BECOMING HUMAN

Our Past, Present and Future

SCIENTIFIC AMERICAN

Becoming Human
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From the Editors of Scientific American

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Letters to the Editor

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The Sprawling Story of Human Evolution

We humans are a strange bunch. We have self-awareness and yet often act on impulses that remain hidden. We were forged in adversity but live in a world of plenty. Who are we? What is to become of us? To these age-old questions, science has in recent years brought powerful tools and reams of data.

We know, for instance, that three million years ago, a group of primates known as the australopithecines was walking capably on two legs—the better to navigate the African savanna—and yet still had long arms suited to life in the trees. As noted in Section One, "Becoming Us," in searching for clues to what selective pressures drove this transition, paleontologists discovered a 3.3-million-year-old fossil—"Lucy's baby"—confirming that the famous *Australopithecus afarensis* skeleton "Lucy" indeed contains a mosaic of traits related to both walking and climbing. Other paleontologists have uncovered remains of a previously unknown human species in South Africa.

Also discussed in Section One, once we came down out of the trees, we lost our hair. Why? It may sound like a dumb question from the back of the classroom, but scientists have asked it and found that a lack of body hair was essential for keeping our primeval bodies cool.

Genetics opens a big window onto our human ancestry. If we share nearly 99 percent of our DNA with chimps, why are we, not them, living in the suburbs and driving cars? How does a small amount of DNA make such a big difference? To find out, biostatistician Katherine S. Pollard and others are figuring out what that 1 percent of DNA is and what it does—her account is in Section Two, “Secrets of our Success.” We also look at how scientists are studying the minuscule bits of DNA that differ from one individual to another for clues to our origins and evolution in Section Three, “Migration and Colonization.”

Human evolution and culture are often intertwined. In one example examined in Section Two, as humans started to live longer, grandparents played a role in family life, which in turn made possible more complex social behaviors.

The more we learn about our own evolution, the more complicated the story becomes. New findings have pushed back the date at which hunter-gatherers colonized the Americas. And in Section Four, “Vanished Humans,” the discovery of “hobbits”—a human species of small stature—has turned the science of human origins on its ear.

Where is evolution taking us? We present two points of view in Section Five, “Our Continuing Evolution.” Jonathan K. Pritchard, professor of human genetics at the University of Chicago, argues that selection pressure typically acts over tens of thousands of years, which means we probably won't evolve much anytime soon. But stasis is only one possible future, says University of Washington astrobiologist Peter Ward. In adapting to new environments—say, a colony on Mars—our human species may eventually diverge into two or more. Or we could go the cyborg route and merge with machines. Whichever option you prefer, there is plenty to ponder.

–Fred Guterl
Executive Editor

SECTION 1

Becoming Us

Lucy's Baby

by Kate Wong

An earlier version of this story was posted on www.ScientificAmerican.com. Readers were invited to send in their comments and questions, and scientists were asked to provide commentaries. That feedback helped to shape the article that follows.

The arid badlands...hunting ground for paleoanthropologists. Many hominins—the group that includes all the creatures in the human line since it branched away from that of the chimps—once called it home. The area is perhaps best known for having yielded "Lucy," the 3.2-million-year-old skeleton of a human ancestor known as *Australopithecus afarensis.* In 2006 researchers unveiled another incredible *A. afarensis* specimen from a site called Dikika, just four kilometers from where Lucy turned up. But unlike Lucy, who was well into adulthood by the time she died, the recently discovered fossil is that of an infant, one who lived 3.3 million years ago (and yet has nonetheless been dubbed "Lucy's baby").

No other hominin skeleton of such antiquity—including Lucy—is as complete as this one. Moreover, as the earliest juvenile hominin ever found, the Dikika child provides an unprecedented opportunity to study growth processes in our ancient relatives. "If Lucy was the greatest fossil discovery of the 20th century," says Donald C. Johanson of Arizona State University, who unearthed the famed fossil in 1974, "then this baby is the greatest find of the 21st thus far."

BUNDLE OF JOY

It was the afternoon of December 10, 2000, when fossil hunters led by Zeresenay Alemseged, now at the California Academy of Sciences in San Francisco, spotted the specimen. Only part of its tiny face was visible;

most of the rest of the skeleton was entombed in a melon-size block of sandstone. But "right away it was clear it was a hominin," Alemseged recollects, noting the smoothness of the brow and the small size of the canine teeth, among other humanlike characteristics. Further evaluation, however, would have to wait until the fossil was cleaned—a painstaking process in which the cementlike matrix is removed from the bone almost grain by grain with dental tools.

