Thanks to an astonishing series of fossil discoveries, researchers are at last glimpsing our earliest ape ancestors, back beyond 4 million years ago. The finds are shifting attention from the savanna to the woods—and changing ideas about what it means to be a hominid

In Search of the First Hominids

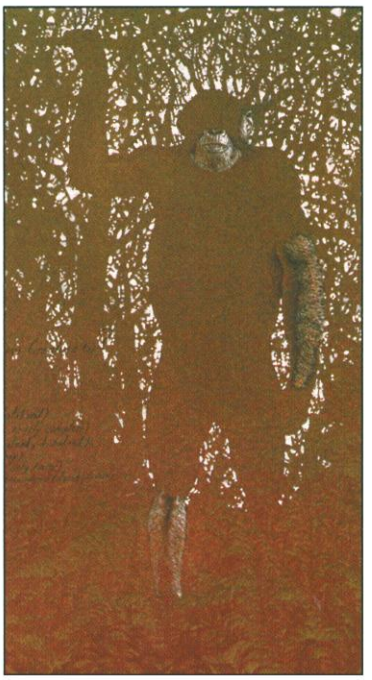
BECOMING HUMAN

This special Focus section explores two crucial moments in human evolution, from the distant past to more recent prehistory. We look at the emerging picture of the earliest members of our lineage, the hominids, and also at the birth of our own species, *Homo sapiens*.

If portraits of our early ancestors were displayed in a museum of human evolution, the collection would include figures of nearly a dozen early humans who lived in Africa from 1 million to 3 million years ago. Visitors would see robust ape-men from the caves of South Africa; a long-limbed boy from Kenya who stood almost 6 feet tall; and lightly built toolmakers from Olduvai, Tanzania. On a pedestal by herself might be a statue of the matriarch called Lucy, a female the size of a small chimpanzee whose species, *Australopithecus afarensis*, walked upright through the East African bushland 3 million to about 3.6 million years ago.

For 2 decades, Lucy stood alone as the first known human ancestor. Her species was thought by many to have given rise to all that came later, including our own lineage. But her own origins were a mystery. No matter where paleontologists searched, they found few fossils of protohumans more ancient than *A. afarensis*. All the older fossils—a few jaw scraps and a single tooth—could fit into the palm of a hand. "All we had were ill-dated scraps. We had almost no clues about what came before *Australopithecus afarensis*," says paleoanthropologist Tim White of the University of California, Berkeley.

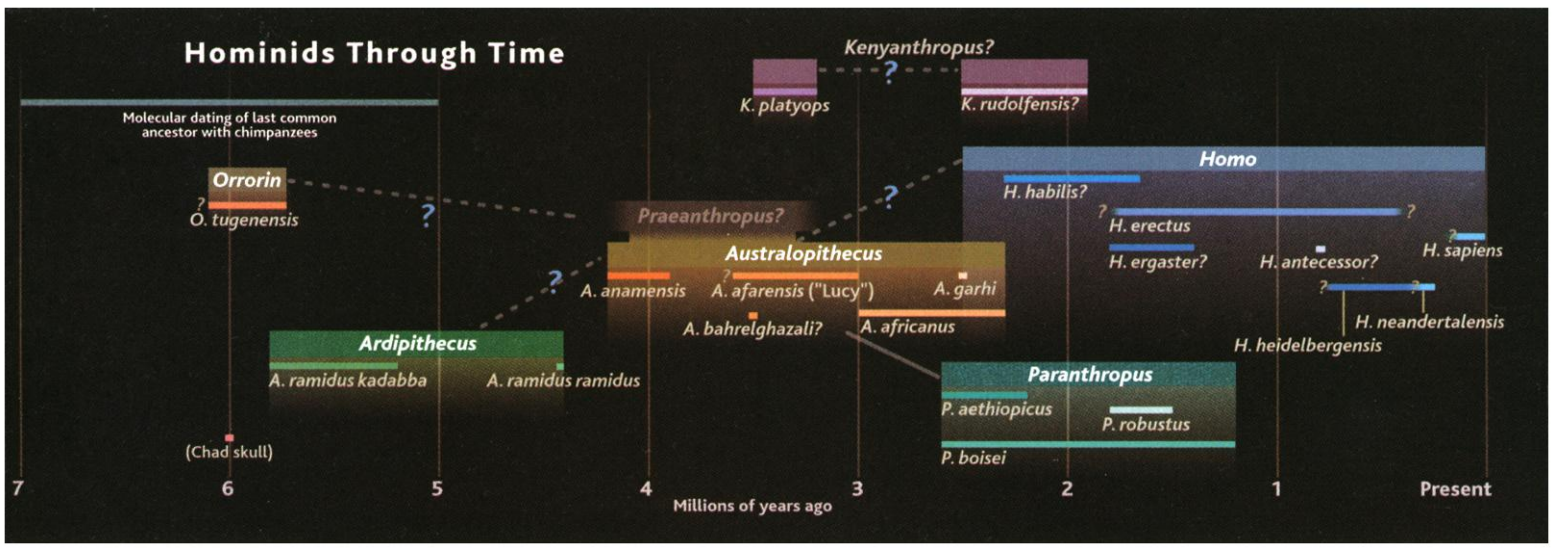
But now researchers are adding a new wing to that gallery of ancestors. In the past few years, paleontologists have unearthed dozens of fossils of new kinds of primates, including at least three that may be the earliest members of the Hominidae, the family that includes humans but no other apes. Just last summer, a skull was discovered in Chad that may date to 6 million years ago, and new details were published on another ape-man who may have been walking upright in Ethiopia at about the same time. This came hot on the heels of the discovery in autumn 2000 of the equally ancient "Millennium Man" in Kenya. The faces and many features of these earliest hominids remain shadowy, but their outlines can be discerned, revealing apes the size of chimpanzees that walked upright through African forests.



