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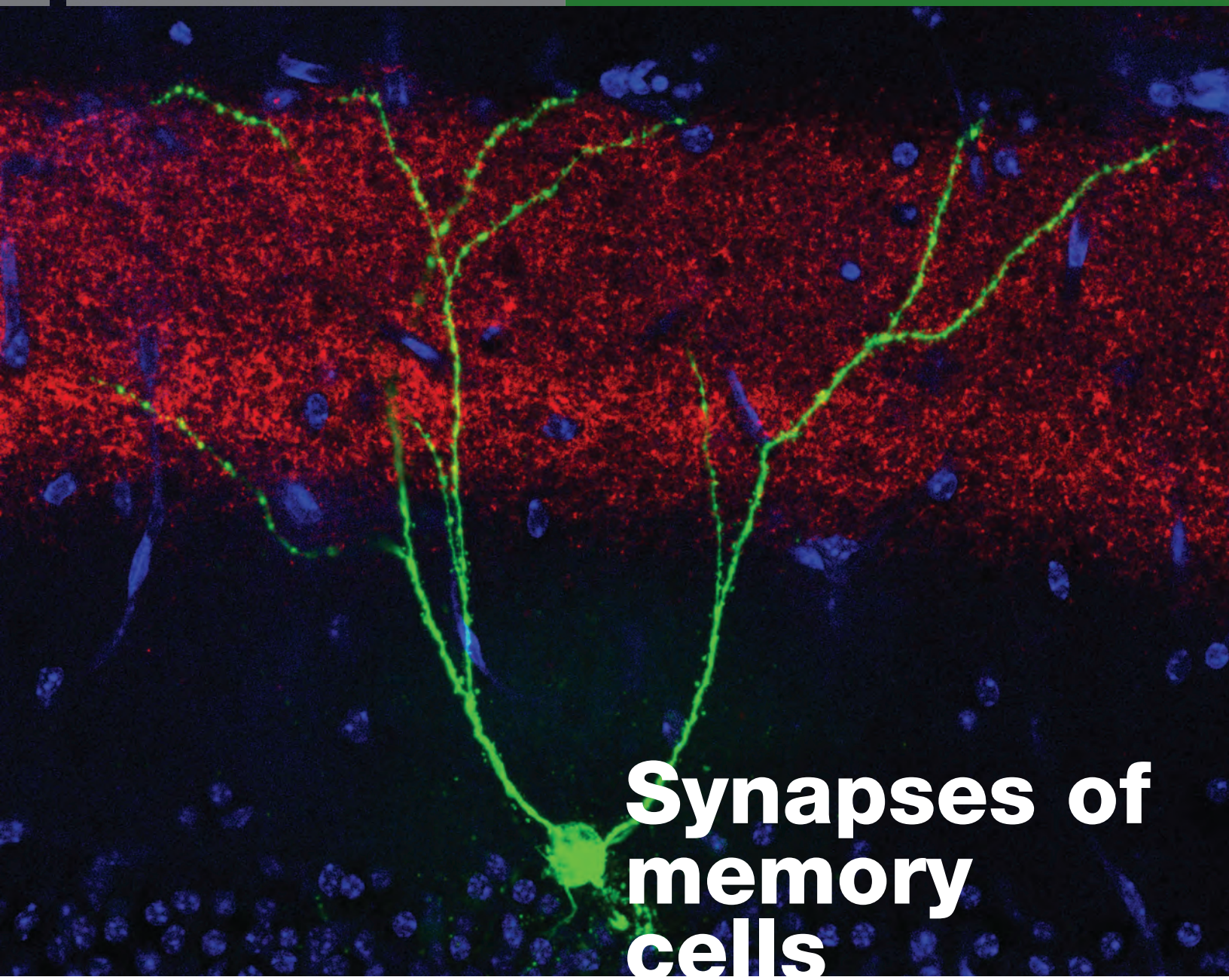

Synapses of memory cells

brain+cognitive sciences

contents

A Message from the Department Head
Jim DiCarlo

As I read through this edition of our newsletter, I am once again reminded that the department is filled with brilliant scientists, young and not so young, each producing great discoveries at the edge of knowledge. I am also reminded that the impact of each scientist is incredibly amplified by the other scientists that he or she is privileged to help teach and mentor to their own great discoveries.

