cludes that of the 27 pueblo groups that flourished along the Colorado Plateau at the beginning of this period, just three—the Zuni, the Hopi, and the Acoma—survived intense warfare among themselves. "The pueblo people you see today are basically the victors."

Some of LeBlanc's most compelling evidence is osteological—the remains of massacres found at five major Anasazi sites. In the early 1990s, for example, Bruce Bradley and other archaeologists at Crow Canyon Archaeological Center in Cortez, Colorado, found human skeletons, primarily men and children, abandoned with no funerary ceremony at two southern Colorado pueblos dating to between A.D. 1250 and 1285. Many bore smashed skulls and other signs of violence. When LeBlanc extrapolated the numbers of dead from the sampled locations to the sites as a whole, he concluded that 50% of the 500 inhabitants of Sand Castle Pueblo and 62% of 80 inhabitants of Castle Rock Pueblo were slaughtered in vicious massacres.

At the same time, the design and location of Anasazi and Mogollon dwellings changed dramatically. In the early 1200s, Anasazi farmers lived in small, single-story room blocks arranged in an L or straight line and situated as much as 0.4 kilometers from the community well. But by about 1300, at every Anasazi site, they had moved into large, two-story pueblos built around central plazas. They also constructed wells on the plaza or within 4 meters of the outer walls. The higher roofs made better fighting platforms for residents warding off an attack, says LeBlanc. "And my suspicion is that this massive desire to have the drinking water very, very close to the pueblo is a way of protecting the women," who would otherwise risk attack while getting daily water.

The murals found in some pueblos of this time also reflect a preoccupation with warfare. Along the walls of a kiva at Pottery Mound near Albuquerque, New Mexico, for example, researchers have found paintings of what appear to be warriors armed with shields to deflect enemy arrows (see illustration on p. 2039).

No one knows just what ignited such an intense war on the Colorado Plateau, but LeBlanc notes that the 500-year-long global cold spell popularly known as the Little Ice Age began about 1300 and may have caused crop failures, famine, and hostilities. High-altitude pollen studies, he notes, revealed that tree lines in southern Colorado dropped in the 1300s as the climate turned colder and wetter. Whatever the cause, however, he argues that the evidence is overwhelming that warfare was an integral part of Anasazi life, shaping the very structure of their settlements. "The idea that you can understand Southwestern prehistory and pretend there was no warfare is just silly," he concludes.

But the Anasazi work too has its critics. "I can construct a model, based on ethnographic evidence, that takes into account virtually all of the warfare data and explains them in terms of ritual behavior," says Adams. Prehistoric pueblo peoples in the Four Corners region, for example, once killed, then burned and mutilated the bodies of people they suspected to be witches. And the Anasazi may have built pueblos on seemingly defensive hilltops simply because they, like many modern tribal groups, viewed high places as sacred. Even depictions of violent acts don't necessarily mean that war was common: Artists often portray mythical battles fought by deities or shamans. "I just don't think we can explain a lot of the archaeological record in terms of conflict," says Adams.

Warfare researchers counter that their opponents are demanding unreasonable standards of proof. "If your only evidence of warfare is going to be bodies all over the place," says Oliver, "then you're not going to be able to find it. Even in modern warfare, only a small percentage of the people involved in a conflict die." These researchers think it's high time that anthropologists accept that life in the ancient Southwest could be very nasty, brutish, and short. "War is something like trade or exchange," says Lawrence Keeley, head of the Department of Anthropology at the University of Illinois, Chicago. "It is something that all humans do."

–Heather Pringle

Heather Pringle is a science writer in Vancouver.

RADIOACTIVE WASTE DISPOSAL

A Hint of Unrest at Yucca Mountain

Geologists studying southern Nevada's Yucca Mountain have always looked to the past to see what the future might hold for the mountain, which is the leading candidate to become the long-term U.S. repository for highly radioactive wastes from nuclear power plants. Because the mountain has been so quiet for millennia, researchers concluded that the risks of earthquakes and volcanoes striking it are low. But on page 2096 of this issue of *Science*, a team of geologists and geophysicists reports that the crust at Yucca Mountain is stretching at least 10 times faster today than it has on average over geologic time.