Into the limelight. New fossils offer glimpses of early hominids such as *A. anamensis*.

CREDIT: (TOP) ©JOHN GURCHE

As paleoanthropologists begin to peer back beyond 4 million years ago, they are also filling in the details of the characters that followed, revealing stunning new fossils of hominids that lived 3 million to 4 million years ago, with descriptive nicknames such as Flat-Faced Man and Little Foot. "During this time, we're dealing with a wetter, warmer Africa that it seems was spawning hominids from the shores of Lake Chad to the caves of Sterkfontein [in South Africa]," exults Phillip Tobias of the University of the Witwatersrand in Johannesburg, South Africa. Adds Meave Leakey of the National

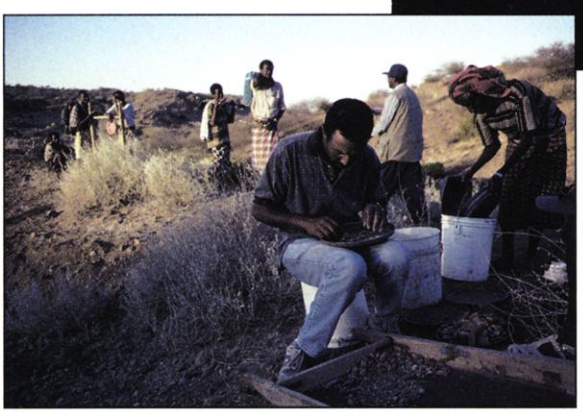


Who begat whom? Researchers have a new view of hominid diversity through time, but the picture is full of question marks—indicating uncertainty about dates, classification, and lines of descent.

Museums of Kenya: "If you look at the number of major discoveries, it's staggering."

Although scientists are still analyzing the oldest specimens and have yet to publish complete descriptions of these top-secret fossils—prompting one colleague to dub the study of the first hominids the Manhattan Project of paleoanthropology—the data thus far are already challenging old views.

The first surprise is that more than one type of hominid may have been living between 6 million and 5 million years ago and that these very early hominids show diversity in their teeth and anatomy. That suggests a period of hominid evolution even earlier than most researchers have believed and also prompts questions about how reliably the molecular clock is calibrated (see sidebar on p. 1217). Another surprise is that the oldest hominids were walking upright yet living in woodlands, dealing a lethal blow to the hypothesis that bipedalism emerged when hominids first stood up and stretched their legs on the savanna. "These fossils are causing a paradigm shift," says paleontologist Martin Pickford of the Collège de France in Paris, co-discoverer of Millennium Man. "A lot of old ideas will be put into the wastebasket."



Toehold. Yohannes Haile-Selassie (*left*) says an *Ardipithecus ramidus kadabba* foot bone (*above*; top row, third from right) shows it walked upright.

Into the trash, in fact, may go the very definition of what it means to be a hominid, as there is now little agreement on what key traits identify an exclusively human ancestor. Nor is there agreement on which species led to *Homo*, or even whether the fossils represent different species or variation within a single species. "Preconceptions of a large-toothed, fully bipedal, naked ape standing in the Serengeti 6 million years ago are *X-Files* paleontology," says White. "What we're learning is we have to approach this fossil record stripped of our preconceptions of what it is to be a hominid."

The First Family

For 20 years, *A. afarensis* was without rival as the first known hominid. Lucy was discovered in 1973 at Hadar, Ethiopia, and since then her species has been characterized by 360 fossils from more than 100 individuals who lived from 3 million to about 3.6 million years ago.

