high-security labs.

According to a White House security official (no announcement was published), the Administration decided after an internal review that live virus should be preserved for use in developing new antiviral drugs and testing improved smallpox vaccines. The aim would be to guard against clandestine development of smallpox weapons by terrorists or hostile states. "We live in a time when bioterrorism is a real concern," says a senior Administration official who spoke on background. And the current smallpox vaccine stockpile, he says, is "grossly inadequate," because it relies on a live virus vaccine that cannot be given to immunocompromised persons.

Anachronism? Doctor extracting vaccinia virus to vaccinate patient. Current smallpox vaccines are still based on vaccinia.

The policy change brings an end to a long-running debate in the U.S. government between advocates and opponents of total eradication of the virus. It represents a victory for defense agencies, which had argued that it would be rash to throw away this potentially valuable research tool, and a defeat for some health leaders who felt the world would be safer if all known variola stocks were destroyed. Only Russia and the United States are currently known to possess cultures of variola, although individual experts have been saying for some time that they suspect that not all variola stocks have been accounted for.

The U.S. debate reflects a split within the World Health Organization (WHO) in Geneva. Advocates of total eradication such as public health researcher D. A. Henderson of The Johns Hopkins University in Baltimore have argued in WHO meetings since the early 1990s that smallpox is such a horrific disease that its source should be obliterated—totally and permanently. Henderson has suggested that the live virus is so infective and lethal—with a mortality rate of around 30%—that it shouldn't even be kept in secure labs. Henderson also has argued that there is little value in preserving the virus. He points out, for example, that it cannot be studied in animals, as it doesn't infect them. And it is so dangerous that few scientists would want to handle it, even in the safest environment.

Such arguments persuaded WHO to do away with variola. WHO members agreed first to send all research stocks of the virus to two repositories, one in Russia and the other in the United States. Then an executive committee voted that these stocks would be destroyed in June 1999, if the WHO general assembly gave the final go-ahead in May. Although most members may still support the plan, the two that control the variola stocks do not.

Resistance to the WHO plan has developed slowly. Russia opposed it from the outset. But the British and U.S. defense establishments disagreed more quietly. Recently, one U.S. official—Alan Zelicoff, a biodefense expert at the Sandia National Laboratory in Albuquerque, New Mexico—has gone public with strong objections to the WHO plan. Zelicoff, who debated Henderson on the smallpox decision last month on National Public Radio, contends that the policy of total eradication had White House support for several years because one National Security Council staffer advocated it. But recently, he says, other national security experts intervened and prompted a policy review.

At the same time, according to Zelicoff, Joshua Lederberg, president emeritus of The Rockefeller University in New York City, who is concerned about bioterror risks, was "influential" in getting federal agencies to fund an external review by the Institute of Medicine (IOM). The IOM report, issued in March, didn't take sides in the debate, but concluded that scientists might use live variola productively to develop new antiviral drugs and vaccines (*Science*, 19 March, p. 1825). The IOM report was crucial, a Clinton Administration official says, to the change in U.S. policy.

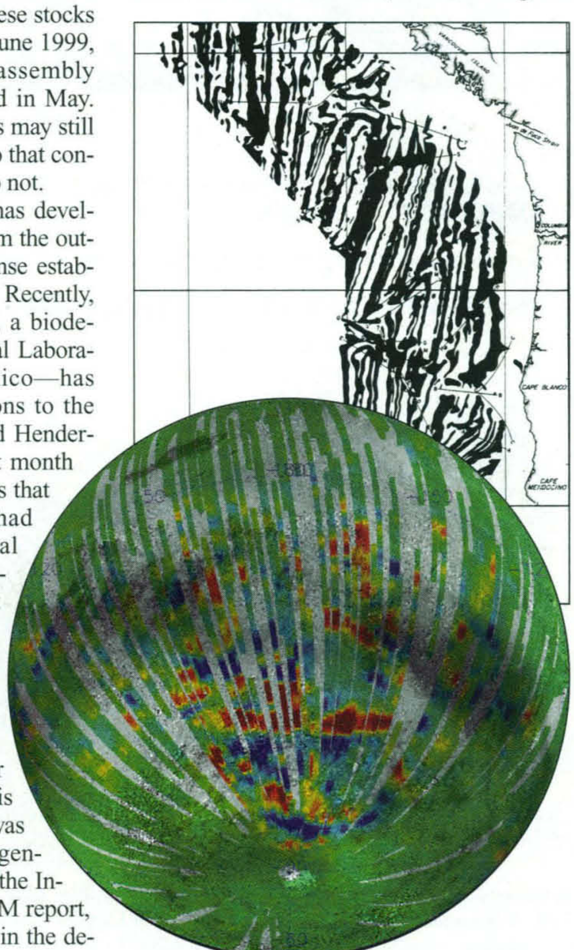
The plan now goes to the WHO general assembly for a vote. But because the two countries that hold the stocks now oppose destruction, the issue may be moot.

