early hominid fossils from AFRICA

The year was 1965.

Bryan Patterson, a paleoanthropologist from Harvard University, unearthed a fragment of a fossil arm bone at a site called Kanapoi in northern Kenya. He and his colleagues knew it would be hard to make a great deal of anatomical or evolutionary sense out of a small piece of elbow joint. Nevertheless, they did recognize some features reminiscent of a species of early hominid (a hominid is any upright-walking primate) known as *Australopithecus*, first discovered 40 years earlier in South Africa by Raymond Dart of the University of the Witwatersrand. In most details, however, Patterson and his team considered the fragment of arm bone to be more like those of modern humans than the one other *Australopithecus* humerus known at the time.

And yet the age of the Kanapoi fossil proved somewhat surprising. Although the techniques for dating the rocks where the fossil was uncovered were still fairly rudimentary, the group working in Kenya was able to show that the bone was probably older than the various *Australopithecus* specimens that had previously been found. Despite this unusual result, however, the significance of Patterson's discovery was not to be confirmed for another 30 years. In the interim, researchers identified the remains of so many important early hominids that the humerus from Kanapoi was rather forgotten.

AUSTRALOPITHECUS ANAMENSIS (*right*) lived roughly four million years ago. Only a few *anamensis* fossils have been found—the ones shown at the left include a jawbone and part of the front of the face (*left*), parts of an arm bone (*center*) and fragments of a lower leg bone (*right*)—and thus researchers cannot determine much about the species' physical appearance. But scientists have established that *anamensis* walked upright, making it the earliest bipedal creature yet to be discovered.

MATT MAHURIN (*illustration*); ROBERT CAMPBELL (*left*); ALAN WALKER; © NATIONAL MUSEUMS OF KENYA (*center* and *right*)

Yet Patterson's fossil would eventually help establish the existence of a new species of *Australopithecus*—the oldest yet to be identified—and push back the origins of upright walking to more than four million years ago. But to see how this happened, we need to trace the steps that paleoanthropologists have taken in constructing an outline for the story of hominid evolution.

An Evolving Story

SCIENTISTS CLASSIFY the immediate ancestors of the genus *Homo* (which includes our own species, *Homo sapiens*) in the genus *Australopithecus*. For several decades it was believed that these ancient hominids first inhabited the earth at least three and a half million years ago. The specimens found in South Africa by Dart and others indicated that there were at least two types of *Australopithecus*—*A. africanus* and *A. robustus*. The leg bones of both species suggested that they had the striding, bipedal locomotion that is a hallmark of humans among living mammals. (The upright posture of these creatures was vividly confirmed in 1978 at the Laetoli site in Tanzania, where a team led by archaeologist Mary Leakey discovered a spectacular series of footprints made 3.6 million years ago by three *Australopithecus* individuals as they walked across wet volcanic ash.) Both *A. africanus* and *A. robustus* were relatively small-brained and had canine teeth that differed from

Updated from the June 1997 issue

A new species of *Australopithecus*, the ancestor of *Homo*, pushes back the origins of bipedalism to some four million years ago

By Meave Leakey and Alan Walker

those of modern apes in that they hardly projected past the rest of the tooth row. The younger of the two species, *A. robustus*, had bizarre adaptations for chewing—huge molar and premolar teeth combined with bony crests on the skull where powerful chewing muscles would have been attached.

Paleoanthropologists identified more species of *Australopithecus* over the next several decades. In 1959 Mary Leakey unearthed a skull from yet another East African species closely related to *robustus*. Skulls of these species uncovered during the past 45 years in the northeastern part of Africa, in Ethiopia and Kenya, differed considerably from those found in South Africa; as a result, researchers think that two separate *robustus*-like species—a northern one and a southern one—existed.

