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Up From The Apes

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Remarkable New Evidence Is Filling In The Story Of How We Became Human

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Despite the protests of creationists and their intellectual allies, and such efforts as the Kansas school board's vote last week to expunge evolution from the school curriculum, science has long taught that human beings are just another kind of animal, but most of the time this seems like a technicality. It's not just the obvious differences--language, civilization, technology--that set us apart. Even basic biology suggests that humanity has special status. Virtually every other type of animal comes in multiple varieties: dozens of species of monkeys, antelopes, whales and hawks walk, swim or fly the earth, to say nothing of beetles, whose hundreds of thousands of species inspired biologist J.B.S. Haldane's famous quip that God must have had "an inordinate fondness" for them. Even our closest kin, the great apes, fall into four species, divided into several subspecies. But there's now only one species of human on the planet, and in the simplified view of evolution most of us have, that's all there has ever been. A few million years ago, most of us think, the half-ape known as Lucy appeared in Africa; eventually she begat a less apelike creature, who evolved in turn into something even more humanlike. Finally, after a few more begettings, Homo sapiens appeared. Except for that odd side branch known as the Neanderthals, the path from proto-apes to modern humans is commonly seen as a succession of new and improved species taking the place of worn-out evolutionary clunkers.

It's a satisfying, if slightly chauvinistic tale, but experts in human evolution have known for years that it is dead wrong. The evolution of a successful animal species almost always involves trial and error, false starts and failed experiments. "Humans are no exception to this," says anthropologist Ian Tattersall of the American Museum of Natural History in New York City, "no matter what we like to think."

True, we're descended from a creature that split off from the apes millions of years ago. But subsequent events were hardly a steady march from primitivism to perfection. Human evolution more nearly resembled an elimination tournament. At just about any given moment in prehistory, our family tree included several species of hominids--erect, upright-walking primates. All were competitors in an evolutionary struggle from which only one would ultimately emerge. Then came yet another flowering of species that would compete for survival. Neanderthals simply represented the most recent version of that contest. And while we'd find it bizarre to share our world with another human species, the fact that we've been alone since the Neanderthals vanished some 30,000 years ago is an evolutionary aberration.

The notion that multiple human species are the norm, not the exception, has only got stronger with a series of major scientific discoveries. Since 1994, four new species of hominid have been added to the human family tree, with the latest announced just a few months ago. These date from 800,000 years ago all the way back to 4.4 million years B.P. (before the present).

Scientists have also unearthed new fossils of known species. This should help them trace the complex relations among our sundry ancestors. One remarkable skeleton, announced this past spring, suggests that modern humans and Neanderthals may even have mated successfully. And new evidence of stone-tool use, dating as far back as 2.5 million years, has provided tantalizing clues to how our forebears thought and behaved.

These discoveries not only further confirm that multiple hominid species are the rule but also bring us much closer to understanding the ultimate mysteries of human evolution: What were the changes that led to modern humans? When did these changes take place, and why? And perhaps most intriguing, will we continue to evolve, or has *Homo sapiens* (wise man) made evolution obsolete?

While all the answers won't be in for some time, experts have identified several key transitions in our evolutionary chronicle. The first, which happened around the time we diverged from the apes, between 6 million and 4 million years ago, was the development of bipedalism--two-legged walking rather than the kind of locomotion Tarzan learned from his adoptive ape family.

The second, which occurred perhaps 2.5 million years B.P., was the invention of toolmaking--the purposeful crafting of stone implements rather than just picking up handy rocks--and the transition to meat eating. Then, somewhere between 2 million and 1 million years ago, came the dramatic growth of the brain and our ancestors' first emergence from Africa. Finally, just a few tens of thousands of years ago, our own species learned to use that powerful organ for abstract thought, which quickly led to art, music, language and all the other skills that have enthroned humans as the unchallenged rulers of their planet.

SPLIT FROM THE APES

As recently as five years ago, all that scientists could really tell about our earliest ancestors was when they first appeared. Molecular biologists had measured the differences between human and chimpanzee DNA, then averaged the rate of genetic change over time. By calculating backward, they determined that great apes and hominids branched from a common ancestor between 6 million and 4 million years ago. But no fossils were on hand to support this scenario. The oldest hominid species known, *Australopithecus afarensis* (southern ape of the Afar), could be dated back only 3.6 million years. Its most famous member, Lucy, unearthed in Ethiopia's bleak Afar Triangle in 1974, is a mere 3.2 million years old.

