Checkpoints keep a growing nerve cell alive

To reach the distant finish line, marathon runners depend on periodic checkpoints where they can pick up food and water. Imagine a macabre race in which those checkpoints are even more vital: Unless the runners reach each one at the correct time, they die a quick death.

The developing brain and spinal cord may employ just such an unforgiving strategy to ensure that nerve cells form appropriate connections. A new study suggests that as a nerve fiber grows to its destination, the cell depends for survival on substances secreted by targets along the fiber's way.

This conclusion, reported in the Oct. 21 NATURE, stems from a chance observation made by Hao Wang, now at Merck Research Labs in West Point, Pa., and Marc Tessier-Lavigne of the Howard Hughes Medical Institute at the University of California, San Francisco. For some time, the two scientists have studied the many signals that guide the fibers, or axons, that extend from one nerve cell to others.

They've examined how axons in the developing spinal cord of rats first grow around the cord's perimeter toward a wedge-shaped structure, the floor plate, at the cord's midline. The axons then turn and extend along the length of the cord.

In laboratory dishes, the nerve-cell axons flourished, but only for a day, the researchers unexpectedly found.

"Like clockwork, they would all die unless [tissue from the] floor plate was present," says Tessier-Lavigne.

Neuroscientists have known for decades that the final nerve-cell targets of axons secrete substances that keep most, but not all, of the fibers that reach them alive. By limiting the availability of the survival factors, the targets seem to prune away unneeded axons.

While these scientists knew that intermediate targets such as the floor plate gave directional cues to growing axons, they had had no clear-cut evidence that these targets also provide factors that kept the nerve cells from committing suicide. This mechanism may guarantee that nerve fibers don't get mistargeted in the maturing brain, says Tessier-Lavigne.

"These studies suggest that if the axons follow the correct route, they'll survive. If they stray, they'll die," agrees John G. Flanagan of Harvard Medical School in Boston.

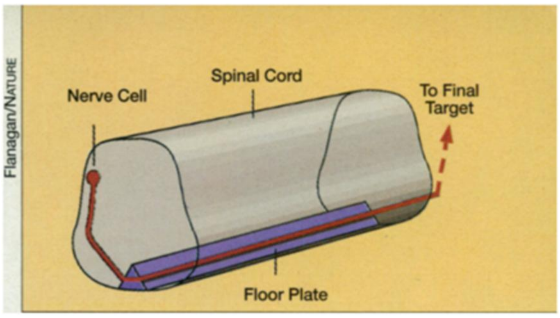
The rat axons don't become dependent on the floor plate until a day after they start to grow, which is about the time it would take them to reach that region of the spinal cord, notes Tessier-Lavigne. He and his colleagues have not yet identified the floor-plate factor or factors that keep the nerve cells thriving, although they tested more than two dozen proteins known to influence nerve-cell growth and movement.

"You name it, we tried it," says Tessier-Lavigne.

After several days of growth along the floor plate in spinal-cord tissue samples, the extending axons developed a dependence on chemicals called neurotrophins. It's unclear whether they lost their need for the floor-plate factor, however.

Finding the survival factor made by the floor plate is crucial to future experiments, says Flanagan. Its discovery could also spark new ideas about stopping nerve-cell death in diseases, he speculates.

While searching for the elusive factor, the investigators will examine whether the intermediate targets of other types of axons perform a similar function. Perhaps only axons that travel long distances, such as the fibers in the spinal cord, face such stringent conditions, says Tessier-Lavigne. —*J. Travis*



Nerve cells project fibers (red) to a region of the spinal cord called the floor plate (blue) before those fibers make a turn and head along the cord's length.

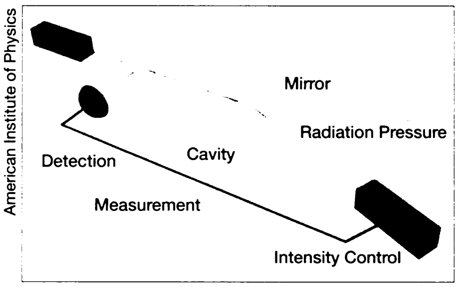
Laser's radiation pressure quiets a mirror

Mirrors play a crucial role in a variety of precision measurements. To detect extremely faint signals from space, for instance, researchers must minimize disturbances that deform a mirror's surface, down to the thermal noise caused by the constant jiggling of the mirror's atoms.

Physicists now report the first experimental evidence that they can reduce thermal-noise effects by using the pressure of laser light to counter a mirror's tiny movements. Antoine Heidmann and his collaborators at the Laboratoire Kastler Brossel in Paris describe their findings in the Oct. 18 PHYSICAL REVIEW LETTERS.

An elementary way to decrease thermal noise is to lower the temperature. For situations where such cooling isn't possible, Paolo Tombesi and his coworkers at the University of Camerino in Italy proposed a scheme last year for reducing thermal fluctuations by using feedback control. Heidmann's team applied their idea: Detect a mirror's movement, then respond by changing the intensity of a laser beam shining on the mirror to make it cancel out much of the motion.

The pressure exerted by the laser light can reduce thermal agitation to one-twentieth of its original intensity, in effect chilling the mirror, Heidmann and his colleagues discovered. In a demonstration of the technique's sensitivity, they also showed that a small alteration in the feedback loop would increase the amount of noise, causing the mirror to heat up.



A laser (left) sends a light beam into an optical cavity, where it's reflected by a moving mirror and then deflected into a detector. That signal modulates the intensity of another laser beam (right), which exerts sufficient pressure to freeze the mirror's motion.

Scientists are currently focusing on one application of this approach. "The cooling mechanism [we have demonstrated] may be useful to increase the sensitivity of gravitational-wave interferometers," Heidmann's group notes.

Theorists believe that interacting black holes and neutron stars can create extreme distortions in the geometry of the space around them. These space-time disturbances travel outward as gravitational waves, which slightly jostle any bodies in their paths (SN: 6/26/93, p. 408).

Reaching Earth, a gravitational wave might change the distance between two test masses 4 kilometers apart by just 10^{-16} centimeter, or one-100-millionth the diameter of a hydrogen atom.

Highly sensitive instruments for detecting such signals are now under construction. The Laser Interferometer Gravitational-Wave Observatory (LIGO) in Livingston, La., and Hanford, Wash., is scheduled to begin operating in the year 2001. Scientists in France and Italy are collaborating on another detector, called VIRGO, located near Pisa, Italy.

Researchers at the Massachusetts Institute of Technology and elsewhere are exploring the possibility of developing technologies that can increase the sensitivity of future gravitational-wave detectors. Finding novel ways to keep mirrors still is an important part of those efforts.

The main difficulty with a laser feedback system is that researchers must make sure that freezing the thermal noise doesn't also nullify the effects they intend to examine, Heidmann and his colleagues remark. The group is now investigating laser feedback schemes that would reduce the background noise without changing an interferometer's response to gravitational waves. —*I. Peterson*