WELCOME TO THE FAMILY

The latest molecular analyses and fossil finds suggest that the story of human evolution is far more complex—and more interesting—than anyone imagined

By Bernard Wood

IN BRIEF

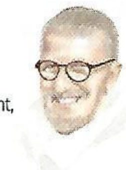
Tracing the evolutionary ancestors of *Homo sapiens* was once thought to be a relatively straightforward matter: *Australopithecus* begat *Homo erectus,* which begat Neandertals, which begat us.

Over the past 40 years fossil finds from East Africa, among other things, have completely shattered that hypothesis.

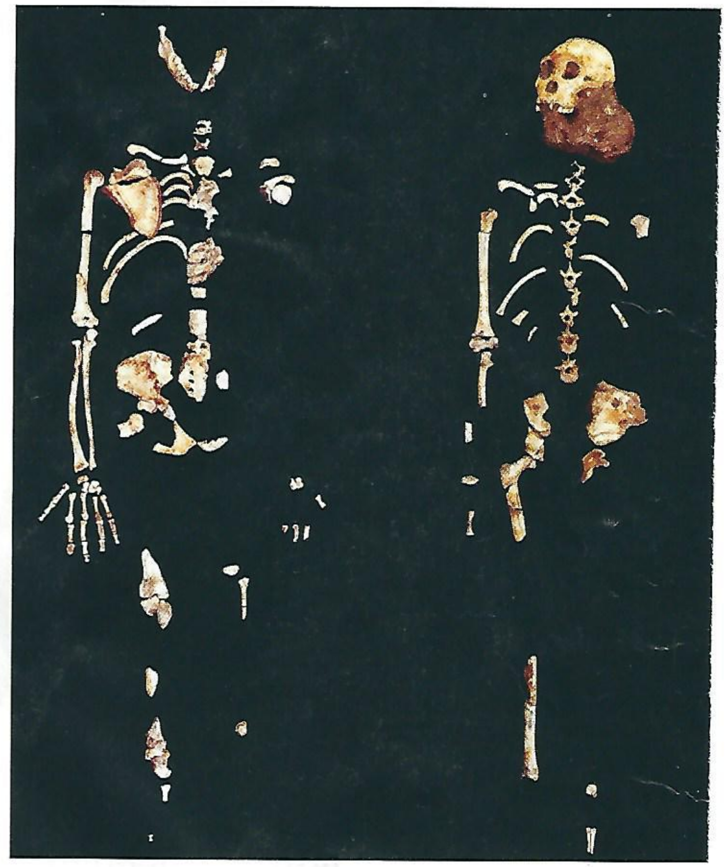
The latest evidence shows that several different hominin species shared the planet at different times. Figuring out how they are all related—and which ones led directly to us—will keep paleontologists busy for decades to come.

Illustration by Christian Northeast

Bernard Wood is a medically trained paleoanthropologist at George Washington University. His interest in human evolution research began in 1968, when as a medical student, he joined Richard Leakey's expedition to northern Kenya.