In 1978 Donald C. Johanson, now at the Institute of Human Origins at Arizona State University, along with his colleagues, identified still another species of *Australopithecus*. Johanson and his team had been studying a small number of hominid bones and teeth discovered at Laetoli, as well as a large and very important collection of specimens from the Hadar region of Ethiopia (including the famous "Lucy" skeleton). The group named the new species *afarensis*. Radiometric dating revealed that the species had lived between 3.6 and 2.9 million years ago, making it the oldest *Australopithecus* known at the time.

This early species is probably the best studied of all the *Australopithecus* recognized so far, and it is certainly the one that has generated the most controversy over the past 30 years. The debates have ranged over many issues: whether the *afarensis* fossils were truly distinct from the *africanus* fossils from South Africa; whether there was one or several species at Hadar; whether the Tanzanian and Ethiopian fossils were of the same species; and whether the fossils had been dated correctly.

But the most divisive debate concerns the issue of how extensively the bipedal *afarensis* climbed in trees. Fossils of *afarensis* include various bone and

joint structures typical of tree climbers. Some scientists argue that such characteristics indicate that these hominids must have spent at least some time in the trees. But others view these features as simply evolutionary baggage, left over from arboreal ancestors. Underlying this discussion is the question of where *Australopithecus* lived—in forests or on the open savanna.

By the beginning of the 1990s, researchers knew a fair amount about the various species of *Australopithecus* and how each had adapted to its environmental niche. A description of any one of the species would mention that the creatures were bipedal and that they had apesize brains and large, thickly enameled teeth in strong jaws, with nonprojecting canines. Males were typically larger than females, and individuals grew and matured rapidly. But the origins of *Australopithecus* were only hinted at, because the gap between the earliest well-known species in the group (*afarensis,* from about 3.6 million years ago) and the postulated time of the last common ancestor of chimpanzees and humans (about six million years ago, according to molecular evidence) was still very great. Fossil hunters had unearthed only a few older fragments of bone, tooth and jaw from the intervening 1.5 million years to indicate the anatomy and course of evolution of the earliest hominids.

Filling the Gap

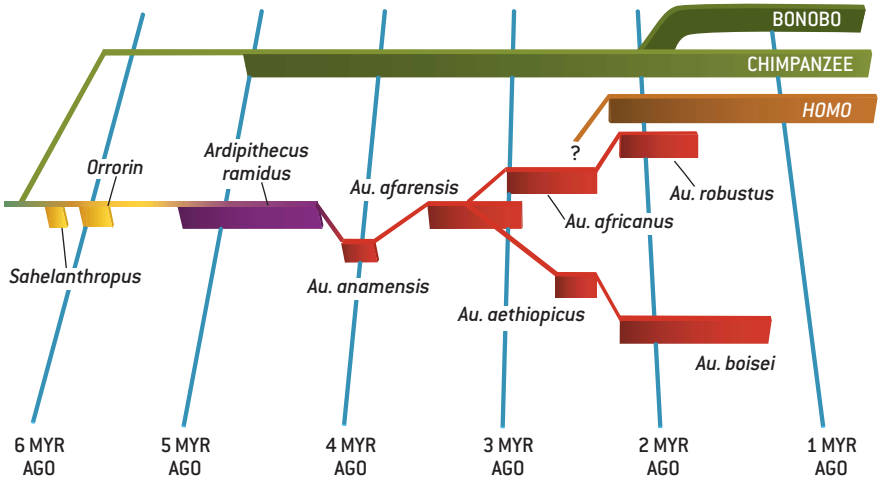
DISCOVERIES IN KENYA over the past several years have filled in some of the missing interval between 3.5 million and 5 million years ago. Beginning in 1982, expeditions run by the National Museums of Kenya to the Lake Turkana basin in northern Kenya began finding hominid fossils nearly four million years old. But because these fossils were mainly isolated teeth—no jawbones or skulls were preserved—very little could be said about them except that they resembled the remains of *afarensis* from Laetoli. But our excavations at an unusual site, just inland from Allia Bay on the east side of Lake Turkana [*see maps on page 18*], yielded more complete fossils.

