

THE GENETICS OF LEARNING AND MEMORY

Slugs Take The Prize

Who would have thought that in the year 2000 *slugs* would lay claim to the Nobel prize?

Over 30 years ago, Eric Kandel and his co-workers set out to discover what happens at a cellular and molecular level in simple tasks of learning and memory. And what could be simpler than the memory of a slug?

In order to get experimental evidence of what happens to nerve cells during learning and memory, they set up an experimental program using the invertebrate animals *Aplysia californica*, more commonly known as sea slugs.

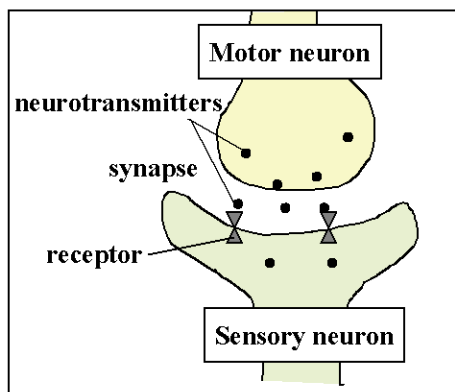
Sea slugs have been used for studying memory for several reasons. One is that slugs have only 10,000 to 20,000 nerve cells (compared with the billions of nerve cells in the human brain). And sea slugs are capable of simple learning. Here's how it works:

Aplysia lives in ocean waters and breathes through a gill. When danger threatens, the gill is pulled back reflexively as a defense mechanism.



Scientists exploited this behavior to study learning and memory storage. They set up experiments in which a blast of air was directed toward the siphon and gill – this stimulation caused the gill to withdraw. When the stimulation was repeated often enough, the withdrawal response decreased. This “learning” lasted for minutes. If a very strong stimulus was used (such as electric shock) the learning lasted for days.

The nerves needed for this simple gill withdrawal response are just 6 motor (movement) neurons and 24 sensory neurons that detect the stimulus. The sensory neurons make direct contact with motor neurons and also interact via intermediaries: interneurons.



Why is this important enough to warrant the Nobel Prize? First it showed that memory could be addressed through experiments with model organisms. Second, sea slugs provided a way to ask specific questions about changes in neurons and synapses as learning occurs.

Eric Kandel and his co-workers wanted to understand what was happening in the neurons to produce this learning response. They found that for short-term effects, certain ion channels let in more calcium ions and as a result, more neurotransmitter was released at

the synapse. This prolongs that activity of the neurons, but eventually the levels of neurotransmitter return to normal, leading to a short-term memory.

In contrast to short-term memory, long-term memory can last for weeks – even in slugs. Dr. Kandel discovered that when the stimulus is very strong, new proteins are made in the neuron, which create long-lasting changes in the cell. These changes produce long-term memories.

At last, in 2000, Eric Kandel's long pursuit of the molecular basis of learning and memory paid off when he shared a Nobel Prize with two other researchers who studied different aspects of the molecular events in memory. For more information about Dr. Kandel and his research, go to the Explore!Gallery and click on the websites for the Nobel Prize.

References

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Website: <http://www.nobel.se/medicine/laureates/2000/press.html>