It took Alemseged five years to expose key elements of the child's anatomy; he continues to analyze bones revealed since then. Still, the find has already surrendered precious insights into a species that most researchers believe gave rise to our own genus, Homo. Alemseged and his colleagues described the fossil and its geologic and paleontological context in two papers published in 2006 in *Nature*. And at a press conference held in Ethiopia to announce the discovery, they christened the child Selam—"peace" in several Ethiopian languages—in hopes of encouraging harmony among the warring tribes of Afar.

The skeleton, judged to be that of a three-year-old girl, consists of a virtually complete skull, the entire torso, and parts of the arms and legs. Even the kneecaps—which are no larger than macadamia nuts—are preserved. Many of the bones are still in articulation. Hominin fossils this complete are incredibly rare, and ones of infants are rarer still because their bones are that much more fragile. Indeed, the next oldest skeleton of a juvenile that is comparably intact is a Neandertal baby dating to around 50,000 years ago.

WALKING VS. CLIMBING

The exceptional preservation of Selam, as well as that of other animals found at the site, indicates to team geologist Jonathan G. Wynn of the University of South Florida that her body was buried shortly after death by a flood event. Whether she perished in the flood or before it is unknown.

Although she was only three when she died, Selam already possessed the distinctive characteristics of her species. Her projecting snout and narrow nasal bones, for example, readily distinguish her from another ancient youngster, the so-called Taung child from South Africa, who was a member of the closely related *Australopithecus africanus* species. And her lower jaw resembles mandibles from Hadar, the site where Lucy and a number of other *A. afarensis* individuals were found.

Selam also exhibits the same mash-up of traits in her postcranial skeleton that has long irked scientists interested in how *A. afarensis* moved around the landscape. Scholars agree that *A. afarensis* was a creature that got around capably on two legs. But starting in the 1980s, a debate erupted over whether the species was also adapted for life in the trees. The argument centered on the observation that whereas the species has clear adaptations to bipedal walking in its lower body, its upper body contains a number of primitive traits better suited to an arboreal existence, such as long, curved fingers for grasping tree branches. One camp held that *A. afarensis* had made a full transition to terrestrial life and that the tree-friendly features of the upper body were just evolutionary baggage handed down from an arboreal ancestor. The other side contended that if *A. afarensis* had retained those traits for hundreds of thousands of years, then tree climbing must have still formed an important part of its locomotor repertoire.

Like her conspecifics, Selam has legs built for walking and fingers built for climbing. But she also brings new data to the controversy in the form of two shoulder blades, or scapulae—bones previously unknown for this species. According to Alemseged, her scapulae look most like those of a gorilla. The upward-facing shoulder socket is particularly apelike, contrasting sharply with the laterally facing socket modern humans have. This orientation, Alemseged points out, may have facilitated raising the hands above the head—something primates do when they climb. (Although gorillas do not climb as adults, they do spend time in the trees as youngsters.)

Further hints of arboreal tendencies reside in the baby's inner ear. Using computed tomographic imaging, the team was able to glimpse her semicircular canal system, which is important for maintaining balance. The researchers determined that Selam's semicircular canals are similar to those of African apes and A. africanus. This, they suggest, could indicate that *A. afarensis* was not as fast and agile on two legs as we modern humans are. It could also mean that *A. afarensis* was limited in its ability to decouple the movements of its head and torso, a feat that seems to play a key role in endurance running in our own species.