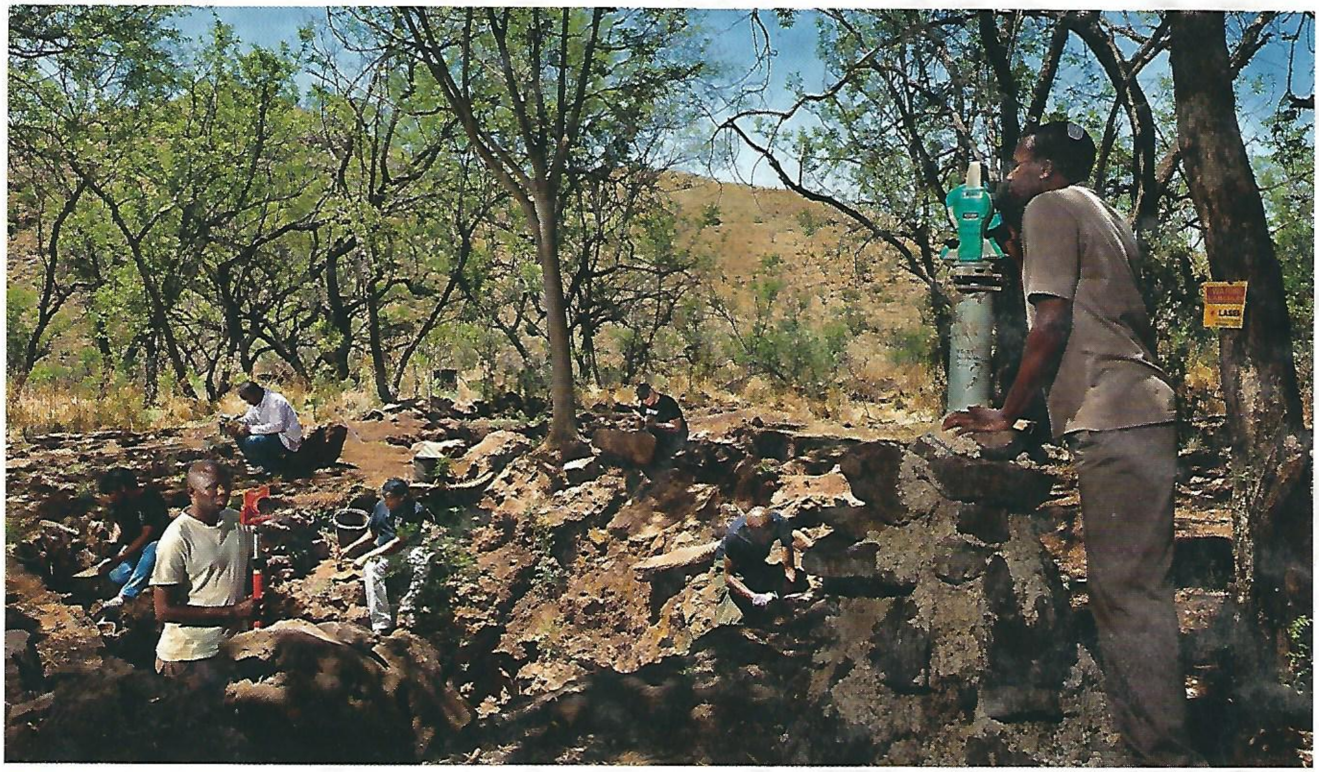
"So what do you think?" said Lee Berger. He had just opened the lids of two big wooden boxes, each containing the carefully laid out fossilized bones of a humanlike skeleton from Malapa, South Africa. These two individuals, who had drawn their last breath two million years ago, had created quite a stir. Most fossils are "isolated" finds—a jawbone here, a foot bone there. Scientists then have to figure out whether the pieces belong to the same individual. Think of walking down the highway and finding parts of cars—a broken fender here, part of a transmission there. Do they belong to the same model, or even make, of car? Or might they not have come from a car at all but from a pickup?



In contrast, the skeletons from Malapa, though not complete, are intact enough to reduce the possibility of random commingling. Like "Lucy" (unearthed in Ethiopia in 1974) and the "Turkana Boy" (found in Kenya in 1984), they have so much more to say than individual fossils. But they had made the headlines not because they are complete and so well preserved but because Berger, a paleoanthropologist at the University of the Witwatersrand, Johannesburg, had suggested that the individuals were part of a population that was directly ancestral to our own genus, *Homo.*

We all have ancestors. I still have an aged living parent. I had the good fortune to have known all four of my grandparents, and I can even dimly remember three of my great-grandparents. But I also have close relatives who are not ancestors. Not many—my father and I were both only children—but I did have a couple of uncles and aunts. They are an essential part of the family tree of their descendants, but in terms of my family tree they are the equivalent of "optional extras" on an automobile. So Berger wanted me to stop admiring the details of the teeth and jaws and tell him if I thought the Malapa skeletons were the evolutionary equivalent of my parents and grandparents or of my uncles and aunts. In other words, did they belong to a population that was a direct ancestor or just a close relative of modern humans?

When I first started studying human fossils in East Africa nearly 50 years ago, the conventional wisdom was that almost all our extinct close relatives were direct ancestors, and as you went further and further back into the past each was less humanlike and more apelike. But we now know from genetic studies and from fossil evidence of the Neandertals and the so-called Hobbit of Flores, Indonesia (*Homo floresiensis*), that our direct ancestors shared the planet over the past few hundred thousand years with several of our close relatives. Furthermore, other fossil discoveries make it clear that much earlier in



TREASURE TROVE: Researchers in South Africa undertake excavations at the Malapa Cave site (*above*), where two nearly complete skeletons (*shown at left*) of early hominins from two million years ago were recovered.

our prehistory (four million to one million years ago) there were also periods when our ancestors and several close relatives walked the earth at the same time. The presence of multiple evolutionary branches at any one time makes it much more difficult to identify direct ancestors of modern humans than paleontologists anticipated even 20 years ago. Yet the challenge also means that the story of human evolution is far more intricate and fascinating than most of us realized.

