PALEONTOLOGY

One Giant Step

Meet your newfound ancestor, a chimplike forest creature that

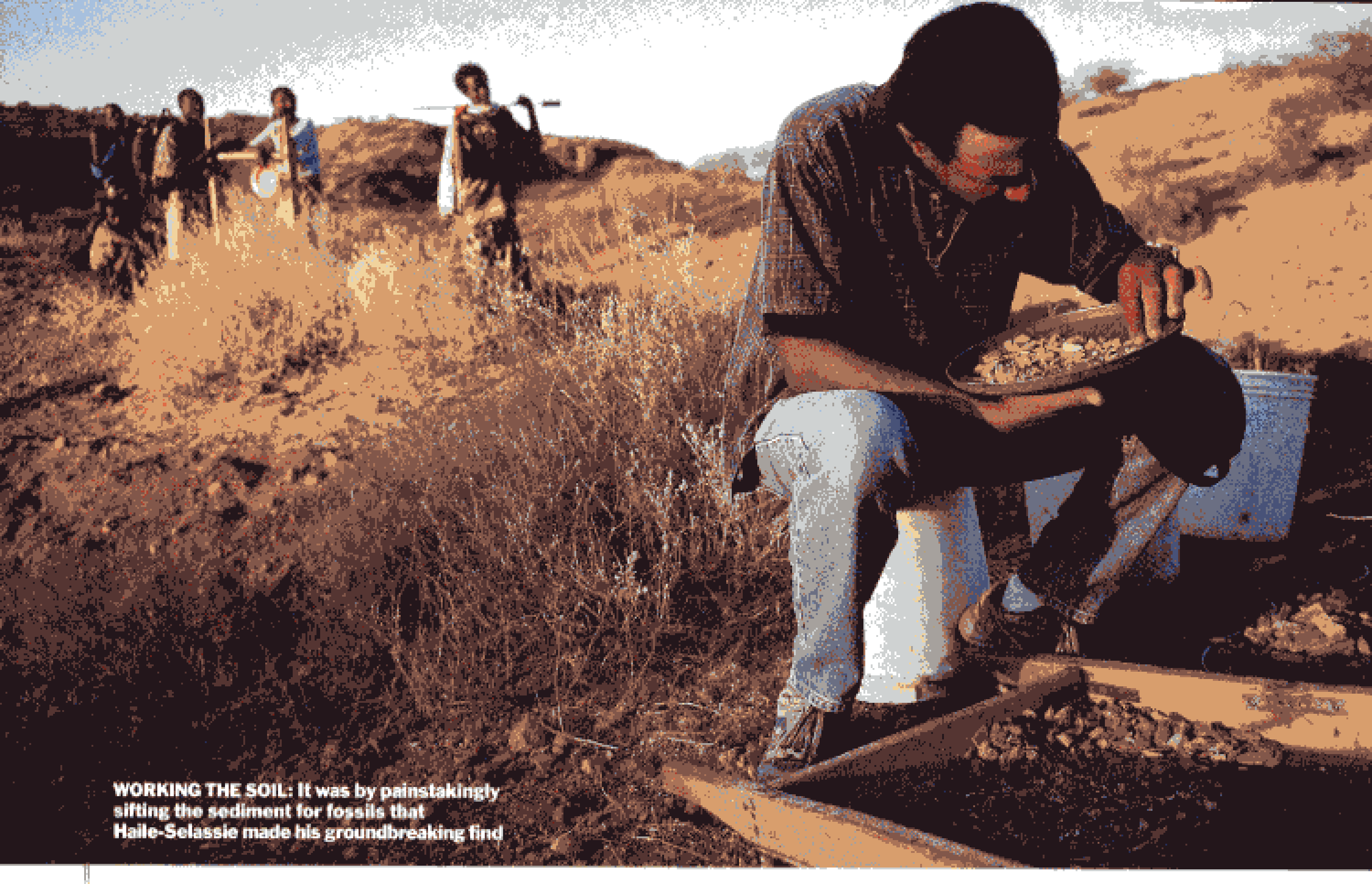
By MICHAEL D. LEMONICK and ANDREA DORFMAN

THE REGION OF ETHIOPIA CALLED THE MIDdle Awash, some 140 miles northeast of the capital of Addis Ababa, is a hot, harsh and inhospitable place—a rocky desert punctuated by tree-lined rivers, the occasional lake and patches of lava that are slowly being buried by sediments flushed out of the hills by the torrential rains that come along twice a year.