With the mix of traits expected in a human ancestor, *A. afarensis* helped define ideas about early hominids. Lucy was the size of a female chimpanzee, with long arms, a small brain, and a strikingly apelike jaw to match. But she also showed more derived, humanlike traits. She and 13 individuals of her species, dubbed the First Family, were bipedal and had thick tooth enamel, large molars, and smaller canines shaped like those of later australopithecines, reflecting a transition from a diet of fruits and leaves to one of hard roots, tubers, insects, and small animals, says paleoanthropologist William Kimbel of the Institute of Human Origins at Arizona State University in Tempe. Her curved fingers revealed grasping hands, whereas apes grasp with both feet and hands.

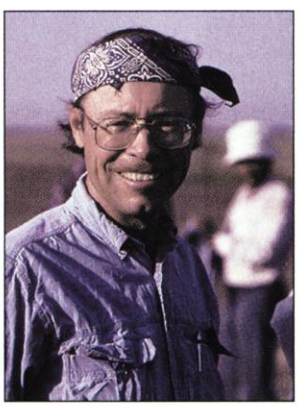
But despite the bounty of *A. afarensis* fossils, researchers were stymied as they sought to discover Lucy's own roots. "Beyond 3.6 million years you were just in a black hole in the fossil record until you got back into the middle Miocene [about 15 million to 9 million years ago]," recalls White. And the "muddle" of ape fossils in the early Miocene, when apes underwent a burst of speciation and came in all sorts of body plans, made it difficult to sort out which anatomical traits were inherited from the common ancestor of chimps and humans—and which ones evolved only in apes or only in humans, notes paleoanthropologist Carol Ward of the University of Missouri, Columbia.

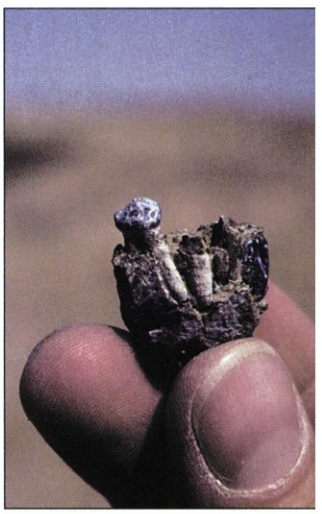
For years the leading explanation was that the diverse Miocene apes went through a bottleneck, with only a few lucky apes emerging, including the ancestor shared by humans and chimpanzees. That root ape fairly quickly gave rise to *A. afarensis*, which in turn was the ancestor for everything that came later, including the *Homo* lineage.

Then in 1992, the Middle Awash Research Team, co-led by White, made a discovery that ended Lucy's reign. About 75 kilometers south of Lucy's resting place, at Aramis in the Afar depression of Ethiopia, the team found fossils of a chimp-sized ape dated to about 4.4 million years ago. This creature earned its place on the human line "metaphorically and literally by the skin of its teeth," as paleoanthropologist Bernard Wood of George Washington University (GWU) in Washington, D.C., wrote when the fossil was announced in *Nature*; many pieces were dental.

What White and his colleagues saw in the mouth of this ape was a mosaic of chimplike features they considered primitive, such as the shape of its baby molars, and more derived humanlike features such as a diamond-shaped canine rather than the honed V shape of chimps. The team named this species *Ardipithecus ramidus*, drawing on two words from the Afar language suggesting that it was humanity's root species. But skeptics argue that the published fossils are so chimplike that they may represent the long-lost ancestor of the chimp, not human, lineage.

The next field season, team member Yohannes Haile-Selassie found the first of more than 100 fragments that make up about half of a single skeleton of this species, including a pelvis, leg, ankle and foot bones, wrist and hand bones, a lower jaw with teeth—and a skull. But in the past 8 years no details have been published on this skeleton. Why the delay? In part because the bones are so soft and crushed that preparing them requires a Herculean effort, says White. The skull is "squished," he says, "and the bone is so chalky that when I clean an edge it erodes, so I have to mold every one





Root ape? Tim White (*left*) thinks *Ardipithecus ramidus* led to *Homo*.

Fossil trail. Many kinds of hominids lived in Africa 6 million to 2.5 million years ago, before *Homo* appeared.

of the broken pieces to reconstruct it." The team hopes to publish in a year or so, and White claims that the skeleton is worth the wait, calling it a "phenomenal individual" that will be the "Rosetta stone for understanding bipedalism."

And a few clues to *Ardipithecus* emerged last year, when Haile-Selassie published fossils of an older subspecies from the Middle Awash, called *A. ramidus kadabba* and dated to 5.2 million to 5.8 million years ago. These fossils have literally a toehold on the hominid branch of the ape family tree: Their classification rests partly on a nearly complete foot bone that the team thinks was used to "toe off" in a manner seen only in upright walkers.

