Orrorin tugenensis
Living around 6 million years ago, *Orrorin tugenensis* is the one of the oldest early humans on our family tree. Individuals of this species were approximately the size of a chimpanzee and had small teeth with thick enamel, similar to modern humans. The most important fossil of this species is an upper femur, showing evidence of bone buildup typical of a biped - so *Orrorin tugenensis* individuals climbed trees but also probably walked upright with two legs on the ground.

**Year of Discovery:** 2001
History of Discovery:
A research team led by French paleontologist Brigitte Senut and French geologist Martin Pickford discovered this species in the Tugen Hills region of central Kenya. They found more than a dozen early human fossils dating between about 6.2 million and 6.0 million years old. Because of its novel combination of ape and human traits, the researchers gave a new genus and species name to these fossils, *Orrorin tugenensis*, which in the local language means “original man in the Tugen region.” So far, *Orrorin tugenensis* is the only species in the genus *Orrorin*.

We don’t know everything about our early ancestors—but we keep learning more! Paleoanthropologists are constantly in the field, excavating new areas with groundbreaking technology, and continually filling in some of the gaps about our understanding of human evolution.

Below are some of the still unanswered questions about *Orrorin tugenensis* that may be answered with future discoveries:

1. Is *Orrorin* a direct human ancestor to *Homo sapiens*? If so, does this make *Au. afarensis* a side branch of our hominin family tree that eventually hit a dead-end?
2. Did *Orrorin* routinely walk on two legs? *Orrorin*’s fossil evidence indicates that *Orrorin* was possibly capable of bipedalism, but not necessarily that *Orrorin* routinely walked bipedal.
3. How did bipedalism originate? One hypothesis suggests early apes walked on branches while using their arms for balance and this technique eventually made its way to the ground.
4. What is the relationship between this species and *Sahelanthropus tchadensis*, the other current contender for the title of earliest human?

http://humanorigins.si.edu/evidence/human-fossils/species/orrorin-tugenensis
First paper:

How They Survived:
From Orrorin's low, rounded molars and small canine teeth, paleoanthropologists can infer that this species ate mainly a plant-based diet. This probably included leaves, fruit, seeds, roots, nuts, and insects.

Evolutionary Tree Information:
Orrorin is at the base of the human family tree, and has more ape-like features than human-like ones -- except that it walked upright on two legs.

There are 13 fossils from at least 5 Orrorin individuals. Two well-preserved thigh bones (femora), BAR 1002’00 and BAR 1003’00, show evidence of bipedal walking. Other parts of the skeleton show apelike features: long, curved finger bones and apelike canine and premolar teeth. The type specimen, BAR 1000’00, is a jaw fragment with three lower molars.

BAR 1002’00
Beginning to walking upright on short legs. The upper part of this femur (thigh bone) is similar in size to those of other large apes. But the angled part more closely resembles that of modern humans. It formed a strong bridge with the hip to support the body’s weight, suggesting Orrorin tugenensis walked upright.
A key specimen of the human story, its position on the tree is debated - it is the oldest known hominin or should it be on placed on the tree before the human-line split from the line leading to chimpanzees?

Background of discovery

Age

6.1 to 5.8 million years ago

Important fossil discoveries

A few fossil fragments, from five individuals, were found in Kenya in 2000. The remains include several limb bones, jaw fragments and isolated teeth. The holotype specimens are 2 mandible fragments, BAR1000a’00 and BAR1000b’00. An isolated lower molar (KNM LU 335), that may belong to this species, was discovered in this area in 1974.

What the name means

The genus name *Orrorin* means ‘original man’ in the Tugen language, whereas the species name *tugenensis* was assigned because the fossils were found in the Tugen Hills of Kenya.

Distribution

Fossils have been found in the Tugen Hills, Kenya.

Relationships with other species

Its discoverers believe this species belongs on the human family tree. They claim that it is dissimilar to the genus Australopithecus, and that this genus should be moved to a side
branch on the human tree, leaving *Orrorin tugenensis* as the earliest direct ancestor of humans. However, there is not enough evidence to support this argument due to the fragmentary nature of the remains. Other experts think this species may have lived before the ape and human line split so could be an ancestor of both lines or that it was a basal member of the hominin clade.

The species lived during a critical period in the human evolutionary timeline. It is widely believed human and chimps diverged from a common ancestor that lived between five and eight million years ago.