If so, the area could be suffering a bout of rapid crustal deformation that would boost the chances of a disaster such as a volcanic eruption during the 10,000-year life of the repository. In fact, the authors, led by Brian Wernicke of the California Institute of Technology in Pasadena and James Davis of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts, suggest that geologists have underestimated the hazards at Yucca Mountain by a factor of 10.

For now, other researchers are intrigued but not yet alarmed by the new findings, which stem from a satellite-based Global Positioning System (GPS) survey. "It's an interesting and provocative idea," says geologist Bruce Crowe, of Los Alamos National Laboratory in New Mexico, who has long worked on volcanic risks at Yucca Mountain. "It has to be looked at carefully."

B. WERNICKE

Safe spot? Tripod-mounted GPS receiver measures movement atop Yucca Mountain.

But he and others caution that Wernicke's group has actually measured only a few millimeters of stretching in 6 years, which is near the limit of what GPS can reliably detect. "This is testing GPS," says geophysicist Robert Smith of the University of Utah. "I don't think the answer is in."

Geologists agree that the best way to get that answer is to continue the GPS survey, which Wernicke and his colleagues have been conducting since 1991. As they report in *Science*, the team measured the positions of five benchmarks set along a 34-kilometer line stretching roughly east-west across Yucca Mountain. By comparing radio signals from several GPS satellites overhead, the researchers could determine the position of a benchmark with millimeter accuracy.

Wernicke's team checked the benchmark positions seven times between 1991 and 1997. They found that their survey line was lengthening at a rate of 1.7 ± 0.3 millimeters per year, giving a total stretching of about a centimeter over the 6 years of the study. Although that's only one-quarter the rate of crustal deformation seen in active areas like the San Andreas fault, it's about 10 times faster than geologists had inferred for the Yucca Mountain region, based on how much nearby faults have slipped over hundreds of thousands of years. Wernicke and his colleagues suggest that the Yucca Mountain area may be undergoing a geologically brief episode of rapid crustal stretching, perhaps driven by magma rising beneath it.

That could change hazard estimates based on the low long-term deformation rate recorded on faults. Previous analyses had put the risk that, say, a new volcano would pierce the repository, due to open in 2010 at the earliest, at 1 chance in 10,000 during the next 10,000 years (*Science*, 8 November 1996, p. 913). But if the rate of crustal deformation is upped by a factor of 10, so are the geologic risks, says Wernicke.

So far, researchers such as Crowe who have helped to evaluate geologic hazards at the repository are cautious about changing their risk estimates. And others such as geophysicist Wayne Thatcher of the U.S. Geological Survey in Menlo Park, California, wonder whether the minute stretching the group observed is real. "The changes they're looking at are really small; that's a little worrisome. In this business, we don't usually look at such small changes," he says. He and others also find the error bars surprisingly small; if they were larger, the observed motions would shrink. But co-author Richard Bennett of CfA finds no sign of additional errors in the data.

Even if the crust is moving as fast as Wernicke's team finds, "I would expect the hazard to go up, but not by an order of magnitude, " says Crowe. A magmatic intrusion might first trigger new volcanoes near the youngest nearby volcano, Lathrop Wells, and so would pose less of a threat to Yucca Mountain, he says.

Some scientists also wonder whether the apparent crustal extension is being driven by anything as threatening as magma intrusion. Thatcher suggests that at least part of the apparent stretching may have been caused by a magnitude 5.4 earthquake that struck Little Skull Mountain in 1992, just 8 kilometers from the eastern end of the GPS line. What Wernicke's team may have measured, he says, is the crust's readjustment to the strain released by the earthquake, which had built up over centuries or millennia. But Bennett says he calculates that such quake-driven effects are quite small, much smaller than the motions observed via GPS.

Thatcher remains cautious, saying that the new work may be showing subtle movement that other studies missed—or errors or fleeting effects may be misleading everyone. Another 5 years of GPS surveying, he says, should suffice to decide whether recent history or the deep geologic past is the best guide to Yucca Mountain's future.

