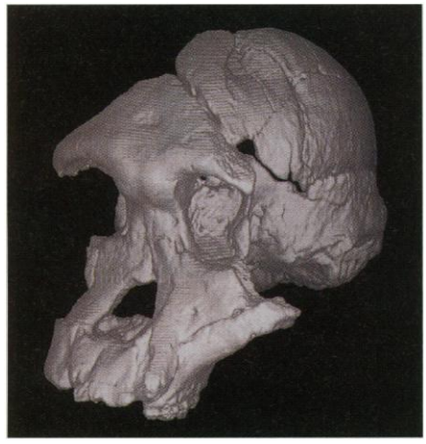
Anthropologists Probe Genes, Brains at Annual Meeting

SALT LAKE CITY—More than 900 anthropologists, geneticists, and primatologists gathered here from 31 March to 4 April for the 67th Annual Meeting of the American Association of Physical Anthropologists. There, they put their heads together to discuss brain evolution and how human mate choice marks our genes.

Sizing Up Ancient Brains

Hominid brain evolution is supposed to have started out slowly and steadily in our apelike ancestors, picking up steam only when our genus, *Homo*, appeared 2 million years ago. But one surprisingly large ancient skull has lately put a wrench in this model: the massive cranium of a 2.6 million year old South African australopithecine known as Mr. Ples. One published report put his cranial capacity at 600 cubic centimeters (cc)—bigger than the brains of some of the first members of our own genus. "The implications for models of brain evolution were profound," says Glenn Conroy, a paleoanthropologist at Washington University School of Medicine in St. Louis, Missouri.



INSTITUTE OF HUMAN BIOLOGY / UNIVERSITY OF VIENNA

Big head? This computer reconstruction showed that Mr. Ples's brain wasn't as big as it first looked.

But at the meeting, after using modern biomedical imaging tools to measure Mr. Ples's cranium, Conroy and colleagues revealed a new estimate for his brain size: about 513 cc. That's decidedly larger than the roughly 385-cc brains of chimpanzees but smaller than estimates for early *Homo* brains—about 640 cc—and much smaller than modern human brains at about 1350 cc. Mr. Ples's revised brain size puts the slow, early expansion model back on firmer footing. But Conroy warns that it still may be vulnerable: He suspects that the brain capacity of several hominids has been overestimated—and that brain size didn't expand until later in human history. If so, "this has dramatic implications for the big picture of brain evolution," says paleoanthropologist Dean Falk of the State University of New York, Albany. "We'll have to rethink the early stages."

Paleoanthropologists' view of hominid brain evolution starts about 3.5 million years ago, with members of *A. afarensis*, the species that includes the famed "Lucy." Although Lucy and her brethren walked upright, their brains averaged about 413 cc, only slightly larger than a chimpanzee's. But between 3 million and 2 million years ago, two new species of more robust australopithecines—*A. africanus* in south Africa and *A. boisei* in east Africa—appeared, and their brain vaults were thought to be slightly larger. Excluding Mr. Ples, the largest of his kind, *A. africanus* brains have been reported to average about 440 cc; *A. boisei* brains were thought to be about 463 cc, with some later members of the species weighing in as high as 500 to 530 cc.

This gradual increase spawned the leading model of early brain evolution. Researchers concluded that our ancestors' brains began to expand with *A. africanus*, who therefore may have had the capability to make tools or use rudimentary language. But they thought the major leap in brain size didn't come until 2.3 million years ago, with the appearance of *Homo habilis*, which has an average brain capacity of 640 cc, says paleoanthropologist Phillip Tobias of the University of Witwatersrand in Johannesburg, South Africa. The data behind this model stem from only a few dozen fossils, however, so one skull could change the picture. If Mr. Ples (also known as STW 505) indeed had a cranial capacity of 600 cc, one of the traits thought unique to *Homo*—big brains—would also be found in australopithecines.

