detectors around the world that are more or less similar to Soudan, but few other physicists have found the evidence convincing. Now, an experiment on the surface—at a high altitude, in fact—operated by Yodh and graduate student Brenda L. Dingus has found a similarly unusual production of muons associated with cosmic-ray air showers. In this case the source seems also to be Hercules X-1.

When an ordinary cosmic ray, which can be a gamma ray, a proton or an atomic nucleus, strikes the top of the atmosphere, it initiates a shower of particles, some knocked out of the atoms of the air, some created in the collision. On the ground, physicists customarily detect these showers by spreading large areas of particle-detecting material. The experiment of Yodh and Dingus, which is located at Los Alamos (N.M.) National Laboratory at an altitude of 7,000 feet, differs from most in having in its center a flash chamber, which is actually part of an accelerator laboratory there, and which can identify muons. Yodh told the Heavenly Accelerators workshop, which met recently at Johns Hopkins University in Baltimore, that just a few months ago a series of air showers initiated by gamma rays that seem to come from Hercules X-1 had "too many muons" associated with them — that is, more than known and accepted physics would expect — and therefore something strange is going on.

To a chorus of murmurs from the audience, Yodh replied, "You are confused; we were surprised." Marshak had suggested that his cygnets were some previously unknown kind of particle. Yodh suggests that the source ot the anomalous muons may be known particles — neutrinos or perhaps those of the class called vector mesons — acting in previously unknown ways. A similar suggestion comes from Gabor Domokos and Susan Kovesi-Domokos of Johns Hopkins, who suggest that ordinary neutrinos could be doing it, provided they are not simple elementary particles but composites.

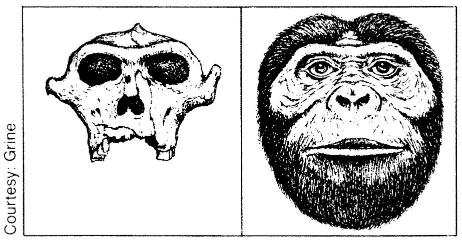
The most widely believed theory at this point holds that the elementary building blocks of matter consist of six quarks and six leptons. Neutrinos and muons are leptons and so are believed to be simple elementary particles. However, for reasons that seem good to them, some theorists have suggested that there may be a level of structure below that of quarks and leptons — that is, that the quarks and leptons are composites made of things called preons. If neutrinos are composites made of preons, Gabor Domokos told the workshop, then a neutrino striking the atmosphere might induce processes of preon exchange that could make numbers of muons that are impossible if preons don't exist.

"I hope we will see the signal again," says Yodh. "If the data are good, it's up to the theorists." — *D. E. Thomsen*

Robust hominids: Tooth and consequences

It is a face that only a mother and a paleoanthropologist could love. The teeth are immense and hammer-like, particularly at the back of the mouth. Massive jaws and a broad face slope toward the back of the head, where a small brain is encased.

The face belongs to a member of the robust australopithecines, a group of hominids, or human-like creatures, that evolved at the same time as the lineage that led to modern humans, but became extinct around 1 million years ago. The size and shape of their fossil skulls, found in eastern and southern Africa, led to the view that they were large, heavily built creatures. That view appears to be wrong, according to Yoel Rak of Tel Aviv University in Israel.


Courtesy: Grine

Skull and artist's conception of robust australopithecine known as A. robustus.

Rak studied several skulls belonging to the east African species *Australopithecus boisei*. "Robust" facial features reached their peak in *A. boisei*, which has been dated at 1.2 million to 2.2 million years old.

"I was astonished at how delicate much of the *boisei* skull is," reported Rak at the annual meeting of the American Association of Physical Anthropologists in New York City last week. "It appears that a massive [chewing] system was imposed on a relatively small creature."

For example, says Rak, the walls of *A. boisei's* brain case were "amazingly thin." Cranial thickness reaches no more than 4 millimeters in the largest specimens, and no more than 2 millimeters in a smaller skull. Fragile bone also surrounds the eye openings.

A number of features typical of *A. boisei* skulls appear, he notes, to have been evolutionary modifications to cope with massive teeth and jaws. Among them are a flared, bony crest running over the top of the head, a visor-like crest over the eyes and the triangular shape of the brain case, all of which helped to anchor enormous facial muscles.

Rak's analysis feeds into the emerging view that east African australopithecines were not more "robust" in stature than their south African counterparts, who have been described as smaller or "gracile" (SN: 1/24/87, p.58). But the east African variety does appear to be characterized by larger teeth and thicker tooth enamel, said Frederick Grine of the State University of New York at Stony Brook, at a press conference held the day before the physical anthropology meeting began. His remark was generated by a five-day workshop in Stony Brook on the robust australopithecines attended by an international group of researchers.

It is difficult to make inferences about australopithecine biology, cautions Pat Shipman of Johns Hopkins University in Baltimore, because "it's hard to tell which heads go with which bodies." Nevertheless, in independent studies presented at the workshop, Henry M. McHenry of the University of California at Davis and William L. Jungers of the State University of New York at Stony Brook conclude that fossil remains provide no evidence of marked differences in body size between geographically separated australopithecines. Furthermore, they suggest that later australopithecines were about the same size as earlier australopithecines and early members of the human lineage.

Both scientists report that while south African robust hominids had thick tooth enamel, that of east African australopithecines was even thicker.

Most workshop participants agreed with McHenry and Jungers. "The terms 'robust' and 'gracile' should refer to australopithecine teeth only," comments Milford H. Wolpoff of the University of Michigan in Ann Arbor. Adds William H. Kimbel of the Institute of Human Origins in Berkeley, Calif., "The concepts of 'gracile' and 'robust' australopithecines should probably be dropped and we should just refer to species names."

One australopithecus species, however, may require revision, according to Ronald J. Clarke of the University of the Witwatersrand in Johannesburg, South Africa. At the workshop, he discussed a recently excavated skull of a creature known as *A. africanus* and proposed that it and other specimens previously found at the same site may in fact represent two species. *A. africanus* has been found only in southern Africa and is estimated to have arisen between 2.5 million and 3 million years ago.

Clarke says some of the specimens have larger teeth and flatter faces and brows, indicating that they were an ancestral stock for both southern and eastern robust australopithecines. Other skulls have smaller teeth and more prominent brows and nasal bones. This species may have been ancestral to the human lineage, he notes.

Kimbel and his colleagues also suggest that *A. africanus* specimens may represent more than one species, based on a study of fossil teeth. "If this proves to be the case," he says, "there may be interesting changes in how we reconstruct early hominid evolution." — *B. Bower*