**Key physical features**

**Brain**
probably similar in size to a modern chimpanzee, but lack of cranial material makes this difficult to determine

**Body size and shape**
uncertain, probably similar in size to a modern chimpanzee

**Limbs**

- some features of the leg bones indicate this species was possibly bipedal. The femur was different from that of modern humans, fossil Homo and living apes and most closely resembled australopithecines that lived three to four million years ago.
- some features of the leg bones are found in non-bipedal primates, suggesting that this species may not be bipedal. At the moment the evidence is inconclusive.
- features of the arms bones (humerus) and a curved finger bone suggest it was also adapted for climbing tree

https://australianmuseum.net.au/orrorin-tugenensis
Jaws and teeth

- primitive dental anatomy
- teeth have thick enamel and are relatively small, although canines are relatively large and pointed compared to humans

Lifestyle

Culture

There is no evidence for any specific cultural attributes. However, it may have used simple tools similar to those used by modern chimpanzees including:

- twigs, sticks and other plant materials that were easily shaped or modified. These may have been used for a variety of simple tasks including obtaining food.
- unmodified stones, that is stones that were not shaped or altered before being used. These tools may have been used to process hard foods such as nuts.

Environment and diet

When this species lived, the environment was open woodland with dense tree forests.

The large, flat molars suggest a diet of fruit and vegetables, but it may have also been an opportunistic meat eater.

Fran Dorey, Exhibition Project Coordinator
Last Updated: 27 October 2009
Orrorin tugenensis is represented by a collection of fossils from the Tugen Hills region of Kenya. Specifically, *O. tugenensis* is known from four sites in this region: Cheboit, Kapsomin, Kapcheberek, and Aragai. “**Orrorin**” means “original man” in the Tugen dialect, and “**tugenensis**” pays tribute to the Tugen Hills region. The sediments in which this specimens have been found are dated to between 6 and 5.8 million years ago using radioisotopic methods, paleomagnetism (dating accomplished using the timing of reversals in Earth’s magnetic poles), and biochronology (dating that utilizes the relative time frames of extinct non-hominin animals). *Orrorin tugenensis* is important to hominin evolution because it (along with *Sahelanthropus tchadensis*, from central Africa) may represent some of the earliest evidence for bipedalism in the human fossil record.

O. tugenensis is represented by 20 fossil specimens, coming from a minimum of five individuals. Specimens include teeth and lower jaw fragments, pieces of the humerus (the bone of the upper arm), pieces of the femur (thigh bone), and a phalanx (finger bone). The molar teeth of O. tugenensis are smaller than in species in the genus Australopithecus and, in this respect, are similar to Ardipithecus ramidus and Kenyanthropus platyops. The thickness of the dental enamel in O. tugenensis, however, is similar to that of Australopithecus afarensis and K. platyops, which have thicker enamel than Ar. ramidus and living apes. The canine teeth of O. tugenensis are very primitive, resembling those of female chimpanzees in shape. The morphology (size and shape) of the O. tugenensis femur has led some researchers to suggest that it practiced bipedal locomotion. In particular, the proximal femur (where the femur articulates with the pelvis) bears a femoral
neck (the part of the bone that connects the shaft of the femur to the head, which articulates with the pelvis) that is longer than in living apes. Some of the muscle markings on this portion of the femur have also been argued to indicate a shift toward bipedality, but arguments concerning the distinctiveness of these traits to bipeds abound. In addition, computed tomography (CT, an imaging technique, similar to x-ray, that permits researchers to observe the internal structures of bones) scans of the *O. tugenensis* proximal femur show that the cortical bone (outer layer of bone) has differential thickness along the top and bottom surfaces; it is thickened inferiorly and thinner superiorly. This morphology has been argued to indicate that *O. tugenensis* was a biped. However, the published CT scans are somewhat ambiguous and the pattern found in *O. tugenensis* is also found in non-bipedal primates. Furthermore, some of the fossils attributed to *O. tugenensis* possess features that are considered specializations for arboreal locomotion (moving around in the trees). The *O. tugenensis* phalanx, for instance, is curved, similar to that of living apes. It should be noted, however, that indisputably bipedal hominins (e.g., *Au. afarensis*) also exhibit curved finger bones.