The site at Allia Bay is a bone bed, where millions of fragments of weathered tooth and bone from a wide variety of animals, including hominids, spill out of the hillside. Exposed at the top of the hill lies a layer of hardened volcanic ash called the Moiti Tuff, which has been dated radiometrically to just over 3.9 million years old. The fossil fragments lie several meters below the tuff, indicating that the remains are older than the tuff. We do not yet understand fully why so many fossils are concentrated in this spot, but we can be certain that they were deposited by the precursor of the present-day Omo River.

Today the Omo drains the Ethiopian highlands located to the north, emptying into Lake Turkana, which has no outlet. But this has not always been so. Our colleagues Frank Brown of the University of Utah and Craig Feibel of Rutgers University have shown that the ancient Omo River dominated the Turkana area for much of the Pliocene (roughly 5.3 to 1.8 million years ago) and the early Pleistocene (1.8 to 0.7 million years ago). Only infrequently was a lake present in the area at all. Instead, for most of the past four million years, an extensive river system flowed across the broad floodplain, proceeding to the Indian Ocean without dumping its sediments into a lake.

The Allia Bay fossils are located in one of the channels of this ancient river system. Most of the fossils collected from Allia Bay are rolled and weathered bones and teeth of aquatic animals—fish, crocodiles, hippopotamuses and the like—that were damaged during transport down the river from some distance away. But some of the fossils are much better preserved; these come from the animals that lived on or near the riverbanks. Among these creatures are several different species of leaf-eating monkeys, related to modern colobus monkeys, as well as antelopes whose living relatives favor closely wooded areas. Reasonably well preserved hominid fossils can also be found here, suggesting that, at least occasionally, early hominids inhabited a riparian habitat.

Where do these *Australopithecus* fossils fit in the evolutionary history of hominids? The jaws and teeth from Allia Bay, as well as a nearly complete radius (the outside bone of the forearm) from the nearby sediments of Sibilot just