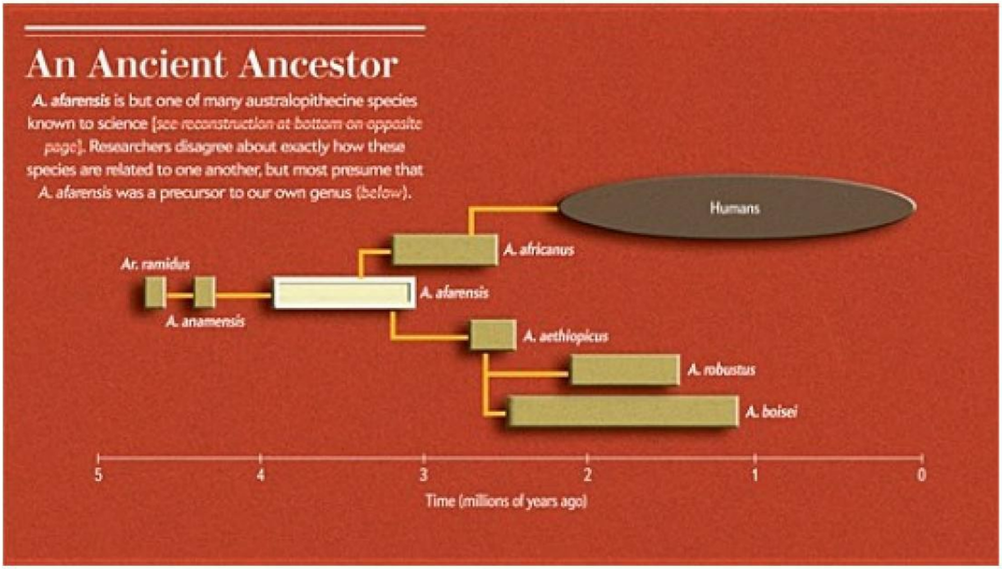
The conclusion that *A. afarensis* was a bipedal creature with an upper body at least partly adapted for life in the trees echoes what Jack T. Stern, Jr., of Stony Brook University and his colleagues wrote years ago in their reports on Lucy and her contemporaries. “I was happy to see that this paper suggests I might have been right,” Stern comments. Johanson agrees that the case for a partly arboreal *A. afarensis* is stronger than it once was. “Early on I was a staunch advocate of strict terrestrial bipedalism in afarensis,” he remarks. But taking more recent findings into consideration, Johanson says, “it’s not out of the realm of possibility that they were still exploiting some of the arboreal habitats for getting off the ground at night and sleeping up there or going back to familiar food sources.”

A combination of walking and climbing would fit neatly with the picture that is emerging from studies of the environments of early hominins, including Selam. Today Dikika is an expanse of dusty hills dotted with only the occasional tree or shrub. But 3.3 million years ago, it was a well-watered delta flanked by forests, with some grasslands nearby. “In this context, it is not surprising to have an ‘ape’ that spends time in the trees and on the ground,” comments project member René Bobe, now at George Washington University.

Not everyone is persuaded by the arboreal argument. C. Owen Lovejoy of Kent State University disputes the claim that Selam’s scapula looks like a gorilla’s. “It’s primitive, but it’s really more humanlike than gorillalike,” he remarks. Lovejoy, a leading proponent of the idea that *A. afarensis* was a dedicated biped, maintains that the forelimb features that are typically held up as indicators that *A. afarensis* spent time in the trees only provide “evidence that the animal has an arboreal history.” The discovery of the famed Laetoli footprints in 1978 closed the debate, he states. The trail did not show a prehensile big toe, without which, Lovejoy says, *A. afarensis* simply could not move about effectively in the trees.

An Ancient Ancestor

A. afarensis is but one of the many australopithecine species known to science. Researchers disagree about exactly how these species are related to one another, but most presume *A. afarensis* was a precursor to our own genus.



Credit: Melissa Thomas

A HODGEPODGE HOMININ

Experts may disagree over the functional significance of Selam's apelike skeletal characteristics, but they concur that different parts of the hominin body were undergoing selection at different times. *A. afarensis* is "a good example of mosaic evolution," Johanson states. "You don't just magically flip some evolutionary switch somewhere and transmute a quadruped into an upright-walking bipedal human." It looks like natural selection is selecting for bipedalism in the lower limbs and pelvis first, and things that are not really used in bipedal locomotion, such as arms and shoulders, change at a later stage, he says. "We're getting to know more and more about the sequence of changes" that produced a terrestrial biped from a tree-dwelling, apelike creature.

Analysis of Selam's skull hints at a similarly piecemeal metamorphosis. The shape of the hyoid—a delicate, rarely preserved bone that helps to anchor the tongue and the voice box—indicates that *A. afarensis* had air sacs in its throat, suggesting the species possessed an apelike voice box. Conversely, the child's brain shows a subtle sign of humanity. By studying the fossil's natural sandstone endocast, an impression of the braincase, Alemseged's team ascertained that Selam had attained only 65 to 88 percent of the adult brain size by the age of three. A chimp of comparable age, in contrast, has reached more than 90 percent of its adult brain size. This raises the tantalizing possibility that *A. afarensis* experienced a more humanlike pattern of brain growth.