Millennium Man

The other chief contender for first hominid was discovered by a joint Kenyan-French team in October 2000, some 1200 kilometers southwest of Aramis in the Lukeino Formation of Kenya's Tugen Hills. In a short paper published last year in the *Comptes Rendus de l'Académie des Sciences des Paris*, paleontologist Brigitte Senut of the National Museum of Natural History in Paris, Pickford, and their colleagues introduced these 13 fossils as *Orrorin tugenensis*, from the Tugen words for "original man" (*Science*, 13 July 2001, p. 187).

Senut and Pickford put the fossils at 5.8 million to 6.1 million years old, although a rival team (*Science*, 13 April 2001, p. 198) now dates the Lukeino Formation at 5.72 million to 5.88 million years ago; those radiometric dates were published this month in the *Journal of Human Evolution* (*JHE*) by paleoanthropologist Andrew Hill of Yale University and colleagues.

Whatever the precise age, the find is sensational. Senut and Pickford say *O. tugenensis* "is definitely a hominid"—a bold claim that rests primarily on three thighbones, or femora. Their initial report focused on the top end of the femur, which they said was "more humanlike than those of australopithecines." In fact, they propose that *O. tugenensis* walked more like humans than Lucy did, based on six features, including the size and shape of the head and neck of *Orrorin*'s femur.

The implications are startling: If Senut and Pickford are right, that suggests that Millennium Man is the ancestor of *Homo* and that Lucy was not the mother of us all (see diagram on p. 1214). Otherwise, it implies what Pickford calls "yo-yo" evolution, where humanlike bipedalism evolved in *O. tugenensis*, was modified in *A. afarensis*, then later returned to a human kind of walking.

Thus Senut and Pickford argue that *O. tugenensis* is ancestral to *Homo* by way of a proposed genus called *Praeanthropus*, which includes certain fossils now assigned to *A. afarensis* and *A. anamensis*. They also suggest that *Ardipithecus* gave rise to chimpanzees.

This view, so far based chiefly on the femur, has been greeted with skepticism. "There is nothing in the announcement that makes that femur bipedal," says Missouri's Ward. "The onus is on them to prove it."

However, those who have seen casts of the fossils say that Senut and Pickford have a leg to stand on: "As a working hypothesis, I think they are correct, although they don't have the most diagnostic set of fragments," says Ian Tattersall, a paleoanthropologist at the American Museum of Natural History in New York City. To cement their claim, Senut and Pickford have made new computed tomography scans, which reveal that the structure of the bone in the neck of the femur resembles that of hominids rather than apes. They have also revealed a groove on the back of the femoral neck for the attachment of the obturator externus muscle, which they say shows that the bone was remodeled by upright walking.

But it may take more than legs to make a hominid. Senut and Pickford, fresh from the field in November, say they now have a total of 22 fossils of *O. tugenensis* from at least six individuals from four sites, including a thumb bone and "pretty much the entire adult dentition," says Pickford. He reports that *O. tugenensis* has thicker tooth enamel than *Ardipithecus ramidus*. And he notes that *O. tugenensis* and *Homo* both have small molars relative to their bigger bodies, a complex not shared by australopithecines, including Lucy, who have big teeth for their small bodies. But *A. ramidus* has the edge in its hominidlike canines, while *O. tugenensis* has small V-shaped canines like a female chimp's (see character table on p. 1218).

Each team ranks the importance of these traits differently and so comes to a different conclusion about ancestry. In fact, only a few parts of each species have

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Spying the thigh. Brigitte Senut and Martin Pickford (*above*) discovered *O. tugenensis*'s thighbone; they say it shows signs of upright walking.

New Fossils Raise Molecular Questions

Paleontologists aren't the only researchers tracing the ape family tree: For years, molecular biologists have been analyzing our family relations by scanning the DNA of living primates and tallying the number of mutations that have occurred over time in comparable stretches. Almost every study has concluded that humans and our closest relatives, the chimpanzees, last shared a common ancestor about 5 million to 7 million years ago.

But with paleontologists uncovering two or more hominids already on different evolutionary paths by about 6 million years ago (see main text), some researchers say that the timing is getting too close for comfort. By molecular reckoning, before 7 million years ago there shouldn't even be a clear "hominid" lineage. That raises the question: "Has our molecular clock been correctly calibrated?" asks Phillip Tobias of the University of the Witwatersrand in Johannesburg, South Africa. For now, there's enough fudge in both kinds of data to make a consistent scenario, but some geneticists are reviewing their calculations.