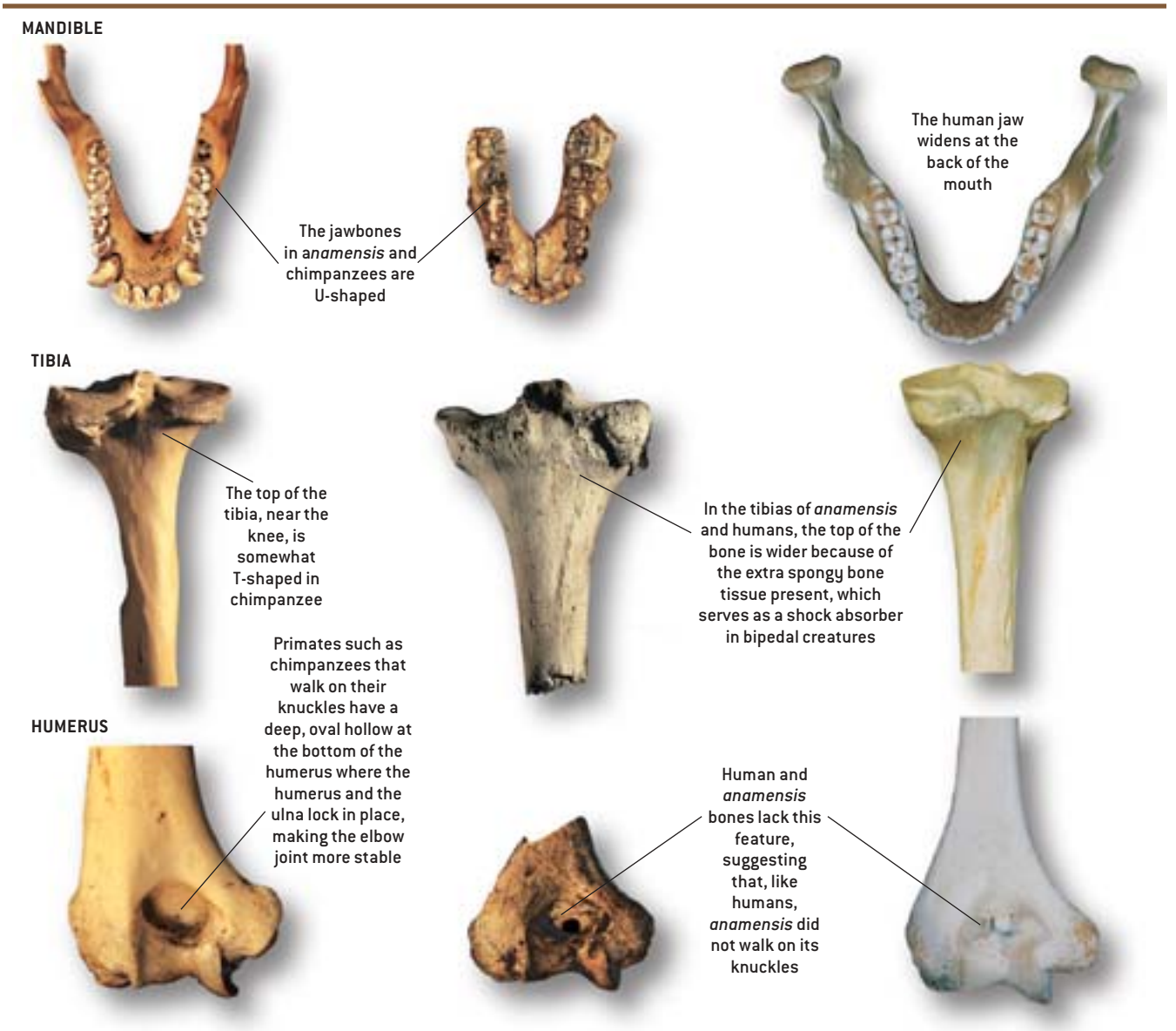


FAMILY TREE of the hominid *Australopithecus* (*red*) includes a number of species that lived between roughly 4 million and 1.25 million years (Myr) ago. Just over 2 Myr ago a new genus, *Homo* (which includes our own species, *H. sapiens*), evolved from one of the species of *Australopithecus*.

THE AUTHORS

MEAVE LEAKEY and *ALAN WALKER,* together with Leakey's husband, Richard, have collaborated for many years on the discovery and analysis of early hominid fossils from Kenya. Meave Leakey is a researcher and former head of the division of paleontology at the National Museums of Kenya in Nairobi. Walker is Evan Pugh Professor of Anthropology and Biology at Pennsylvania State University. He is a MacArthur Fellow and a member of the American Academy of Arts and Sciences.

SLIM FILMS



FOSSILS from *anamensis* (*center*) share a number of features in common with both humans (*right*) and modern chimpanzees (*left*). Scientists use the similarities and differences among these species to determine their interrelationships and thereby piece together the course of hominid evolution since the lineages of chimpanzees and humans split some five or six million years ago.

ALAN WALKER; © NATIONAL MUSEUMS OF KENYA (*chimpanzee and anamensis*); VIDEO SURGERY *Photo Researchers, Inc.* (*human*)

to the north, show an interesting mixture of characteristics. Some of the traits are primitive ones—that is, they are ancestral features thought to be present before the split occurred between the chimpanzee and human lineages. Yet these bones also share characteristics seen in later hominids and are therefore said to have more advanced features. As our team continues to unearth more bones and teeth at Allia Bay, these new fossils add to our knowledge of the wide range of traits present in early hominids.

Across Lake Turkana, some 145 kilometers (about 90 miles) south of Allia Bay, lies the site of Kanapoi, where our story began. One of us (Leakey) has mounted expeditions from the National Museums of Kenya to explore the sediments located southwest of Lake Turkana and to document the faunas present during the earliest stages of the basin's history. Kanapoi, virtually unexplored since Patterson's day, has proved to be one of the most rewarding sites in the Turkana region.