A SINGLE BRANCH—OR SEVERAL?

AT THE TIME I entered the field in 1968, Charles Darwin's conception of the Tree of Life held firm sway. He argued that the living world is linked in the same way that the branches of a tree are connected. In Darwin's Tree of Life, all the species alive today sit on the outer surface of the tree, and all the species that are no longer living are located closer to the trunk. Just as each individual modern human must have ancestors, so does each species alive today. In theory, then, the only branches, or lineages, that *must* be in the Tree of Life are the ones that lead from a living species down into the depths of the tree, and the only extinct species that *have* to be within the Tree of Life are the ones situated on those connecting branches; any others represent evolutionary dead ends.

In the case of modern humans and the living apes, this rule means the only branches and species that need to be in our particular part of the tree are the ones that link us to the common ancestor we share with chimpanzees and bonobos—a creature now thought on the basis of molecular evidence to have lived between about eight million and five million years ago.

In the 1960s the outermost branch of the Tree of Life leading to modern humans looked pretty straightforward. At its base was *Australopithecus,* the ape-man that paleoanthropologists had been recovering in southern Africa since the mid-1920s. *Australopithecus,* the thinking went, was replaced by the taller, larger-brained *Homo erectus* from Asia, which spread to Europe and evolved into the Neandertals, which in turn evolved into *Homo sapiens* (aka modern humans). All these were interpreted as direct ancestors of modern humans—the equivalent of my parents, grandparents and great-grandparents. Only one type of hominin (modern humans and any extinct relatives that are more closely related to humans than to chimpanzees or bonobos), called the robust australopiths because of their large jaws and chewing teeth, were surmised to be on a short twig of the human branch and thus the equivalent of my uncle and aunt.

This thinking changed when Louis and Mary Leakey's discoveries of hominins at Olduvai Gorge in Tanzania shifted the focus of research into early hominins that lived more than one million years ago from southern to East Africa. The focus changed not only because the trickle of fossil discoveries in East Africa in the early 1960s turned into a torrent but also because the context of the fossil evidence in East Africa—particularly with respect to its dating—was very different from that in southern Africa.

In the south, the hominin fossils were—and still are—mostly found in caves that form in rocks made of dolomite (a magnesium-rich carbonate). Although researchers occasionally find a well-preserved skeleton of an individual (such as those from Malapa), most of the early hominin fossils found in these caves were leftovers from the meals of leopards and other predators. These unconsumed bones and teeth were washed into the cave along with soil from the surface. Once inside the cave, the soil and bones formed what are called talus cones. These are untidy versions of the neat cones of sand in the bottom of an old-fashioned egg timer, and the layers, or strata, in the cave do not always follow the general rule that the older layers are at the bottom and the youngest at the top. As if this was not frustrating enough, researchers were until recently at a loss to know how to date the sediments in the caves, and in the early 1960s all investigators could do was fit the hominin finds in a very rough-and-ready time sequence based on the types of fossil animals found in the caves.

In contrast, hominin fossil evidence from East Africa comes from sites close to the Eastern Rift Valley, which slices through this part of Africa from the Red Sea in the north to the shores of Lake Malawi and beyond in the south. Instead of being found in caves, the hominin fossils from East Africa are found in sediments laid down around lakes or along riverbanks. Many of these rock layers preserve the direction of the earth's magnetic field at the time they were laid down, and because they are open-air sites the strata incorporate ash expelled from the many volcanoes generated in and around the Eastern Rift Valley by the movement of tectonic plates. These features mean that at each site researchers have ways of establishing the age of the strata independent of the fossils they contain. In addition, because the layers of volcanic ash function like a series of date-stamped blankets thrown over the region, they allow researchers to correlate fossils deposited thousands of miles apart.

