tons, depending on the assumptions McCormick made in his calculations. He arrived at these figures by compiling ground-based and airborne observations from around the world made by light detection and ranging systems (LIDAR). These are instruments that determine the altitude and concentration of particles on the basis of the way that they scatter the light of a laser.

Geoffrey Kent of the Institute for Atmospheric Optics and Remote Sensing in Hampton reported that the Stratospheric Aerosol and Gas Experiment (SAGE) satellite observed similar increases (0.28 to 0.39 million tons). Orbiting once every 1.5 hours, this satellite measures the attenuation of sunlight after it passes through the upper atmosphere during about 30 sunrises and sunsets each 24-hour day.

A fraction of a million tons of material lingering in the stratosphere, it seems, is not enough to block much sunlight and cool the climate. Estimates of the long-term increase in stratospheric aerosols after the Agung eruption vary between 10 and 30 million tons, at least 20 times more than after the Mount St. Helens eruption. Whereas Agung lowered the mean temperature a few tenths of a degree, Mount St. Helens could probably lower the mean by only a few hundredths of a degree, Mitchell estimates.

The explanation for this large difference in the effects on climate, despite comparable injections of ash, is that most volcanic dust falls out of the stratosphere too quickly to cool the entire globe. Within the past few years, researchers have realized that the strongest link between volcanoes and climate change is not always dry, dusty ash; rather, it is often an aerosol of submicron droplets of concentrated sulfuric acid derived from sulfurous volcanic gases. While most of the ash is rapidly falling out of the stratosphere, the accompanying sulfur dioxide and other sulfur-containing gases are converted into sulfuric acid droplets small enough to stay in the stratosphere for years. This conversion is slow enough to prolong the effect of the additional aerosol beyond the time required for a droplet to be removed naturally.

Atmospheric scientists watched this conversion of gases into particles as the debris from Mount St. Helens began to circle the world. The SAGE satellite detected about four times as much new aerosol over the Northern Hemisphere in August as it did in late May, Kent notes. The most likely explanation, he says, is that gases already in the atmosphere in late May produced the new aerosols seen in August. McCormick says that researchers using LIDAR saw a change within the first month in the light-scattering characteristics of stratospheric material. That change would be consistent with a shift from an aerosol dominated by relatively large, ashlike particles to one consisting of small, liquid particles, he says. James Rosen of the University of Wyoming found on the basis of particle size alone that the shift from ash to acid over Wyoming may have occurred within a few days.

Once worldwide observations became available, it was obvious that Mount St. Helens had been a minor source of gaseous sulfur in the stratosphere. The eruption had been energetic, but the magma that erupted as ash had contained a relatively small concentration of sulfur, according to analyses of magmatic glass by William Melson of the Smithsonian Institution. Self suggests that Agung achieved its greater effect on the stratosphere, and thus climate, because its eruption happened to be both powerful and rich in sulfur. The usual trend, he notes, is for more sulfurous magmas to produce less powerful, less explosive eruptions. Agung seems to have struck a balance between the amount of sulfur available and its ability to carry it into the stratosphere so that the climatic effect was maximized. Rose adds that the amount of sulfur released during an eruption may also depend on the amount of magma that gives up its sulfur as gas but is never erupted from the volcano.

A researcher wishing to study the connection between past volcanic eruptions and climate thus faces a quandary. He knows that sulfur in the form of acid droplets, not ash, often has the greatest effect on climate, yet estimates of sulfur output during past eruptions are even

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What is needed, Mitchell says, are data that take into account the conversion of sulfur gases into acid aerosol.

Ancient Cut Marks Reveal Work of Prehuman Hands

Fossil bones on archeological sites have long been regarded as important but frustratingly mute evidence of early human activity. But it turns out that petrified bones as old as 2 million years bear previously unnoticed telltale signs of the use of stone tools.

Working with a selection of fossils from Olduvai Gorge in Tanzania, Patricia Shipman of Johns Hopkins University and Richard Potts of Harvard have developed an electron microscopic technique that clearly reveals the shallow cut marks in the surface of fossil bone that were made by the edge of a stone flake wielded by prehuman hands.

Alan Walker, of Johns Hopkins University, reported the preliminary results from Shipman and Potts's work. He said, "some of the marks on fossil bones were made by carnivores, and these appear as long smooth U-shaped valleys under the electron microscope." The marks made by stone flakes are distinctive, however, because "running along the bottom of the valleys are sets of 'tram-lines' that were made by the many jagged facets on the edge of the flake."

Shipman and Potts have submitted a paper to *Nature* on this intriguing new discovery, as has Henry Bunn who works with Glynn Isaac at Berkeley. "Henry Bunn has detected distinct marks of tool use on a 1.5-million-year-old pygmy hippo bone from East Turkana in Kenya," reported Isaac, leader of the archeology work in the area. "This is an important extension of archeological sites," he claimed, "because if we find cut marks on bones that are not directly associated with stone tools we still have a clear indication of prehuman activity that wasn't previously available."

The discovery of this new evidence of early human tool use initiated what one worker called "cut mark fever." Researchers began looking for, and finding, cut marks on all kinds of fossil bones. The work is still in its early stages, but it is already giving a profitable new perspective through the archeological window. "Shipman and

The American Association for the Advancement of Science held its annual meeting from 3 to 8 January in Toronto.