The first molecular study back in 1967 dated the split between humans and apes to 5 million years ago, and Vince Sarich of the University of California, Berkeley, co-author of the study, still stands by that date. "I still bet that either the morphology or dates or both will be found wanting for these '6-million-year-old hominids,' " he says.

Since Sarich's work, about 10 studies have done the analysis with different stretches of DNA, and most came up with the same range of dates, says evolutionary biologist Blair Hedges of Pennsylvania State University, University Park. In the most recent study, published in the December issue of the *Journal of Heredity*, Hedges's team compares 50 nuclear genes among great apes and Old World monkeys and concludes that humans split from chimpanzees 4.5 million to 6.5 million years ago.

Even if the new fossils hold up as hominids, Hedges says the data fit, allowing half a million years for hominids to diversify into the fossil genera *Orrorin* and *Ardipithecus*. "If [paleontologists] have something at 6 million years [ago], no problem," Hedges says.

But at least one geneticist consistently comes up with much earlier dates, because he uses a different fossil calibration point. Researchers must calibrate their molecular clocks—that is, calculate how many nucleotide changes occur per million years—by using a date from the fossil record. Most use the split between apes and monkeys, typically between 20 million and 25 million years ago. But geneticist Ulfur Arnason of the University of Lund in Sweden thinks that the ape-monkey split is poorly recorded in fossils and probably occurred twice as long ago, about 50 million years ago. To calibrate his clock, he uses several fossil data points that he considers more reliable, such as when whales split from even-toed ungulates, which he dates to 60 million years ago. As a result, he has dated the human-chimp split to 10.5 million to 13.5 million years ago.

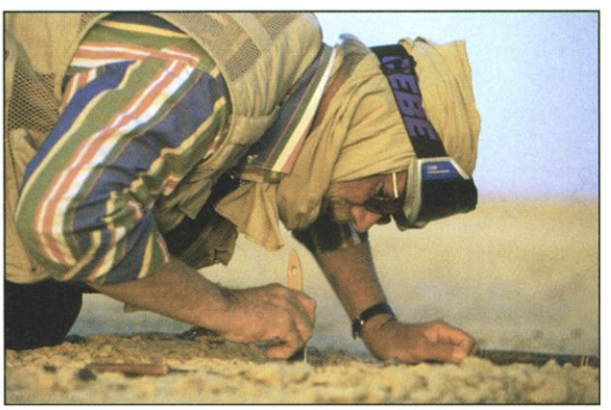
Those dates are now getting a second look. But Hedges and phylogeneticist Morris Goodman of Wayne State University in Detroit stick by their analysis, saying it requires a primate calibration point because mutation rates may have sped up in primates. At any rate, both geneticists and paleontologists will be watching the molecular clock as the new fossils are evaluated. **–A.G.**

been published so far, and thus it's possible that both teams' fossils are the same creature. "I think there's a good chance that *Orrorin* is really *Ardipithecus*," says White's collaborator, C. Owen Lovejoy of Kent State University in Ohio. Lovejoy suggests that the differences in the two apes may merely be variation within the genus of *Ardipithecus*, which he suggests was the root ape that once ranged throughout Africa—a view Senut and Pickford strongly protest.

Into the woods

While each team has been analyzing its fossils and preparing its case, a third team has unearthed an equally ancient, as-yet-unpublished skull that may shed light on the competing claims. The skull was discovered last summer in the Djourab Desert in Northern Chad, in a layer of sediment that may date to over 6 million years. Members of the French-Chadian Paleoanthropological Mission, led by paleontologist Michel Brunet of the University of Poitiers, won't discuss details until they publish, but those who have seen the skull are intrigued by its mix of old and new traits. "You only have to look at Brunet's skull to see that things were more complicated than we thought," says GWU's Wood.

The desert where Brunet's team found the skull is perhaps the most hostile environment for plumbing human origins. One field rule is never to touch metal, as it might be a land mine, and the wind is relentless. But that wind moves the dunes and exposes new fossils, says Brunet. Since 1994, his team has found an amazing 8000 fossils, mostly animals, at 300 sites dating from 3 million to 7 million years ago. Their discoveries include a hominid lower jaw dated to 3.5 million years ago that Brunet has assigned to a new species, *A. bahrelghazali*, though others suspect it may be *A. afarensis*.



Digging the desert. Michel Brunet searches for fossils in Chad.

CREDIT: SIGMA-CORBIS PARIS

If the older, unpublished skull proves to be a hominid, it would kill once and for all the old idea that all hominids evolved on the east side of the African Rift Valley, where most fossils have been found, and that the other African apes evolved on the western side. "Chadian hominids show that part of our human story is in West Africa," says Brunet.

