Saving NEW BRAIN CELLS

Fresh neurons arise in the adult brain every day. New research suggests that the cells ultimately help with learning complex tasks—and the more they are challenged, the more they flourish

BY TRACEY J. SHORS

If you watch TV, read magazines or surf the Web, you have probably encountered advertisements urging you to exercise your mind. Various brain fitness programs encourage people to stay mentally limber by giving their brain a daily workout—doing everything from memorizing lists and solving puzzles to estimating the number of trees in Central Park.

It sounds a bit gimmicky, but such programs may have a real basis in neurobiology. Recent work, albeit mostly in rats, indicates that learning enhances the survival of new neurons in the adult brain. And the more engaging and challenging the problem, the greater the number of neurons that stick around. These neurons are then presumably available to aid in situations that tax the mind. It seems, then, that a mental workout can buff up the brain, much as physical exercise builds up the body.

The findings may be particularly interesting to intellectual couch potatoes whose brains could benefit from a few cerebral sit-ups. More important, though, the results lend some support to the notion that people who are in the early stages of Alzheimer's disease or who have other forms of dementia might slow their cognitive decline by keeping their minds actively engaged.

It's a New Neuron!

In the 1990s scientists rocked the field of neurobiology with the startling news that the mature mammalian brain is capable of sprouting new neurons. Biologists had long believed that this talent for neurogenesis was reserved for young, developing minds and was lost with age. But in the early part of the decade Elizabeth Gould, then at the Rockefeller University, demonstrated that new cells arise in the adult brain—particularly in a region called the hippocampus, which is involved in learning and memory. Similar reports soon followed in species from mice to marmosets, and by 1998 neuroscientists in the U.S. and Sweden had shown that neurogenesis also occurs in humans [see "New Nerve Cells for the Adult Brain," by Gerd Kempermann and Fred H. Gage; SCIENTIFIC AMERICAN, May 1999].

KEY CONCEPTS

- Thousands of new cells are generated in the adult brain every day, particularly in the hippocampus, a structure involved in learning and memory.
- Within a couple of weeks, most of those newborn neurons will die, unless the animal is challenged to learn something new. Learning—especially that involving a great deal of effort—can keep these new neurons alive.
- Although the neurons do not seem to be necessary for most types of learning, they may play a role in predicting the future based on past experience. Enhancing neurogenesis might therefore help slow cognitive decline and keep healthy brains fit.