Currently, the debate over whether or not *O. tugenensis* was bipedal is unresolved. Thus, its evolutionary relationships with later hominin species are not well established. While some researchers are convinced by the features in this species that seem to indicate that it practiced bipedalism, others remain skeptical. If *O. tugenensis* is, in fact, a biped it would mark some of the earliest evidence for this form of locomotion in the human fossil record and would shed light on the evolutionary causes of the shift to bipedality. In addition, due to the fact that *O. tugenensis* dates to the time period during which the lineages leading to humans and living chimps are thought to diverge (based on molecular studies), clear evidence of bipedalism in this species would imply that some of the earliest species to evolve after this split were bipedal. Drawing connections between *O. tugenensis* and later hominin species, however, is difficult because it possesses a mixture of primitive features (more generalized, e.g., canine morphology and smaller molar teeth, shared with *Ar. ramidus* and living chimps) and derived (more specialized) features, e.g., thicker dental enamel, shared with *Au. afarensis*) that confound efforts to connect it directly to later hominin species.
The habitats in which *O. tugenensis* has been found are reconstructed as areas nearby lakes and streams. Evidence from non-hominin animals found at *O. tugenensis* sites (e.g., impalas and leaf monkeys) corroborates this finding, suggesting that *O. tugenensis* inhabited woodland environments. If *O. tugenensis* is bipedal, these environmental reconstructions would suggest that the earliest species practicing this form of locomotion evolved in more forested habitats, contrary to the once widely held belief that bipedality was an adaptation to life on the savanna.
Orrorin Tugenensis:

Pushing back the hominin line

The Kenya Palaeontology Expedition (KPE) report in December 2000 the discovery of what is almost certainly a new species of hominid at Kapsomin in Kenya’s Baringo district; see the BBC news story; for background, see family trees. The excavating team includes Martin Pickford from the KPE and Brigitte Senut from the Museum of Natural History in Paris. The remains have not yet been dated, but they were found in found in six-million-year-old rocks. They include a left femur, pieces of jaw with teeth, isolated upper and lower teeth, arm bones, and a finger bone; the excavations are ongoing. Preliminary analyses suggest the hominid, the size of a chimpanzee, was an agile climber and that it walked on two legs when on the ground. The tentative date of six million years indicate a date very close to the common ancestor of humans and chimpanzees, although this date may now need to be pushed back.

The find was published by Senut et al. in January 2001 (see bibliography below). The authors report the recovery of remains of an early hominid from four localities in the Lukeino Formation in the Tugen Hills, Kenya. Radioisotopic age determinations from lavas underlying and overlying the Lukeino Formation and from crystals from the sediments themselves indicate an age of ca 6 million years for these hominids. The Lukeino hominids are thus the oldest known members of the family (Pickford & Senut, 2001).

The find comprises thirteen fossils belonging to at least five individuals. "The femora indicate that the Lukeino hominid was a biped when on the ground, whilst its humerus and manual phalanx show that it possessed some arboreal adaptations. The upper central incisor is large and robust, the upper canine is large for a hominid and retains a narrow and shallow anterior groove, the lower fourth premolar is ape-like, with offset roots and oblique crown, and the molars are relatively small, with thick enamel." (Senut et al., 2001). A new genus and species is proposed: Orrorin tugenensis.
The authors note that the molars of Orrorin are smaller than those of Australopithecines and are closer in size to those of Ardipithecus. "The anterior teeth, upper incisor and canine, as well as the lower P4 are less hominid-like and more ape-like, being closer in morphology to teeth of female chimpanzees. The molar enamel is thick. Another important feature is the relatively great depth of the corpus mandibularis, which is an archaic feature among hominids. Compared to later hominids, it seems that small jugal teeth relative to body size would be a primitive feature, inherited from the common ancestor of African apes and hominids, and retained in the Homo lineage. If this is so, then Australopithecines would have progressively developed megadonty -- large jugal teeth and relatively small bodies.

The postcranial evidence suggests that Orrorin tugenensis was already adapted to habitual or perhaps even obligate bipedalism when on the ground, but that it was also a good climber.

Many scholars have considered that the earliest hominids were small animals; the femur and humerus of Orrorin are 1.5 times larger than those of AL 288.1, probably equivalent in size to a female common chimpanzee, indicating that the ancestor may have been larger than previously envisaged." (Senut et al., 2001).

