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UCSB Scientists Discover How the Brain Encodes Memories at a Cellular Level

Scientists at UC Santa Barbara have made a major discovery in how the brain encodes memories. The finding, published in the December 24 issue of the journal Neuron, could eventually lead to the development of new drugs to aid memory.

The team of scientists is the first to uncover a central process in encoding memories that occurs at the level of the synapse, where neurons connect with each other.

"When we learn new things, when we store memories, there are a number of things that have to happen," said senior author Kenneth S. Kosik, co-director and Harriman Chair in Neuroscience Research, at UCSB's Neuroscience Research Institute. Kosik is a leading researcher in the area of Alzheimer's disease.

"One of the most important processes is that the synapses –– which cement those memories into place –– have to be strengthened," said Kosik. "In strengthening a synapse you build a connection, and certain synapses are encoding a memory. Those synapses have to be strengthened so that memory is in place and stays there. Strengthening synapses is a very important part of learning. What we have found appears to be one part of how that happens."

Part of strengthening a synapse involves making new proteins. Those proteins build the synapse and make it stronger. Just like with exercise, when new proteins must build up muscle mass, synapses must also make more protein when recording memories. In this research, the regulation and control of that process was uncovered.

The production of new proteins can only occur when the RNA that will make the required proteins is turned on. Until then, the RNA is "locked up" by a silencing molecule, which is a micro RNA. The RNA and micro RNA are part of a package that includes several other proteins.

"When something comes into your brain –– a thought, some sort of stimulus, you see something interesting, you hear some music –– synapses get activated," said Kosik. "What happens next is really interesting, but to follow the pathway our experiments moved to cultured neurons. When synapses got activated, one of the proteins wrapped around that silencing complex gets degraded."

When the signal comes in, the wrapping protein degrades or gets fragmented. Then the RNA is suddenly free to synthesize a new protein.

"One reason why this is interesting is that scientists have been perplexed for some time as to why, when synapses are strengthened, you need to have proteins degrade and also make new proteins," said Kosik. "You have the degradation of proteins going on side by side with the synthesis of new proteins. So we have now resolved this paradox. We show that protein degradation and synthesis go hand in hand. The degradation permits the synthesis to occur. That's the elegant scientific finding that comes out of this."

The scientists were able to see some of the specific proteins that are involved in synthesis. Two of these –– CaM Kinase and Lypla –– are identified in the paper.

One of the approaches used by the scientists in the experiment was to take live neuron cells from rats and look at them under a high-resolution microscope. The team was able to see the synapses and the places where proteins are being made.

The first author on the paper is Sourav Banerjee, a postdoctoral fellow with the Neuroscience Research Institute and the Department of Cellular, Molecular, and Developmental Biology. The other author is Pierre Neveu, who is affiliated with the Neuroscience Research Institute and the Kavli Institute of Theoretical Physics.

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