And it would cast more doubt on the once-popular idea that bipedalism emerged after climate change forced apes out of the trees into the grasslands. Animal remains associated with Brunet's putative hominid fossils—including monkeys and a species of extinct pig—indicate that they may have been living in trees near the shores of ancient Lake Chad, perhaps on the edge of a vast, barren steppe or desert.

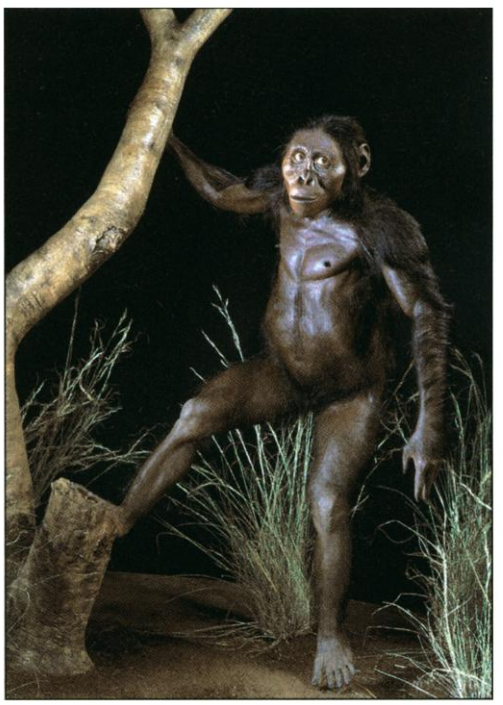
Those environmental details are significant, says White, because they fit with the ancient environment at *Ardipithecus ramidus* sites in Ethiopia. Analysis of the carbon chemistry of the soils at those sites shows that *A. ramidus* was not living in grassy savanna, but probably in a forested upland, says paleoanthropologist Stanley Ambrose of the University of Illinois, Urbana-Champaign. And the older *A. ramidus kadabba* also roamed a thick forest, 25 kilometers to the east.

At about the same time, the small chewing teeth of *O. tugenensis* suggest that it, like *Ardipithecus*, was eating soft fruit and leaves as it foraged through the trees. Soil chemistry and the mix of animal fossils support a wooded environment for the Lukeino Formation too, according to both Pickford and

Hill. The bottom line: Thus far, "all older hominids have been found in forested environments," notes Ambrose.

If these ancient forest-dwellers do prove to be bipedal, upright walking may have started in the forest, for any number of reasons, such as to carry food, display strength, attract mates, or use tools, says paleoanthropologist Henry McHenry at the University of California, Davis. And it may be that these different hominids had more than one way to walk upright, an idea that gets support from yet another new discovery, this time of a later hominid. South African workers recently unveiled a spectacular 3.3-million-year-old australopithecine skeleton, still partly encased in rock in the Sterkfontein Caves, with an unusual, slightly divergent big toe. Known as Little Foot, this nearly complete skeleton resembles its northern contemporary, *A. afarensis*, but it has yet to be classified. Although Little Foot was an upright walker, that big toe could have been used to grasp tree limbs and may have created a gait different from Lucy's, says discoverer Ron Clarke of the University of the Witwatersrand (*Science*, 5 May 2000, p. 798).

Such diversity in walking styles means that the signature of bipedalism in the bones may vary among upright apes, says paleoanthropologist Jeff Schwartz of the University of Pittsburgh—and even raises the possibility that bipedalism evolved more than once.



Mother of us all. Many researchers think Lucy's species eventually led to humans.

Lucy's origins

The new insight into ancient hominids' preferred habitat is helping paleontologists find them. "We're learning that these hominids are not ubiquitous; they were restricted to certain habitats," says White. "Often we find them with seeds, fossil woods, abundant monkeys, and kudu [forest-dwelling antelopes] but lack of abundant aquatic mammals. Often we find them where carnivores have destroyed a lot of the bone. It's this signature that says slow down, stick on this patch, and you're likely to find a hominid."

In fact, one reason it took so long to find fossils older than 4 million years is probably because fossil hunters were scouring the wrong places. Through trial and error, paleoanthropologists have learned that the open shorelines of ancient lakes and open grasslands—where later hominids are found—contain few traces of our earliest ancestors. For example, Meave Leakey spent much of the 1990s painstakingly gathering fossils from what were the swampy shores of an ancient river at Lothagam, in northern Kenya. But she found no hominids in that layer, although a scrap of jaw came from an upper layer. "It clearly wasn't where the hominids were," says Leakey.