The authors conclude that on the basis of dental and postcranial morphology, it appears that Orrorin belongs to the hominid lineage, which was already present 6 million years ago. They suggest this confirms the hypothesis that the divergence between apes and humans took place prior to 6 million years ago, and probably between 9 and 7 million years ago, as they show in the diagram to the right. In this diagram, Ardipithecus ramidus is the ancestor of Pan and the Australopithecines an extinct line -- a view at odds with the view of most paleoanthropologists (cf. family trees and Ardipithecus ramidus).

http://cogweb.ucla.edu/ep/Orrorin.html
L.C. Aiello and M. Collard (2001), Our newest oldest ancestor? *Nature* 410 (29 Mar): 526, applaud the find but question the interpretations, as reported in *Science Week*:

Aiello and Collard "point out that the announcement of the Orrorin find has caused considerable stir, partly because the deposits of the Tugen Hills are being prospected by two competing groups of researchers, and partly because Orrorin is claimed to be approximately 6 million years old. This makes Orrorin 1.5 million years older than Ardipithecus ramidus, the oldest previously recognized candidate for the earliest hominin. Orrorin’s apparent age falls within the molecularly determined range of the last common ancestor between humans and the African apes."

"Aiello and Collard point out that the great age of Orrorin does not seem to be in serious question. The geology of the Lukeino Formation is well known; the volcanic tuffs in this formation have been securely dated at 6.2 to 5.6 million years old by radiometric techniques; and there is little doubt that the specimens come from the Lukeino Formation sediments. But Aiello and Collard suggest that it is difficult to have the same confidence in the conclusions of Senut et al about human evolutionary history, since they adopt a scheme that contrasts sharply with prevailing ideas and that glosses over many areas of controversy and uncertainty."

"Aiello and Collard point out that at least 13 known hominin species from Africa existed before Homo erectus, and that currently in consensus among most paleoanthropologists are only the following ideas concerning the main evolutionary paths: a) There are 5 hominin genera (Ardipithecus, Australopithecus, Paranthropus, Kenyanthropus, Homo). b) The large-toothed and massive-jawed genus Paranthropus represents a dead-end branch" (cf. hominoid taxonomy).
Aiello and Collard conclude,

It... appears that cranial and dental anatomy does not necessarily mirror molecularly determined phylogenies in modern primates, which casts considerable uncertainty on anatomically based evolutionary trees. For now, at least, it is probably best to avoid naming ancestors, and maintain a simple division: that between hominins of archaic aspect (Orrorin, Ardipithecus, Australopithecus -- including Paranthropus -- and Kenyanthropus) and hominins of modern aspect (Homo sapiens and the remaining species of Homo).


Bibliography of the orrorin tugenensis find


Chapter Five/Macroevolution and the Early Primates

"... the evidence from this period has until recently been particularly scrappy. Controversy surround the interpretation of many of these new fossil finds."

"The evidence for Orrorin consists of fragmentary arm and thigh bones, a finger bone, some jaw fragments, and teeth of at least five individuals. The thigh bones demonstrate possible, but not definite, bipedalism. Unfortunately, the distal or far ends of the thigh bone that would prove this are not fully preserved."

Orrorin and the African ape/hominid dichotomy

"Whilst evolutionary reversal is possible, it is generally viewed not to be indiscriminate, suggesting that its likelihood of occurring together in the hand, leg, dentognathic system and a metabolic relationship is negligible. It is more parsimonious to postulate that Orrorin gave rise, sometime during the Pliocene, to humans, without the interposition of an australopithecine stage. The latter group could have evolved from Orrorin or a similar early hominid, but once having emerged it diverged more and more from the human lineage, eventually becoming extremely megadont and possessing a different locomotor style from that of humans."
"In summary, the available morphological evidence suggests that there is a more direct evolutionary lineage between *Orrorin* and *Homo*, while the australopithecines represent a side branch that went extinct without issue."

"Comparable in age is another recently discovered fossil. *Orrorin tugenensis* ("Original Man from the Tugen Hills" found in northern Kenya. This is dated between 6 and 5.8 million years ago and is represented by a few teeth and limb bones, which show some interesting differences from *Sahelanthropus*. The teeth have thick enamel, as in the Chad hominine and in later hominines (and many species of fossil apes), but the canine is large and pointed like those of apes, both conditions that opposite to that seen in *Sahelanthropus* and later hominines.