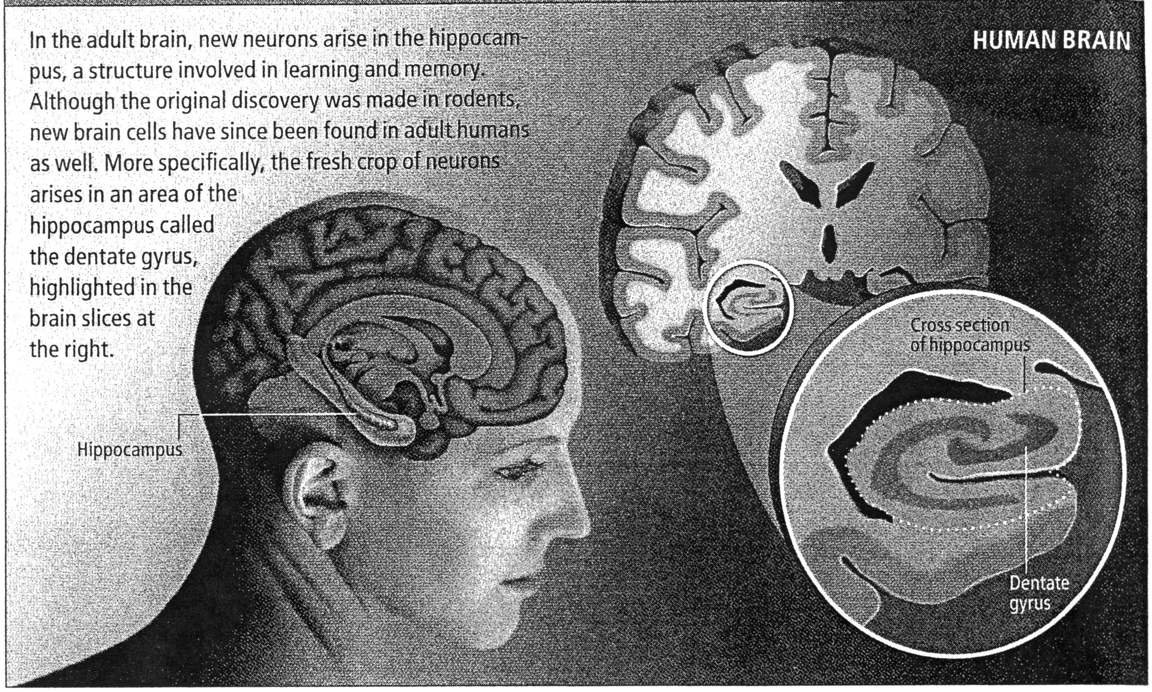
—The Editors

JANA LEON

The tasks that rescue the most neurons are the ones that are hardest to learn.

[BASICS]

WHERE NEW NEURONS FORM



In the adult brain, new neurons arise in the hippocampus, a structure involved in learning and memory. Although the original discovery was made in rodents, new brain cells have since been found in adult humans as well. More specifically, the fresh crop of neurons arises in an area of the hippocampus called the dentate gyrus, highlighted in the brain slices at the right.

In rodents, studies of neurogenesis generally involve injecting the animals with a drug called BrdU (bromodeoxyuridine), which marks newly formed cells, making them stand out when viewed under a microscope. Those studies indicate that in rats, between 5,000 and 10,000 new neurons arise in the hippocampus every day. (Although the human hippocampus also welcomes new neurons, we do not know how many.)

The cells are not generated like clockwork, however. Instead their production can be influenced by a number of different environmental factors. For example, alcohol consumption has been shown to retard the generation of new brain cells. And their birth rate can be enhanced by exercise. Rats and mice that log time on a running wheel can kick out twice as many new cells as mice that lead a more sedentary life. Even eating blueberries seems to goose the generation of new neurons in the rat hippocampus.

Use It or Lose It

Exercise and other actions may help produce extra brain cells. But those new recruits do not necessarily stick around. Many if not most of them disappear within just a few weeks of arising. Of course, most cells in the body do not survive indefinitely. So the fact that these cells die is, in itself, not shocking. But their quick demise is a bit of a puzzler. Why would the brain go through the trouble of producing new cells only to have them disappear rapidly?

From our work in rats, the answer seems to be: they are made "just in case." If the animals are cognitively challenged, the cells will linger. If not, they will fade away. Gould, who is now at Princeton University, and I made this discovery in 1999, when we performed a series of experiments looking at the effect of learning on the survival of newborn neurons in the hippocampus of rat brains.

The learning task we used, called trace eyeblink conditioning [*see box on page 50*], is in some ways similar to the experiments in which Pavlov's dogs started to salivate when they heard a sound they associated with the arrival of dinner. In eyeblink conditioning, an animal hears a tone and then, some fixed time later (usually 500 milliseconds, or half a second), gets hit with a puff of air or a mild stimulation of the eyelid, which causes the animal to blink.

After enough trials—usually several hundred—the animal makes a mental connection between the tone and the eye stimulation: it learns to anticipate when the stimulus will arrive and to blink just before that happens. This "conditioned" response indicates that the animal has learned to associate the two events together in time. The rats' accomplishment may sound trivial, but the setup provides a good way to measure "anticipatory learning" in animals—the ability to predict the future based on what has happened in the past.

To examine the connection between learning

[THE AUTHOR]

Tracey J. Shors, a professor in the department of psychology and the Center for Collaborative Neuroscience at Rutgers University, has had a long-standing interest in the neurobiology of learning and memory. Working with Elizabeth Gould of Princeton University, a discoverer of adult neurogenesis, Shors showed that learning enhances the survival of new neurons in the hippocampus and that these neural recruits seem to be involved in some aspects of learning. Some 10 years later Shors continues to ponder the question: "Neurogenesis: What's learning got to do with it?"