But Leakey had much better luck in slightly younger rocks. Throughout the 1990s, on the scrubby shores of Lake Turkana, Kenya, she and her colleagues found the best contender for the long-sought ancestor of Lucy herself: *A. anamensis*, which means "of the lake" in the local Turkana language. The 88 fossils, which include many fragmented teeth, several jaws, part of a humerus, and possibly a shinbone, reveal a bipedal australopithecine with a narrow, apelike lower jaw. The fossils were dated to 3.9 million to 4.2 million years ago and were found in what were once the tree-lined banks of an ancient river.

A. anamensis appears after a major shift at these sites, from browsing species to those that eat more grasses, according to work Leakey published in *JHE* last November with paleontologist Alan Walker of Pennsylvania State University, University Park. That's a sign that "hominids are beginning to get into more open country," says Leakey. "They would have been eating fruit, insects, small mammals, and perhaps some bird eggs and were predominantly bipeds with tree-climbing [ability]."

This progression into the bush continued, as Leakey showed with another discovery in 1999, of a skull and jaw fragment of a new species called *Kenyanthropus platyops*, nicknamed Flat-Faced Man. By 3.5 million years ago, this species, whose flattened face resembles that of a fossil called *H. rudolfensis*, was moving between grasslands and wooded habitats on the western side of Lake Turkana. Leakey suggests that both fossils may fit into the new *Kenyanthropus* genus. If that classification holds up (the *K. platyops* skull was so damaged that many question its classification), it adds another character to the hominid cast from 4 million to 3 million years ago. In addition to Lucy's species, *A. afarensis*, the players now include *K. platyops* and *A. bahrelghazali* at 3.5 million years, Little Foot at 3.3 million, and possibly the proposed genus *Praeanthropus*. Although Little Foot may prove to be *A. afarensis*, Clarke and his colleagues last September announced six even older and more apelike australopithecine fossils from Sterkfontein in South Africa. Thought to be about 3.3 million to 3.5 million years old, these are still being classified.

Single line or bushy tree?

Given all this diversity, it is "quite obvious that australopithecines lived all over Africa," says Walker. But he thinks that all these new fossils may represent diversity within single species that unfolded into each other in a linear procession. Although the number of

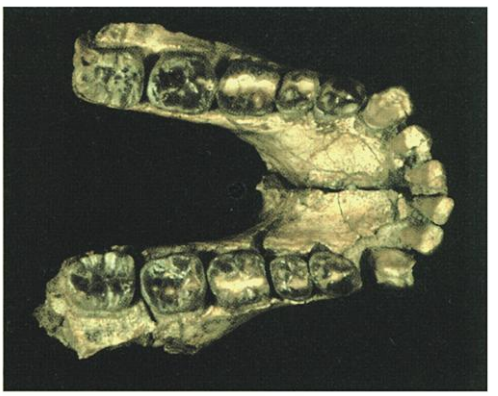
TRACKING TRAITS

	Locomotion	Canine size, shape	Molar size relative to body size	Tooth enamel
Pan (chimpanzee)	Knuckle-walker	Large, sharpened, V shape	Small	Thin (thick in orangutan and some extinct apes)
Ardipithecus	?	Small, diamond shape	Small	Intermediate
Orrorin	Bipedal?	Size of female chimp, sharpened, V shape	Small	Thick
Australopithecus anamensis	Bipedal	Smaller, diamond shape	Large	Thick
Australopithecus afarensis	Bipedal	Smaller, diamond shape	Large	Thick
Homo habilis	Bipedal	Smallest, diamond shape	Large	Thick
Homo erectus	Bipedal	Smallest, diamond shape	Small	Thick

CREDIT: (TOP) © JOHN GURCHE

new species has doubled in the past decade, Walker cautions that they are spread over millions of years. "I think there's no strong evidence that there's anything more than one evolving hominid from 6 million years to 2.5 million years," he says. White and his collaborators share this linear view, even connecting the dots between species, saying that *Ardipithecus ramidus* gave rise to *A. anamensis*, then *A. afarensis* on down to *Homo*, with some diversity at about the time *Homo* emerges.

But the field is deeply divided over this issue. When researchers such as Leakey, Wood, Tattersall, Pickford, and Senut look at the new fossils, instead of a parade of hominids, they see a bushy tree with different hominids hanging off different branches at the same time, making it difficult to draw a clear line of descent. "We're seeing a radiation," says Wood. "If you look at other mammals, what's so unusual about that?" Indeed, says Tattersall, "the big lesson from each of these new finds is that diversity [in anatomy and species] was present from the start."



An ancestor's smile. The teeth, jaw, and other bones of *A. anamensis* suggest that it is Lucy's ancestor.