The femur (thigh bone) has a larger head than in later Pliocene hominines, which has been claimed as evidence of bipedalism, although in this character it is like that of similar sized fossil apes as well as extant chimpanzees."
07/07/2001 "But not everyone buys the story. Indeed, the French and Kenyan team that presented a 6 million-year-old fossil last December insists that theirs, known as Orrorin tugenensis (or, more familiarly, Millennium Man because it was announced in 2000), is the true human ancestor and that Ardipithecus is nothing more than a monkey’s uncle—or a chimp’s great-great-grandfather, anyway. They even dismiss Lucy and her close kin, about as firmly entrenched in the human lineage as you can get, as evolutionary dead ends that left no living descendants."

"No one disputes that this competing ancestor is 6 million years old and thus more ancient than Ardipithecus.

What's still to be proved is that it's a hominid. Says Leakey: "If you read their paper, almost everything they say about the teeth suggests it's more apelike." And when they get to the femur, she says, they present no evidence disproving that it walked on all fours. Haile-Selassie makes precisely the same point.

But Brigitte Senut of the National Museum of Natural History in Paris and Martin Pickford, chairman of paleoanthropology and prehistory at the College de France,
co-leaders of the team that found Orrorin, dismiss the criticisms. Additional fossils found just last March, they say, along with the more detailed analysis they now have in hand of the earlier bones, will prove their case. "We are absolutely delighted about it," says Senut. "We had the possibility to show the evidence to some colleagues in South Africa recently, and just looking at the cast they said, 'Fantastic, it's a biped! And a better biped than Lucy.'"

"Even if they're right, though, establishing the precise path of human descent might be very hard. For most of the past 6 million years, multiple hominid species roamed the earth at the same time—including a mere 30,000 years ago, when modern humans and Neanderthals still coexisted. We still can't figure out exactly how Neanderthals relate to the human family; it's all the more difficult to know where these newly discovered species, with far fewer fossil remains to study, belong."

"If Orrorin turns out to be a hominid, the same skepticism will apply to any claims about its pivotal position on the family tree. According to University of Tokyo paleontologist Gen Suwa, a co-discoverer of the 4.4 million-year-old Ardipithecus ramidus ramidus, Orrorin could well be ancestral to the new Ardipithecus remains, rather than the other way around." There is nothing in the fossils," he says, "that would preclude such a position. But which side of the chimp-hominid split Orrorin occupies can be determined only by further analyses and new finds." Indeed, suggests Haile-Selassie, while Orrorin may be one of the earliest chimps or an ape that became extinct, it could also turn out to be the last common ancestor of humans and chimps—a creature paleontologists have been dreaming of finding for decades."
"Two other late Miocene hominins, Orrorin tugenensis and Sahelanthropus tchadensis, show predictable variability in this evolving lineage. This is a plausible scenario. However, Ardipithecus, Orrorin, and Sahelanthropus offer evidence of striking diversity. Orrorin has modern-looking thickly enameled molars and robust jaws but has postcranial morphology that is distinct from that of Pliocene hominins (the epoch following the Miocene when clearly bipedal humans are found) (3, 9). Sahelanthropus is also quite distinct from Pliocene hominins in craniofacial and dental morphology (4, 10). Do these samples represent stages in early hominin evolution or discrete lineages? In other words, how many taxa are represented by these fossil samples? Could all of these fossils belong to the same genus, or even the same species? This is implied by Haile-Selassie et al. but seems unlikely to me. Comparisons among these taxa are difficult because they preserve little in common. Nonetheless, we know that Orrorin has mandibular and molar morphology similar to that of australopithecines, but female canines resembling those of apes (3, 11). Sahelanthropus has a unique combination of superficially modern-looking facial and periorbital morphology, primitive-looking teeth and braincase, and a probably homologous hominin suite of features of the basicranium (4, 10). A. kadabba is distinctive in having canines that appear to partly hone or sharpen against the lower first premolar (P3 by paleontological convention), not as much as in apes but more than in humans. In crown cross section and shape, however, the canines are more
hominin-like than the more chimpanzee-like Orrorin canines. But Orrorin has australopithecine-like thickly enameled teeth, usually associated with a diet requiring powerful chewing forces, whereas Sahelanthropus, A. ramidus, and A. kadabba have intermediate-thickness enamel (less thick than in other hominins, but much thicker than in African apes) (5). Miocene hominids range from thinly enameled chimpanzee-like molars, as in Dryopithecus, to Australopithecus-like thickly enameled molars, as in Sivapithecus and Ouranopithecus, and it is unclear which among these or the intermediate condition in Ardipithecus and Sahelanthropus represents the ancestral condition for hominins. Differences in enamel thickness often distinguish taxa at the genus level and usually reflect dietary adaptation rather than phylogeny.