It is my sincere pleasure to introduce to you BCS assistant professor Steven Flavell. Flavell's research examines how the brain sustains or switches between behavioral states at the molecular and circuit levels in c. *elegans*. He comes to us from a PhD at Harvard and a postdoc at Rockefeller University, where he was trained by MIT alum, Dr. Cori Bargmann, who was herself trained by MIT Professor Bob Horvtiz.

We also take a moment to share the academic journeys of four students. Undergraduate and graduate students are a vital part of the BCS Community's research, participating in cutting edge laboratory experiments that allow them to contribute directly to some of the best science in the field. I hope you enjoy meeting and learning about BCS undergraduate students Kara Presbrey, Anthony Preza, and Ian Zaun. MD / PhD student Stephen Allsop recently finished the PhD portion of his graduate degree here in BCS – Stephen's beautiful PhD work was carried out under the mentorship of BCS Assistant Professor Kay Tye, and Kay was one of the first undergraduate students I had the privilege of teaching when I was a new assistant professor here in BCS!

It would not be possible to bring these brilliant minds together and to train the next generation of these minds without the generous support of alumni and friends of the department. Your support has given us the ability to recruit the best faculty, postdocs, students and staff to address fundamental questions about the mind, the brain, and the connection between the two. I am very excited to see what the future holds – both the discoveries, and the incredible women and men that will make them. Thank you for your contributions to our mission.

On the Cover

10x_DG Engram Cells: This image represents a coronal section of hippocampal dentate gyrus (DG) from a mouse model of early Alzheimer's disease (AD). These AD mice exhibit severe -amyloid plaques (red) in the DG at 9-months of age. Using these mice combined with a novel viral strategy, engram cells (green; non-engram cells are in blue) for a contextual fear memory were tagged with a light-sensitive protein channelrhodopsin-2.

Image courtesy of Dheeraj Roy, Tonegawa laboratory

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In His Own Words

BCS MD / PhD Candidate Stephen Allsop Studies Social Cognition in the Tye Lab

What is social cognition?
In a nutshell, social cognition is the idea that we rely on social cues from other animals, or other humans, to understand things about our environment. There are many interesting questions we can ask about how the social brain works. For example, how are we able to take someone else's experience and use it to learn about something we didn't have to experience for ourselves? For example, If I see someone touch a hot stove and get burned, I learn that touching a hot stove is a bad thing even though I didn't get burned myself.

The approach we take to understanding how the brain allows us to engage in social behavior is to look at very basic, simple forms of social communication and see if we can understand those on a circuit level. To do this, I study observational fear learning in mice to see if one mouse can learn from watching the negative experience of another mouse. Many animals freeze when they are in a defensive state. If the observing mouse freezes when exposed to the cue that signaled danger for the demonstrator mouse, it shows that it picked up on that danger signal. As we run the experiment, we record information from the brain regions of the mouse that's observing, learning where in the brain these things are actually being encoded, and what cells are learning about this cue.

Why are you pursuing a MD / PhD?
Traditionally MD PhDs want to study things during the PhD part of their program that they might want to use clinically. In my case, I really see myself doing something in psychiatry, which is part of the reason I chose to study the brain for my PhD at MIT. There are a few ways you can tie the nervous system into a medical life, and I'm looking forward to exploring those options.

I have really enjoyed grad school at Brain and Cognitive Sciences I'm so fortunate to be in a great lab and have a fantastic PI in Kay Tye – someone who has been incredibly supportive of my work here at MIT, and knows exactly how to motivate me to do my best work. Emery Brown, my MD PhD advisor, has also been a great resource. On my main research project, I ended up collaborating with a postdoc in his lab.

What are your plans after finishing your degree?
In 20 years, I hope to be the PI of a successful lab that does interesting research that people find compelling and transformative. I also want to see patients, helping them work through and with whatever disorders they might struggle with. Lastly, I am a professional jazz musician, and I want to keep going with my music, doing shows and maybe having an album or two.

Interested in supporting students like Stephen? Join Champions of the Brain Fellows. Contact Elizabeth Chadis, Assistant Dean at (617) 253-8903 | echadis@mit.edu or find out more at bcs.mit.edu/champions

Allsop with BCS faculty member Kay Tye

Allsop speaking at the inaugural Champions of the Brain Fellows celebration. Champions was created to recognize the generosity of those friends and alumni who make it possible for BCS graduate students to explore their scientific dreams: to determine the right area of specialization and have the freedom of time to develop new insights and ideas.