More fossils are needed to discern whether the new skeleton is representative of *A. afarensis* infants, and scientists are doubtless eager to recover remains of other *A. afarensis* children of different ages—if they ever can—to see how they compare. But the little girl from Dikika still has more secrets to spill. "I think the impact of this specimen will be in its information of the growth and development of *Australopithecus*, not only for individual body parts but for rates of development among structures within one individual," observes Carol V. Ward of the University of Missouri–Columbia.

Since the initial description of Selam, continued removal of the sandstone adhering to her remains has exposed all of the bones to some extent. Alemseged expects that he will eventually be able to reconstruct nearly the entire body of an *A. afarensis* three-year-old—and begin to understand what growing up australopithecine was all about.

What Readers Wanted to Know

In an earlier version of this article, posted on our Web site, we invited readers to submit any questions they had about Selam. Kate Wong answered their questions in the blog. An edited selection of those exchanges follows.

How was Selam's age at death assessed? —Stephen

A: Selam's age was estimated based on her apparent stage of dental development. Using comparable data from African apes, the researchers judged her to be about three years old when she died. But *Australopithecus afarensis* no doubt had a developmental schedule that differed from that of chimps and gorillas, so this is only an educated guess.

How was sex determined? —Debra Martin

A: The skeleton is believed to be that of a female based on computed tomographic measurements of the fully formed permanent tooth crowns still embedded in the jaws. When compared with measurements of teeth from *A. afarensis* individuals from the sites of Hadar, Laetoli and Maka, the Dikika child's teeth grouped closely with those of confirmed females.

What is the uncertainty of the measurement of the age of a fossil like Selam? What technology is used? —Juan Moreira

A: Diana C. Roman of the University of South Florida dated the fossil by ascertaining the ages of the layers of volcanic ash around Selam. One layer was deposited before the child died; the other was deposited some time after she died. By interpolating the position of the fossil relative to those two layers, Roman determined that the fossil was between 3.31 million and 3.35 million years old—an uncertainty of 40,000 years.

What's the big deal? We know that our ancestors had to come down out of the trees sometime. Kids nowadays have a predilection for climbing trees, too. (Maybe an unconscious link to an arboreal past?) —Matthew T.

A: The question is to what extent *A. afarensis* was adapted for terrestriality. No one is suggesting that *A. afarensis* could not get up into a tree under any circum-stances—as you correctly point out, humans can still do that—the debate is over whether it was adapted to do so. It's a big deal because bipedalism is a hallmark of human evolution, so paleoanthropologists are eager to understand the details of how it emerged.

Are there any plant or animal fossils associated with *A. afarensis* finds that would indicate what kind of environment they lived in? —Traveler

A: The animal fossils found at Dikika indicate that the child inhabited a moist, mosaic en-vironment composed of wood-lands and grasslands, with per-manent water nearby. This is very similar to the environment in which Lucy and other repres-entatives of *A. afarensis* lived.

What does the animal have to gain from being able to engage in endurance running? —Donald McMiken

A: Endurance running has been hypothesized to have given early humans a leg up (if you will) in hunting or scavenging, by allowing them to wear the prey out or reach the carcass faster, respectively.

What Experts Said

We polled the experts for their thoughts on the discovery of Selam shortly after the find was announced. Their views are encapsulated here.

John Hawks of the University of Wisconsin–Madison wondered whether Selam spells the end of a hotly contested hominin genus. In 2001 paleoanthropologists announced that they had found a fairly complete skull and some jaws and teeth at a site called Lomekwi in Kenya. They assigned the 3.5-million-year-old remains to a new genus of hominin, *Kenyanthropus*. Skeptics counter that the fossils are instead a regional variant of *A. afarensis*. It is an obvious sample with which to compare Selam. But oddly enough, no mention of *Kenyanthropus* appears in the formal description of the child.

Ralph L. Holloway of Columbia University hoped that the brain endocast would show enough details in the so-called Broca's regions and the occipital region to reveal a posterior placement of the lunate sulcus, a curved depression in the brain's surface. This would indicate a definite reorganizational pattern of the cerebral cortex toward a more humanlike rather than chimplike or gorillalike pattern.