–ELIOT MARSHALL

PLANETOLOGY

Signs of Plate Tectonics On an Infant Mars

Almost 40 years ago, geophysicists made history by realizing that Earth's surface is shaped by plate tectonics—that new crust is born in midocean ridges and plates move around the globe. Pivotal to the discovery were rank upon rank of magnetic stripes that march across the sea floor, each marking the



How did Mars earn its stripes? Magnetic banding on Mars (orange and blue) may be the mark of plate tectonics, as it is on Earth *(top)*.

CREDIT: (TOP) STOCK MONTAGE; (RIGHT) J. CONNERNEY AND M. ACUÑA/GSFC orientation of Earth's flip-flopping magnetic field at the moment the crust was born. Now scientific history may be repeating itself on a close planetary neighbor: On pages 790 and 794 of this issue, researchers report magnetic stripes on Mars.

The data, gathered by the Mars Global Surveyor (MGS) spacecraft, suggest that in its early days, Earth's diminutive cousin resurfaced itself the way Earth does today, spreading freshly made crust away from long, narrow volcanic rifts. The martian magnetic stripes are "absolutely fascinating," says Frederick Vine, a professor emeritus at the University of East Anglia in Norwich, United Kingdom, whose work on magnetic stripes was instrumental to the plate tectonics revolution of the 1960s. That the martian examples are also the work of plate tectonics is "an eloquent hypothesis," he says, and indeed no one has a good idea what else could form such stripes. Yet the shape and pattern of the martian stripes are so different from Earth's that geophysicists are reserving judgment for the moment. The stripes point to some sort of interesting geodynamics on ancient Mars, says planetary geophysicist Maria Zuber of the Massachusetts Institute of Technology, but she's not sure what it was.

"[Crustal] spreading seems like the best guess at this time."
—Ronald Merrill

The finding has its origin in a catastrophe—the loss of the Mars Observer spacecraft as it approached the planet in 1993—say Mario Acuña and John Connerney of NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, members of the MGS magnetometer team. For the Mars Observer's successors, NASA switched into a "faster, cheaper, better" mode. As a result, MGS did not carry enough rocket fuel to send it directly to its intended high, circular orbit when it arrived at Mars. Instead, it first entered a more fuel-efficient elliptical orbit that periodically dipped it into the upper martian atmosphere, where it experienced atmospheric drag that bit by bit nudged the spacecraft closer to the desired circular orbit. These aerobraking passes carried the spacecraft as low as 100 kilometers above the surface, low enough to detect magnetization of the rocks below.

MGS first detected patches of magnetic field embedded in the crust apparently at random, like so many bar magnets strewn on the surface (*Science*, 10 October 1997, p. 215). They had apparently formed when blobs of magma near the surface solidified and cooled earlier in martian history, locking in bits of the magnetic field that existed at the time. That meant that although the interior of Mars has cooled and produces no magnetic field today, it once had enough heat to churn the planet's molten iron core into a magnetic dynamo.

A month later, another problem led to even better observations. An apparent weakening of a solar panel arm meant that the spacecraft's orbit had to be adjusted more slowly, so that MGS made about 1000 aerobraking passes rather than 100. With the additional coverage, some of the magnetic patches began to coalesce into a pattern. Across a huge swath of the southern hemisphere, wrapping a quarter of the way around the planet, irregular stripes about 100 kilometers wide and up to 2000 kilometers long appeared. The half-dozen or more stripes are roughly parallel and appear to alternate in polarity, one having its "north pole" pointing vertically up and the next with its south pole up. The stripes peter out near the boundary with the northern lowlands.

The magnetometer team members, who are planetary scientists, tend to be more familiar with the magnetic field of Jupiter than with Earth's ocean crust, but even they saw the resemblance to terrestrial stripes. Back in the 1960s, researchers realized that when magma rises into the crest of a midocean ridge, cools, and solidifies, it records the current magnetic field. Magnetized crust continuously spreads away from the ridge in both directions like tapes in a tape recorder; when Earth's magnetic field reverses, a new pair of stripes appears, one on each side of the ridge.