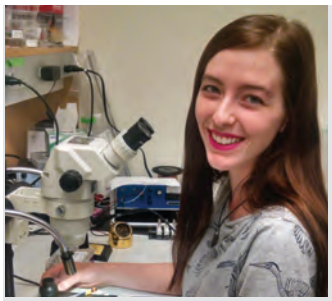
Allsop in the lab, working on optrodes used in social cognition experiments

Meet The Undergraduates

By Rachel Traughber | BCS Communications

BCS undergraduates are as varied geographically as they are diverse in their scientific interests. Recently, three of them sat down with bcsnews to chat about their experiences as undergraduates in the department.

Kara Presbrey, MIT senior in the Tye laboratory
Hometown: Fort Myers, FL



Kara Presbrey is an undergraduate researcher in Assistant Professor Kay Tye's lab using optogenetic techniques to manipulate and record neural activity in a cell-type and projection-specific manner. She has worked on several projects, including investigation of stress-induced alcohol seeking, memory retrieval and context-dependent conditioned responses, amongst others.

Kara Presbrey knew MIT was the place for her very quickly after attending an information session. "I saw a proof chalked on to one of the walls on the outside of the building where they held the info session and thought it was the greatest thing. It just felt right," she explains.

While her experience at MIT has been academically challenging, she quickly discovered that academics alone don't define undergraduates at the Institute. "I came to MIT thinking that everyone would be devoted exclusively to their academic interests. I found out rapidly that that's not at all the case. People here are very eccentric and have a wide variety of talents and recreational interests outside of the classroom. That is a big part of what has made me like MIT so much," says Presbrey.

After arriving, she had to choose between majoring in neuroscience or physics.

"The type of physics that interested me was more theoretical in nature, and I realized that, for me, studying the brain is more central to existence than physics. And on top of that, if I studied neuroscience, I can expect to get data, and I can expect to be able to test my hypotheses quickly In theoretical physics, it's possible to have a theory and spend forty years just trying to find a way to test it. While I don't necessarily expect to cure a disease, I do want to be able to show progress towards something in less time," explains Presbrey.

For the last four years, her scientific home has been BCS Assistant Professor Kay Tye's laboratory. She's particularly interested in memory, psychiatric diseases, and the questions of attention and emotion that touch both. "When neural circuits go awry and lead to disease, what's actually going wrong? In the Tye lab, we use a variety of approaches, from molecular and cellular to computational and systems. While we think of our study generally from the systems perspective, we really need techniques from many different levels to answer questions in an exhaustive manner," says Presbrey.

After graduation, Presbrey is taking a gap year before attending the University of California at San Francisco for a PhD in neuroscience, where she plans to continue her study of circuits.

"I think I want to stay in academia, but there are a vast number of opportunities in industry, as well. I'm looking forward to being able to make that choice."

Anthony Preza, MIT Junior in the Bear laboratory
Hometown: Los Angeles, CA

Anthony Preza is a member of Professor Mark Bear's lab where he performs biochemical assays, Golgi staining, spine imaging, and behavioral testing. His current project seeks to investigate the neurobiological mechanisms of convergent pathways among different genetic causes of Autism Spectrum Disorder (ASD), and to potentially identify therapeutic targets for treatment of ASD.

Anthony Preza was first inspired to join Professor Mark Bear's laboratory by his experience in 9.12 (Experimental Neurobiology) with BCS graduate student Laura Stoppel.

"Laura was really helpful in the class - she knew all the experiments and was fantastic at biochemistry. When I learned more about her research in the Bear Laboratory, I thought it was amazing. I was particularly interested in using biochemical techniques that I was familiar with to study the questions I care about the most."

Those questions center around studying autism as a developmental disease on the molecular level. Working with both neurotypical mice and mouse models that have genetic markers for different types of autism,

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BCS Community News

1. BCS welcomes new graduate students on the annual fall boat cruise. From left to right: (back row) **Sean Dae Houlihan, Luke Hewitt, Dustin Hayden, Sarah Schwettmann, Peilun Dai, Michael Lee, Chad Sauvola (front row) Anthony Martorell, Rosary Lim, Madeline Cusimano, Yi-Ning Leow, Xiangyu Zhang, Marie-Sophie van der Goes, Lou Beaulieu-Laroche**

2. Dean Sipser greets MIT alumni **Time Aune** ’85 and **Prisca Marvin** ’85 at the fall 2015 **Champions of the Brain Fellows** celebration