Defining what is special about the human lineage gets harder as the fossils get older and older. "I just told my students, 'I'm sorry, but I don't know how to distinguish the earliest hominid from the earliest chimp ancestor anymore,' " says Wood. Others say there are a few signs of hominid status—at least for now. "Right now the two key traits are bipedality and canine reduction and shape modification," says Arizona State's Kimbel. "As we go back further in time, it will be fascinating to see if one of these fades away, leaving the other as the seminal hominid modification."

Even the current favorite trait, bipedalism, may not be enough to qualify as a hominid if other ancient apes were bipedal too. In the late Miocene, "there was a whole proliferation of these apes, sometimes running around on two legs, sometimes not. Why do they have to be ancestral to us?" wonders paleoanthropologist Peter Andrews of the Natural History Museum in London.

For casual visitors to that museum of human evolution, all the early figures may look similar—and very much like other apes. But in one ape-man's smile or stance, researchers hope to find the hint of things to come.

–ANN GIBBONS

BECOMING HUMAN
▶MODERN HUMANS

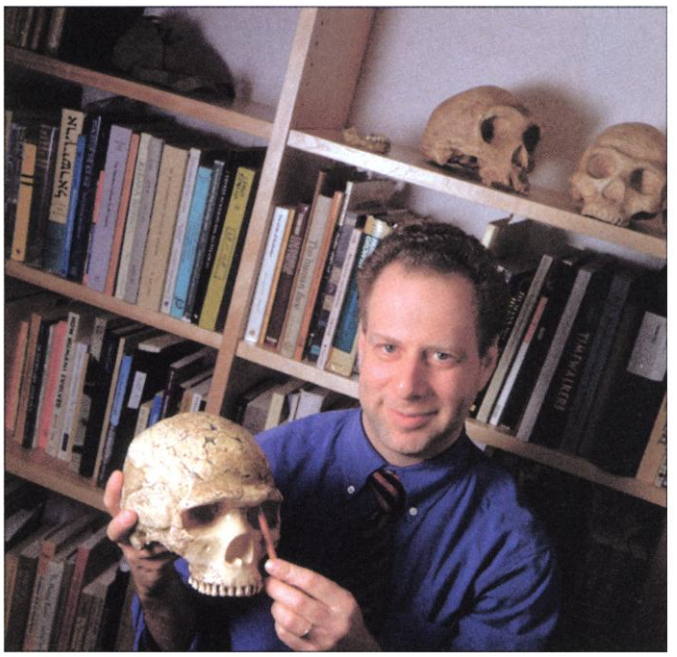
What Made Humans Modern?

Could our species have been born in a rapid burst of change? Researchers from different disciplines are trying to find out

CAMBRIDGE, MASSACHUSETTS, AND CAMBRIDGE, U.K.—Three hominid skull casts sit in a row on Daniel Lieberman's desk, their empty eye sockets staring eerily ahead. If they could see, they might catch a glimpse of Harvard University's peaceful green quad, just outside the anthropologist's window. But these skulls bear witness, between them, to some of the most dramatic events in human prehistory, including the mysterious birth of our own species, *Homo sapiens*.

The first skull, perhaps 300,000 years old, was found in Zambia. It comes from a species that may have been ancestral to both modern humans and Neandertals. The second is a Neandertal from France dating back 70,000 years. And the last is a 100,000-year-old *H. sapiens* discovered in Israel.

Lieberman picks up each skull in turn and pokes a pencil up through the eye socket. "Look at the difference," he says. "When I do this with the modern human, I touch the underside of the frontal lobe. But with the other two, my pencil ends up under the thick, bony brow ridge." In modern humans, he explains, the face and eyes are tucked under the braincase, rather than thrust forward prognathously, as in all other now-extinct human species. And the modern human skull is globular like a volleyball, instead of oblong like a football.



Poking into human origins. Daniel Lieberman thinks a few genetic changes might have produced the *Homo sapiens* skull.

In Lieberman's view, these two traits—rather than the long list of characters anthropologists usually rely on—are the key distinguishing features of modern human skulls. And, he says that this reshaping of the skull, which may have accommodated an expansion in the key frontal or temporal lobes of the brain, was produced by small evolutionary adjustments in a few bones along the base of the skull, possibly due to only a handful of genetic changes. If he's right, the rise of modern humans may have been a relatively abrupt event rather than a gradual evolution.

"It shows that the speciation event doesn't have to be complicated, with a lot of steps," says Lieberman. "You may only need one change, not 15 or 20 changes."

Lieberman's bold proposal is the latest entry in a newly invigorated debate over the making of modern humans. A flurry of new evidence from three sources—fossils, art and artifacts, and genes—is forcing researchers to rethink just what traits mark the origin of our species and how and when these traits appeared.

Some of this new evidence challenges the notion that the de-

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