sessed heavily muscled arms with elbows that could not support knuckle walking. This arrangement suggests that they split their time between tree climbing and two-legged walking, White asserts.

An analysis of the ratio of two forms of argon in grains of volcanic ash found just below the fossils, as well as data on magnetic reversals in the ancient soil, produced the age estimate of 4.4 million years. Giday WoldeGabriel, a geologist at Los Alamos (N.M.) National Laboratory, directed this effort.

The researchers note that *A. ramidus* probably lived in a wooded environment. Later hominids resided on drier, more open savannas, where bones have a much greater chance of fossilizing. Extensive volcanic ash at Aramis helped preserve the bones, White says.

In addition to hominids, the scientific team recovered fossils of rhinos, elephants, birds, bats, rodents, the first large bear known to inhabit eastern Africa, and numerous bones of ancestors of monkeys and antelope that now live in forests and wooded areas. Fossilized plant and seed remains also come from varieties still common in African woodlands and forests.

A. ramidus probably ate whatever plants and other foods it could find on the forest and woodland floor, White holds. "Like all hominids, it was an omnivore," he says.

An estimate of the earliest known hominid's body size and the degree to which it relied on two-legged walking must await the discovery of foot, leg, and hip fossils. The scientists plan to return to Aramis in November to look for more hominid remains.

Further study of pollen, carbon isotopes, soil, and fossilized wood and small mammals at Aramis should clarify the nature of the habitat favored by *A. ramidus*.

White suspects that the common ancestor of humans and apes, as well as the early members of human and ape evolutionary families, all lived in wooded areas. Therefore, the chances of finding fossils for these animals are slim.

"We're in uncharted territory at Aramis for hominids and other mammals, as well as for Earth history," White maintains. *— B. Bower*

Gene gun, growth factors promote healing

Five years ago, researchers discovered that they could speed wound recovery by adding some of the body's own chemicals to an injury (SN: 7/15/89, p.39). But developing an efficient and economical way to administer those chemicals — called growth factors — in low, sustained doses proved difficult.

Now, a Boston-based team has come up with an innovative way around this obstacle: transferring the gene for the growth factor instead of trying to use the chemical itself. The scientists accomplish this transfer with a gene gun, a technique first developed for plants and recently applied to animals (SN: 1/1/94, p.6).

"We have proven the feasibility of inserting a gene directly into the wound, and we have seen a significant biological effect," says Elof Eriksson of Brigham and Women's Hospital in Boston.

For their experiments, Eriksson and his colleagues developed an incubation chamber that they place over a wound to isolate it from the rest of the body. They use this chamber on people and on pigs, whose skin closely resembles that of humans.

Solutions of skin cells called keratinocytes, even genetically altered ones, survive and regenerate when added to a wound inside a chamber, they report in the Sept. 27 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES. For those studies, they used a modified retrovirus to add genes to the skin cells.

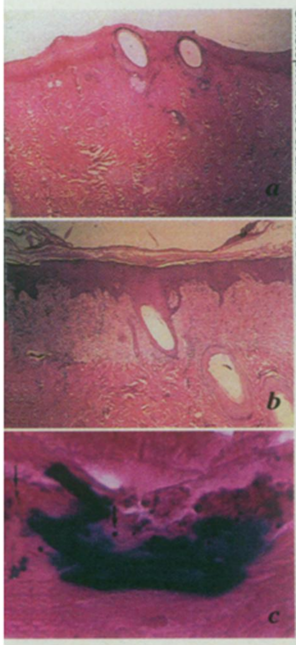
Working with Agracetus, a biotechnology company based in Middleton, Wis., the Boston group next tried a more direct gene transfer. They coated gold particles with rings of DNA containing either a piece of the gene for human epidermal growth factor or a marker gene. Electric pulses then drove the particles into wounds in anesthetized pigs.

This approach provides the wound with an adequate supply of growth factor and speeds healing by 2 days, the group will report in an upcoming PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

"They were able to generate the biological response with what appears to be much lower doses [of growth factor] than when we give it exogenously," comments Gregory S. Schultz, a biochemist at the University of Florida in Gainesville. "That makes everybody feel much more warm and fuzzy about doing it."

Previously, researchers were concerned that adding growth factors in high amounts could lead to excessive scarring or possibly cancerous transformations. Moreover, a wound does best if these factors are available throughout the healing process rather than at the initial high doses typical of most drug delivery techniques.