3. BCS community enjoying the fall 2015 boat cruise

4. Attendees at the fall 2015 **Champions of the Brain Fellows** celebration. Champions was created to thank those who support graduate student fellowships in the department

Department Welcomes New Assistant Professor

Steven Flavell studies the nervous system of *C. elegans*

By Rachel Traughber | BCS Communications

BCS Assistant Professor Steven Flavell

"The fundamental mechanisms that brain cells use to communicate with each other occur over the time scale of milliseconds, yet our brains can generate behaviors that last for minutes or even hours," says new Brain and Cognitive Sciences assistant professor Steven Flavell. "The goal of my lab's research is to try to understand how activity in the brain is organized over these longer time scales so that these persistent behaviors can be generated."

Flavell and his researchers are particularly interested in behaviors like sleeping and waking and the mechanisms that allow the brain to both persist in each state or to transition from one to the other. Studying these persistent behavioral states provides an ideal testing scenario for understanding how the brain organizes its behavior over a long period of time.

"Sleep and wakefulness are brain states that reflect the organization of neural activity over many hours," explains Flavell. "When a brain is in a state like wakefulness or sleep, we want to know which mechanisms allow the brain to persist in that state, rather than just fluctuate from millisecond to millisecond between states."

To study a problem with this level of complexity, he uses the nematode *C. elegans*. Consisting of 959 cells, 302 of which are brain cells, the animal's connectome, or the blueprint of its nervous system, has been mapped since the 1980s. *C. elegans*' small size is an advantage: Its simple nervous system generates long lasting behavioral states in many ways resembling our own, allowing researchers to examine complex behaviors generated by a simple nervous system.

"Numerically, *C. elegans* is very simple," explains Flavell. "There are around seven thousand electrical and chemical synapses between its 302 brain cells. To put that in perspective, one cell in the human hippocampus receives more synaptic connections than that by itself. And we have billions of neurons in our brains."

While this may seem far removed from the human brain, many of the basic biological mechanisms in *C. elegans* are replicated in the human nervous system.

"Its genome is very similar to our genome," says Flavell, "and it uses many of the same neurotransmitters that humans do." These similarities have allowed researchers to study this simple animal and make transformative discoveries in many different areas of biology.

Flavell is excited about the research possibilities that come with being part of the MIT community.

"MIT is one of the great places in the world to do neuroscience and I am thrilled to have so many new fantastic colleagues. My lab studies a system [*C. elegans*] that at times can be esoteric and perhaps far removed from neuroscience's mainstream. Working at an institution where there is tremendous mammalian neuroscience is a way for me to make sure that what we're doing with *C. elegans* is specifically interesting and important for neuroscience on the larger scale. It absolutely pushes us to do our best work," says Flavell.

Want to learn more about the Flavell lab's research? Check out bcs.mit.edu/flavell

Flavell speaking at the spring 2016 BCS Community Retreat in Newport, RI

Noteworthy News

Edward Boyden was one of five scientists honored with the Breakthrough Prize in Life Sciences, given for "transformative advances toward understanding living systems and extending human life." He was also recently awarded the BBVA Foundation Frontiers of Knowledge Awards for his work on optogenetics. The awards are given annually for "outstanding contributions and radical advances in a broad range of scientific, technological, and artistic areas."

Emery Brown is now a full Investigator in the Picower Institute. He was also recently named a Fellow of the National Academy of Inventors.

Kwanghun Chung was awarded a Packard Fellowship. The Packard Foundation invites 50 universities to nominate early-career professors from their institutions for the five-year $875,000 grants, which give emerging young scientists and engineers the freedom to take risks, pursue innovative ideas, and creatively explore new frontiers.

Jim DiCarlo was named Peter de Florez chair of Neuroscience.

Susan Hockfield has been chosen to serve as president-elect of the American Association for the Advancement of Science (AAAS). She will begin her three-year term as an officer and member of the Executive Committee of the AAAS Board of Directors on Feb. 16, 2016, at the conclusion of the 182nd AAAS Annual Meeting in Washington.

Feng Zhang received the 2015 Transformative Research Award from NIH. The award supports exceptionally innovative, unconventional, paradigm-shifting research projects that are inherently risky and untested.