To settle the issue of the size of Mr. Ples's brain once and for all, Conroy traveled to South Africa to perform computerized tomography (CT) scans of the skull. Working on his computer in St. Louis, he then reconstructed a virtual three-dimensional model of the skull and calculated its internal volume. The answer of 513 cc surprised him, so he joined forces with anthropologists Horst Seidler and Gerhard Weber at the University of Vienna, who create physical models in resin from computer models. They got similar measurements. And with their computer-generated resin model, they also used the traditional method of measuring the volume of water inside the brain case—and again got the same result. "It's very reassuring that virtually identical results were given by the old and new methods," says Tobias, a co-author on Conroy's paper.

These results suggest to Conroy that it's time to reexamine more specimens. Mr. Ples has the biggest brain case of any australopithecine, but published brain size estimates for some early hominids are "similar to, or even larger than, Mr. Ples's is now"—and so may be overinflated, he says. He is reevaluating another skull of *A. africanus*, known as STS 71, and thinks it also is smaller than its published estimate. "It may be that australopithecines have a lower mean brain size than previously thought," says Conroy. That would force a rethinking of the "entire early picture of brain evolution," says Falk.

Others, such as Columbia University neuroscientist Ralph Holloway, who has estimated brain size in many early hominids, are pleased to see Mr. Ples's measurements corrected but think it's premature to say that other earlier estimates are wrong. "I don't think it's going to have much of an impact," says Holloway. But Tobias notes that as CT scans allow researchers to estimate capacities for crania that are full of material, there will likely be more measurements—and perhaps more surprises.

Indian Women's Movement

The marriage choices of most people in India—who today number almost 1 billion, or one-sixth of the world's population—were controlled for more than 3000 years by the strict rules of the Hindu caste system. Now, by studying men of different castes, a group of researchers in Utah, India, and Arizona has found that those rules have left a clear mark on the genes of modern Hindus. The researchers traced maternal and paternal ancestry in the same men by analyzing markers on the Y chromosome—which is inherited only through the paternal line—and mitochondrial DNA (mtDNA), which is inherited maternally. The results indicate that women sometimes married up and ascended the social ladder into higher castes. But men tended to stay in the castes into which they were born, says Lynn Jorde, a human geneticist at the University of Utah in Salt Lake City, and co-author of the report presented at the annual meeting.

Although researchers have tried for years to use blood groups and genes to track differ-

SUPERSTOCK

Moving on up. Genes show that some Hindu women could marry men of higher castes.

ences among Hindu castes, this study is one of the first to show the impact of social rules on the genome. "It is one of the clearest applications of molecular genetics to an anthropological question about mate choice and population substructuring," says Rebecca Cann, an evolutionary biologist at the University of Hawaii, Manoa. The work offers genetic proof that "humans choose mates according to certain rules ... [which are often] different for men and women."

In their study, Jorde, University of Utah pediatric geneticist Michael Bamshad, and research specialist Scott Watkins worked with anthropologists Bhaskara Rao and J. M. Naidu of Andhra University in Vishakhapatnam, India. The team collected blood samples from 300 unrelated men from 12 populations spanning the Hindu caste hierarchy and set up a molecular genetics lab at Andhra University.

The researchers compared the DNA sequences of men of different castes, measuring how many differences there were in the same 400-base-pair segment of mtDNA and in seven markers, or segments, of their Y chromosomes. The mtDNA showed a slight blurring of caste lines. Men in closely ranked castes had similarities in their maternally inherited mtDNA, but there were few similarities between the mtDNA of men in the highest castes, such as Brahmins, and those in the lowest castes. "The genetic distances between upper and lower castes are much greater than [those] between upper and middle castes and [between] middle and lower castes," says Jorde. This gradient means, says Jorde, that these men's maternal ancestors had moved between adjacent ranks, mixing the genes between closely related castes. And historical records and strict social rules make it clear that women must have moved up, rather than down. "You get this ladder effect, where women tend to move to a caste of the next higher rank but [don't make] dramatic leaps from the lower castes to the very highest," says Jorde.