Gene transfer avoids both of these problems, but the technology may have other drawbacks. "My understanding is that [gene transfer] is not inexpensive, and it is much more technically difficult to do than a cream or a slow-release polymer," Schultz says. Several companies are now testing creams and slow-release delivery systems in people. Both those companies and Eriksson's group are also evaluating different combinations of growth factors to find the best healing recipe. *— E. Pennisi*

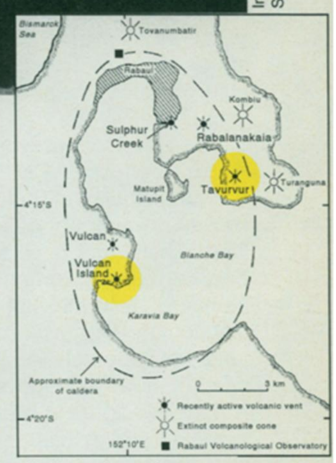


Christoph Andree et al./PROC. NATL. ACAD. SCI.

Wound at 1 day after receiving growth factor genes (a) has healed by 9 days (b). Close-up (c) shows gold particles (arrows) and extent of gene expression (blue).

Prediction averts volcanic disaster

Image by: Earth Satellite Corp. Smithsonian Global Volcanism Network



Yellow dots show active volcanoes, which are visible in satellite image. Broken line indicates caldera rim.

Thanks to careful planning and geologic luck, volcanologists from Papua New Guinea successfully forecast a pair of eruptions last week, allowing 30,000 people to escape the endangered town of Rabaul.

Situated on a bay along the east coast of New Britain Island, Rabaul sits within a sunken crater, or caldera, formed during a huge eruption 1,400 years ago. The current blasts emanate from two volcanoes, Vulcan and Tavurvur, on opposite sides of the bay.

Scientists at the Rabaul Volcanological Observatory called for an evacuation on Sept. 18, hours after strong quakes rocked the area and seismometers detected a distinctive tremor that precedes eruptions. Early the next day, Vulcan and Tavurvur sent plumes of ash 70,000 to 100,000 feet into the air. In the days that followed, a thick layer of ash covered much of the town, combining with rain to collapse many roofs.

The United Nations' Department of Humanitarian Affairs says that the eruption displaced 45,000 people, but it has received no reports of casualties.

Geoscientists say the work of the researchers and civil defense officials at Rabaul averted untold fatalities. "The town is pretty much nestled inside a caldera — inside a volcano. This time, they managed to get everyone out before the eruption," says James J. Mori of the U.S. Geological Survey in Pasadena, Calif. From 1984 to 1988, Mori worked as a seismologist at the Rabaul observatory.

Rabaul is one of several active calderas — including Long Valley, Calif., and Yellowstone National Park — that have concerned volcanologists during the last decade. Because scientists have never witnessed such a large eruption, they remain unsure of how one starts. They suspect that several spots on the outside of the old caldera might become active, releasing magma around the entire rim of the crater. After such an outflow, the center of the volcano collapses to form a new caldera.

Scientists have worried about Rabaul because it seemed to fit this pattern of widespread unrest. Vulcan and Tavurvur both erupted strongly in 1937. In the 1970s and 1980s, the caldera produced significant quakes and other ominous signs, leading officials to draw up evacuation plans and prepare the populace.

"The eruptions in 1937 and this intense period of unrest starting in 1971 made people worry that the next event could unzipper the ring fracture and lead to a caldera-forming eruption," says volcanologist Daniel Dzurisin of the USGS' Cascades Volcano Observatory in Vancouver, Wash.

Instead, the current events seem a repeat of 1937. The blasts have weakened this week, but a USGS team is en route to set up monitoring devices in case the activity renews.

Satellite measurements indicate that the Rabaul eruption equals the 1980 Mount St. Helens blast in scale but has released far less climate-altering sulfur dioxide than the 1991 explosion of Mt. Pinatubo did. — *R. Monastersky*

Cold nuclei, magnetic order, and hot spins

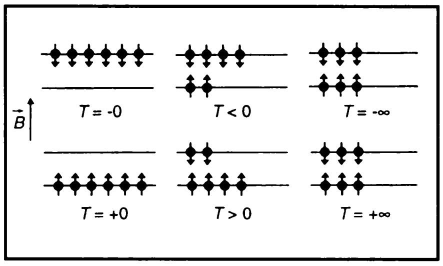
Striving for a new low in solid-state physics, researchers have chilled the nuclei of rhodium atoms to a temperature of 280 picokelvins (pK), just barely above absolute zero. These experiments have also produced negative temperatures as "high" as -750 pK.

