rules or action plans depending on the context — is key to many of our everyday activities. A new study published by BCS Prof. Michael Halassa (MIBR) describes a region of the thalamus that is key to the process of switching between the rules required for different contexts. This region, called the mediodorsal thalamus, suppresses representations that are not currently needed. That suppression also protects the representations as a short-term memory that can be reactivated when needed.

The findings could help guide the development of better artificial intelligence algorithms, Halassa says. The human brain is very good at learning many different kinds of tasks — singing, walking, talking, etc. However, neural networks (a type of artificial intelligence based on interconnected nodes similar to neurons) usually are good at learning only one thing. These networks are subject to a phenomenon called “catastrophic forgetting” — when they try to learn a new task, previous tasks become overwritten. Halassa and his colleagues now hope to apply their findings to improve neural networks' ability to store previously learned tasks while learning to perform new ones.

- Anne Trafton | MIT News Office

Electrical properties of dendrites help explain our brain's unique computing power

Neurons in the human brain receive electrical signals from thousands of other cells, and long neural extensions called dendrites play a critical role in incorporating all of that information so the cells can respond appropriately. Using hard-to-obtain samples of human brain tissue, BCS Prof. Mark Harnett (MIBR) and his research team published findings that demonstrate human dendrites have different electrical properties from those of other species. Their studies reveal that electrical signals weaken more as they flow along human dendrites, resulting in a higher degree of electrical compartmentalization, meaning that small sections of dendrites can behave independently from the rest of the neuron. This could lead to increased computational capabilities of single neurons, potentially contributing to the enhanced computing power of the human brain, the researchers say. Harnett notes that there are many other differences between human neurons and those of other species, making it difficult to tease out the effects of dendritic electrical properties. In future studies, he hopes to explore further the precise impact of these electrical properties, and how they interact with other unique features of human neurons to produce more computing power.

- Anne Trafton | MIT News Office



Image credit:
Lou Beaulieu-Laroche
and Mark Harnett

MIT scientists discover fundamental rule of brain plasticity

Our brains are famously flexible, or “plastic,” because neurons can do new things by forging new or stronger connections with other neurons. But if some connections strengthen, neuroscientists have reasoned, neurons must compensate lest they become overwhelmed with input. In a new study in *Science*, BCS Prof. Mriganka Sur (PILM/Director, Simons Center for the Social Brain) demonstrate for the first time how this balance is struck: when one connection, called a synapse, strengthens, immediately neighboring synapses weaken based on the action of a crucial protein called Arc. Strengthening synapses increase Arc to weaken their neighbors, which helps explain how learning and memory might work at the individual neuron level because it shows how a neuron adjusts to the repeated simulation of another. This finding, he said, provides an explanation of how synaptic strengthening and weakening combine in neurons to produce plasticity. This information allows us to understand not only how neuronal circuits develop and remodel in a physiological setting, but provides clues that will be important in identifying how these processes go awry in various neurological diseases.

- David Orenstein | Picower Institute for Learning and Memory

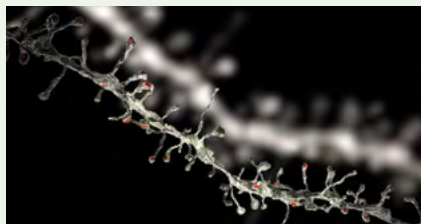


Image credit: Sur Laboratory

Neuroscientists discover roles of gene linked to Alzheimer's

People with a gene variant called APOE4 have a higher risk of developing late-onset Alzheimer's disease: APOE4 is three times more common among Alzheimer's patients than it is among the general population. However, little is known about why this version of the APOE gene, which is normally involved in metabolism and transport of fatty molecules such as cholesterol, confers higher risk for Alzheimer's. To shed light on this question, BCS Prof. Li-Huei Tsai (Director, PILM and Aging Brain Initiative) and her research team performed a comprehensive study of APOE4 and the more common form of the gene, APOE3 in brain cells derived from a type of induced human stem cells. They found that APOE4 promotes the accumulation of the beta amyloid proteins that cause the characteristic plaques seen in the brains of Alzheimer's patients, and that they could reverse these effects by editing the gene to turn it into the APOE3 variant. In another experiment, the researchers created three-dimensional “organoids,” or miniature brains, from cells with genes that are known to cause early-onset Alzheimer's. These organoids had high