But between 5 million and 6 million years ago, the landscape here was very different. The same tectonic forces that racked the region with earthquakes and volcanic eruptions had also thrust the land up as much as a mile higher than it is today. As a result, the area was cooler and wetter and overgrown with trees, bushes and patches of grass. These fertile woodlands were rich in wildlife. Primitive elephants, giant bears, horses, rhinos, pigs, rats and monkeys lived here, along with dozens of other mammal species long since extinct.

And it was here too that nature indulged in what was perhaps her greatest evolutionary experiment. For it was in eastern Africa at about this time that a new type of primate arose—an animal not so different from its apelike ancestors except in one crucial respect: this creature stood on two legs instead of scurrying along chimplike on all fours. Its knuckle-walking cousins would stay low to the ground and never get much smarter. But while it wouldn't happen until millions of years in the future, this new primate's evolutionary descendants would eventually develop a large, complex brain. And from that would spring all of civilization, from

Illustration for TIME by Gregory Manchess



WORKING THE SOIL: It was by painstakingly sifting the sediment for fossils that Haile-Selassie made his groundbreaking find

DAVID L. BRILL—ATLANTA

Mesopotamia to Mozart to *Who Wants to Be a Millionaire.*

That's the broad outline, anyway. While this view of human evolution has generally been accepted by scientists for decades, no one has yet been able to say precisely when that first evolutionary step on the road to humanity happened, nor what might have triggered it.

But a discovery reported last week in the journal *Nature* has brought paleontologists tantalizingly close to answering both these questions. Working as part of an international team led by U.S. and Ethiopian scientists, a graduate student named Yohannes Haile-Selassie (no relation to the Emperor), enrolled at the University of California, Berkeley, has found the remains of what appears to be the most ancient human ancestor ever discovered. It's a chimp-size creature that lived in the Ethiopian forests between 5.8 million and 5.2 million years ago—nearly a million and a half years earlier than the previous record holder and very close to the time when humans and chimps first went their separate evolutionary ways.

"Having a fossil in this region of time, very near the divergence point, is really exciting," says anthropologist C. Owen Lovejoy of Ohio's Kent State University. "Going all the way back to Darwin, people have speculated how, when and why humans stood up on two legs. For paleontologists, this find is a dream come true."

As is often the case with discoveries like this, Haile-Selassie was not specifically looking for the things he found. He had set out to better understand how the ancient ecosystems worked and evolved. "I didn't even think about finding hominids," he says. "All I wanted to do was collect enough vertebrate bones so that I could write my dissertation." In December 1997, though, at a place called Alayla, he spotted a piece of jawbone lying on the rock-strewn ground. "I picked up the mandible less than five minutes after we got there," he recalls, "but didn't realize I had something really special until a year later, when we found some more bones and I started the serious analysis."

In all, the team eventually found 11 specimens—from at least five different individuals—in a cluster of sites, including Haile-Selassie's partial lower jaw with associated teeth, several hand and foot bones, and pieces of three arm bones and a collarbone. Luckily, the fossils were trapped in sediments that were sandwiched between layers of volcanic ash, whose age can be accurately gauged by a technique known as argon-argon dating. (This layering is still visible in places that have not been so heavily eroded, enabling the scientists to trace the area's geologic history.) The verdict, confirmed by a second dating method and by the other primitive animals found with the hominid remains: most of the fossils are between 5.6 million and 5.8 million years old, although one toe bone is a few hundred thousand years younger.

