Hominid Headway

Scientists have used modern technology to scour the inside of an ancient child's skull, but the youngster's growth patterns remain controversial

By BRUCE BOWER

In 1925, Raymond Dart, an upstart 31-year-old anatomist at the University of the Witwatersrand in Johannesburg, South Africa, ushered in the new year by announcing what is now considered one of the major scientific discoveries of the 20th century. The beautifully preserved skull of an ancient child had been found near the South African village of Taung. And to the dismay of many prominent anthropologists at the time, Dart proposed that its features were those of an early species of hominids, the evolutionary family that includes modern humans.

Prevailing opinion held that Asia was the cradle of humanity, a notion Dart rocked with his African fossil. Respected scholars contended that the brains of the first hominids visibly began to enlarge, although their jaws and teeth may still have been ape-like. But the Taung skull turned that proposal on its head. In Dart's view, the approximately 2-million-year-old child had human-like teeth, a head that rested on an upright spinal cord capable of supporting a two-legged gait and indications of an advanced brain structure, although the size of its brain remained quite small.

It took 30 years for Dart's analysis, and his designation of Taung as a member of the species *Australopithecus africanus*, to gain widespread scientific acceptance. Yet only in the last couple of years have investigators really gotten inside Taung's head.

In July 1986, Glenn C. Conroy and Michael W. Vannier of Washington University School of Medicine in St. Louis used high-resolution computer tomographic (CT) scans to create a three-dimensional image of the interior of the Taung skull, minus its filling of rock and hardened sediment. For the first time, recently developed technology (SN: 10/27/84, p.260) enabled researchers to use CT to examine hidden parts of a hominid fossil.

"This provides dramatic evidence of Taung's internal structure beyond what we had ever dreamed we'd get out of that little child," says paleoanthropologist Phillip V. Tobias of the University of the Witwatersrand, who granted the American scientists access to the skull.

In the Oct. 15 NATURE, Conroy and Vannier report that although Dart correctly held that the shapes of Taung's teeth, such as the small canines, were more like those of humans than apes, the CT data show that its dental eruption pattern is closer to that of a 3- to 4-year-old ape.

Their conclusion goes to the heart of an ongoing debate over the dental characteristics of ancient hominids. B. Holly Smith of the University of Michigan in Ann Arbor holds that human ancestors of more than 2 million years ago display patterns of tooth eruption similar to those of modern apes (SN: 4/18/87, p.255). In independent research that dovetails with Smith's, Timothy G. Bromage and C. Christopher Dean of University College in London, England, have identified a rapid, ape-like rate of tooth development in 3.5-million- to 1.5-million-year-old infant hominids (SN: 10/26/85, p.260).

In strong opposition to their argument stands Alan E. Mann of the University of Pennsylvania in Philadelphia. In the late 1960s and early 1970s, Mann used X-rays to study the jaws of juvenile hominids found in South Africa. His conclusion: The pattern of their dental growth is much like that of modern humans. Studies challenging his analysis, says Mann, have been inadequate.

What is the big deal about the pattern and timing of dental development in our earliest ancestors? Simply put, the growth characteristics of teeth provide important signs of how long infancy lasted. Compared with apes, modern humans have an extended infancy to en-

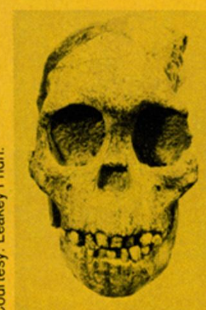
Taung: The last common ancestor?

The Taung child is considered a prime example of the hominid species *Australopithecus africanus*. Phillip V. Tobias of the University of the Witwatersrand in Johannesburg, South Africa, says it may in fact be a representative of an "advanced" form of *A. africanus* that led in one direction to the now-extinct robust australopithecines, *A. robustus* and *A. boisei*, and in another direction to *Homo habilis*, the first direct ancestor of modern humans.

The critical branching of the hominid lineage took place around 2.5 million years ago, suggests Tobias, while evolutionary advances in the anatomical structure of *A. africanus* occurred between 2.8 million and 2.5 million years ago.

Tobias first proposed that *A. africanus* was a common ancestor of *Homo habilis* and the robust australopithecines in 1968, but modified his view based on data presented in the February 1986 CURRENT ANTHROPOLOGY by Randall Skelton and his colleagues at the University of California at Davis. They argued that a population of *A. africanus* evolved 16 "derived" or advanced anatomical features that are shared exclusively by *A. robustus*, *A. boisei* and *H. habilis*. The Taung skull, says Tobias, fits the bill as a member of the less primitive *A. africanus* population proposed by the Davis researchers.

A firm date for Taung has not been established, but the best estimates put its age at around 2 million years. *A. africanus* specimens from the two best-known South African sites are dated at between 3 million and 2.4 million years old. It is possible, says Tobias, that Taung was a late survivor of the derived *A. africanus* population.



Courtesy: Leakey Fndn.

Whatever the case, Tobias holds that some members of the advanced form of *A. africanus* appear to have been the first hominids to use stone tools. The oldest known stone tools in East Africa date to about 2.4 million years ago, he says, approximately 200,000 years before the oldest well-dated remains of *H. habilis*, commonly referred to as the first stone-tool user. Culture, as reflected by stone-tool making, "played an important, probably a crucial role in the genesis of [the genus] *Homo* and its earliest species, *H. habilis*," concludes Tobias.

While most investigators see *A. africanus* as a pivotal species in the hominid family tree, the consensus is not with a "common ancestor" interpretation at this point. *A. africanus* is most often classed as a sister species or direct ancestor only of the *Homo* lineage, although its evolutionary role remains controversial (SN: 7/4/87, p.7).