levels of amyloid aggregates, and exposure to APOE3, but not APOE4, cleared most of them away. Tsai believes that APOE4 may disrupt specific signaling pathways within brain cells, leading to the changes in behavior that the researchers saw in this study, revealing possible avenues for therapeutic intervention. The findings also suggest that if gene-editing technology could be made to work in humans, which many biotechnology companies are now trying to achieve, it could offer a way to treat Alzheimer's patients who carry the APOE4 gene.

- Anne Trafton | MIT News Office

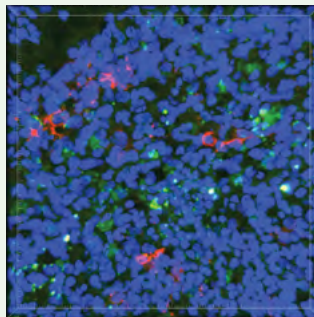


Image credit: Tsai Laboratory

Student Spotlight



Image credit: Steph Stevens Photo

Exploring unknowns in cancer, the human brain, and the road ahead

MIT senior Kerrie Greene's goals in coming to MIT was to study drug design, a topic that incorporates her interests in both medicine and engineering. For Greene, drug design offers a chance to increase the efficiency and accessibility of new drugs, and ultimately maximize their impact and reach. She found the ideal first major in bioengineering. Then, as a sophomore, Greene read a description of the social cognition research led by BCS Prof. Rebecca Saxe and began working in the Saxe lab through the Undergraduate Research Opportunities Program (UROP). Greene was instantly hooked.

“The more involved I was in the lab, the more I wanted to learn about the brain,” Greene explains. “I knew I had to take classes in brain and cognitive sciences.”

Inspired by Saxe's research, she added brain and cognitive sciences as a second major her junior year. For Greene, the intense coursework is outweighed by her passion for both fields. “It's been great,” she says. “I've really enjoyed getting to know students in both schools. Whichever class I'm in is the major I like more.”

- Brittany Flaherty | School of Science

Community Highlights



1. Throwback to summertime! 2018 marked the biennial Building 46 community retreat, held in Newport, Rhode Island this year. Image credit: McGovern Institute for Brain Research

2. BCS welcomed newest graduate students at the annual fall harbor cruise. From left to right, first row: Madison Leet, Sara Simpson, Sugandha Sharma, Qianli Xu, Cecilia Pellegrini, Jennifer Hu, Katya Tsimring, Cathy Wong, Tzu-Hsuan Ma and Omar Rutledge. Second row: Daniel Cho, Milan Halgren, Frances Reilly-Andujar, Mackenzie Lee, João Loula, Dimitra Vardalaki, Maxwell Henrich and Yuan Bia. Missing from photo: Josephina Correa and Gabrielle Drummond.

3. A group of BCS volunteers, led by grad student Joyce Wang, joined the MIT Museum for Girls Day, a community outreach event to promote girls in science. Hands-on demos included The Claw (a robot arm you controlled with your own brain activity, demonstrated by Joyce and 8-year-old future scientist Rhia, while her mom Shweta looks on), mirror tracing, exploring brain slices, make-your-own neuron art and more.

Noteworthy News

Earl Miller received the 2018 George A. Miller Prize in Cognitive Neuroscience from the Cognitive Neuroscience Society.

Emery Brown received the 2018 Dickson Prize in Science from Carnegie Mellon University.

The Institute of Electrical and Electronics Engineers (IEEE) has named **Ted Adelson** an elected Fellow for his contributions to “image representation and analysis in computer vision.”

Josh Tenenbaum was named R&D Magazine’s 2018 Innovator of the Year award for his work in cognitive science and AI.

Gloria Choi received the 2018 Peter Gruss Young Investigator Award from the Max Planck Florida Institute for Neuroscience.