IT WAS THE DETAILED ANATOMY OF these fragmentary fossils, especially the teeth, that convinced Haile-Selassie that he had discovered a new human ancestor. Although apelike, the lower canines and upper premolars, in particular, display certain traits found only in the teeth of later hominids—the term scientists use to describe ourselves and our non-ape ancestors. They also differ in shape from the teeth of all known fossil and modern apes. Even the way in which the teeth had been worn down was telling. Explains Haile-Selassie's thesis adviser, Berkeley paleontologist Tim White: "Apes all sharpen their upper canines as they chew. Hominids don't." The new creature's back teeth are larger than a chimp's too, while the front teeth are narrower, suggesting that its diet included a variety of fibrous foods, rather than the fruits and soft leaves that chimps prefer.

When Haile-Selassie compared the newly discovered bones and teeth with those of *Ardipithecus ramidus*, a 4.4 million-

GROUND ZERO: Scientists scour barren African hills where humankind was born in more fertile times millions of years ago

year-old hominid found in the Middle Awash in the early 1990s that was the previous record holder, he realized that the two creatures were very similar. But the older one's teeth, while different from an ape's, do have a number of characteristics that are decidedly more apelike than those of the younger hominid.

On the basis of these minor but distinctive differences, Haile-Selassie decided to classify the new human ancestor as a subspecies, or variant, of *ramidus* and has given it the name *Ardipithecus ramidus kadabba.* (The name is derived from the local Afar language. *Ardi* means ground or floor; *ramid* means root; and *kadabba* means basal family ancestor. In accordance with the sometimes bizarre nomenclature of science, the younger creature now gets renamed *Ardipithecus ramidus ramidus.*)

Haile-Selassie and his colleagues haven't collected enough bones yet to reconstruct with great precision what *kadabba* looked like. But they do know it was about the size of modern common chimpanzees, which when standing average about 4 ft. tall. That makes it roughly the same size as its close relative *A. ramidus ramidus* and about 20% taller than Lucy, the famous 3.2 million-year-old human ancestor discovered about 50 miles away in 1974 that is even further along the evolutionary track. The size of *kadabba's* brain and the relative proportions of its arms and legs were probably chimplike as well.

But unlike a chimp or any of the other modern apes that amble along on four limbs, *kadabba* almost certainly walked upright much of the time. The inch-long toe bone makes that clear. Two-legged primates (modern humans included) propel themselves forward by leaving the front part of their foot on the ground and lifting the heel. This movement, referred to as toeing off, causes the bones in the middle of the foot to take on a distinctive shape—a shape that is readily apparent in the ancient toe bone. "If you compare a chimp's foot bones with its hand bones, they look the same because they're used for the same thing"—that is, for grasping—Haile-Selassie explains. "Hominid fingers and toes don't look alike at all."

Exactly how this hominid walked is still something of a mystery, though with a different skeletal structure, its gait would have been unlike ours. Details of *kadabba's* lifestyle remain speculative too, but many of its behaviors undoubtedly resembled those of chimpanzees today. It probably still spent some

Discovery Zone

Africa's Rift Valley has yielded most of our earliest ancestors

time in trees. It probably lived in large social groups that would include both sexes. And rather than competing with one another for mates, the males may well have banded together to defend the troop against predators, forage for food and even hunt for game.

But that *kadabba* walked upright at all is hugely significant. Paleontologists have suspected for nearly 200 years that bipedalism was probably the key evolutionary transition that split the human line off from the apes, and fossil discoveries as far back as Java Man in the 1890s supported that notion. The astonishingly complete skeleton of Lucy, with its clearly apelike skull but upright posture, cemented the idea a quarter-century ago.

WHAT'S BEEN MUCH TOUGHER to pin down is just why two-leggedness arose. The conventional wisdom has long focused on the fact that eastern Africa became significantly dryer about the time that humans first evolved. The change would have tended to favor grasslands over forests, and, so went the theory, our ancestors changed to take advantage of the new conditions. We learned to walk upright so that we could see over the tall grasses to spot predators coming; an upright posture, moreover, would offer a much smaller target for the oppressive heat of the grassland sun, and a larger target for cooling breezes.