C. Owen Lovejoy of Kent State University made the case that rather than reopening the debate over whether *A. afarensis* was a dedicated biped or whether it also spent some time in the trees, the Dikika child firmly closes it in favor of the species being strictly bipedal. Although the shoulder blade bears some resemblances to the gorilla shoulder blade, it actually shows some striking similarities with the human shoulder blade.

Also, the fact that the youngster already had curved fingers at age three suggests that this is an inherited, primitive characteristic—as opposed to the individual having developed curved fingers as a result of grasping tree branches, which is what the arborealists envision.

René Bobe of George Washington University observed that one of the many important aspects of this fossil is that its geologic and paleontological context can be studied in detail. Dikika reveals hominin adaptations and environments that existed just before major climatic changes led to the ice ages, before *Homo* made its first appearance in the fossil record and before the earliest known stone tools. In Selam's day, Dikika was largely a lush, forested place. But by the time *Homo erectus* emerged, a little less than two million years ago, grasslands were much more prominent.

William E. H. Harcourt-Smith of the American Museum of Natural History in New York City argued that features of Selam's upper limbs and inner ear are strong evidence that *A. afarensis* was partly arboreal. It will be very interesting, he said, to see whether analyses of her foot reveal that she was able to move her big toe so as to grasp branches. In his view, the first obligate bipeds were early members of our own genus, *Homo*.

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First of Our Kind

by Kate Wong

Sometime between three million and two million years ago, perhaps on a primeval sa vanna in Africa, our ancestors became recognizably human. For more than a million years their australopithecine predecessors—Lucy and her kind, who walked upright like us yet still possessed the stubby legs, tree-climbing hands and small brains of their ape fore bearers—had thrived in and around the continent's forests and woodlands. But their world was changing. Shifting climate favored the spread of open grasslands, and the early australopithecines gave rise to new lineages. One of these offshoots evolved long legs, toolmaking hands and an enormous brain. This was our genus, *Homo*, the primate that would rule the planet.

For decades paleoanthropologists have combed remote corners of Africa on hand and knee for fossils of *Homo's* earliest representatives, seeking to understand the details of how our genus rose to prominence. Their e.orts have brought only modest gains—a jawbone here, a handful of teeth there. Most of the recovered fossils instead belong to either ancestral australopithecines or later members of *Homo*—creatures too advanced to illuminate the order in which our distinctive traits arose or the selective pressures that fostered their emergence. Specimens older than two million years with multiple skeletal elements preserved that could reveal how the *Homo* body plan came together eluded discovery. Scientists' best guess is that the transition occurred in East Africa, where the oldest fossils attributed to *Homo* have turned up, and that *Homo's* hallmark characteristics allowed it to incorporate more meat into its diet—a rich source of calories in an environment where fruits and nuts had become scarce. But with so little evidence to go on, the origin of our genus has remained as mysterious as ever.

Lee Berger thinks he has found a big piece of the puzzle. A paleoanthropologist at the University of the Witwatersrand in Johannesburg, South Africa, he recently discovered a trove of fossils that he and his team believe could revolutionize researchers' understanding of *Homo's* roots. In the white-walled confines of room 210 at the university's Institute for Human Evolution, he watches as Bernard Wood of George Washington University paces in front of the four plastic cases that have been removed from their fireproof safe and placed on a table clothed in royal blue velvet. The foam-lined cases are open, revealing the nearly two-million-year-old fossils inside. One holds pelvis and leg bones. Another contains ribs and vertebrae. A third displays arm bones and a clavicle. And a fourth houses a skull. On a counter opposite the table, more cases hold a second partial skeleton, including a nearly complete hand.

Wood, a highly influential figure in the field, pauses in front of the skull and leans in for a closer look. He strokes his beard as he considers the dainty teeth, the grapefruit-size braincase. Straightening back up, he shakes his head. "I'm not often at a loss for words," he says slowly, "but wow. Just wow."

