BIOLOGY

Julie Ann Miller reports from Anaheim at the annual meeting of the Society for Neuroscience

Singing in the pond

Twenty-six hundred species of frog and toad each emit a unique mating call. On the basis of that serenade, a female frog selects a male from among the many species breeding in a pond. For 20 years Cornell University researchers have been looking for a region of the brain that recognizes mating calls, distinguishing them from other frog calls and meaningless sounds. Now they have found such a center.

The bullfrog's inner ear has two structures sensitive to different ranges of sound frequencies. Of the frog's vocal repertoire, only the mating call simultaneously stimulates the two inner ear structures. Therefore, any mating call detector in the brain must receive input from both structures.

Robert R. Capranica and co-workers used a sound synthesizer that could mimic natural frog calls. They probed the brain, level by level, looking for mating call detectors. In anesthetized animals they found four orders of sound processing, but no center for the mating call. However, Karen Mudry recorded electrical activity in the thalamus of the conscious bullfrog and found an area that responds to the simultaneous high and low frequencies of the mating call. That fifth-order response was not previously detected because it does not operate in anesthetized animals.

Capranica believes that the mating call detector is a population of cells instead of a single cell. Redundancy ensures that functions are not lost when specific single brain cells die. "Cells die all the time in the brain, yet you don't suddenly lose the ability to detect 'hello' or 'good-bye,' " Capranica says.

The social hiss evolves

Giant Madagascar cockroaches communicate with a loud hiss. Margaret C. Nelson of Harvard Medical School and Jean Fraser of Brandeis University have identified four hisses with different amplitude patterns and social purposes. The roaches hiss through a breathing structure, a spiracle, that has been modified during evolution. When the investigators "mute" a male roach by temporarily gluing shut his spiracle, the roach's success, both in fighting and in copulation, plummets.

The hiss apparatus is the fourth spiracle in a series that extends along the side of the cockroach. That valve doesn't participate in normal respiration; it opens during a hiss while the others are held closed. By comparing the fourth spiracle with its less specialized neighbors, Nelson and Fraser are examining the changes that contribute to evolution of a significant behavior. They find a narrow junction in the air passage of the fourth spiracle is responsible for the hissing sound. Both the muscles that open and close the valve are larger in the hiss spiracle, and the former has an extra segment. As yet, the investigators have seen no difference in the nerve cells contacting those muscles, but they do measure differences in the rhythm of the nerve signals. Eventually, Nelson and Fraser hope to map all the participating nerve cells and identify the signals that switch the roach from breathing to each type of hiss.

Synaptic death

The strategy by which the brain makes billions of connections between nerve cells may be more spendthrift than frugal. Researchers used to think once a synapse was established with a target cell, the cells were committed to maintaining that connection. New data indicate that the brain is more extravagant. "Neurons have been caught wantonly abandoning many of their synaptic contacts," says David C. Van Essen of the California Institute of Technology. The situation may be similar to cell death, where as many as 75 percent of the cells in some part of the nervous system die during normal development. Van Essen and colleagues have found that in the rat soleus muscle up to 80 percent of the synapses initially formed are lost during maturation. Shortly after birth each nerve cell is connected to about 600 muscle fibers, while in the adult it contacts only about 120.

So far the researchers do not know what biochemical signals direct the decay of the synapses, but they do know that the tendency to remove connections is strong. When the investigators sever a large number of nerve cells, the remaining few originally contact much of the muscle. But they do not permanently compensate for the missing neurons. In the weeks after birth, the nerve cells withdraw about two-thirds of the connections, even though that leaves some muscle fibers with no nerve input at all.

Under normal conditions each muscle fiber in the adult has one nerve input. Van Essen believes that the fiber eliminates extra connections until there is only one left. "It is like a miniature wrestling match," he says. "One chokes off the other if they are close together." By implanting a foreign nerve, he has shown that inputs can coexist indefinitely if they are more than one millimeter apart.

Elimination of synapses is not an oddity of the neuromuscular junction, Van Essen points out. There are examples in several parts of the nervous system. Van Essen concludes, "The general notion is that survival of synapses depends on interactions of the presynaptic and the target cells"

Nerve patterns behind a step

A single step is a complex business. Continuous reports of changes in skin pressure, temperature, muscle length and joint position travel to the spinal cord where they produce automatic adjustments in muscle tension. A cat's hind limb has more than 100,000 nerve cells providing such sensory information. A new technique now permits biologists to eavesdrop on some of these signals.

Gerald E. Loeb and Jacques Duysens of the National Institutes of Health implant a number of fine wires into the section of a cat's spinal cord that contains cell bodies for sensory neurons. Long cell processes run from the spinal cord to the receiving area at the skin or muscle or joint. The cats recover from the surgery within two days and show no limp or apparent discomfort. The wires from the spinal cord are attached to a connector mounted on the back of the animal. For several days the researchers can plug wires of their recording equipment into that connector to detect nerve signals in the freely walking animal.

The researchers have recorded activity from all types of sensory nerve cells. Some receptors generate simple patterns of activity that correlate with the tension a muscle exerts on a tendon. The investigators were surprised by the vigorous activity of the receptor cells sensitive to hair movements and light touches on the skin. Most of these cells produce consistent volleys of signals at specific points in the step cycle. Often the cells fire when their receptors do not appear to be touching any object. Loeb and Duysens suggest that small skin stretching movements are sufficient to activate these cells.

Many receptors appear to respond in a more complex manner. The new results indicate that joint receptors do not respond only to the angle of the joint, but also to a number of related factors. And muscle spindle organs do not sense muscle length linearly. They use their own internal muscle fibers to adjust sensitivity during the step cycle.

Finally, Loeb and Duysens find a number of nerve cells generating complex patterns that seem unrelated to any aspect of movement. They suggest these cells may monitor blood circulation or muscle fatigue.