Then, in 1994 and 1995, teams working in Ethiopia and Kenya announced that they had each found a new species of hominid. Both discoveries smashed the 4 million-year barrier. The first--and at 4.4 million years, the oldest--was dug up by an international team in the Middle Awash region of Ethiopia, about 50 miles south of where Lucy was discovered.

All told, the scientists excavated the bones and teeth of 17 individuals. Given their age, no one was

surprised that they showed a mix of chimpanzee-like and human traits that as a whole are more primitive than those of *A. afarensis*: smaller molars, larger canines and thinner tooth enamel, suggesting a diet rich in easy-to-chew fruits and vegetables. The new species, says paleontologist Tim White of the University of California at Berkeley, a co-leader of the expedition, "is way closer to an ape than to an australopithecine and is significantly different from any other hominid."

Because the fossils were too distinctive to be included in Lucy's extended *Australopithecus* family, the researchers called the new species *Ardipithecus ramidus* (*ardi* means ground or floor in the local Afar language, and *ramid* means root). White and his colleagues have since found other *ramidus* fossils at their site but are giving out precious few details until they complete their methodical analysis of the bones. Says *ramidus* co-discoverer Berhane Asfaw of the Rift Valley Research Service in Addis Ababa: "It will be worth the wait."

One prize specimen, they acknowledge, is a partial skeleton found by Berkeley graduate student Yohannes Haile-Selassie (no relation to the Emperor). Alas, the back of the skull is badly crushed. A hippo or elephant probably trampled it soon after the creature died. "It looks like roadkill," quips White. Given the small skulls of *A. afarensis* and other later australopithecines, however, this specimen undoubtedly had a pint-size brain. At this point in evolution, says White, "we're in the minor leagues of brain development."

But the skeleton does include many bones that will help White's team answer the much more important question of how *Ardipithecus* got around. Paleoanthropologists believe that bipedalism was the first significant modification separating our ancestors from the great apes. By studying the bones and fossil footprints of *A. afarensis* (Lucy and her line) as well as those of half a dozen other australopithecine species, scientists already knew that our ancestors walked upright long before they acquired other human traits--and that bipedalism gave them a huge edge.

According to conventional wisdom, this evolutionary breakthrough came at a time when climate change was transforming eastern and southern Africa from dense forest into open grassland. Standing upright in such an environment could have offered our ancestors many advantages. It could have let them scan the horizon for predators, exposed less body surface to the scorching equatorial sun (and, conversely, more to the cooling wind) or freed their hands for carrying food. But these ideas may be in trouble. Fossilized seeds, petrified wood and animal bones found by White and his colleagues at the digging site, near the village of Aramis, indicate that it was quite densely wooded when *A. ramidus* lived there. If the hominid turns out to have been bipedal, as preliminary studies indicate, this could wash away existing theories--though the scientists can't say for sure until other hominid fossil sites of comparable age are found.

Even if *ramidus* didn't walk upright, however, another of the recently discovered human ancestors certainly did. Less than a year after *A. ramidus* made headlines, a team led by Meave Leakey of the National Museums of Kenya (wife of well-known fossil hunter Richard Leakey) and Alan Walker of Pennsylvania State University revealed that it too had found fossils of an ancient human ancestor at two sites near Lake Turkana, in Kenya. Not only is the new hominid very old, dating to 4.2 million years B.P., but it is similar in some ways to *A. afarensis*--though clearly more primitive. Given the family resemblance, Leakey and Walker assigned the fossils to the same genus, *Australopithecus*, and gave the new species the name *anamensis* (*anam* is the Turkana word for lake).

Several of the bones underscore that *A. anamensis* did indeed walk upright, some 500,000 years before the next oldest two-legged hominid known. But these creatures didn't walk in the modern sense. As Leakey explains, "They weren't nearly as efficiently upright as we are, and they had relatively short legs. They had a form of locomotion that we don't know today because there isn't anything equivalent."