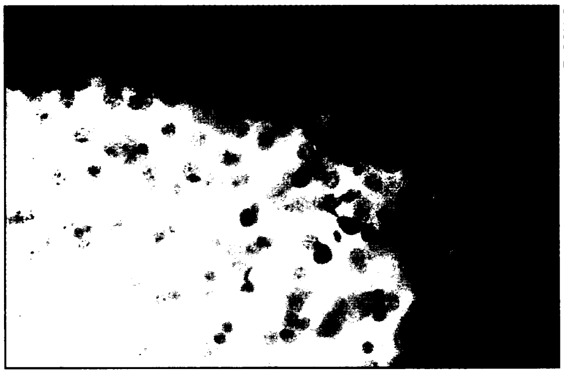
–Richard A. Kerr

NEUROBIOLOGY

No-New-Neurons Dogma Loses Ground

For many decades, both popular and scientific wisdom have held that adult brains can't make new neurons, so the ones we form when we're young have to last a lifetime. But last week, a research team from Princeton University, Rockefeller University in New York City, and the German Primate Center in Göttingen provided a challenge to this conventional dogma. In the 17 March issue of the *Proceedings of the National Academy of Sciences* (*PNAS*), they report that adult marmoset monkeys make new neurons in the hippocampus, a part of the brain associated with learning and memory.

Previous work had shown that lower species, including birds and rodents, produce brain neurons throughout their lives. But some neuroscientists have hailed the new result as a potential breakthrough, because it is the first evidence that the same may be true for primates—perhaps even humans, says neuroscientist Ron McKay, of the National Institute of Neurological Disorders and Stroke. If further work confirms that the adult human brain can make new neurons, and if these cells join existing functional networks in the brain—both of which are in the realm of speculation at this point—it may open doors for enhancing neurogenesis, as new neuron formation is called, to repair brain damage from disease or trauma.



E. GOULD

Newborn neurons. BrdU marks the nuclei of 3-week-old neurons (arrows) in the dentate gyrus of an adult marmoset.

Recent studies even suggest that stress reduction or an enriching experience can boost neurogenesis in some cases. In the current work, Elizabeth Gould from Princeton and her colleagues Bruce McEwen at Rockefeller University and Eberhard Fuchs at the German Primate Center found that stress decreases the rate of birth of new neurons in marmosets, while recent research on rodents by Fred Gage of the Salk Institute in La Jolla, California, and his colleagues has shown that an enriched environment can increase the neurogenesis rate. Together, the results "suggest that behavioral stimuli can regulate neuronal replacement rates," says McKay. "That is what I find so exciting."

Other researchers in the field caution that it's a big leap from marmosets to humans, especially when one considers work that both the *PNAS* paper and a *New York Times* report on it failed to mention: a set of experiments published in the mid-1980s by neuroscientist Pasko Rakic and his colleagues at Yale that found no evidence of new neurons being born in the hippocampus of adult rhesus monkeys. Rhesus monkeys are more closely related to humans than marmosets are, and neuroscientists have interpreted those experiments as indicating that higher primates, and probably humans as well, lack the ability to generate new brain neurons.

Gould and her colleagues chose to do their experiments on marmosets—a New World primate native to South America—because these animals are more readily available and less expensive than Old World primates like rhesus monkeys or chimpanzees, which are more closely related to humans. For their studies, the team injected adult male marmosets with bromodeoxyuridine (BrdU), which labels dividing cells. Two hours later, they sacrificed half of the animals and examined their brains for new cells that had picked up the BrdU. They found lots, in a part of the hippocampus called the dentate gyrus. Indeed, Gould calculated that "thousands of cells per day" were being born there. Three weeks later, when the team examined the brains of the remaining marmosets, they found that 80% of the BrdU-labeled cells looked like neurons and were making a neuron-specific protein. "A significant number of [the cells] survived," says Gould, "and the majority of those ... became neurons."

In a separate experiment, the researchers put adult male marmosets into the home cages of other adult males—a situation that is very stressful for the so-called "intruder" animals—and then injected the intruders with BrdU. The stress apparently decreased the number of new cells by 30%, suggesting it has a chilling effect on neuron replacement.

Gould's group had shown last year that tree shrews, close relatives of primates, grow new neurons in their hippocampuses, and marmosets represent another step up the evolutionary ladder. To Gould, the combined discoveries of neurogenesis in the adult brains of rodents, tree shrews, and marmosets suggests that this is a common phenomenon, which