Many of the richest East African hominin fossil sites, such as those in the Omo-Turkana basin and farther north along the Awash River, contain strata that represent millions of years of time. Thus, it is possible to give minimum "start" and "finish" dates for each particular group of fossil hominins. This specificity makes it clear that even within East Africa—let alone between East and southern Africa—there were many times in the past one million to four million years when more than one—and in some periods, several—hominins lived contemporaneously. For example, across a million years (from roughly 2.3 million to 1.4 million years ago), two very different kinds of hominins—*Paranthropus boisei* and *Homo habilis*—lived in the same region of East Africa. They were so different that a prehistoric safari guide would have made the point that their skulls and teeth are almost *never* confused, no matter how fragmentary the fossil evidence. It is also clear that the hominins at the sites in East Africa are different from the ones found in southern Africa—but more on that later.

Finding evidence of *P. boisei* and *H. habilis* in the strata that record thousands of years does not necessarily mean the two hominins had to take turns at the same water hole. But it does mean that one, or perhaps both, of these hominins was not ancestral to modern humans. Although evidence from much later in human evolution is consistent with a small amount of interbreeding between Neandertals and modern humans, in my view the much greater physical differences between *P. boisei* and *H. habilis* indicate that interbreeding was much less likely. And even if it did occur, it did little to blur the substantial differences between these two species. In other words, the image of a single, simple branch no longer seems apt for representing humans a couple of million years ago. Our early ancestry looks more like a bundle of twigs—one might even think it looks like a tangled bush [*see illustration on page 40*].

There is also evidence of multiple lineages in our more recent past. For example, Neandertals have been recognized as a separate species for more than 150 years, and as time goes by researchers discover more and more ways in which they differ from modern humans. We also know that a third hominin, namely *H. erectus,* probably survived much later than was originally thought and that *H. floresiensis,* although it may have been confined to the island of Flores, is almost certainly a fourth hominin that lived on the planet within the past 100,000 years. Evidence of a distinctive fifth hominin, the Denisovans, has come from ancient DNA extracted from a 40,000-year-old finger bone. And evidence has emerged for at least one more "ghost lineage" in the DNA of living modern humans from 100,000 years ago. Thus, our recent evolutionary history is much "bushier" than people thought even 10 years ago.

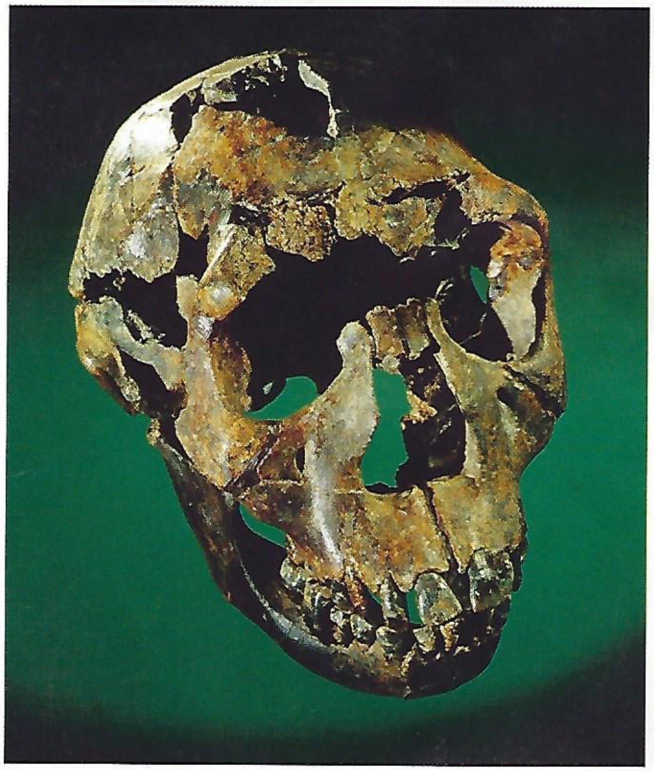
Perhaps the discovery of bushiness in our evolution should not have been surprising. Contemporary existence of multiple related species seems to have been the rule in the past for many groups of mammals, so why should hominins have been any different? Still, critics of the bushy family tree have charged that paleoanthropologists have been overzealous in identifying new species from their finds—presumably out of a desire for fame and further research funding.

Genetic and fossil evidence shows closely related hominin species shared the planet many times in the past few million years, making it more difficult to identify direct ancestors of modern humans than scientists anticipated even 20 years ago.