"I don't see any solid evidence for Tobias's position," says Frederick E. Grine of the State University of New York at Stony Brook. "I just see Taung as a specimen of *A. africanus*, not a derived form of the species." — *B. Bower* compass the greater need for intellectual and social nurturing. If early hominids had prolonged infancies, than it would be fair to assume that they had taken a giant biological and cultural leap toward "humanness."

One reflection of this trend, the approach taken by Smith and Mann, revolves around distinctive patterns of tooth eruption. For example, canine teeth emerge before the second molar in humans and after the second molar in apes. Bromage and Dean, on the other hand, attempt to estimate the time over which tooth eruption takes place. The three molar teeth can be used as one yardstick of dental timing; in apes they appear around ages 3, $6\frac{1}{2}$ and $10\frac{1}{2}$ years, respectively, and in humans they appear at ages 6, 12 and 18.

"The evidence is beginning to become overwhelming that Smith, as well as Bromage and Dean, are correct in maintaining that australopithecines [early small-brained hominids, including *A. africanus*, that do not belong to the *Homo* lineage] have a more ape-like dental maturation period," says Conroy.

CT scans of Taung's jaw, whose first molar has erupted, were compared with CT scans of a modern chimpanzee skull and human skull at the same stage of eruption. The chimp is estimated to be 3 to 4 years of age, the human 5 to 6.

Taung displays several ape-like dental patterns, says Conroy. These include the lack of significant root development in any permanent teeth save the first molar, delayed canine eruption and a horizontal alignment of the developing incisors at the front of the mouth. Furthermore, the CT scans show "extraordinary" extensions of sinuses behind the upper jaw for such a small skull, according to Conroy. This characteristic has been noted only in chimps and "robust" australopithecines, an East African line of hominids that became extinct around 1 million years ago.

Nevertheless, adds Conroy, Taung has human-like aspects that were first described by Dart. These include a lack of brow ridges, a cranial base that could hold the head in an erect position and adaptations in tooth shape, such as smaller canines.

In other words, Taung is a good example of the "mosaic" evolution that many scientists believe characterized early hominids. Anatomical changes occurred piecemeal, not wholesale. Increases in brain size and a lengthened infancy may have been later pieces of the mosaic, arising a million years or more after *A. africanus* departed the evolutionary scene.

"Conroy and Vannier have shown that Taung resembled the robust australopithecines more closely than it resembled modern humans in its sequence of dental development," says Tobias. "I think Alan Mann's work will have to be reexamined."

Notes Holly Smith, "The new CT study is quite important, but it clearly shows that Taung would not have grown up to be a robust australopithecine." She has examined 20 early hominid juvenile jaws, including both East African robusts and South African "gracile" australopithecines such as *A. africanus*. Both lines had apelike eruption patterns, says Smith, but there are "superficial" resemblances to the human pattern among the robusts.

"We need to study more fossil skulls of the robusts with CT scanning," she says.

Mann agrees that the new technology has much potential for studying hominid fossils, but Conroy and Vannier's report, he contends, "doesn't show anything of significance about Taung." He and his co-workers have sent a letter to NATURE to present their case.

Many skulls of modern human children in archaeological collections, says Mann, contain the same dental eruption pattern as that shown in the CT images of Taung. He and his co-workers have examined a sample of 90 infant skulls dating to 3000 B.C., and, adds Mann, about 4 out of 5 specimens display an eruption pattern that looks like that assigned to modern apes by Smith.

"There is enormous variation in patterns of human dental maturation," he says. "Conroy and Vannier used one specimen, but the eruption pattern of one specimen does not represent an entire species."

The pattern of tooth eruption is, however, only part of the story. Bromage and Dean claim to have established an absolute scale for estimating the time over which tooth eruption occurs in modern humans, apes and early hominids. In their initial study, they used a scanning electron microscope to examine incisor teeth from 10 modern youngsters and nine juvenile hominids. They estimated age at the time of death by counting a series of ridges on the surface of the enamel, called perikymata. Each layer of enamel framed by the ridges forms over an average of seven to eight days, according to Bromage and Dean. They also maintain that cross-striations embedded in the ridges represent daily increments of enamel formation.

Counting the number of microscopic enamel ridges on teeth at a given point in tooth eruption, say Bromage and Dean, permits comparisons of the rate of dental development of modern humans, apes and hominids. Greater numbers of perikymata indicate faster, ape-like enamel growth; fewer numbers point to slower, human-like growth.

Not all paleoanthropologists are sure that perikymata form on a weekly basis, but the British researchers have gained a number of supporters.

"Their results are exciting," says Tobias, "but more work needs to be done on the perikymata evidence."

Conroy says that studies suggesting a weekly cycle of enamel formation are "60 to 70 percent convincing at this point," although it is unclear why the periodicity occurs or what function perikymata serve.

But Mann, as well as Frederick E. Grine of the State University of New York at Stony Brook, regards the perikymata data as dubious and based on inadequate studies of enamel formation in modern populations.

With dental anatomist David Beynon of the University of Newcastle, England, Dean has reviewed independent lines of evidence on the timing of perikymata formation in apes, humans and early hominids. A seven-day periodicity appears reasonable, says Beynon, "but it could be eight or nine days."

Compared with modern humans, apes show a faster rate of crown formation, particularly on incisors, according to the British researchers. The limited data on early hominid teeth, they say, also point to a more rapid rate of crown formation.

But for the time being, there is no final word on how best to analyze either the pattern or the timing of dental growth.

"We're really talking about probabilities," says Conroy. "Any paleoanthropologist who's dogmatic about [growth characteristics of] early hominids is kidding himself." □