On Mars, the crustal tape machine turned on early but wound down quickly, according to Connerney and Acuña. The heavily cratered highlands that recorded the stripes date back to Mars's first half-billion years, when its interior might have been hot enough to support both an internal magnetic dynamo and the surface motions of plate tectonics. By 4 billion years ago, meteorites that crashed into the stripes left unmagnetized holes in the pattern, suggesting that the magnetic dynamo had shut down by then, says Acuña. But crustal spreading may have continued for a time; in the north, some process later produced the unmagnetized, thinner, and therefore lower crust of the lowlands.

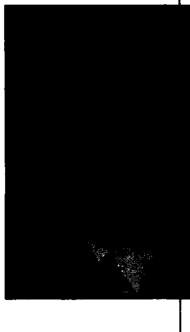
The stripes are "convincing evidence that there was a [magnetic] dynamo early on Mars and it reversed," says paleomagnetist Ronald Merrill of the University of Washington, Seattle. And as an explanation for the overall pattern, crustal "spreading seems like the best guess at this time," he says, especially because there's no persuasive alternative.

But the pattern doesn't exactly match

CREDIT: U.S. DEPARTMENT OF VETERANS AFFAIRS

ScienceScope

New Marching Orders Chastened by an inquiry that uncovered multiple violations of its code of research ethics, the Veterans Administration (VA) is adopting a new plan to ensure that its clinical studies follow orders. VA undersecretary for health Kenneth Kizer (right) told Congress last week that the agency's research centers will soon undergo review and accreditation from a new independent authority. Once established, the agency might also act to protect patients' rights at all federal facilities and even private clinics, according to government officials.



The decision follows the VA's shutdown last month of research at its West Los Angeles Medical Center, prompted by the discovery that a cardiologist had performed an invasive research procedure on a patient who had refused consent (*Science*, 2 April, p. 18). To prevent future lapses, Kizer told members of the House Veterans Affairs Committee on 21 April that he is creating a new headquarters office to enforce guidelines. And to fill a "vacuum" in monitoring human studies, he says the VA will hire a private group to certify, every 3 years, that patient safeguards are in place at research institutions.

Worldly Scientists It's time for global leaders to have an esteemed body they can turn to for independent scientific advice, according to U.S. National Academy of Sciences (NAS) head Bruce Alberts. "The world badly needs an impartial mechanism, based only on science, to promote smarter decision-making" on everything from climate change to water policy, he said last week.

To fill that gap, Alberts announced plans to create a new international group—modeled on the academy's National Research Council—that could assemble expert panels to advise the United Nations, the World Bank, and other global institutions. Members could come from the NAS's 80-odd sister academies around the world, Alberts said.

The concept is a good one, says Roland Schmitt, president emeritus of Rensselaer Polytechnic Institute in Troy, New York, noting that other scientific societies have expressed a similar need. But NAS may be the first to move from words to action: Officials plan to meet with potential partners at a science summit in Budapest, Hungary, in June.

Earth's, so most researchers aren't yet ready to embrace martian plate tectonics. "You wouldn't say this is a dead ringer for the sea floor," notes paleomagnetist Robert Coe of the University of California, Santa Cruz. The martian stripes are 10 times wider than Earth's, implying faster spreading, slower magnetic field reversals, or both; they are also far less regular in shape and spacing; and the symmetrical pattern of stripes on either side of a spreading center, the clincher in the plate tectonics debate, is not yet apparent. Indeed, there's no sign of a "spreading center" at all. Says Merrill: "If plate tectonics was operating on Mars, it worked differently or it was recorded differently by the rocks."

Another sign of that difference is the "staggering" intensity of the recorded magnetism, says Merrill. To achieve it, Connerney calculates that each martian plate would have to be 30 kilometers thick, assuming that they were uniformly magnetized as intensely as the uppermost few hundred meters of Earth's ocean crust. "It's hard for me to understand how that could happen on Mars," says geophysicist Sean Solomon of the Carnegie Institution of Washington. On Earth, the upper ocean crust is intensely magnetized because seawater cooled it rapidly, forming tiny, easily magnetized crystals. But cooling a 30-kilometer slab would take tens of millions of years, leading to larger crystals that would be less easily magnetized. This prompts researchers to wonder if perhaps the stripes formed not through creation of new crust but through some other means, such as slow chemical alteration.

"There's so much we don't know," says Solomon. "You have to remember how difficult it was to convince people about seafloor spreading in the 1960s. It'll keep people scratching their heads for quite a while."