A series of deep erosion gullies, known as badlands, has exposed the sediments at Kanapoi. Fossil hunting is difficult here, though, because of a carapace of lava pebbles and gravel that makes it hard to spot small bones and teeth. Studies of the layers of sediment, also carried out by Feibel, reveal that the fossils here have been preserved by deposits from a river ancestral to the present-day Kerio River, which once flowed into the Turkana basin and emptied into an ancient lake that we call Lonyumun. This lake reached its maximum size about 4.1 million years ago and thereafter shrank as it filled with sediments.

Excavations at Kanapoi have primarily yielded the remains of carnivore meals, so the fossils are rather fragmentary. But workers at the site have also recovered two nearly complete lower jaws, one complete upper jaw and lower face,

the upper and lower thirds of a tibia, bits of skull and several sets of isolated teeth. After careful study of the fossils from both Allia Bay and Kanapoi—including Patterson's fragment of an arm bone—we felt that in details of anatomy, these specimens were different enough from previously known hominids to warrant designating a new species. So in 1995, in collaboration with both Feibel and Ian McDougall of the Australian National University, we named this new species *Australopithecus anamensis,* drawing on the Turkana word for "lake" (*anam*) to refer to both the present and ancient lakes.

To establish the age of these fossils, we relied on the extensive efforts of Brown, Feibel and McDougall, who have been investigating the paleogeographic history of the entire lake basin. If their study of the basin's development is correct, the *anamensis* fossils should be between 4.2 and 3.9 million years old. McDougall has determined the age of the so-called Kanapoi Tuff—the layer of volcanic ash that covers most of the fossils at this site—to be just over four million years old. Now that he has successfully ascertained the age of the tuff, we are confident in both the age of the fossils and Brown's and Feibel's understanding of the history of the lake basin.

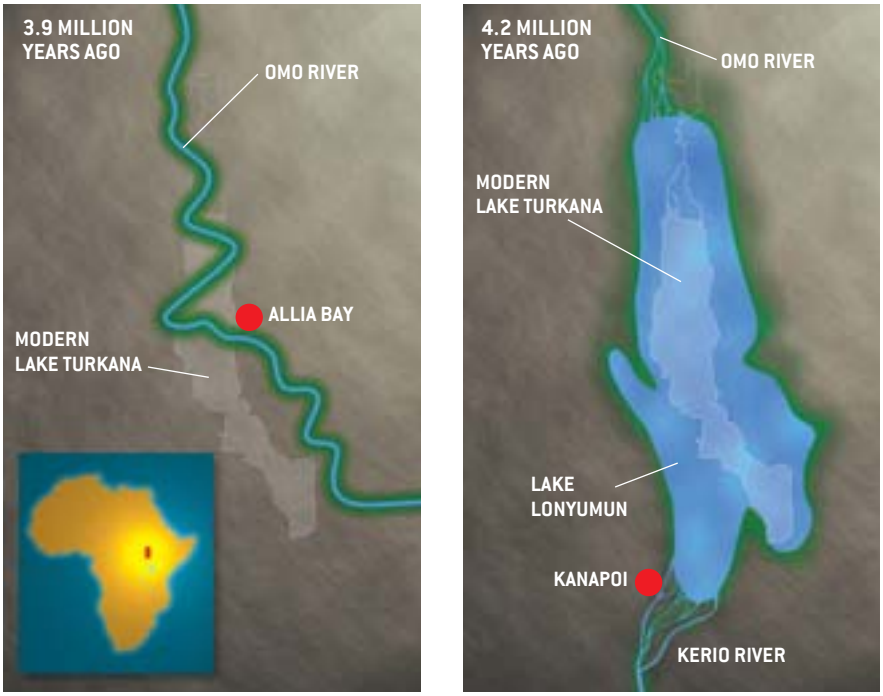
A major question in paleoanthropology today is how the anatomical mosaic of the early hominids evolved. By comparing the nearly contemporaneous Allia Bay and Kanapoi collections of *anamensis,* we can piece together a fairly accurate picture of certain aspects of the species, even though we have not yet uncovered a complete skull.

