

Another face in our family tree

Daniel E. Lieberman

The evolutionary history of humans is complex and unresolved. It now looks set to be thrown into further confusion by the discovery of another species and genus, dated to 3.5 million years ago.

Until a few years ago, the evolutionary history of our species was thought to be reasonably straightforward. Only three diverse groups of hominins — species more closely related to humans than to chimpanzees — were known, namely *Australopithecus*, *Paranthropus* and *Homo*, the genus to which humans belong. Of these, *Paranthropus* and *Homo* were presumed to have evolved between two and three million years ago^{1,2} from an early species in the genus *Australopithecus*, most likely *A. afarensis*, made famous by the fossil Lucy.

But lately, confusion has been sown in the human evolutionary tree. The discovery of three new australopithecine species — *A. anamensis*³, *A. garhi*⁴ and *A. bahrelghazali*⁵, in Kenya, Ethiopia and Chad, respectively — showed that genus to be more diverse and widespread than had been thought. Then there was the finding of another, as yet poorly understood, genus of early hominin, *Ardipithecus*, which is dated to 4.4 million years ago⁶. And earlier this year, a French team claimed to have discovered another (albeit controversial) candidate for the oldest known hominin, *Orrorin tugenensis* (ref. 7; to be discussed here next week). To those of us who are interested in reconstructing the evolutionary history of our species, these discoveries have been fun, if a little bewildering.

The confusion (and enjoyment) now looks set to increase still further. On page 433 of this issue⁸, Leakey and colleagues describe what they assert to be a new genus and species of early hominin, *Kenyanthropus platyops*. The species, whose type specimen is a spectacular partial skull, called KNM-WT 40000 (Fig. 1), was found at the site of Lomekwi on the western side of Lake Turkana in northern Kenya. The hominin bones discovered there include more than 30 skull and dental fragments, two of which have been assigned to *K. platyops*. (The other fragments have not yet been assigned to any genus or species.) These fossils were all found in deposits reliably dated to between 3.5 million and 3.2 million years ago. The other mammalian species found at Lomekwi suggest that, during this period, the site was part of a complex mixture of grassland and wooded habitats, not unlike other roughly contemporary sites such as Laetoli (Tanzania) and Hadar (Ethiopia), where remains of *A. afarensis* have been found.

Is the authors' claim⁸ — that the fossils



Figure 1 Two fossil skulls from early hominin species. Left, KNM-WT 40000. This newly discovered fossil is described by Leakey *et al.*⁸. It is judged to represent a new species, *Kenyanthropus platyops*. Right, KNM-ER 1470. This skull was formerly attributed to *Homo rudolfensis*¹, but might best be reassigned to the genus *Kenyanthropus* — the two skulls share many similarities, such as the flatness of the face and the shape of the brow. However, they are clearly different species, as *K. platyops* had a significantly smaller brain.

represent a new species and genus — likely to be true? The first part is easier to answer; KNM-WT 40000 is almost certainly a new species. The fossil has a dizzying mosaic of features. None of these characteristics is in itself new. But the combination of features is not found in any other known species, and would be hard to explain even if the species were remarkably diverse, with considerable morphological differences between sexes. The fossil resembles chimpanzees and one of the australopithecine species, *A. anamensis*, in having a small earhole. And it shares many other features of primitive hominins with *A. afarensis* and *A. anamensis*, such as cheek teeth with thick enamel, a small brain the size of that of a chimpanzee, and flat nasal margins.

But the fossil's face also has several important 'derived features' (defined as those not present in the closest known ancestor) that unequivocally distinguish it from *A. anamensis*, *A. afarensis* and *A. africanus*. These include an anterior origin for the root of the cheekbone arch on the upper jaw; the existence of a flat plane beneath the nose bone (and so the appearance of a flat face); and a tall cheek region. KNM-WT 40000 also differs from *A. garhi* in a number of ways: for example, the postcanine teeth and brow of the skull are smaller in KNM-WT

40000. The skull also lacks most of the derived features of *Paranthropus*, with a few exceptions such as the presence of three roots in the upper premolars. And, most interestingly, KNM-WT 40000 has a small cranial capacity but otherwise much in common with the famous KNM-ER 1470 fossil (Fig. 1), which is generally referred to as *Homo rudolfensis*¹. These similarities are mostly in the face, and include the flat plane beneath the nose bone, the tall, vertically oriented cheek region, and the lack of a depression behind the ridge of the brow.