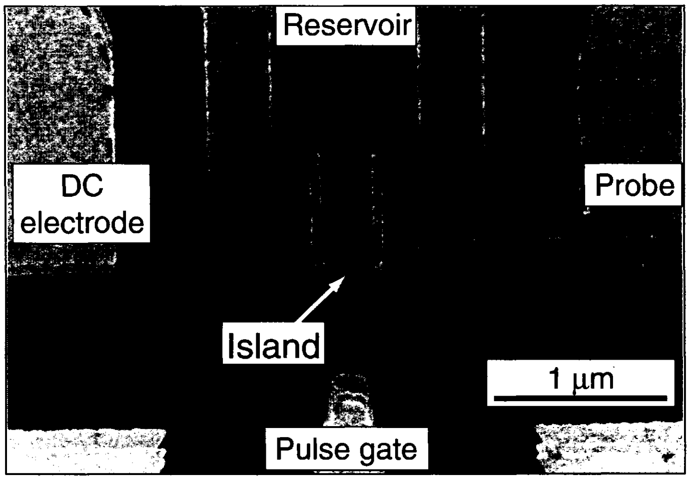
–RICHARD A. KERR

QUANTUM MECHANICS

Quantum Computing Makes Solid Progress

It's no wonder that the prospect of quantum computers gets people excited. If harnessed, the essential fuzziness of the quantum world could allow researchers to breeze in minutes through computations that would take today's supercomputers billions of years to crunch. Although quantum computing researchers have managed to carry out a few simple logic operations in the quantum regime, these typically have relied on ions poised in beams of light or jiggling molecules in a solution. Just getting them to serve as a single quantum circuit element required roomfuls of lasers, magnets, or other control equipment—a far cry from the millions of circuits that can be crammed onto a conventional silicon chip. But now a team of Japanese researchers has turned a simple metal- and silicon-based device into the key component of a quantum computer.

In this week's issue of *Nature*, physicist Yasunobu Nakamura of the NEC Fundamental Research Laboratory in Tsukuba, Japan, and his colleagues describe how they created the first electrically controlled bit of quantum data, or qubit, in an electronic device that in theory could be reproduced manyfold. "It's an extremely significant success," says David Awschalom, a physicist at the University of California, Santa Barbara. "It opens the door to building a solid-state quantum computer that's scalable. In computing, that's the name of the game." Still, Awschalom and others caution that making complex solid-state quantum computers is still many years away, and researchers must first learn how to keep their quantum data from decaying almost the instant they're made. Says Dmitri Averin, a quantum computing expert at the State University of New York, Stony Brook, "It will definitely be a long and difficult challenge."



Data point. A superconducting electron pair oscillates between the island and reservoir, forming an indecisive quantum bit, or qubit.

Even creating a single qubit was no simple task. Like all quantum computing schemes, this one makes use of the superposition principle of quantum mechanics, which states that, until it's measured or observed, a quantum system—such as the magnetic orientation of an atomic nucleus, or the location of an electron—exists as a superposition of all its possible states at once. Unlike the classical bits of data in a computer, which are decidedly either a zero or a one, qubits hover in an indecisive fog somewhere between these two values. When this fuzzy two-state bit is plugged into a logical operation, the computer in essence computes both outcomes simultaneously. Couple together just 300 qubits and a computer would instantly compute all 2^{300} possible outcomes—roughly the same number as there are elemental particles in the universe.

The difficult part, however, is coupling qubits together. Since the mid-1990s, researchers have managed to make qubits from the magnetic spin of atomic nuclei in atoms or molecules and from the polarization of light, but these schemes are hard to miniaturize into working computers. "It's difficult to imagine scaling up an atomic or molecular system" to create the dozens or hundreds of qubits needed for sophisticated quantum computing, says Awschalom. In conventional computers, solid-state components have made it possible to shrink circuit elements to the scale of a few hundred nanometers. But the solid state seemed too unruly for quantum computing, for electrons in solids can have innumerable quantum states that are impossible to tell apart. For a qubit, you need easily distinguishable on-off states.

One class of solids, superconductors, offers a simpler quantum environment, as their electrons all share the same quantum state and travel together in pairs. So the NEC team designed a set of tiny electrical components, made from metals that superconduct at very low temperature, that enabled single electron pairs to jump between a tiny bar-shaped metal island and a nearby metal reservoir. Applying a brief voltage pulse to a control electrode connected to the island creates equivalent energy states for electron pairs on both the island and the reservoir. The result is that the superconducting electron pairs oscillate back and forth between the two locations, representing the one and zero of a digital system. Such a setup does not work in semiconductors, where electrons' oscillations are disrupted by heat, lattice vibrations, and other troublemakers.

In a working quantum computer, researchers would have to find a way for the state of this first qubit to influence the behavior of a second. But for this experiment with just one qubit, the NEC researchers simply read out the electrons' location. To do so, they apply a continuous voltage to a so-called DC electrode. This boosts the energy level of electron pairs on the island, causing them to break their superconducting bond to one another and hop to a nearby

CREDIT: NAKAMURA ET AL.