Precisely where do *A. ramidus* and *A. anamensis* fit into the scheme of human evolution? Leakey believes the latter is a direct ancestor of *A. afarensis* and thus a direct ancestor of modern humans. White and his colleagues have tentatively labeled the older *ramidus* a "sister species" of all later hominids; it's either our direct ancestor or a close relative of that ancestor. Whichever *ramidus* turns out to be, it's clear that paleontologists are closing in on the split between apes and humans. "We're in the ballpark. Five or 10 years ago, we couldn't even have conceived of this," asserts White. "Ardipithecus is the closest thing we currently have to the common ancestor of African apes and humans, but its derived characteristics, particularly its teeth, suggest that it postdates that ancestor."

As for the ancestor, White hints that his team has already discovered hominid fossils that are more than 5 million years old, though he refuses to elaborate before detailed studies are completed. But Leakey and Walker readily acknowledge that they are studying two 5.5 million-year-old hominid teeth and a similarly ancient jaw fragment with an embedded tooth from a site in northern Kenya. "They look like australopithecines with lots of primitive features," Walker says, but there isn't enough evidence from these fossils alone to claim a new species.

THE EARLIEST HUMANS

Given their 2 million-year-plus life-span, the australopithecines were surely one of evolution's better experiments. But nature is an inveterate tinkerer, even with successful species. Between 3 million and 1.9 million years B.P., several variations on the *Australopithecus* theme popped up in eastern and southern Africa, including *A. africanus*, *A. aethiopicus*, *A. robustus* and *A. boisei*. (Just to complicate matters, the last three are assigned by some experts to an entirely different genus, *Paranthropus*.)

But figuring out how they arose, how they were related and what they evolved into--those that weren't evolutionary dead ends--has proved elusive. Not only is the fossil record full of holes, but the hominid species from eastern Africa haven't shown up in southern Africa, and vice versa. A remarkably preserved skeleton found in South Africa's Sterkfontein cave could change all that. Believed to be at least 3.3 million years old, the bones may belong to *A. afarensis*, making it the first of Lucy's species uncovered in that area. But the skeleton hasn't been fully excavated yet, and its discoverer, Ron Clarke of the University of the Witwatersrand, in Johannesburg, thinks it may represent yet another previously unknown species.

Whatever the evolutionary relationships between these prehuman species, paleoanthropologists know that at some point a second major shift took place. One of Lucy's descendants gave rise to a new kind of creature, the first of the genus *Homo*. Yet none of the known variants of *Australopithecus* seemed anatomically close enough to the *Homo* line to qualify.

Then, four months ago, Asfaw and White's team made another dramatic announcement. A frag-

mentary skull found near Bouri, an Ethiopian village in the Middle Awash region northeast of Addis Ababa, could well be from the missing australopithecine that sired the human race (see cover photo). Excavated in 1997, its jutting face and upper jaw filled with large teeth clearly belong to a species more advanced than *A. afarensis* yet more primitive than the earliest humans.

The mix of characteristics wasn't precisely what the experts expected--they were looking to see smaller, more specialized teeth and a larger braincase. So they named their hominid *Australopithecus garhi* (*garhi* means surprise in Afar). But the skull's intermediate anatomy and its age--about 2.5 million years--put it midway in both time and form between the most recent *A. afarensis* and the oldest known fossils of our own genus.

That alone would make *A. garhi* a prime candidate for the long-sought evolutionary link between Lucy's species and the first humans. But the researchers also found that nearby animal bones dating from the same period had been butchered with stone implements. Cut marks on one antelope jawbone suggest that the hominids used a sharp stone flake to remove the animal's tongue. The leg bone of another animal is scarred by cuts, chop marks and signs of hammering, evidence that it was scraped clean of meat and bashed open to expose the nutritious marrow.

Earlier discoveries at Gona, an Ethiopian site about 60 miles north of Bouri, had already shown that someone was using carefully manufactured stone tools in the area at about that time. Now Asfaw and White's team could make a circumstantial case that their species, *A. garhi*, was the gifted toolmaker. If so, this was a crucial bit of scientific sleuthing. In the 2 million years since the first human ancestor began to walk upright, nothing much had changed. Now something had. Rather than just using sticks and stones to leverage innate abilities--something done by plenty of animals, from chimps to otters to finches--someone had deliberately selected and modified specific raw materials in a sophisticated and consistent way, and with careful intent.

