

Human Evolution Inferred from Tooth Growth and Development

To study human evolution, researchers sometimes use microstructures found in human teeth and their knowledge of the processes by which those structures grow. Human fetuses begin to develop teeth in utero. As teeth grow, they form a hard outer substance, called enamel, through a process called amelogenesis. During amelogenesis, incremental layers of enamel form in a Circadian rhythm. This rhythmic deposition leaves the enamel with microstructures, called cross-striations and striae of Retzius, which have a regular periodicity. Because enamel is not renewed throughout life like other tissues, teeth preserve the timing and details of a person's growth and development. Thus, enamel microstructures, from living people and from fossilized teeth, can be used to reconstruct the growth, development, and life histories of current and past humans. Researchers can also compare current and fossilized microstructures to trace changes in those traits over the course of human evolution.

Researchers use enamel microstructures to study life-history traits unique to humans. Humans differ from their closest living relatives, the great apes—chimpanzees, gorillas, and orangutans—by an enlarged brain, a long life span, and an extended childhood period that delays the age at which they can first reproduce. Many researcher hold that brain size is simple to track in the fossil record, but that the length of childhood and of life span requires more complicated methods for detection. Scientists can examine enamel microstructures to estimate when life history traits, such as weaning, malnutrition, or diseases, occurred during the life of an individual. Biologists in the early twentieth century discovered that enamel develops in cycles. Even though some researchers used teeth to reconstruct the human fossil record, scientists studying human evolution did not look to enamel microstructures as sources of information until late in the twentieth century.

In the mid-1980s, paleoanthropologists began to use enamel microstructures to reconstruct human evolution. Previously, for fossil samples of juvenile hominids, scientists had estimated the ages at which those juveniles had died from human standards of tooth development, a practice that biased the results by reflecting the age of specimens in human years. In 1985, Timothy Bromage and Christopher Dean, of the University of Toronto in Toronto, Ontario, and University College London in London, UK, respectively, introduced a way of using enamel microstructures to determine the age of immature fossil hominids without appealing to human standards. Bromage and Dean counted perikymata, the visible remnants of striae of Retzius on the surface of tooth crowns, of immature fossil hominids. To derive the age of the individuals, the researchers then multiplied the number of perikymata by seven days, the mean formation time for each line. When Bromage and Dean compared the ages of the individuals that they derived from this technique to the ages estimated from standard methods used to determine the age of a human skeleton, they noted that the human-based results significantly overestimated the ages of the samples. Bromage and Dean demonstrated that, compared to modern humans, hominids had much shorter growth periods for teeth, which the researchers extrapolated to growth periods for bodies. Their estimates were much more similar to the growth periods of modern great apes.

Building on the work of Bromage and Dean, David Beynon of the Newcastle University-upon-Tyne in Newcastle-upon-Tyne, UK, and Bernard Wood of the University of Liverpool in Liverpool, UK, published an article in 1987 on the growth of hominid dentition. In this paper, Benyon and Wood accounted for a factor that earlier authors had missed: the size and orientation of the enamel increments. The researchers used polarized light to highlight the enamel microstructures visible on the broken surfaces of naturally fractured teeth from fossil hominids. They then plotted the course

of the striae of Retzius and measured the length of the daily increments. Based on the patterning of the striae, they suggested that the teeth of robust australopithecines, a group of extinct human ancestors living in Africa between 2 million and 1.4 million years ago, deposited enamel in a pattern that differed from the pattern found in members of the genus *Homo*. Beynon and Wood also found that the daily deposition of enamel in the robust australopithecines was much greater than in *Homo*. They considered this finding especially interesting in light of the fact that robust australopithecines have much thicker enamel than both modern humans and African apes. Although thicker, the enamel of robust australopithecines appears to form over a shorter developmental period than human enamel, signaling a higher rate of deposition in robust australopithecines than in modern humans. These results indicated that the developmental processes of teeth can provide insights into the evolutionary history of adult morphologies beyond those inferred via comparative morphology. Apparently similar adult characters, like the thick enamel of humans and australopithecines, can develop in subtly different ways.

Subsequent studies further illuminated human evolutionary history. For example, scientists had thought that *Homo erectus*, an early African and south east Asian member of the genus *Homo*, was similar to modern humans in key events during tooth development. However, in 2001, Dean and his colleagues looked at enamel microstructures and showed that *Homo erectus* retained an enamel growth rate that was similar to earlier hominids. Their work overturned the supposed similarity in dental development between *Homo erectus* and modern humans. Dean argued that evidence for a modern growth rate within enamel microstructures does not exist in the fossil record until the origins of *Homo neanderthalensis*, more than 100 thousand years ago.

Sources

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