velop a theory and keep it within the scientific circles," said Eaton, who spent two weeks last summer with members of the Institute of Geophysics in Peru, helping put Brady's prediction in perspective in light of other U.S. seismologists' views.

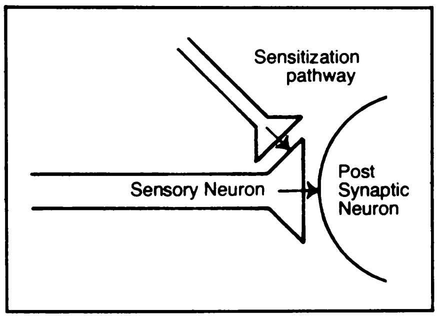
Despite his feeling that Brady was premature in publicizing a theory still unsubstantiated in the eyes of most seismologists, Eaton says that in the long run, the attention focused on the need for a better seismic program in Peru may be beneficial. While scientists have a responsibility to disclose all facts and theories regarding earthquake prediction as soon as they can be evaluated, Eaton asserts, private citizens worried about earthquakes must understand the tentativeness of such information. Just as weather forecasts can predict only the probability of storms and sunshine, even the best quake prediction program will only be accurate part of the time. □

Basics of learning: Enzymes and pores

Simple marine snails may not play the piano, write poetry or do calculus, but they do learn behaviors appropriate to their life-styles. Because their nervous systems have only a few thousand cells, which are large and identifiable (SN: 9/29/79, p. 218), these snails are accessible subjects for the scientists who dissect behavior. At the recent meeting called "Physiology: The Next Decade" at Cornell University, Eric R. Kandel described in minute detail the basic biochemistry of a simple form of sea snail learning.

The behavior Kandel studies at Columbia University in New York is a defensive reflex. When disturbed by a light touch to its siphon, the marine snail *Aplysia* withdraws its gill and siphon. With repeated touches and no dire consequences, the animal habituates and stops withdrawing its mantle organs. In contrast, a strong stimulation elsewhere on the body enhances the defensive reflex for up to an hour. It is this sensitization that Kandel now describes in great biochemical detail.

Kandel and colleagues have worked out the exact nerve cell connections involved in much of *Aplysia*'s behavioral repertoire. The gill withdrawal reflex, with the sensitization pathways, involves about 36 cells.



Twenty-four sensory neurons carry a signal from the skin at the siphon and synapse, or make contact, both on the six motor neurons that make the gill contract and on an intermediary neuron. This interneuron also synapses on the motor neurons that withdraw the gill.

The sensitization pathway studied by Kandel runs from the tail surface to the sensory neurons that respond to light touch on the siphon. A group of five interconnected cells contact the sensory neurons at their endings and modify the signals the neurons send. In the presence of a sensitization message, the sensory nerve cells release more of their transmitter chemical and thus send a stronger message to the next cells in the gill withdrawal pathway.

The message from the sensitizing cells to the sensory cells is conveyed by the transmitter chemical called serotonin. Kandel reports that serotonin binds to a receptor on the sensory cell synaptic membrane and blocks a previously unrecognized channel for potassium ions. When that channel is blocked, the signals that travel along the sensory cells have a longer influence on the synapse, so the sensory cell releases more neurotransmitter.

The biochemical steps between serotonin binding and potassium channel blockage are being worked out. As in the case of other receptors, the binding appears to activate the enzyme that makes cyclic AMP (often called the "second messenger"). The increase in cyclic AMP activates yet another enzyme. This one, a kinase, adds a phosphate group to a protein, either the potassium channel itself or a molecule that regulates it.

Which step of the biochemical path allows sensitization to last an hour? Experiments using an enzyme inhibitor indicate that the kinase must be active throughout the period, so cyclic AMP levels probably remain elevated the entire time. Kandel expects a new technique that allows scientists to maintain single sensory neurons of *Aplysia* in laboratory culture to allow a more complete answer to this question.

Sensitization may seem far removed from learning, but Kandel believes it has features in common with the behavior called direct conditioning (or associative learning). *Aplysia* can be conditioned to withdraw their gills in association with a tail shock, a stimulus similar to the one that causes sensitization. Experiments with fruit flies also link the phenomena. The mutant fly named dunce, which lacks an enzyme of cyclic AMP metabolism (SN: 11/18/78, p.344), cannot become sensitized nor can it show associative learning.

The mechanism described by Kandel is expected to whet the appetites of biochemists rather than to definitively explain learning phenomena. Kandel cautions, "Learning is a wide family of events. We have to expect a variety of mechanisms." □

Upright walking: Teeth tell the tale

It's not easy to describe someone's life-style when all you have to go on are a few teeth, but that's what anthropologists have to do in their attempts to understand ramapithecines, the apelike creatures that lived between 14 million and 7 million years ago and are believed to have been on the direct line of human evolution. With a few skulls, jawbones and teeth as evidence, some researchers have concluded that ramapithecines were ground-dwelling, possibly bipedal hunters or scavengers. Richard F. Kay of the Duke University Medical Center in Durham, N.C., challenges this theory in the just-released AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY (55: 1981). Based on an analysis of modern primate molars and fossilized ramapithecine molars, he concludes that *Ramapithecus* was a gentle, tree-dwelling animal and suggests that our ancestors may not have come down from the trees until about six million years ago — seven million years later than some researchers have assumed.

One line of reasoning that places *Ramapithecus* on the ground proceeds from what is known about *Australopithecus*, the bipedal hominid that roamed Africa six million years ago. Both ramapithecines and australopithecines had thickly enameled molars. Projecting backward in time from what is known of the ground-dwelling australopithecines to the ramapithecines, some anthropologists concluded that the ramapithecines also were terrestrial. This is not necessarily so, says Kay. His analysis of enamel thickness in extant species suggests that "enamel thickness per se has nothing whatever to do with terrestriallity." *Gorilla gorilla*, for example, is the most terrestrial of all extant apes yet has the thinnest enamel of all apes.

The shape of the molar offers another line of evidence. Ramapithecine molars are distinguished by low crown-relief and poorly developed shearing surfaces. Kay says there is no evidence that ramapithecines were equipped to chew meat. The molars also show a high degree of polish. "This type of wear," he explains, "is seen in living animals with tree-dwelling habits. Ground dwellers have many pits and gouges in their teeth from grit in their diet." He concludes that ramapithecines were well suited for crushing nuts and eating hard fruits — foods that practically never occur in tree-sparse open country.

Kay's arguments do not prove that ramapithecines were necessarily tree dwellers, but if his suggestion that they stayed in the trees until six million years ago is correct it cuts in half the time commonly believed to have been involved in the development of upright walking by hominids. □