BCS undergraduate **Kate O’Neill’19** received a Marshall Scholarship.

In recognition of his groundbreaking development of CRISPR-Cas9-mediated genome engineering in cells and its application for medical science, **Feng Zhang** received the Keio Medical Science Prize.

Mark Harnett has been named a 2018 Vallee Scholar from The Bert L and N Kuggie Vallee Foundation.

At the 2018 Advances and Perspectives in Auditory Neuroscience meeting, **Richard McWalter**, a postdoctoral associate in Josh McDermott’s lab, received a Best Talk award and **Alex Kell**, BCS graduate student in the McDermott lab received a Best Poster award.

Matheus Victor, postdoctoral fellow in Li-Huei Tsai’s laboratory, was among 15 researchers across the country who received a Hanna Gray Fellowship from the Howard Hughes Medical Institute.

Steven Flavell has been named the Lister Brothers Career Development Professor.

Rebecca Saxe has been named the inaugural John W. Jarve (1978) Professor in Brain and Cognitive Sciences.

Michale Fee received the 2018 McKnight Technological Innovations in Neuroscience Award for his research on “new technologies for imaging and analyzing neural state-space trajectories in freely-behaving small animals.”

Mary Potter was one of four faculty members featured in a new MIT Libraries initiative that seeks to highlight MIT’s women faculty by acquiring, preserving, and making accessible their personal archives to highlight the accomplishments and challenges faced by women in academia.

Ed Boyden and **Feng Zhang** were named Howard Hughes Medical Institute (HHMI) investigators in recognition of their work recognizing, developing, and sharing robust tools with broad utility that have revolutionized the life sciences.

Joel Blanchard, postdoctoral fellow in Li-Huei Tsai’s laboratory, received the Glenn Foundation for Medical Research Postdoctoral Fellowship in Aging Research.

Mark Bear received the 2018 Beckman-Argyros Vision Research Award from The Arnold and Mabel Beckman Foundation.

To view the full list of noteworthy news, visit the newsletter online at bcs.mit.edu

Department Welcomes New Associate Professor

Ila Fiete combines theoretical and computational approaches to understand the neural codes that underlie behavior and cognition

By Sara Cody

According to Ila Fiete, who joined the BCS faculty as an associate professor in the fall of 2018, it's an exciting time for brain research. The past two decades have seen rapid expansion in our capability to collect and analyze real-time activity in large numbers of neurons as animals perform tasks and exhibit interesting behavior. Computational approaches to extract understanding from these data are necessary for learning how brain and mind function.

"I study questions of mechanism and coding in the brain: how circuits in the brain compute, and why they represent information the way they do. It's exciting to see a renewed interest in theory overall. Advances in experimentation have opened a bigger peephole into the landscape of brain with new opportunities for insight," says Fiete. "With the wealth of data, we can more quickly validate or cast away old ideas, which in turn will free us to dream up new, bold ideas that will take us further than we ever thought possible."

Fiete's trajectory into neuroscience was serendipitous. As an undergraduate at the University of Michigan, she majored in physics, mathematics and philosophy. It wasn't until she was halfway through her graduate work in physics at Harvard University that she took a biophysics course at MIT. Led by former BCS faculty member Sebastian Seung, the course focused on computational systems biology. The intersection of her interests came together to illuminate an exciting new path forward: applying her physicist's mindset to study the brain.

"Physics appealed to me because I saw it as a way of thinking and approaching problems," says Fiete. "As a physicist, the types of questions I ask are how different time scales interact in neural processing, or how unavoidable fundamental processes, like fluctuations and noise, degrade memory and information processing."

Fiete's training helped inform her approach to research, where she combines theory with computation and theory-driven data analysis to explore longstanding questions about systems and cognitive neuroscience. Her research program focuses primarily on understanding how neural circuits support codes that underlie behavior.