Orrorin is said to share hominin synapomorphies (newly evolved, shared characteristics indicating a recent common ancestry) of the lower limb related to bipedalism (3, 9), but this is far from established. The most important features suggesting bipedalism either are found in nonbipeds (the groove for the obturator externus muscle) or appear different enough from the morphology of known bipeds to call the functional homology of these features into question (the linea aspera, which is unusually laterally displaced in Orrorin, or the asymmetric femoral neck cortical bone, which is less asymmetric than in known bipeds) (12). A. kadabba also lacks synapomorphies of A. ramidus and Australopithecus in canine, premolar, and last molar morphology, which suggests that the Asa Koma and other older samples belong to another genus (note that A. ramidus was originally named Australopithecus ramidus because of an understandable hesitation to name a new human genus, and was later elevated to a new genus when no Australopithecus-Homo synapomorphies were discovered).

It is tempting to see evidence of anagenesis (unilinear evolution) in the late Miocene hominin record in part because continuity is suggested by claims for some evidence of bipedalism in all known taxa. The evidence from Orrorin is ambiguous (see above), whereas that from Sahelanthropus is indirect, based only on the position of the foramen magnum.
The region is severely distorted in the only cranial specimen of Sahelanthropus, and even the describers recognize the uncertainty (4). A. kadabba is interpreted as a biped on the basis of a single toe bone, a foot proximal phalanx, with a dorsally oriented proximal joint surface, as in more recent hominins (6). However, the same joint configuration occurs in the definitely nonbipedal late Miocene hominid Sivapithecus (13), and the length and curvature of this bone closely resembles those of a chimpanzee or bonobo. In addition, the specimen is 400,000 to 600,000 years younger than the rest of the A. kadabba sample, 800,000 years older than A. ramidus, and from a locality that is geographically much closer to Aramis than to Asa Koma. It may or may not be from a biped, and if it is, which biped?

Another issue is the canine/premolar complex. Tall crowned interlocking canines are usually associated with agonistic (aggressive) displays typical of primate societies characterized by strong male competition (14). A shorter canine crown in humans is interpreted as an indication of greater levels of male coalitionary behavior, or at least reduced competitiveness. Chimpanzee males are intermediate between humans and most other great ape males in canine crown height and competition levels, and bonobos are intermediate between chimpanzees and humans. But the remarkable reduction of canine crown height in humans is thought to signal a dramatic increase in the degree of male cooperation, cited as a hallmark of human origins [e.g. (15)]. The diversity of canine/premolar morphology described by Haile-Selassie et al., from chimpanzee-like to humanlike, represents a striking and unlikely degree for a single genus, especially in an anatomical complex strongly correlated to an aspect of socioecology that is considered to be a primary distinction between apes and humans.
Both clade (synapomorphies) and grade (diet, locomotion, and socioecology) criteria suggest more rather than fewer taxa among the earliest possible hominins. Why the different interpretations? Evidence is scarce and fragmentary, and uncertainty predominates. Interpretations rely especially heavily on past experience to make sense of incomplete evidence. Haile-Selassie and colleagues interpret diversity in fossil hominids in terms of variability and gradual evolutionary change in an evolving lineage. Others see cladistic diversity as opposed to ancestor-descendant relations (see the figure). Ancestor-descendant relations must exist, but adaptive radiation and cladogenesis also must exist, or organic diversity would be the same today as it was at the beginning of biological evolution. Rather than a single lineage, the late Miocene hominin fossil record may sample an adaptive radiation, from a source either in Eurasia or yet undiscovered in Africa (16), the first of several radiations during the course of human evolution (see the figure). Regardless, the level of uncertainty in the available direct evidence at this time renders irreconcilable differences of opinion inevitable. The solution is in the mantra of all paleontologists: We need more fossils!