The distribution of markers on the Y chromosome showed a very different pattern. Men in the highest castes didn't share any more genetic markers with men in middle castes than they did with men in lower castes, suggesting little crossing of caste lines. In other words, "the men are stuck," says Jorde. The study confirms a pattern found in cultures worldwide—that women can move up in social rank, because higher ranking males will marry lower ranking females, but that low-ranking males have the least choice in mates, notes molecular anthropologist Mark Stoneking of Pennsylvania State University, University Park.

The study also gives the geneticists confidence that they can detect historical and social events in the genome. The effects of caste were still evident even though the system was outlawed in the 1960s. And the study shows an Asian origin for people in most castes, but the DNA of people in the upper castes has some similarities to that of Caucasians, which fits historical records that say the caste system was imposed by Caucasians sweeping in from the northwest. "It should make us optimistic about the power of genetic studies to reveal history," says Jorde.

–Ann Gibbons

PLANETARY SCIENCE

Fiery Io Models Earth's First Days

HOUSTON—To planetary geologists, the closest thing in the solar system to biblical fire and brimstone can be found on Jupiter's moon Io. Scorching eruptions pit the sulfur-laden surface of Io, which is the most volcanically active body known. Now this planetary hell has gotten even hotter. Using sophisticated instruments aboard the Galileo spacecraft orbiting Jupiter, researchers observed a surface temperature of about 1800 kelvins at the site of a particularly powerful eruption, they reported last month at the annual Lunar and Planetary Science Conference here.

"This is probably the highest temperature volcanism ever seen anywhere," says planetary geologist Ashley Davies of the Jet Propulsion Laboratory (JPL) in Pasadena, California. "It's really exciting," because such high temperatures imply a sort of volcanism that has not been common on Earth for billions of years. "We can use Io as a volcanological laboratory to test our models of terrestrial volcanism," Davies adds.

Io's behavior has made it the oddball of the solar system since the two Voyager spacecraft flew by in 1979. Thanks to Jupiter's gravitational kneading, Io burns with unusually hot inner fires, evidenced in Voyager images of umbrella plumes of sulfur dioxide shooting hundreds of kilometers above volcanic calderas. And the rest of Io's surface looked odd too, coated with sulfur of various pale yellow hues. Researchers assumed that lavas of elemental sulfur at about 700 K were reshaping the surface.

By the mid-1980s, increasingly sophisticated infrared observations from ground-based telescopes observed surface temperatures on Io as high as 1450 K—too hot for sulfur, which melts at much lower temperatures. That suggested basaltic lavas enriched in iron and magnesium, which melt at higher temperatures and are similar to the magmas that feed Earth's midocean ridges.

NASA / JPL

The devil's playground. A new volcanic hot spot at Pillan Patera produced record high temperatures and spewed dark debris (circular deposits, upper right) over an area the size of Arizona.

Now Io's perceived temperature has taken yet another jump. Planetary scientists Alfred McEwen and Laszlo Keszthelyi of the University of Arizona in Tucson and their colleagues reported at the meeting that Galileo's Solid State Imaging instrument recorded hot spots, including the caldera Pillan Patera, that reach temperatures in excess of 1600 K and probably as high as 2000 K. The Near-Infrared Mapping Spectrometer on Galileo confirmed a temperature for Pillan of 1825 K, reported Davies. About 30 hot spots—many of which are associated with sulfur dioxide plumes—glow in the infrared at temperatures greater than 1000 K, McEwen reported.

"Something very hot and very vigorous is going on" at Io's volcanic hot spots, says Davies. He envisions fiercely hot magma glowing through cracks in a thin solid crust atop churning lava lakes, lobes of flowing lava breaking out from encrusted volcanic material, or even lava