Berger grins. He has seen this reaction before. Since he unveiled the finds in 2010, scientists from all over the world have been flocking to his lab to gawk at the breathtaking fossils. Based on the unique anatomical package the skeletons present, Berger and his team assigned the remains to a new species, *Australopithecus sediba*. They furthermore propose that the combination of primitive *Australopithecus* traits and advanced *Homo* traits evident in the bones qualifies the species for a privileged place on the family tree: as the ancestor of *Homo*. The stakes are high. If Berger is right, paleoanthropologists will have to completely rethink where, when and how *Homo* got its start—and what it means to be human in the first place.

THE ROAD NOT TAKEN

In the middle of the rock-strewn dirt road that winds through the John Nash Nature Reserve, Berger brings the Jeep to a halt and points to a smaller road that branches right. For 17 years he had made the 40-kilometer trip northwest from Johannesburg to the 9,000-hectare parcel of privately owned wilderness and driven past this turno), continuing along the main road, past the resident gira)es and warthogs and wildebeests, to a cave he was excavating just a few kilometers away called Gladysvale. In 1948 American paleontologists Frank Peabody and Charles Camp came to this area to look for fossils of hominins (modern humans and their extinct relatives) on the advice of famed South African paleontologist Robert Broom, who had found such fossils in the caves of Sterkfontein and Swartkrans, eight kilometers away. Peabody suspected that Broom had intentionally sent them on a wild goose chase, so unimpressed was he with the sites here. Little did Berger or the expeditioners before him know that had they only followed this smaller path—one of several miners' tracks used in the early 1900s to cart the limestone that built Johannesburg from quarries out to the main road—they would have made the discovery of a lifetime.

Berger, now 46 years old, never imagined he would find something like *A. sediba*. Although he thought *Homo* might have had roots in South Africa instead of East Africa, he knew the odds of making a big find were slim. Hominin fossils are extremely rare, so "you don't have any expectations," he reflects. What is more, he was focused on the so-called Cradle of Humankind, an already intensively explored region whose caves had long been yielding australopithecines generally considered to be more distantly related to *Homo* than the East African australopithecines seemed to be. And so Berger continued to toil at Gladysvale day after day, year after year. Because he found little in the way of hominins among the millions of animal fossils there, he busied himself with another goal: dating the site. A critical problem with interpreting the South African hominin fossils was that scientists had not yet figured out how to reliably determine how old they were. In East Africa, hominin fossils come from sediments sandwiched between layers of volcanic ash that blanketed the landscape during long-ago eruptions. Geologists can ascertain how old an ash layer is by analyzing its chemical "fingerprint." A fossil that originates from a layer of sediment that sits in between two volcanic ashes is thus intermediate in age between those two ashes. The cave sites in the Cradle of Humankind lack volcanic ashes, but through his 17 years of trial and error at Gladysvale, Berger and his colleagues hit on techniques that circumvented the problem.

Those techniques would soon come in very handy. On August 1, 2008, while surveying the reserve for potential new fossil sites in the area that he had identified using Google Earth, Berger turned right on the miners' track he had passed by for 17 years and followed it to a three- by four-meter hole in the ground blasted by the miners. Eyeballing the site, he found a handful of animal fossils—enough to warrant a trip back for a closer look. He returned on August 15 with his then nine-yearold son, Matthew, and dog, Tau. Matthew took off into the bush after Tau, and within minutes he shouted to his father that he had found a fossil. Berger doubted it was anything important—probably just an antelope bone—but in a show of fatherly support, he made his way over to inspect the find. There, protruding from a dark hunk of rock nestled in the tall grass by the corpse of a lightning-struck tree, was the tip of a collarbone.

As soon as Berger laid eyes on it, he knew it belonged to a hominin. In the months that followed he found more of the clavicle's owner, along with another partial skeleton, 20 meters away in the miners' pit. To date, Berger and his team have recovered more than 220 bones of *A. sediba* from the site—more than all the known early *Homo* bones combined. He christened the site Malapa, meaning "homestead" in the local Sesotho language. Using the approaches honed at Gladysvale, the geologists on Berger's team would later date the remains with remarkable precision to 1.977 million years ago, give or take 2,000 years.

A PATCHWORK PREDECESSOR

That the Malapa fossils include so many body parts is important because it means they can offer unique insights into the order in which key *Homo* traits appeared. And what they show very clearly is that quintessentially human features did not necessarily evolve as a package deal, as was thought. Take the pelvis and the brain, for example. Conventional wisdom holds that the broad, flat pelvis of australopithecines evolved into the bowlshaped pelvis seen in the bigger-brained *Homo* to allow delivery of babies with larger heads. Yet *A. sediba* has a *Homo*-like pelvis with a broad birth canal in conjunction with a teeny brain—just 420 cubic centimeters, a third of the size of our own brain. This combination shows brain expansion was not driving the metamorphosis of the pelvis in *A. sediba*'s lineage.