A harder problem is whether KNM-WT 40000 belongs in a new genus. The difficulty is that, ideally, a genus should reflect a lineage that is unique, in terms of both its adaptations to a given environment and its relationships with other genera⁹. At present, it is hard to believe any reconstruction of hominin relationships because of the abundance of independently evolved similarities in the hominin fossil record. The complex mosaic of features seen in the new fossil will only exacerbate the problem.

Yet Leakey *et al.*'s proposal⁸ to erect a new genus, *Kenyanthropus*, for the fossil is attractive, for the simple reason that none of the other possible solutions seem feasible. First, the species does not fit comfortably in the diagnoses of any existing genus, whether

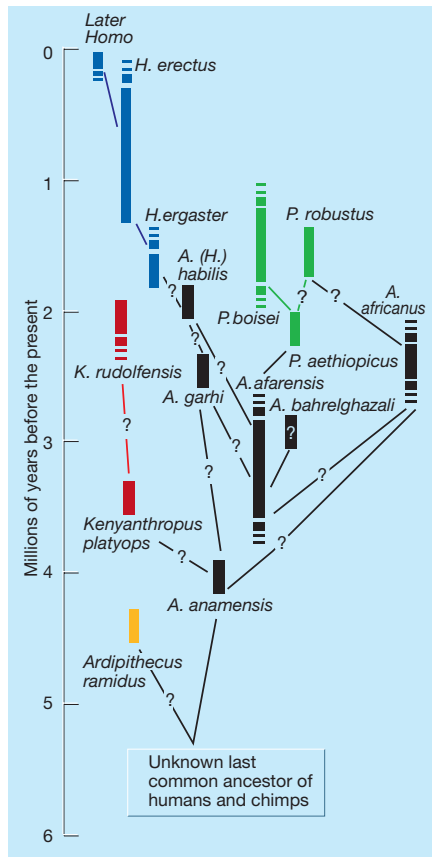


Figure 2 Possible evolutionary relationships of the hominins, indicating the five major genera, with *Kenyanthropus* in red, *Homo* in blue, *Paranthropus* in green, *Australopithecus* in black and *Ardipithecus* in yellow. Question marks indicate hypothetical or conjectural relationships; horizontal bars indicate uncertainty in the species' temporal spans.

Ardipithecus, *Australopithecus*, *Paranthropus* or *Homo*. Second, classifying the species as *Australopithecus* would also create problems because of the many derived features that KNM-WT 40000 shares with *H. rudolfensis*, which, in turn, shares other derived features with *Paranthropus*¹⁰. Species in a genus should be 'monophyletic' (have a single origin), but these similarities would probably render current definitions of *Australopithecus* species non-monophyletic. A third way round the problem might have been to dump the whole lot, including *Paranthropus* and early *Homo*, into *Australopithecus* for the time being. The advantage of this solution — my favourite of the three — is that it avoids non-monophyletic genera. But, as Leakey *et al.* point out, this scheme would render *Australopithecus* a confusing 'garbage can' genus. Hence the new genus, *Kenyanthropus*.

The nature of *Kenyanthropus platyops* raises all kinds of questions, about human evolution in general and the behaviour of this species in particular. Why, for example, does it have the unusual combination of small cheek teeth and a big flat face with an anteriorly positioned arch of the cheek bone?

All other known hominin species with big faces and similarly positioned cheek bones have big teeth. I suspect the chief role of *K. platyops* in the next few years will be to act as a sort of party spoiler, highlighting the confusion that confronts research into evolutionary relationships among hominins (Fig. 2).