Potts have found, for instance, cut marks superimposed on marks made by carnivore teeth," Walker reported. This is the kind of incontrovertible evidence for prehuman scavenging that paleoanthropologists will welcome enthusiastically. "They've also found extensive cut marks on fossil horse limbs from Olduvai at a point where virtually no meat would be present, only tendons and skin," he added. "Either these creatures weren't smart enough to know where the meat was, which is unlikely; or they were interested in something other than meat. One can only speculate what they were after."

Genetic Link with Human Behavior Causes Stir

"There are a lot of serious limitations to the study of genetically controlled behavior in humans," observed Xandra Breakefield of Yale University School of Medicine.

Breakefield and her colleagues are studying human monoamine oxidase, an important enzyme in the metabolism of certain chemical transmitters in the brain. "Why are variations in levels of the enzyme thought to influence behavior?" asked Breakefield. "Because if you inhibit its activity in experimental animals you affect the firing pattern of certain neurons; some people with psychiatric problems, such as schizophrenia or alcoholism, have lower levels of the enzyme in their tissues; and some supposedly normal people who display abnormal tendencies, such as excessive thrill-seeking, also have lowered monoamine oxidase levels."

Monoamine oxidase comes in two forms, A and B, and the Yale group is analyzing their biochemical and genetic profiles. "The two enzymes have related but distinct structures, A having a molecular weight of 63,000 and B 60,000," Breakefield reported. The two genes may have arisen from a single ancestor gene, she speculated.

Analysis of a number of human subjects, including two pairs of identical twins, led Breakefield and her colleagues to conclude that the levels of the enzyme—and by implication certain behavioral traits—are inherited. And she closed her talk with a slide projection of two faces: one a normal individual denoted as having genetically determined normal levels of monoamine oxidase; and another individual whose unmistakably "disturbed" expression is attributed to genetically controlled abnormal levels of the enzyme.

Up jumped MIT biologist Jonathan King, protesting that the speaker's data show that "the levels of variation in enzyme levels due to genotype differences are small compared to differences due to nongenetic influences." Breakefield conceded that environmental influences are certainly important, but pointed to the data from twins to emphasize the genetic argument. King restated his assessment of the Yale data, saying that "the person having more fun does so because of phenotypic rather than genotypic factors," and sat down, adding, "this is a potentially dangerous area, but we're getting into an old argument that you must know about."

Indeed, there are serious limitations to the study of genetically controlled behavior in humans, and King and many other biologists believe the goal to be unattainable in any reasonable and objective sense.

Is Longevity a Positive Selection?

Many ideas about aging focus on self-destruct systems that are supposedly activated when reproductive capacity is either at an end or is overladen with molecular errors that reduce the fitness of the offspring. "I offer a positive theory," said George Sacher, of the Argonne National Laboratory, "in which the length of life is the biological variable on which evolution operates." In other words, Sacher sees the products of natural selection that determine life-span as genetic systems that prolong life to a particular point rather than bring it to an end when the point is reached.

Sacher's "longevity assurance theory" says that one species may live longer than another "because it is better at carrying out the normal vital function of stabilizing and protecting the essential information molecules in the organisms." How is this done? "By evolving more efficient mechanisms for detecting and repairing defective DNA," suggested Sacher.

Mammalian life-spans vary enormously: from about 2 years for some shrews to more than 60 years for elephants, the great whales, and human beings. Many of the differences can be accounted for in terms of body size and related metabolic rate: larger species have lower metabolic rates and longer life-spans. Brain size is another important determining factor, correlating positively with longevity.

"Because of the high predictability of these factors, it is not reasonable to assume that the only means whereby a species can evolve increased life-span is through the selective elimination of an unknown number and variety of senescence genes from the genome," argued Sacher. Instead he looks to positive selection for genes influencing, for instance, DNA repair.

"There's evidence for this from an experiment that Ronald Hart and Richard Setlow did several years ago," claimed Sacher. They exposed cultured cells from seven species to ultraviolet light, and discovered that the amount of DNA repair observed in the cells correlated highly with the life-spans of the species.

Sacher collaborated with Hart in another experiment in which they examined DNA repair and cultured cells from two species of mice, one of the genus *Mus*, the common house mouse, which lives at most $3^1/_2$ years, and one of *Peromyscus*, which generally lives more than twice as long, 8 years. "We found that cultured fibroblasts of *Peromyscus* go through about 20 divisions before they die out, while *Mus* cells accomplish only 10 divisions," Sacher reported. "This is a good indicator of longevity potential," he claimed.

More important for the longevity assurance theory, however, is the discovery that *Peromyscus* cells repair DNA damaged by ultraviolet light about 2.5 times faster than do the cells of *Mus*. "This is almost exactly the ratio of the life-spans of the two species," Sacher pointed out," and this is particularly important in view of the absence of any significant difference in body size, metabolic rate, diet, or housing of the two species. . . . This discovery of the relation between a molecular repair system and life-span provides confirmation of the longevity-assurance theory."

—Roger Lewin