The only trouble with this theory is that it's wrong. The earliest humans, it turns out, didn't live in grasslands. Dry climate or not, a companion paper published last week in *Nature* shows on the basis of the other fossilized flora and fauna, as well as the chemistry of the ancient soil, that *Ardipithecus ramidus kadabba* lived in a well-forested environment. That's also the case with other extremely ancient hominids found during the past several years, including *Ardipithecus ramidus ramidus* and a species called *Orrorin tugenensis*, announced last December by French and Kenyan researchers. And while the ability to walk on two legs probably started out as an increasingly frequent behavior, evolution demands an explanation for why it persisted. On first blush, bipedalism just doesn't make much sense. For our earliest ancestors, it would have been slower than walking on all fours, while requiring the same amount of energy. Says Lovejoy bluntly: "It's unnatural. It's bizarre."

WALK LIKE A MAN

Chimps can walk on two legs, but with a gait that is awkward and precarious. That's largely because their heads and torsos are thrust forward, not balanced over the hips and legs. Humans have evolved to correct that imbalance.

1 SPINE

A chimp's **lumbar region,** or lower spine, is **short and stiff;** a human's is **longer and curved** to push the torso's center of gravity forward so that it lies over the feet

2 PELVIS

Chimps sway when they walk upright because lifting one leg off the ground throws them off balance; humans prevent such swaying with a **broader pelvis** and a **specialized hip joint** and its associated muscles

3 THIGHBONE

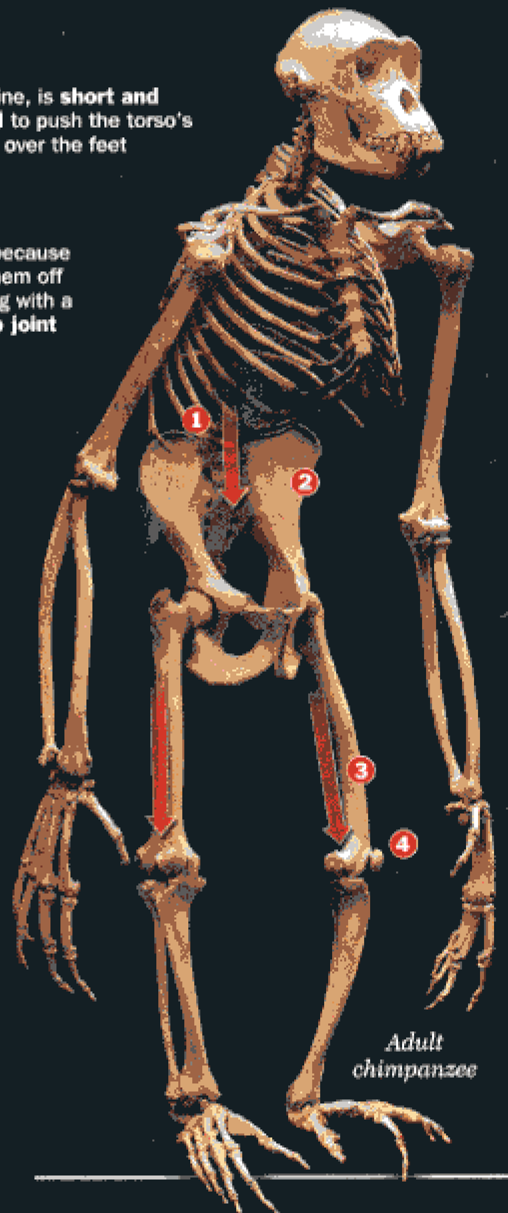
In chimps, the **femur** runs **straight** from hip to knee. The human femur **angles inward,** moving support more directly under the torso

4 KNEE JOINT

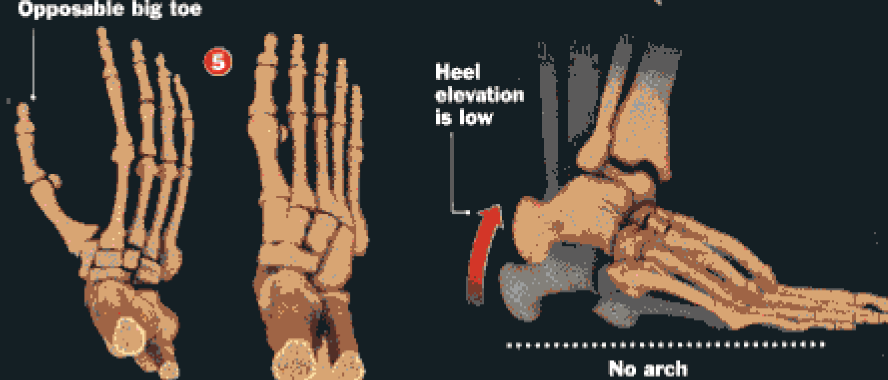
To support the human body's weight, the **femur** is **larger** at the bottom and the **tibia is larger** at the top. A groove at the bottom of the inward-angled femur keeps the **patella** from sliding off