Not only do the *A. sediba* fossils mingle old and new versions of general features, such as brain size and pelvis shape, but the pattern repeats at deeper levels, like an evolutionary fractal.

Analysis of the interior of the young male's braincase shows that the brain, while small, possessed an expanded frontal region, indicating an advanced reorganization of gray matter; the adult female's upper limb pairs a long arm—a primitive holdover from a tree-dwelling ancestor—with short, straight fingers adapted to making and using tools (although the muscle markings on the bones attest to powerful, apelike grasping capabilities). In some instances, the juxtaposition of old and new is so improbable that had the bones not been found joined together, researchers would have interpreted them as belonging to entirely different creatures. The foot, for instance, combines a heel bone like an ancient ape's with an anklebone like *Homo's*, according to Malapa team member Bernard Zipfel of the University of the Witwatersrand. It is as if evolution was playing Mr. Potato Head, as Berger puts it.

The extreme mosaicism evident in *A. sediba*, Berger says, should be a lesson to paleoanthropologists. Had he found any number of its bones in isolation, he would have classified them differently. Based on the pelvis, he could have called it *Homo erectus*. The arm alone suggests an ape. The anklebone is a match for a modern human's. And like the blind men studying the individual parts of the elephant, he would have been wrong. "*Sediba* shows that one can no longer assign isolated bones to a genus," Berger asserts. That means, in his view, finds such as a 2.3-million-year-old upper jaw from Hadar, Ethiopia, that has been held up as the earliest trace of *Homo* cannot safely be assumed to have belonged to the *Homo* line.

Taking that jaw out of the running would make *A. sediba* older than any of the well-dated *Homo* fossils but still younger than *A. afarensis*, putting it in pole position for the immediate ancestor of the genus, Berger's team contends. Furthermore, considering *A. sediba*'s advanced features, the researchers propose that it could be specifically ancestral to *H. erectus* (a portion of which is considered by some to be a different species called *Homo ergaster*). Thus, instead of the traditional view in which *A. afarensis* begat *Homo habilis*, which begat *H. erectus*, he submits that *Australopithecus africanus* is the likely ancestor of *A. sediba*, which spawned *H. erectus*.

If so, that arrangement would relegate *H. habilis* to a dead-end side branch of the human family tree. It might even kick *A. afarensis*—long considered the ancestor of all later hominins, including *A. africanus* and *Homo*—to the evolutionary curb, too. Berger points out that *A. sediba*'s heel is more primitive than that of *A. afarensis*, indicating that *A. sediba* either underwent an evolutionary reversal toward a more primitive heel or that it descended from a different lineage than the one that includes *A. afarensis* and *A. africanus*—one that has yet to be discovered.

"In the South, we have a saying: 'You dance with the girl you brought,'" quips Berger, who grew up on a farm in Sylvania, Ga. "And that is what paleoanthropologists have been doing" in trying to piece together the origin of *Homo* from the fossils that have turned up in East Africa. "Now we have to recognize there is more potential out there," he states. Maybe the East Side story of human origins is wrong. The traditional view of South Africa's oldest hominin fossils is that they represent a separate evolutionary experiment that ultimately fizzled out. *A. sediba* could turn the tables and reveal, in South Africa, another lineage, the one that ultimately gave rise to humankind as we know it (indeed, *sediba* is the Sesotho word for "fountain" or "wellspring").

William Kimbel of Arizona State University, who led the team that found the 2.3-million-year-old jawbone in Ethiopia, is having none of it. The idea that one needs a skeleton to classify a specimen is a "nonsensical argument," he retorts. The key is to find pieces of anatomy that contain diagnostic traits, he says, and the Hadar jaw has features clearly linking it to *Homo*, such as the parabolic shape formed by its tooth rows. Kimbel, who has seen the Malapa fossils but not studied them in depth, finds their *Homo*-like traits intriguing, although he is not sure what to make of them. He scoffs at the suggestion that they are directly ancestral to *H. erectus*, however. “I don’t see how a taxon with a few characteristics that look like *Homo* in South Africa can be the ancestor [of *Homo*] when there’s something in East Africa that is clearly *Homo* 300,000 years earlier,” he declares, referring to the jaw.