The confusion is in part a testament to the intense, successful fieldwork efforts that have almost doubled the number of recognized hominin species over the past 15 years. We can now say with confidence that hominin evolution, like that of many other mammalian groups, occurred through a series of complex radiations, in which many new species evolve and diversify rapidly. It seems that between 3.5 and 2 million years ago there were several human-like species, which were well adapted to life in different environments, although in ways that we have yet to appreciate fully. But these radiations bring with them systematic headaches, because they make it hard to work out where new species fit in by using standard information

from skull and teeth fossils. A challenge for the next decade will be for skeletal biologists, palaeontologists and molecular biologists to work together, to devise new analytical methods with which to tease trustworthy signals from these data. My guess is that it will be quite a while before we can confidently determine the position of *Kenyanthropus platyops* in the human evolutionary tree. ■

Daniel E. Lieberman is in the Department of Anthropology, The George Washington University, 2110 G. Street NW, Washington DC 20052, USA. e-mail: danlieb@gwu.edu

1. Wood, B. A. *Koobi Fora Research Project, Volume 4: Hominid Cranial Remains* (Clarendon, Oxford, 1991).
2. Strait, D. S., Grine, F. E. & Moniz, M. A. *J. Hum. Evol.* **32**, 17–82 (1997).
3. Leakey, M. G., Feibel, C. S., McDougall, I. & Walker, A. C. *Nature* **376**, 565–571 (1995).
4. Asfaw, B. *et al. Science* **284**, 629–635 (1999).
5. Brunet, M. *et al. Nature* **378**, 273–275 (1995).
6. White, T. D., Suwa, G. & Asfaw, B. *Nature* **371**, 306–312 (1994).
7. Senut, B. *et al. CR Acad. Sci.* **332**, 137–144 (2001).
8. Leakey, M. G. *et al. Nature* **410**, 433–440 (2001).
9. Wood, B. A. & Collard, M. C. *Science* **284**, 65–71 (1999).
10. Lieberman, D. E., Pilbeam, D. R. & Wood, B. A. *J. Hum. Evol.* **30**, 97–120 (1996).

Materials science

A pore view of corrosion

Martin Stratmann and Michael Rohwerder

The mechanism by which an alloy corrodes into a potentially useful porous sponge is understood qualitatively, but quantitative predictions of its final structure have been lacking. A model for this has now been proposed.

Alloys have an important role in modern life. Bronzes, stainless steels and alloys of noble (inert) metals, to name but a few, are all designed to have various properties, such as mechanical strength, ductility or resistance to corrosion. Pure metals are almost never used for technical applications because of their softness. Conversely, the corrosion of more reactive materials can be significantly reduced by adding even a small amount of a more inert component. For example, iron–chromium alloys containing as little as 13% chromium can survive long periods of exposure to salt water, whereas pure iron corrodes quickly. Alloys are also useful economically for materials based on noble metals such as platinum or gold: adding less noble components to noble metals used for jewellery, electrical contacts and dentistry significantly reduces their cost.

An interesting class of alloys is those that can be selectively depleted or 'dealloyed', because one component is more reactive (less noble) than the other. This process leaves behind an intricate nanoporous structure made almost entirely from the noble component. Although dealloying is quite common, and can generate useful nanoporous materials, the underlying physics of the process remains poorly understood.

On page 450 of this issue, Erlebacher *et al.*¹ present a model that predicts all of the characteristic features of dealloying, including the pore size of the final structures.

For dealloying to occur, the less inert component has to be selectively dissolved — either naturally in acid or more quickly in an electrochemical system. By using the alloy as one of the electrodes in an electrochemical cell, and then applying a voltage, ions will be stripped from the electrode and dissolve in the electrolyte. For selective dissolution to occur, the electrode potentials at which the alloy's two metals form ions must be significantly different, allowing one to dissolve in the electrolyte while the other remains intact. For example, gold–copper will dealloy, but gold–platinum will not.

Although studies of dealloying have been largely prompted by concerns about corrosion, the high surface area of dealloyed materials also makes them potentially useful as catalysts or sensors. The final structure usually has a spongy nature, consisting of a system of interconnected pores or tunnels in a skeleton of filaments of the pure, or almost pure, inert metal. Previous studies have shown that, depending on the alloy and electrolyte used, the pore and filament size is typically around 5–50 nm, and surface areas as high as 20 m² g⁻¹ are possible. These