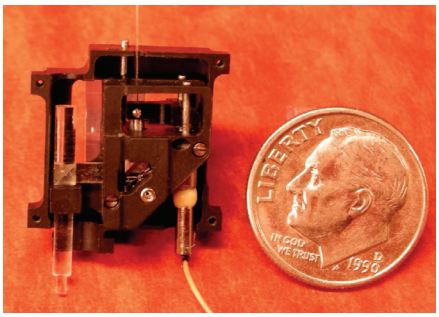
Unraveling the Mysteries of the Brain



A team led by **Mark Schnitzer,** assistant professor of biological sciences and applied physics, developed the world's smallest two-photon fluorescence microscope, which is roughly the size of a dime.
Photo:

It takes less than half a second to recognize a face. For most people, the process is innate, yet others struggle with it. They suffer from a rare but socially debilitating disease called Prosopagnosia, or face-blindness.

"It's like a learning disorder, but the underlying brain mechanisms are unclear," says Kalanit Grill-Spector, an assistant professor of psychology who leads the Visual Perception and Neuroscience Lab at Stanford. Her main research focus is in understanding how the human brain recognizes objects—faces in particular—and how the ability develops from childhood to adulthood.

"Faces are a particularly interesting stimulus," she says, explaining that faces are extremely similar, because they contain the same features and everyone's eyes, nose, and mouth are roughly in the same place. Yet most of us are naturally able to distinguish one person from another in a way we can't with many other objects.

Although neuroscientists agree that there is a constellation of regions in the brain that processes objects and faces, there is debate in the field on whether there is a unique region that specializes only in processing faces. To uncover the answer to this mystery, Grill-Spector and colleagues are looking at the brain's intricate structure using functional magnetic resonance imaging, or fMRI.

The fMRI machine uses magnetic fields to measure changes in blood oxygenation in the brain in response to neural activity. For example, say a research subject is shown a picture of Harrison Ford. The part of the brain that works to recognize the actor's face needs oxygen, which is delivered through the bloodstream. The fMRI can detect the changes in the amount of oxygen in the blood and thus create a map of where activity is occurring in the brain.

Several researchers in Stanford's Department of Psychology, which has been top-ranked nationally for decades, use imaging techniques to investigate a diverse set of unanswered questions about the brain. Assistant Professor of Psychology Brian Knutson and collaborators in Stanford's Graduate School of Business use fMRI to look at activation in the portions of the brain linked to excitement and anxiety in their studies on financial decision making. Ian H. Gotlib, professor of psychology and senior associate dean for the social sciences, examines genetic information and brain responses in young women to understand mechanisms that increase vulnerability to depression. And Brian Wandell, the Isaac and Madeline Stein Family Professor and chair of the psychology department, explores the pathways that are important in children's brains as they learn to read.

"Each one of us has something we're passionate about," says Wandell, who serves as co-chair of The Stanford Challenge's Initiative on Human Health. He is leading an effort to create a campus center for cognitive and neurobiological imaging with colleagues from psychology, engineering, radiology, neurobiology, physics, and even philosophy. The center would promote sharing of instrumentation, methods for computation and data analysis, training courses, and new ideas and knowledge. "Our goal is to make Stanford the leader in obtaining images and building new instruments to obtain new kinds of images," Wandell says.

Mark Schnitzer, assistant professor of biological sciences and applied physics, is passionate about building those instruments. His research group has developed the world's smallest two-photon fluorescence microscope—a dime-sized apparatus that can rest on a mouse's head and produce detailed pictures of

components in its brain. The tool has potential for both basic science studies of the brain and clinical applications like guided surgeries.

Next, Schnitzer hopes to build what he calls "the world's largest fluorescence microscope," a tool that would allow researchers to examine how groups of cells interact across the entire span of the brain. The envisioned instrument would help researchers see how neurons network with each other, process information, and pass information to other areas. Schnitzer believes that a key unanswered question in neuroscience is how these processes ultimately lead to behaviors, and he hopes his microscopes will help find answers.

The face-recognition studies performed by Grill-Spector and colleagues also push the cutting edge of instrumentation. She works with physicists and engineers like Gary H. Glover, a professor in Stanford's radiology department with courtesy appointments in electrical engineering and psychology, to make improvements in fMRI measurements and image the visual portion of the brain with higher resolution than ever before. "When you increase the resolution," she says, "a region that looks very homogeneous with standard resolution shows much more detail. This helps us make more accurate measurements of brain function."

Insights gained from Grill-Spector's work shed light on disorders like autism, while other teams contribute knowledge of brain conditions such as dyslexia, depression, Alzheimer's disease, and stroke. However, researchers are still most driven by basic science and the challenge of unraveling the brain. As Schnitzer says, "To understand the brain would be a major intellectual feat."

Need caption copy for large photo.

"Insights gained from Grill-Spector's work shed light on disorders like autism, while other teams contribute knowledge of brain conditions such as dyslexia, depression, Alzheimer's disease, and stroke."