Kimbel is not alone in rejecting the argument for *A. sediba* as the rootstock of *Homo*. “There are too many things that do not fit, particularly the dates and geography,” comments Meave Leakey of the Turkana Basin Institute in Kenya, whose own research has focused on fossils from East Africa. “It is much more likely that the South African hominins are a separate radiation that took place in the south of the continent.”

René Bobe of George Washington University says that if the *A. sediba* remains were older—say, around 2.5 million years old—they might make for a plausible *Homo* ancestor. But at 1.977 million years old, they are just too primitive in their overall form to be ancestral to fossils from Kenya’s Lake Turkana region that are just a tad younger yet have many more indisputable *Homo* traits. Berger counters that *A. sediba* almost certainly existed as a species before the Malapa individuals. Bobe and others maintain that such information is not currently known. “Paleoanthropologists tend to think of the fossils they find as being in a key position within the [hominin] phylogenetic tree, and in many cases that’s unlikely to be the situation,” Bobe observes. From a statistical standpoint, “if you have [hominin] populations distributed across Africa, evolving in complex ways, why would the one you find be the ancestor?"

Berger has found a sympathetic ear in Wood, who says Berger is "absolutely right" that *A. sediba* demonstrates that isolated bones do not predict what the rest of the animal looks like. *A. sediba* shows that the combinations of traits evident from previous fossil discoveries do not exhaust the possibilities, Wood remarks. But he does not endorse the suggestion that *A. sediba* is the ancestor of *Homo*. "There are not many characters linking it to *Homo*," he notes, and *A. sediba* may have evolved those traits independently from the *Homo* lineage. "I just think *sediba* has got too much to do in order to evolve into [erectus]," Wood says.

Resolution of the issue of where *A. sediba* belongs in our family tree is hampered by the lack of a clear definition of the genus *Homo*. Coming up with one, however, is a taller order than it might seem. With so few specimens from the transition period, and most of them being scraps, identifying those features that first distinguished *Homo* from its australopithecine forebearers—those traits that made us truly human—has proved challenging. The skeletons from Malapa expose just how vexing the situation is: they are so much more complete than any early *Homo* specimen that it is very difficult to compare them with anything. "Sediba may force us to come up with a definition," Berger says.

ALL IN THE DETAILS

Whatever the position of the Malapa fossils in the family tree, they are poised to provide researchers with the most detailed portrait yet of an early hominin species, in part because they make up multiple individuals. In addition to the juvenile male and the adult female, the two most complete specimens, Berger's team has collected bones representing another four individuals, including a baby. Populations are incredibly rare in the human fossil record, and the individuals at Malapa have the added benefit of peerless preservation. Hominin bones that virtually never survive the ravages of deep time have turned up here: a paper-thin shoulder blade, the delicate sliver that is the first rib, pea-size finger bones, vertebrae with spiny projections intact. And a number of bones that were previously known only from fragments are complete.

Before the discovery of Malapa, paleoanthropologists did not have a single complete arm from an early hominin, meaning that the limb lengths that are used to reconstruct such essential behaviors as locomotion are estimates. Even Lucy—the most complete hominin of such antiquity back when she was found in 1974— is missing significant chunks of her arm and leg bones. In the adult female from Malapa, in contrast, virtually the entire upper limb is preserved—from shoulder blade to hand. Only the very last digits of some of her fingers and some wristbones are missing, and Berger expects to find those—and the rest of the bones of both skeletons—when he begins systematically excavating the site. (Thus far the team has collected only bones visible from the surface.) In fact, some of the missing bones of the young male may have already turned up. In July, Berger announced that CT scanning of a large rock from the site revealed a number of bones inside, including parts of a lower jaw and possibly a complete femur. Together the Malapa fossils will enable researchers to reconstruct how *A. sediba* matured, how it moved around the landscape, and how members of the population differed from one another.

It is not only the bones that promise to furnish vital clues to our newfound relative's way of life. Malapa has also yielded some other materials that could literally flesh out researchers' understanding of *A. sediba*. Paleontologists have long thought that during the fossilization process, all of an organism's organic components—such as skin, hair, organs, and so forth—are lost to