The results stem from a long-standing research effort by Pertti J. Hakonen, Olli V. Lounasmaa, and their coworkers at the Helsinki University of Technology in Finland. Their goal is to study interactions between the spinning nuclei of metal atoms to glean insights into the nature of magnetism. Because these spin interactions are extremely weak, the experiments must be done at very low temperatures.

"Nuclear spins in metals provide good models to investigate magnetism," Hakonen and Lounasmaa report in the Sept. 23 SCIENCE.

Ordinarily, temperature (measured in kelvins) describes the average energy associated with either the motion of free particles, such as electrons, in a material or the vibration of particles bound to certain sites in the material. In a metal at ultralow temperatures, however, the spinning nuclei and the free electrons may coexist at different temperatures. Hakonen and his colleagues focus on the spin behavior of atomic nuclei, particularly silver and rhodium.

When placed in a magnetic field at temperatures below 1 microkelvin, these nuclei organize themselves so that their spins tend to line up in the same direction as the magnetic field (see diagram). As the temperature gets closer to absolute zero, the number of misaligned nuclear spins decreases. Spins that are initially oriented in the opposite direction of the magnetic field flip over to a parallel orientation, which has a lower energy.



Hakonen and Lounasmaa/SCIENCE

Energy-level diagram of silver (or rhodium) nuclei showing spin orientation in a constant magnetic field for positive (lower row) and negative (upper row) temperatures.

By suddenly reversing the magnetic field, the researchers can create a situation in which nearly all of the nuclear spins are oriented in the opposite direction, or antiparallel to the magnetic field. Because more nuclei are in the high-energy state than in the low-energy state, the nuclei are said to have a negative spin temperature.

In this case, achieving even lower negative temperatures means adding energy to flip more spins into the higher-energy, antiparallel state. Thus, negative temperatures are actually "hotter" than positive ones, the researchers say. Similarly, a temperature of -750 pK is, technically speaking, warmer than one of -800 pK. — *I. Peterson*

Cesium atoms for optical computers

The task of computing largely involves comparing pieces of information.

A typical personal computer will size up small bits of data, matching one against another. Usually, it does so in series, one bit at a time. Even parallel computers, which run many processors simultaneously, ultimately fall back on step-by-step analysis.

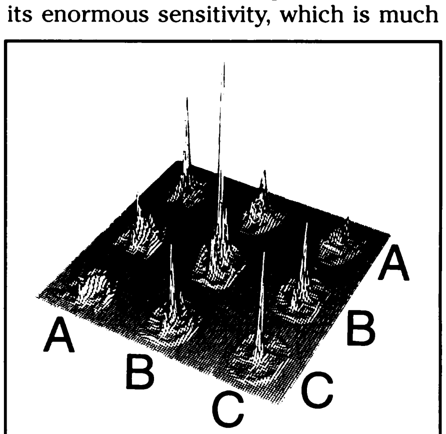
The ability to compare, say, a million pieces of information in one deft stroke would therefore offer tremendous computational advantages. Optical computers, which rely on transmissions of light rather than electricity to perform calculations, might provide such benefits. To date, though, no good material for making the machinery to handle optical comparisons has been found.

Seeking to supply this missing link, Randall J. Knize, a physicist at the University of Southern California in Los Angeles, and his colleagues describe fabricating an optical correlator, a device that uses a vapor of cesium atoms to compare images. They report their work in the Sept. 22 NATURE.

"Optical computing aims to take advantage of the massive parallelism of light," says Knize. "If you expand a laser beam so that it can carry a million pieces of information, then process all of that information at the same time, you could make massively parallel computations in a way that isn't possible with ordinary electronic computers."

"This optical correlator offers a way to process information by comparing two images to see if they are similar," he says. Two laser beams carrying information about two images pass through a glass cell containing a cesium vapor. The cesium cell senses similarities and differences, then emits a third signal that reveals where the two images do and do not overlap.

"We chose cesium vapor because of its enormous sensitivity, which is much



Knize et al.

A cesium optical correlator compares images of the letters A, B, and C. Same-letter matches yield tall spikes.