The jaws of *anamensis* are primitive—the sides sit close together and parallel to each other (as in modern apes), rather than widening at the back of the mouth (as in later hominids, including humans). In its lower jaw, *anamensis* is also chimplike in terms of the shape of the region where the left and right sides of the jaw meet (technically known as the mandibular symphysis).

Teeth from *anamensis,* however, appear more advanced. The enamel is relatively thick, as it is in all other species of *Australopithecus;* in contrast, the tooth enamel of African great apes is much thinner. The thickened enamel suggests *anamensis* had already adapted to a changed diet—possibly much harder food—even though its jaws and some skull features were still very apelike. We also know that *anamensis* had only a tiny external ear canal. In this regard, it is more like chimpanzees and unlike all later hominids, including humans, which have large external ear canals. (The size of the external canal is unrelated to the size of the fleshy ear.)

The most informative bone of all the ones we have uncovered from this new hominid is the nearly complete tibia—the larger of the two bones in the lower leg. The tibia is revealing because of its important role in weight bearing: the tibia of a biped is distinctly different from the tibia of an animal that walks on all four legs. In size and practically all details of the knee and ankle joints, the tibia found at Kanapoi closely resembles the one from the fully bipedal *afarensis* found at Hadar, even though the latter specimen is almost a million years younger.

Fossils of other animals collected at Kanapoi point to a somewhat different paleoecological scenario from the setting across the lake at Allia Bay. The channels of the river that laid down the sediments at Kanapoi were probably lined with narrow stretches of forest that grew close to the riverbanks in otherwise open country. Researchers have recovered the remains of the same spiral-horned antelope found at Allia Bay that very likely lived in dense thickets. But open-country antelopes and hartebeest appear to have lived at Kanapoi as well, suggesting that more open savanna prevailed away from the rivers. These results offer equivocal evidence regarding the preferred habitat of *anamensis*: we know that bushland was present at both sites that have yielded fossils of the species, but there are clear signs of more diverse habitats at Kanapoi.



TURKANA BASIN was home to *anamensis* roughly four million years ago. Around 3.9 million years ago a river sprawled across the basin (*left*). The fossil site Allia Bay sat within the strip of forest (*green*) that lined this river. Some 4.2 million years ago a large lake filled the basin (*right*); a second site, Kanapoi, was located on a river delta that fed into the lake.

An Even Older Hominid?

AT ABOUT THE SAME TIME that we were finding new hominids at Allia Bay and Kanapoi, a team led by our colleague Tim D. White of the University of California at Berkeley discovered fossil hominids in Ethiopia that are even older than *anamensis*. In 1992 and 1993 White led

SLIM FILMS; SOURCE: FRANK BROWN AND CRAIG FEIBEL (1991)

an expedition to the Middle Awash area of Ethiopia, where his team uncovered hominid fossils at a site known as Aramis. The group's finds include isolated teeth, a piece of a baby's mandible (the lower jaw), fragments from an adult's skull and some arm bones, all of which have been dated to around 4.4 million years ago. In 1994, together with his colleagues Berhane Asfaw of the Paleoanthropology Laboratory in Addis Ababa and Gen Suwa of the University of Tokyo, White gave these fossils a new name: *Australopithecus ramidus*. In 1995 the group renamed the fossils, moving them to a new genus, *Ardipithecus*. Earlier fossils of this genus have now been found dating back to 5.8 million years ago. Other fossils buried near the hominids, such as seeds and the bones of forest monkeys and antelopes, strongly imply that these hominids, too, lived in a closed-canopy woodland.

This new species represents the most primitive hominid known—a link between the African apes and *Australopithecus*. Many of the *Ardipithecus ramidus* fossils display similarities to the anatomy of the modern African great apes, such as thin dental enamel and strongly built arm bones. In other features, though—such as the opening at the base of the skull, technically known as the foramen magnum, through which the spinal cord connects to the brain—the fossils resemble later hominids.