Takashi Kitamura, **Ram Madabhushi**, **Michele Pignatelli di Spinazzola**, **Lindsey Powell**, and **Feng-Ju Weng** won Infinite Kilometer Awards. Recipients of these awards are exceptional contributors to their research programs. In many cases, they are also deeply committed to their local or global MIT community, and are frequently involved in mentoring and advising their junior colleagues, participating in the school's educational programs, making contributions to the MIT Postdoctoral Association, or contributing to some other facet of the MIT community.

Congratulations to the following students who passed their qual exams: **Deniz Atabay**, **Jake Donoghue**, **Alex Kell**, **Rosa Lafer-Sousa**, **Tuan Le Mau**, **Julia Leonard**, **Chris Leppla**, **Michael Reed**, **Josh Rule**, **Chen Sun**, **Hongyi Zhang**.

The following people have received School of Science Spot Awards: **Toni Oliver**, **James Traer**, and **Samantha Floyd**. Spot Awards are intended to acknowledge and demonstrate appreciation and recognition for the exceptional contributions of individuals and teams, large or small.

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his hope is to trace autism spectrum disorders to converging biochemical pathways that can be targeted with beneficial drugs.

"We're particularly interested in the hippocampus, which is the area of the brain where working memory is formed," explains Preza. "The mouse models we study seem to have a very hard time habituating to new environments. In contrast, neurotypical mice learn about a new environment by exploring it a bit at first and becoming accustomed to their setting."

When a mouse that has genetic characteristics associated with particular forms of autism is placed in the same environment, it has difficulty becoming familiar with its surroundings.

"These mice appear to believe that they're always encountering a new environment, even after they have had time to explore the environment," says Preza. "We think this result is explained by a failure to habituate to the novel environment, which may be correlated to social behavior challenges in humans."

After graduating, Preza looks forward to taking a gap year before pursuing his dream of attending an MD / PhD graduate program.

"I see myself having an integrative approach in my career that combines research and treating patients. I want to be there for families. When you have a child who has an intellectual or developmental disability, it can be an incredible financial burden, especially if the resources aren't immediately available in your community, or if you come from a family that doesn't have the means to get that family member help. I want to be part of solving that problem before it starts."

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Ian Zaun, MIT junior in the Kanwisher laboratory
Hometown: Los Angeles, CA

Zaun demonstrates ASL Eyetracking glasses. The glasses locate and track the retina and project its gaze points into camera footage by shooting infrared waves onto the glass monocle that reflects onto the eye. The eye then bounces these waves back to the eye tracker. By accounting for the differences between the initial infrared waves it sent out and the infrared waves that bounced back, the tracker is able to show on scene camera video where the retina was focused, indicating where the subject was looking.

"Majoring in brain and cognitive sciences is so much more than just neuroscience and psychology. The range of options is so broad. You can work with mice, you can work with computers, you can code – you're really taking multiple disciplines and forging your own path. And after you're done, you can take the skills you've learned here and work anywhere in the world, doing anything," says Ian Zaun.

The BCS junior is a member of the Kanwisher lab, where he works on psychophysical applications.

"The primary focus of our work is social cues. We know that people who have autism or prosopagnosia struggle with recognizing faces and picking up social cues. If we're able to figure out where that circuitry breaks down, hopefully we can develop therapies that will help correct it," explains Zaun.

They accomplish this by identifying where neurotypical subjects look on people's faces to see how they navigate the world. "Recently, we've been working on a real world eye tracker that's more succinct and compact than the current models," says Zaun.

In addition to his work in the lab, Zaun is a volunteer EMT on campus and the MedLinks director for his dorm. Supported by MIT's Community Wellness at MIT Medical, MedLinks is a student based health advocacy program that connects students to each other for medical help, from recommending over the counter medications to lending a friendly ear when things get tough.

"The mental health support aspect of MedLinks is incredibly attractive to me. It's a way to change the dialog about mental health in our society and build a safe space for those who struggle," explains Zaun. "The more people who accept that mental illness is a problem and are willing to talk about it, the better chance we have of making a real difference in people's lives down the road." His desire to be of service to others doesn't stop at the borders of MIT's Cambridge campus. Post graduation, Zaun hopes to attend medical school.

"I spent some time in children's hospitals growing up and was really impressed with the medical staff. The hope and the caring demonstrated there was absolutely inspirational. It would be a great place to contribute to that legacy of raising the quality of life for people in need."

Learn more about the undergraduate program in the department at bcs.mit.edu/undergraduate