This wasn't just tool use; it was technology. Explains archaeologist Sileshi Semaw, a postdoctoral researcher at Indiana University in Bloomington, who helped find a huge cache of 2.6 million-year-old tools at Gona in the early 1990s: "The Gona hominids [carefully] selected workable raw materials." Since there are no local sources of such materials at Bouri, where the *A. garhi* fossils were found, the hominids must have carried their tools with them when they traveled there.

Did *A. garhi* make both the tools Semaw found and the ones used to butcher animals at Bouri? "If it wasn't *garhi*," asks White, "what would it have been?" Semaw is more cautious. "*Australopithecus garhi* is the best candidate thus far," he concedes, but he doesn't rule out the possibility that another species, yet undiscovered, deserves the credit.

Whoever did it, the creation of technology gave its inventors an astonishing advantage over other hominid species. Stone hammers and blades let them exploit carcasses left behind by other predators and permitted them to shift to an energy-rich, high-fat diet. "That," asserts Asfaw, "leads to all kinds of evolutionary consequences."

One of these, White suggests, was the ability to exploit a broader range of habitats, eventually enabling our ancestors to leave Africa and colonize most of the globe. But even more important was the expansion of our brain, with all the potential that went with it. Explains Meave Leakey: "The brain is a very expensive organ in terms of metabolism." It can grow larger only in a species that's

routinely consuming high-energy food. One impetus for such growth--and in particular, the growth of the cognitive areas that distinguish ours from other large brains--could have come from our increasingly creative use of tools. Still, the ultimate use to which those big, sophisticated brains would be put would not appear for many hundreds of thousands of years.

MODERN HUMANS

Just as *australopithecus afarensis* eventually gave rise to the genus *Homo*, so one species came to stand out among the *Homo* line and eventually led to modern humans. The fossil record is far too spotty to say how *Homo habilis* (handy man) and other members of its genus--*H. rudolfensis*, *H. ergaster* and *H. erectus*--were related, to what extent they overlapped or even whether they all represent distinct species. Many scientists believe, though, that it was *H. erectus* that was the ultimate victor, the direct ancestor of our own species.

H. erectus was also the first hominid to emigrate from Africa, at least 1.8 million years ago, spreading all the way to China and Indonesia. Then, at some point--for reasons still mysterious--the lineage diverged, with one branch leading to Neanderthals and another to modern humans.

Exactly when and how it happened is unclear. The oldest Neanderthal fossils in hand date only to 200,000 B.P., and the oldest *Homo sapiens* to about 100,000. But some recent discoveries may help answer those questions. A 1 million-year-old cranium from Buia, Eritrea, for example, has characteristics of both *H. erectus* and *H. sapiens*. And what Asfaw and his colleagues call a "spectacular" partial cranium of the same age from Ethiopia should help as well when it's formally unveiled.

An unusually rich trove of fossils has been found at two sites in northern Spain's Atapuerca mountains. One, known as Gran Dolina, has yielded 800,000-year-old hominids that Spanish researchers believe are a new species, perhaps the most recent common ancestor of modern humans and Neanderthals. Named *Homo antecessor* (Latin for explorer or pioneer), they had a primitive jaw and prominent brow ridges but a projecting face, sunken cheekbones and tooth development similar to that of modern humans.

Less than half a mile away, *antecessor*'s co-discoverer, Juan Luis Arsuaga of the Universidad Complutense de Madrid, is excavating at Sima de los Huesos (Pit of Bones), deep inside a natural cave. So far, his team has found thousands of fossils from at least 33 hominids of all ages. About 300,000 years old, they appear to represent an early stage of Neanderthal evolution. Explains Eric Delson, a professor of anthropology at Lehman College in New York City: "For the first time, we have a good population from a single place and enough variation to show Neanderthal features being distilled and standardized."