My prejudice, on the other hand, is that we are most likely dealing with a real phenomenon. First, there are sound, logical reasons to suspect that the fossil record always underestimates the number of species. Second, we know from living animals that many uncontested species are difficult to distinguish using the bones and teeth—the so-called hard tissues, which is all that survives into the fossil record. Furthermore, most of the mammal species that were living between three million and one million years ago have no direct living descendants. Therefore, the existence of several contemporary early hominins with no direct living descendants is not "odd" after all.

If it is true that hominins had rich diversity in their past, it behooves biologists to uncover the evolutionary pressures that

SCIENTIFIC AMERICAN ONLINE Wood talks about where humans originated—Africa, Asia or Europe?—at ScientificAmerican.com/sep2014/wood-origins



TURKANA FIND: Fossilized skull of a young *Homo ergaster* male that lived and died in Kenya 1.6 million years ago.

KEN GARRETT *National Geographic*

triggered it. Climate is one of the obvious candidates. Climates and thus habitats change over time—they show trends, and they oscillate within those trends. By and large over the period we are considering, there is a trend toward cooler and drier conditions, but within that trend the climate oscillates at predictable intervals, so at times it will be hotter and wetter, and at other times it will be cooler and drier. The type of posture, diet and locomotion that worked at one time may not be so successful at another. Another pressure favoring hominin diversity may have been competition among hominins; if two hominins shared a habitat, even in a very general sense, they would have tended to force each other into different survival strategies. This phenomenon, called character displacement, may explain how *H. habilis* and *P. boisei* came to have such different teeth and jaws—with one group favoring tough, fibrous foods such as grasses and the other leaning toward a diet that included softer, but harder to find, fruits plus the occasional meal of meat or bone marrow. Moreover, as hominins evolved different cultures, their different worldviews and practices could have militated against species merging as the result of interbreeding.

In addition to anatomical differences, researchers can now analyze fossils on a molecular level. Yet when it comes to early hominins—for whom we do not yet have genetic evidence—distinguishing the equivalent of my parents, grandparents and great-grandparents from the equivalent of my uncles and aunts remains challenging. Just because two fossils have similarly shaped jaws or teeth does not mean they share a recent evolutionary history. These overlaps can occur because similar ecological challenges prompt similar morphological solutions. By way of illustration, consider an ax design that works as well to cut down gum trees in Australia as it does to fell spruce in northern Europe; Australians and Europeans could well have hit on the same design without one group having introduced it to the other. We also know that morphology is not infinitely evolvable—for any type of animal or plant, there are a finite number of anatomical or physiological solutions to the same ecological challenge. Thus, the discovery of a shared feature in fossils from two species does not necessarily mean that they are direct taxonomic buddies; they could merely be close relatives that have converged on the same physical solution to a similar ecological challenge.

So what does the future hold for identifying our direct ancestors? I am willing to go a step further than supporting the view that many hominin species roamed the planet simultaneously. I predict that the increased hominin diversity that has been identified in the past four million years will be shown to extend back even further. I think this in part because researchers have not been looking as long or as hard for hominins that lived in even earlier times. Consequently, they have explored fewer sites from before four million years than after. Admittedly, the work is hard. Hominins are among the scarcest mammals in the fossil record. You have to sort through a lot of pig and antelope fossils before you can expect to find the occasional hominin. But if we make a concerted effort to find them, they will surely turn up.

Another reason to predict that more early hominin species remain to be discovered: the fossil records of the more common mammals have nearly as many lineages before three million years as they do after that time. Why would we would not expect hominins to show the same pattern? Finally, existing early hominin sites cover no more than 3 percent of the landmass of Africa, probably less. It is unlikely that such a small geographical sample has managed to capture evidence of all the early hominin species that ever lived on that continent.

And yet each new discovery from before four million years most likely will bring even less certainty. The closer you get to the split between the human and the chimpanzee-plus-bonobo lineages, the more difficult it will be to tell a direct human ancestor from a close relative. It will also be harder to be sure that any new species is a hominin rather than an ancestor of chimpanzees and bonobos or even a species belonging to a lineage that has no living representative. If paleoanthropology is challenging and difficult now—and I remain to be convinced that the Malapa skeletons were direct human ancestors—it is only going to get more so in the future. But it is these challenges that make the field so fascinating. SA

MORE TO EXPLORE

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