Describing early hominids as either primitive or more advanced is a complex issue. Scientists now have almost decisive molecular evidence that humans and chimpanzees once had a common ancestor and that this lineage had previously split from gorillas. This is why we often use the two living species of chimpanzee (*Pan troglodytes* and *P. paniscus*) to illustrate ancestral traits. But we must remember that since their last common ancestor with humans, chimpanzees have had exactly the same amount of time to evolve as humans have. Determining which features were present in the last common ancestor of humans and chimpanzees is not easy.

But *Ardipithecus,* with its numerous chimplike features, appears to have taken the human fossil record back close to the time of the chimp-human split. More recently, White and his group have found parts of a single *Ardipithecus* skeleton in the Middle Awash region. As White and his team extract these exciting new fossils from the enclosing stone, reconstruct them and prepare them for study, the paleoanthropological community eagerly anticipates the publication of the group's analysis of these astonishing finds.

But even pending White's results, new fossil discoveries are offering other surprises. A team led by Michel Brunet of the University of Poitiers has found fragments of *Australopithecus* fossils in Chad. Surprisingly, these fossils were recovered far from either eastern or southern Africa, the only areas where *Australopithecus* had appeared. The Chad sites lie 2,500 kilometers west of the western part of the Rift Valley, thus extending the range of *Australopithecus* well into the center of Africa.

These fossils debunk a hypothesis about human evolution postulated by Dutch primatologist Adriaan Kortlandt and expounded in *Scientific American* by Yves Coppens of the College of France [see "East Side Story: The Origin of Humankind," May 1994]. This idea was that the formation of Africa's Rift Valley subdivided a single ancient species, isolating the ancestors of hominids on the east side from the ancestors of modern apes on the west side.

Brunet's latest discovery, an important cranium older than six million years, is also from Chad and shows that early hominids were probably present across much of the continent. This cranium, which the team called *Sahelanthropus tchadensis,* together with fragmentary jaws and limb bones from about six million years ago in Kenya [see "An Ancestor to Call Our Own," on page 4], are even older than the *Ardipithecus* fossils.

FOSSIL HUNTER Alan Walker (*foreground*) and two colleagues excavate the bone bed at Allia Bay, where several *anamensis* fossils have been recovered. The bone bed appears as a dark band about 18 inches thick at the top of the trench.

The significance of these exciting discoveries is now the center of an active debate.

The fossils of *anamensis* that we have identified should also provide some answers in the long-standing debate over whether early *Australopithecus* species lived in wooded areas or on the open savanna. The outcome of this discussion has important implications: for many years, paleoanthropologists have accepted that upright-walking behavior originated on the savanna, where it most likely provided benefits such as keeping the hot sun off the back or freeing hands for carrying food. Yet our evidence suggests that the earliest bipedal hominid known to date lived at least part of the time in wooded areas. The discoveries of the past several years represent a remarkable spurt in the sometimes painfully slow process of uncovering human evolutionary past. But clearly there is still much more to learn. SA

MORE TO EXPLORE

***Australopithecus ramidus,* a New Species of Early Hominid from Aramis, Ethiopia.** Tim D. White, Gen Suwa and Berhane Asfaw in *Nature,* Vol. 371, pages 306–312; September 22, 1994.

New Four-Million-Year-Old Hominid Species from Kanapoi and Allia Bay, Kenya. Meave G. Leakey, Craig S. Feibel, Ian McDougall and Alan Walker in *Nature,* Vol. 376, pages 565–571; August 17, 1995.

From Lucy to Language. Donald C. Johanson and Blake Edgar. Simon & Schuster, 1996.

The Earliest Known *Australopithecus, A. anamensis.* C. V. Ward, M. G. Leakey and A. Walker in *Journal of Human Evolution,* Vol. 41, pages 255–368; 2001.

KENNETH GARRETT *National Geographic Image Collection*