Listen to neuroengineers talk among themselves and you might mistake their more animated flights of conversation for science fiction. For instance, take Caleb Kemere, who recently joined the department of electrical and computer engineering (ECE) at Rice University as an assistant professor:

"I have seen a memory in a brain. I can look at thoughts as they're happening. I've looked into a hippocampus and said, 'There it is. He's having a memory right now, and I can see it.' It's an amazing thing, and I'm seeing it in real time."

Or Jacob Robinson, another recent arrival on the ECE faculty: "It's amazing to see two cells talking to each other. It's like eavesdropping, and we're listening in on their conversation. This is something we couldn't do until recently."

Both men are sober researchers, practitioners in a newly minted and still loosely defined discipline that draws from neuroscience, biomedical engineering and physical medicine and rehabilitation, as well as electrical engineering and other fields. Robinson, who is an assistant professor, likens neuroengineering today to the promise posed by physics a century ago:

"Think of Einstein early in the 20th century, and think of how his work changed the world in just a few years. A flood of new techniques, often borrowed from disciplines like physics and engineering, are enabling us to study the brain at a level of detail that has never before been possible."

Caleb Kemere

NEUROENGINEERING: A NEW WORLD FOR ENGINEERS

Recently organized is the Center for NeuroEngineering (CNE), bringing together researchers from Rice, Baylor College of Medicine and the University of Texas Health Science Center. Its mission has been defined as "the analysis and control of the nervous system in order to enhance and restore neuronal function."

Robinson defines the emerging discipline as "engineers moving in the direction of neuroscience." He notes that "circuits" are present in both electronics and the central nervous system, including the brain. He and his students in the Robinson Research Group study the behavior of neural circuits using nano-fabricated devices in tandem with optical, genetic and electrophysiological techniques.

The conversations between cells involve thousands to millions of neurons. The challenge is to monitor the activity of all the cells involved in making decisions within the brain. Using new nanofabrication technology, he hopes to make such measurements possible.

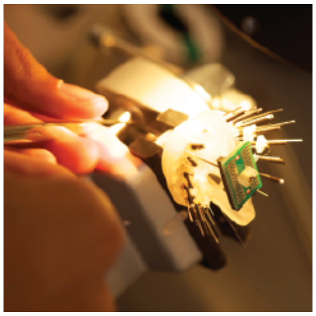
For instance, his lab uses vertical nanowires to deliver biomolecules into living cells, including neurons. Robinson's chief interest is in the interface between cells and manmade circuitry, what he calls "plugging into the brain."

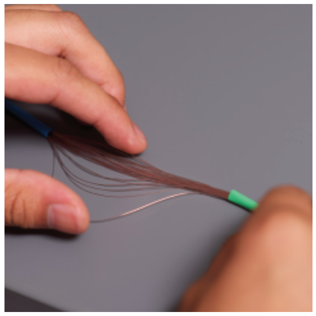
Rob Raphael, associate professor of bioengineering, organized the Membrane and Auditory Bioengineering Group when he joined the Rice faculty in 2001. His research focuses on prestin, a membrane protein that converts electrical signals into mechanical motions.

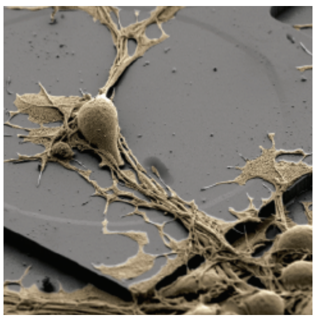
"From a materials perspective," he said, "prestin is a nanoelectromechanical device that enables us to hear high frequencies."

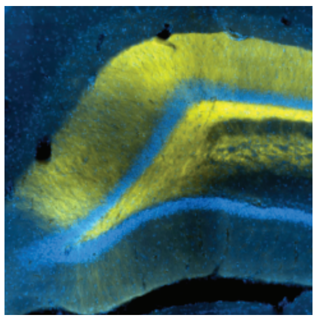
By taking an engineering approach to the molecular and biophysical basis of hearing, his lab has made fundamental contributions to auditory bioengineering. It built the first systems-biology model of ion homeostasis in the inner ear, collaborated on research into the feasibility of an optical cochlear implant and developed microfabricated devices to electrically and mechanically manipulate cells.

