Monitoring memories moving in the brain

You're trying to find your car in a crowded parking lot. You remember what your car looks like, the appearance of the lamppost you parked beside, and glancing at that lamppost over your shoulder as you walked off the parking lot. How can you piece these bits of information together to find your car?

If you'd parked just a few hours before — to go shopping, for example — a new experiment indicates that you would use a banana-shaped region of your brain called the hippocampus to navigate your way back to your car. But if you'd parked weeks before — say, at an airport before embarking on a month-long trip — the study suggests that you would have to retrieve the information about your car's whereabouts from another part of your brain, probably the neocortex, where longer-term memories are stored.

In a series of tests involving rats, behavioral neuroscientists Michael S. Fanselow and Jeansok J. Kim of the University of California, Los Angeles, have demonstrated what physicians treating brain-damaged patients have suspected for nearly 100 years — that the hippocampus plays a vital role in the short-term memory of "contextual" information, such as the series of clues you would recall to find your car in a crowded lot. The researchers report their finding in the May 1 SCIENCE.

Fanselow and Kim trained 22 rats to associate being in a specific type of box while hearing a given tone with receiving a small electrical shock to their feet. The box was square, had an even floor and smelled of ammonia.

The researchers then damaged the hippocampi of eight of the rats at four different times after the training: one day, one week, two weeks and four weeks. For controls, Fanselow and Kim damaged the brain region just above the hippocampus in a group of eight rats a day after training and left the brains of another group of six rats undamaged.

To test whether hippocampal damage affected the rats' ability to remember the shock, the researchers put each of the animals back into the box. While both groups of control animals showed their fear of the box by crouching in a corner and "freezing," Fanselow and Kim observed that the rats whose hippocampi had been damaged the day after training ran around the box normally, as if they had forgotten their shock experience. Rats whose hippocampi had been damaged four weeks after training were as afraid of the box as both groups of controls.

When Fanselow and Kim put each of the animals into a triangular box with an uneven floor that smelled of vinegar, they found that none of the animals showed fear of their surroundings. But when they turned on the tone, all of the rats — including those with damaged hippocampi — became afraid.

"The animals which didn't have hippocampal damage showed a fear of the tone and a fear of the place where they got a shock," summarizes Fanselow. "But while some of the animals that had a damaged hippocampus showed no fear of the place, they were afraid of the tone."

He concludes that the hippocampus is involved in learning that requires integrating various stimuli — such as the look, feel and smell of a box or the different views of a car in a parking lot — but not in learning a single stimulus, such as the tone. Moreover, he says, the study shows that the hippocampus is necessary only for the short-term recall of such memories. After a certain period, Fanselow theorizes, the memories are transferred to another part of the brain, such as the neocortex, for long-term storage.

"This experiment demonstrates that the contribution of the hippocampus is only temporary," says Larry R. Squire, a neuroscientist at the San Diego Veterans Administration Medical Center. But he cautions that "memories may well be in the neocortex all along, with the hippocampus just playing a role in storage and retrieval. . . . Whether memories move or not is not so clear, but that's certainly one possibility." — *C. Ezzell*

Radwastes may escape glass via new route

Over the next several years, the Department of Energy (DOE) will begin vitrifying — incorporating within glass — highly radioactive liquids and sludgy nuclear wastes to prevent them from escaping into the environment. But new research indicates that exposure to the slow dripping of water can change the largely nonreactive borosilicate glass into a form that facilitates the flaking of microscopic mineralized shards. More important, the DOE-funded study shows, some of the water-borne flecks bear unexpectedly enriched concentrations of certain of the interred radionuclides.

This flaking process, or spalling, represents a previously unknown mechanism for directly generating colloids — particles too tiny to settle out of water, says study leader John K. Bates of Argonne (Ill.) National Laboratory. As colloids, the chemically stable castoffs can hitch a ride downstream, carrying radioactive contamination far from its source (SN: 3/17/90, p.169).

For the past five years, Bates' team has dripped water slowly (about one drop per week) over glass suspended in a stainless steel vessel. Water passing over the inch-long, half-inch-diameter glassy cylinder — containing the radionuclides neptunium, americium and plutonium — collected in the enclosing vessel.

Engineers evaluating high-level-waste barrier systems have assumed that any plutonium or americium leached from vitrified waste would dissolve into passing water, Bates says. However, his group found that only neptunium dissolved.

By filtering the water that collected in the vessel after one 39-week period, they discovered that all of the americium and plutonium remained suspended in water as colloids of clay containing the mineral brockite. Indeed, they report in the May 1 SCIENCE, the vitrified waste did not spall microscopic shards of the original borosilicate glass, but of clay and other glass-derived minerals formed under the water's influence.

Cross-section of water-altered glass: Some new minerals (A) form on original surface (B). Radionuclide-rich brockite (C) forms well below original surface.

Glass is only quasi-stable, explains Bates, a physical chemist. Water breaks bonds between its silicon and oxygen atoms. In the spongy, gel-like zone that results near the surface, the once evenly mixed elements become "free to diffuse around" and recongregate into more stable minerals, he says.

Bates and his co-workers say their findings suggest that engineers must account for spalled colloids when designing barriers to prevent the escape of radionuclides at repositories.

"I agree that the colloidal aspect should not be ignored in assessing the impact of [radioactive-waste] repositories," says Laura McDowell-Boyer of Oak Ridge National Laboratory's office in Grand Junction, Colo. But, she adds, "it would be premature to suggest that [colloid spalling] is necessarily a significant environmental problem."

The Energy Department agrees. According to DOE's Fred Lash, an internal assessment of Bates' paper states: "There are no data presented nor is there discussion that indicates that the alteration of glass to form colloids diminishes or compromises its performance in [a waste repository]."

In fact, says Bates, as long as you can trap spalled colloids, "I think it's an advantage to form these," since their intrinsically greater stability should make their long-term behavior more predictable. — *J. Raloff*