"I'm very interested in how noise interacts with processing in neural systems, both positively and negatively, and in error control, or how the brain corrects the effects of noise" says Fiete. "For example, noise in memory systems is a disadvantage because it can corrupt memories that are being stored, so the brain has sophisticated strategies to fight against noise buildup to preserve memories. But in learning, motor control, and maybe even creativity, noise can be helpful because it helps with exploration and learning new strategies for navigating the world."

Fiete is also interested in understanding spatial navigation, which she became interested in with the discovery of grid cells, neurons that track our movement through the world and enable us to understand our environment. According to Fiete, these neural substrates are a "theorist's dream come true" because of their striking geometric fields with periodic response patterns as a function of space, and perplexing coding properties.

"Because animals must synthesize a lot of different types of sensory data and resolve large amounts of ambiguity to navigate successfully through the world, and at the same time the problems of navigation can be defined crisply in computational terms, spatial navigation is a beautifully contained example of complex cognitive computation in the brain, open to multiple levels of analysis," says Fiete. "There are environmental landmarks whose spatial relationships you can learn and then recall from your memory, your own body generates motion cues from sensory perception modalities like vision and audition, and you likely use probabilistic reasoning to help make inferences as you navigate through a noisy, ambiguous, changing world."

Understanding how navigation works in the brain could have a broad impact across many fields, such as the development of robust search-and-rescue robots that can successfully navigate new or unpredictable environments, much like humans and many animals can.

Coming to MIT, Fiete is excited by the collaborative possibilities of working with faculty who have expertise spanning both neuroscience and cognitive sciences. She hopes to focus her research program on mechanistic cognitive modeling to understand abstract cognitive function at the circuit level, while continuing to pursue her interests in memory and learning.

"An intrinsic piece of who we are as human beings is the drive to try to understand ourselves better, and the brain gives us the ultimate way to rise to that challenge," says Fiete. "As the most complex computing device that we know of, trying to understand how it works is an incredible intellectual pursuit." ■



Professor Ila Fiete

Meeting of the Minds

By Bridget E. Begg | Office of Graduate Education

In the summer of 2006, before their teenage years began, Mahdi Ramadan and Alexi Choueiri were spirited from their homes amid political unrest in Lebanon. Evacuated on short notice by the U.S. Marines, they were among 2,000 refugees transported to the U.S. on the aircraft carrier USS Nashville.

The two never met in their homeland, nor on the transatlantic journey, and after arriving in the U.S. they went their separate ways. Yet their paths converged 11 years later as graduate students in MIT's Department of Brain and Cognitive Sciences (BCS). One day last fall, on a walk across campus, Ramadan and Choueiri slowly unraveled their connection. With increasing excitement, they narrowed it down by year, by month, and eventually, by boat, to discover just how closely their lives had once come to one another.

Mahdi Ramadan (left) and Alexi Choueiri (right)
Photo credit: Joseph Lee



Despite different Lebanese cultural backgrounds — Ramadan's family is Muslim and Choueiri's Christian — both credit their experiences as refugees with motivating their interest in neuroscience. Questions about human behavior — How do people form beliefs about the world? Can those beliefs really change? — led them to graduate work at MIT.

Now in his second year, Ramadan plans to pursue his interest in neuroplasticity in Professor Mehrdad Jazayeri's lab by investigating how learning changes the brain's underlying neural circuits; understanding the physical mechanism of plasticity has application to both disease states and artificial intelligence.

Choueiri, a third-year student in the program, is a member of Professor Ed Boyden's lab, where he focuses his approach on making sense of people's choices. Choueiri wants to understand not just the human brain, but also the human condition — and to use that understanding to alleviate pain and suffering. In the Synthetic Neurobiology Group, Choueiri's research involves developing neurotechnologies to map the molecular interactions of the brain, to reveal the fundamental mechanisms of brain function and repair dysfunction.

Ramadan and Choueiri revel in the freedom of thought they have found in their academic home here. They say they feel they are taken seriously as students and, more importantly, as thinkers. BCS values interdisciplinary thought, and cultivates extracurricular student activities like philosophy discussion groups, the development of neuroscience podcasts, and independent, student-led lectures on myriad neuroscience-adjacent topics. ■■