5 FOOT

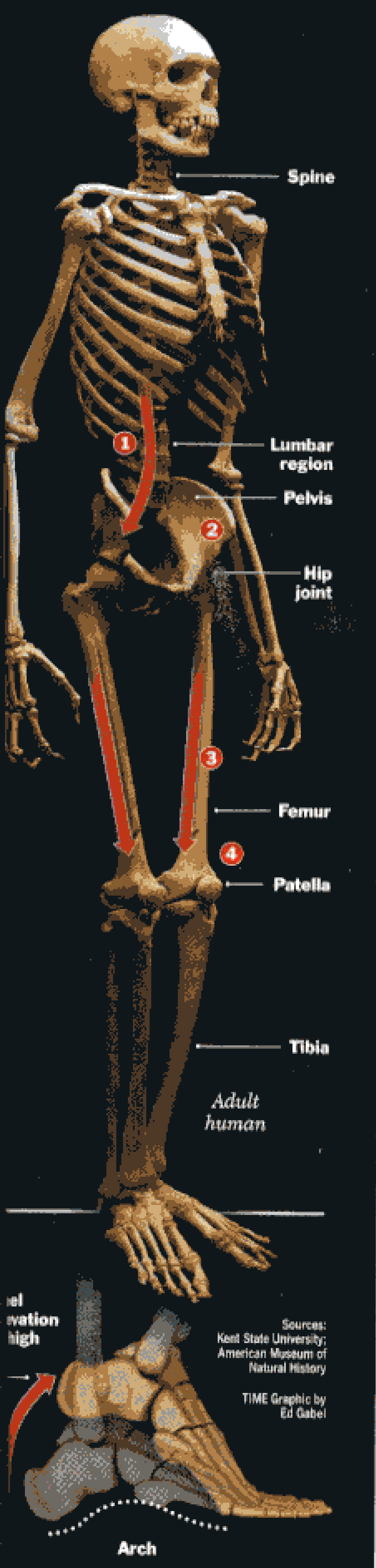
A chimp's **big toe** is **opposable,** like a thumb, allowing the chimp to grasp with its feet. A human's big toe is **lined up** with the other four toes – bad for climbing but good for forming an **arch** that runs from front to back. The arch acts as a shock absorber, deflecting impacts that would otherwise travel up the leg. This enables humans to walk long distances and run with less chance of injury



Adult chimpanzee



Chimpanzee foot *Human foot* *Chimpanzee foot when walking*



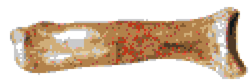
Human foot when walking

Yet the advantages of walking upright were somehow so great that the behavior endured through thousands of generations. Indeed, the anatomy of our ancestors underwent all sorts of basic changes to accommodate this new way of moving. Many of the changes help the body stay balanced by stabilizing the weight-bearing leg and keeping the upper torso centered over the feet. Lovejoy, who studies the anatomy and biomechanics of locomotion, thinks the changes may have improved coordination as well. "To walk upright in a habitual way, you have to do so in synchrony," he says. "If the ligaments and muscles are out of synch, that leads to injuries. And then you'd be cheetah meat."

By far the most crucial changes, according to Lovejoy, were those in the spine. The distance between chest and pelvis is longer in humans than in apes, allowing the lower spine to curve, which locates the upper body over the pelvis for balance. The pelvis grew broader, meanwhile, and humans developed a hip joint and associated muscles that stabilize the pelvis. Explains Lovejoy: "That's why a chimp sways from side to side as it walks upright and humans don't."