What occurred some 200,000 years later, when *Homo sapiens* first met their Neanderthal cousins--the only other hominid species that hadn't dwindled into extinction--is a matter of much speculation, scientific and otherwise. Our species would end up the only one left standing, but whatever happened to the Neanderthals didn't happen quickly. Plentiful archaeological evidence proves that *Homo sapiens* and *Homo neanderthalensis* inhabited the same general turf in many parts of Europe and the Middle East for thousands of years. That doesn't prove, however, that they lived as peaceable neighbors. Populations were so sparse that run-ins probably would have been rare.

A romantic notion of how the Neanderthals disappeared has been around for decades: perhaps they were eliminated by interbreeding with us. Maybe we all carry a bit of Neanderthal in our DNA. Two years ago, molecular biologists tested that hypothesis by extracting some DNA from a Neanderthal fossil and comparing it with that of modern humans. Their conclusion: the differences are great enough to rule out significant interbreeding, even though such mating would have been biologically possible.

But a skeleton discovered in Portugal last December gives new life to the old idea. Co-discoverer Joao Zilhao, director of the Portuguese Institute of Archaeology, and consultant Erik Trinkaus of Washington University in St. Louis, Mo., claim that the 24,500-year-old remains of a four-year-old child show a mix of human and Neanderthal features. The boy could simply be the love child from a single prehistoric one-night stand--except that the last true Neanderthals had disappeared from the area at least 3,000 years earlier. Plenty of experts are unwilling to be swayed by romance, however--especially the American Museum's Ian Tattersall, who says flatly, "It's just a chunky modern kid. There's nothing special about it."

Besides, one isolated case can't explain the demise of an entire population spread across thousands of miles. The mystery is all the greater as paleoanthropologists learn how similar to our own ancestors the Neanderthals were. They hunted cooperatively, they buried their dead, and their brains were as big as ours. The species' relative equality, says Trinkaus, "makes perfect sense, given that the two groups coexisted for several thousand years without one or the other being dominant." What may have happened, suggests Tattersall, is that some 50,000 years after modern humans arose, we began using our brains in a fundamentally different way. Despite their burials, for example, the Neanderthals left no clear evidence of any ritual or any belief in an afterlife. Nor is there any hint of Neanderthal language. Most telling of all, *Homo sapiens* began, some 40,000 years ago, to create art in an astonishing variety of forms, including cave paintings and female statuettes. All this, Tattersall and others believe, represents a single, profound change: the development of symbolic thought. "Art, symbols, music, notation, language, feelings of mystery, mastery of diverse materials and sheer cleverness: all these attributes, and more, were foreign to the Neanderthals and are native to us," he writes in his 1998 book, *Becoming Human*. For the first time, innovation was a routine part of human life that could easily be shared with others--not just something that occurred every million years or so. Against that kind of competition, no other human species could hold out.

THE END OF EVOLUTION?

The development of symbolic thought and complex communication did nothing less than alter human evolution. For one thing, high-tech transportation means that the world, though ethnically diverse, now really consists of a single, huge population. "Everything we know about evolution suggests that to get true innovation, you need small, isolated populations," says Tattersall, "which is now unthinkable."

Not only is a new human species next to impossible, but technology has essentially eliminated natural selection as well. During prehistory, only the fittest individuals and species survived to reproduce. Now strong and weak alike have access to medicine, food and shelter of unprecedented quality and abundance. "Poor peasants in the Third World," says University of Michigan anthropologist Milford Wolpoff, "are better off than the Emperor of China was 1,000 years ago."

And technology shows no signs of slowing down, which means that even dramatic changes in the natural world won't necessarily have evolutionary consequences. Argues Wolpoff: "We're not going to [adapt to] the next ice age by changing our physical form. We'll set off an atom bomb or set up a space mirror or whatever [to control climate]." Manipulation of the human genome, meanwhile, will eventually let us change the basic characteristics of our species to order. Evolution by natural selection could be replaced, perhaps chillingly, with evolution by human intervention.

That's not to say humanity can't become extinct. A 50-mile-wide asteroid crashing down from space would do it. So could a sudden and thorough collapse of earth's ecosystem through pollution, deforestation and the like--unless we establish some colonies in space beforehand. But whatever happens, the long history of multiple hominid species struggling for supremacy on earth is over. After millions of years, evolution by natural selection, operating blindly and randomly, has produced a creature capable of overturning evolution itself. Where we go from here is now up to us.