How nerves and muscles get together

One of the most provocative questions facing neurobiology today is how neurons decide which muscle cell to hook up with. Do they have certain recognition molecules that interact with only the right muscle cell, thus leading to synapse formation? Or do they zero in on whatever target cell is available, in an indiscriminate manner?

The latter explanation appears to be the correct one, according to research by Donald G. Puro and Nobel laureate Marshall Nirenberg of the National Heart and Lung Institute. The scientists report their findings in the October PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

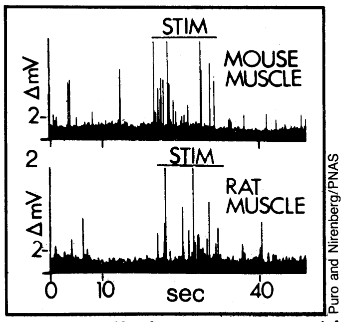
The best way to understand interactions between neurons and target cells would be to study a homogenous population of embryonic neurons as they synapse with target cells. But unfortunately, embryonic neurons, unlike other kinds of cells, are only one of a kind: they do not divide into more copies of themselves. So Nirenberg and two other researchers in his lab, Berndt Hamprecht and Takehiko Amano, using specific laboratory techniques, decided to make a population of homogenous embryonic neurons.

They made a clonal line of mouse neuroblastomas—embryonic neurons that are cancerous and therefore, unlike normal embryonic neurons, able to divide into copies of themselves. They fused neuroblastoma cells from their clone with cancerous neurons from rats in order to form an ultimate clone of hybrid neurons that secreted the neurotransmitter acetylcholine. Neither of the parent clones of neurons made this neurotransmitter. Acetylcholine is a nerve chemical that electrically stimulates muscle cells.

Puro and Nirenberg then took some of these acetylcholine-secreting hybrid neurons, called NG108-15 cells, and put them in the presence of muscle cells. The muscle cells were from three different organisms—the rat, mouse and chicken. The muscle cells were also from different kinds of muscle, for example, pectoral and hindlimb.

By electrically stimulating individual neurons and measuring the electrical response of individual muscle cells to this stimulation, the scientists were able to determine which neurons had formed synapses with which muscle cells. They found that the neurons formed synapses with some 75 percent of the muscle cells present. These included muscle cells from all three organisms and also from several kinds of muscle. The synapses did not show any obvious differences in the efficiency of electrical stimulation, nor did the muscle cells show any significant variations in response to it.

These findings suggest that neurons form synapses indiscriminately with muscle cells in their presence rather than zeroing in on select ones, not others. This situation in turn suggests that neurons do not have molecules that act as receptors for hooking up with select muscle cells. Puro and Nirenberg, in fact, have some other, yet unpublished evidence to support this conclusion: Under certain conditions, muscle cells were innervated by functionally inappropriate neurons. Several other groups of investigators have found the same thing.



Hybrid cells form synapses with mouse and rat muscle respectively.

So what gets the right neurons "talking" with the right muscle cells if a cell molecule recognition code does not? Whether neurons communicate with neighboring cells may depend on events that take place *only* after synapses are formed, Puro and Nirenberg propose. In other words, whether a synapse works may depend on how effective the transmission of electrical and chemical signals across the synapse is, not on whether certain neurons and target cells make contact in the first place. □

Viking: Riches in a radio beam

How big is Mars? How dense is the sun's corona? How much matter fills the not-so-empty space between planets? And just where did the Viking landers really land? Such wide-ranging questions—and there are twice as many more on the list—are all part of the assignment for the least-known of the Viking project's 13 science teams. Second only to the orbiter imaging team in size, the group has no scientific instruments of its own on any of the four spacecraft, yet its work will aid geologists, astronomers, seismologists, chemists and a host of others.

The radio science team, headed by William H. Michael of the NASA Langley Research Center in Virginia, does almost all of its work by studying the normal Viking-to-earth communications channels. Not for the messages they carry, but for what the radio beams themselves tell about the positions of the spacecraft, and for the ways in which the signals are changed as they pass through the Martian atmosphere, graze the planet's surface, pierce the fringes of the sun and traverse interplanetary space.

Thanksgiving Day, for Michael's team, will be a big event indeed. For months, the motions of the planets have been approaching a point at which the sun will be directly between Mars and the earth, an alignment known as solar conjunction. As Viking's radio path to earth has moved closer and closer to the sun, solar interference has had an increasing effect on the radio signals in both directions, producing noise or static that shows up as a growing "bit error rate" in the messages. For solar conjunction, Thanksgiving Day is dead center.

The sun's effects began showing up in Viking's messages as early as September, and some project engineers predicted that communications with the spacecraft would be cut off for as long as two weeks on either side of conjunction. But in fact, says Michael, the blackout may become total only for "a day or so," and perhaps not at all. The rate at which it develops and the changes it produces in the frequency, amplitude and phase of the spacecraft signals, together with irregular variations produced by changes in the sun's actvity, are all grist for the radio team's mill. Data from these changes will lead to improved measurements of the extent of the corona, the density and velocity of solar plasma streams and other findings.

Other parts of the team's work are much closer to Mars. The two Viking landers, for example, would be lost on the planet but for their radio signals, since they are too small to be photographed by the orbiters. Careful tracking of the signals as the planet and the orbiters move, however, has pinned down lander 1 at 22.48°N by 47.9°W and lander 2 at 47.97°N by 225.7°W, with further refinements to follow. Furthermore, the radius of Mars at the two sites is now known to within as little as 100 meters: 3,389.38±0.1 kilometers for the first site, in the Chryse basin, and 3,381.88±0.25 kilometers for lander 2's resting place in Utopia.

The same equations which pinned down the landers have also produced refined estimates of the orientaton of the planet's axis of rotation (right ascension 317.34°, declination 52.71°; an order of magnitude more precise than calculations enabled by Mariner 9) and of its rate of spin. All these measurements, including the lander locations, are produced together by simultaneous equations, since none can be figured out without taking the rest into account. The spin rate, says Michael, has now been timed to within milliseconds—a severalfold improvement over Mariner 9—and another year or two of tracking may reduce the uncertainty by another factor of 10.

Such extended tracking, he adds, may