Changes also had to take place in the femur, or thighbone. For example, the femoral neck—the bent portion at the top of the bone—is broader in humans than it is in apes, which improves balance. The human knee is specialized for walking upright too: to compensate for the thighbone's being at an angle, there's a lump, or groove, at the end of the femur that prevents the patella from sliding off the joint. "A chimp doesn't have this groove because there is no angulation between the hip and the knee," Lovejoy says. "This change says you're a biped."

Finally, there's the foot. "What's important here is the arch," Lovejoy says. "It's a really important shock absorber. It's like wearing a good pair of running shoes." In order to create that arch, the chimp's opposable great toe became aligned with the others, and the toe's muscles and ligaments, which had been used for grasping and climbing, were repositioned under the foot. "The shape of the big toe is indicative of this. You can see it in Lucy's species," Lovejoy says, but not in the bone Haile-Selassie found, because it's from a different toe. "What we can see [in the new discovery's foot] is that the base of the bone adjacent to the knuckle has a distinct angle, showing that the creature walked step after step after step with its heel off the ground, using the front of its foot as a platform."



THIS TOE BONE PROVES THE CREATURE WALKED ON TWO LEGS

That's how it walked. *Why* it walked is tougher to understand, since motivation leaves behind no physical remains. But armed with knowledge about our ancestors' physical attributes and the environment that surrounded them, scientists have come up with several theories. Anthropologist Henry McHenry, of the University of California, Davis, for example, champions the idea that climate variation was part of the picture after all. When Africa dried out, say McHenry and his colleague Peter Rodman, the change left patches of forest widely spaced between open savannah. The first hominids lived mostly in these forest refuges but couldn't find enough food in any one place. Learning to walk on two legs helped them travel long distances over ground to the next woodsy patch, and thus to more food.

Meave Leakey, head of paleontology at the National Museums of Kenya and a member of the world's most famous fossil-hunting family, suspects the change in climate rewarded bipedalism for a different reason. Yes, the dryer climate made for more grassland, but our early ancestors, she argues, spent much of their time not in dense forest or on the savannah but in an environment with some trees, dense shrubbery and a bit of grass. "And if you're moving into more open country with grasslands and bushes and things like this, and eating a lot of fruits and berries coming off low bushes, there is a hell of an advantage to be able to reach higher. That's why the gerenuk [a type of antelope] evolved its long neck and stands on its hind legs, and why the giraffe evolved its long neck. There's strong pressure to be able to reach a wider range of levels."

But for Kent State's Lovejoy, the real answer is sex. Males who were best at walking upright would get more of it, leading to more offspring who were good on two legs, who in turn got more sex. His reasoning, first proposed nearly two decades ago, goes like this: like many modern Americans, monkeys and apes of

TIM WHITE

both genders work outside the home—in the latter case, searching for food. Early humans, though, discovered the *Leave It to Beaver* strategy: if males handled the breadwinning, females could stay closer to home and devote more time to rearing the children, thus giving them a better shot at growing up strong and healthy.

And if you're going to bring home the bacon, or the Miocene equivalent, it helps to have your hands free to carry it. Over time, female apes would choose to mate only with those males who brought them food—presumably the ones who were best adapted for upright walking. Is that the way it actually happened? Maybe, but we may never know for sure. Leakey, for one, is unconvinced. "There are all sorts of hypotheses," she says, "and they are all fairy tales really because you can't prove anything."

IF PALEONTOLOGISTS ARGUE ABOUT why bipedalism evolved, they're even more contentious over the organization of the human family tree. According to Haile-Selassie and his colleagues, the picture looks pretty straightforward from about 5.8 million years ago to the present. First comes *Ardipithecus ramidus kadabba*, the newest find. Then, more than a million years later, its descendant, the newly renamed *Ardipithecus ramidus ramidus*, appears. After that comes a new genus, called *Australopithecus* (where Lucy belongs), and finally, about 2 million years ago, the first members of the human genus *Homo*.

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 Collège 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.'"