Raphael has taught courses in neuroengineering since 2003, and has long believed it represents a strategic opportunity for Rice: "Our traditional strengths in signal processing, computational modeling, biomaterials and nanotechnology, coupled with new thrusts in systems and synthetic biology make it an ideal place to build a cross-departmental initiative in neuroengineering."









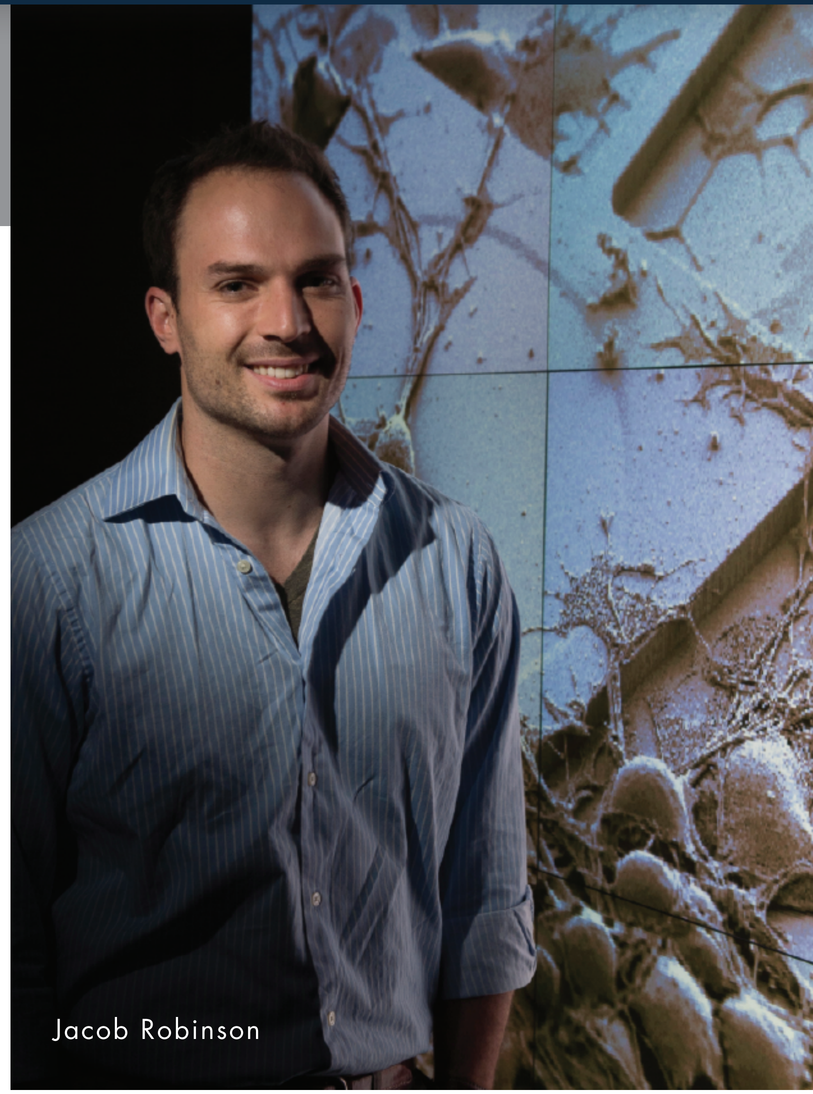
Much of Kemere's research is devoted to the hippocampus, the region in the brain where spatial learning takes place and where memories are formed, stored and used. Injury or disease in the hippocampal circuit can lead to memory problems, such as those associated with Alzheimer's and post-traumatic stress disorder, as well as depression and anxiety.

Kemere aims at understanding the hippocampus at the systems level in healthy brains, how it goes wrong and what can be done to change how it functions.

"We're starting with basic brain science, learning how it works," he said. "Can studying a traumatic memory in a rat help us understand the human brain? We're recording the activity of dozens of neurons in behaving rodents and manipulating genetically-selected populations of neurons using light, a technique known as "optogenetics."

By using information decoded from neural activity, Kemere can manipulate the hippocampal circuit. Detecting the neural activity that underlies individual memories in real-time, he hopes to selectively inhibit the recall or long-term storage of trauma.

"Truly, our field is in its infancy, but I can foresee a time when we'll be able to treat and maybe even eliminate such human diseases as drug addiction, epilepsy and Parkinson's disease. Who knows where it may lead?" Kemere asked.



Jacob Robinson

Rob Raphael