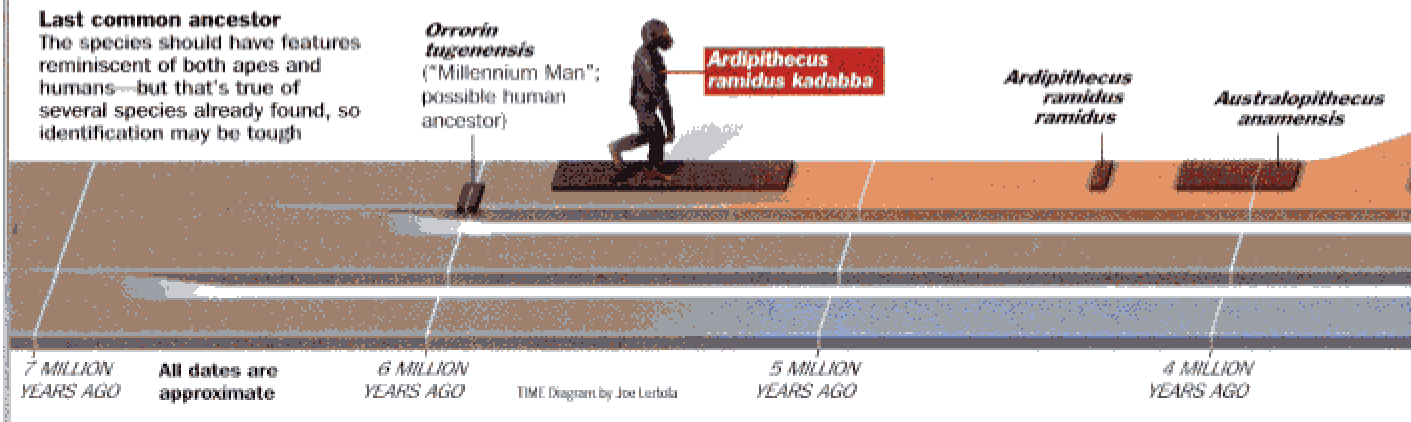
Even if they're right, though, establishing the precise path of human descent might be very hard. For most of the past 6 million years, multiple hominid species roamed the earth at the same time—including a mere 30,000 years ago, when modern humans and Neanderthals still coexisted. We still can't figure 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.

In the case of *Ardipithecus*, says Donald Johanson, professor of anthropology and director of the Institute of Human Origins at Arizona State University (and the man who discovered Lucy back in 1974), "when you put 5.5 million-year-old

MARC DEVILLE—GAMMA PRESSE (2)

A WALK THROUGH HUMAN EVOLUTION

The newest fossils have brought scientists tantalizingly close to the time when humans first walked upright—splitting off from chimpanzees. Their best guess is that it happened at least 6 million years ago



TIME Diagram by Joe Lertola

THIS LEG BONE COULD BE FROM AN EVEN OLDER HUMAN ANCESTOR

DARK HORSES: Senut, left, and Pickford still must convince the world their 6 million-year-old hominid is legit

fossils together with 4.4 million-year-old ones as members of the same species, you're not taking into consideration that these could be twigs on a tree. Everything's been forced into a straight line." Beyond that, he's dubious about categorizing the 5.2 million-year-old toe bone with the rest of the fossils: not only is it separated in time by several hundred thousand years, but it was also found some 10 miles away from the rest.

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.

One of the most intriguing questions the new discoveries raise, says Bernard Wood, a professor of human origins at George Washington University, is whether bipedalism should still be considered the defining characteristic of being human. After all, all birds have wings, but not all creatures with wings are birds. It's already clear that eastern Africa was bubbling with evolutionary experiments 6 million years ago. Maybe two-legged walking evolved independently in several branches of the primate family. Says Wood: "This might be the first example of a creature it's not possible to label as hominid ancestor or chimp ancestor. But that doesn't make it the last common ancestor of both. I think it's going to be very hard to pin the tail on that donkey."

In the end, that may be the most exciting thing about these latest discoveries from the human race's birthing ground. Not that long ago, paleontologists were pretty certain we started on the road to becoming human by standing upright on the grassy savannah. Now that science is actually bringing in hard evidence, the story is getting more complicated—and more interesting. Clearly, there are still plenty of questions to ask, and plenty of surprises left to uncover, in the ancient sediments of eastern Africa. —*With reporting by Simon Robinson/Nairobi*