1. Paleoanthropology

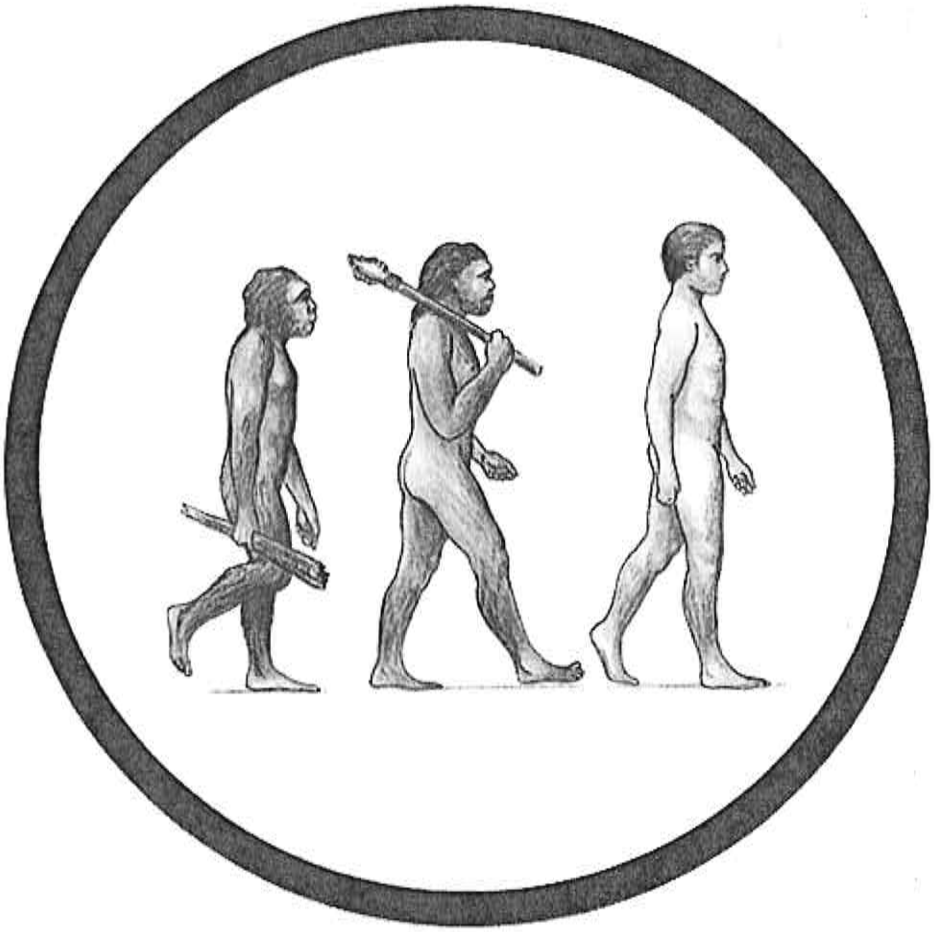


Figure 1.1 Human evolution. "Human Evolution Icon" by Magnetic Hyena is licensed under CC BY-SA 3.0.

WHAT IS PALEOANTHROPOLOGY?

Paleoanthropology, a subdiscipline of anthropology, is the study of extinct primates. While the majority of researchers doing this kind of work are anthropologists, paleontologists (within the discipline of geology) may also study fossil primates. The primary method used by paleoanthropologists is the analysis of fossil remains. However, they increasingly rely on other scientific disciplines to gain a better understanding of the environmental forces that played a role in our evolution, as well as the formation of the fossil record. For example, **geologists** identify processes of sedimentation and fossilization, and date fossils and their associated sediments using a variety of techniques (see DATING TECHNIQUES below). A variety of disciplines are involved in helping to reconstruct ancient environments and biological communities. **Paleontologists** identify ancient floral and faunal fossils. **Palynologists** analyze particles in ocean and lake cores, as well as pollen in terrestrial sediments (see Figure 1.2), to determine the predominant flora in a given area at a particular time. **Taphonomists** help determine how fossil assemblages were formed.

In the 1920s, **Raymond Dart** proposed that early hominins (bipedal primates, like ourselves) found in South African caves had inhabited those caves. In addition, he interpreted puncture wounds found in some of the skulls as evidence that those hominins made and used weapons for hunting and male-male aggression. The taphonomist **C. K. Brain** argued in more recent times that either hominins fell through cracks into subterranean caves after having been cached in trees by leopards, or their bones were dragged in by rodents, such as porcupines, for gnawing. We now realize that while those early members of our tribe likely used simple tools, they were not big-game hunters or warmongers (see Chapter 15 for more information).

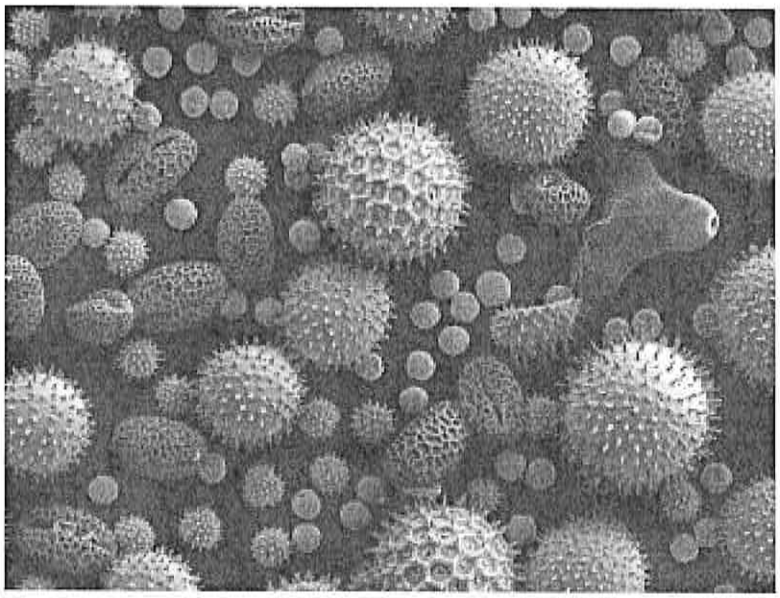


Figure 1.2 Pollen grains under scanning electron microscope. "Misc pollen colorized" by Dartmouth Electron Microscope Facility, Dartmouth College is in the public domain.

HISTORY OF THE DISCIPLINE

While paleoanthropology, as a formally recognized science, is fairly recent, questions and beliefs related to our origins extend back to the earliest members of our species and possibly even earlier. All modern humans living in traditional (e.g., hunter-gatherer bands, tribes, or chiefdoms) or state-level societies have a set of beliefs associated with their origins. However, any ideas that fall outside the realm of science are part of a culture's religion and are termed creation myths.

The most influential fields to have contributed to the science of paleoanthropology are geology, biology, and archaeology. Geologists (even those who were not recognized as such, e.g., Charles Darwin) are primarily responsible for the realizations that (1) the earth is ancient, and it formed via natural processes; (2) the earth was originally covered with water, and life began in that "primordial sea"; (3) life on earth originated with simple forms, with some descendent species becoming more complex over time, as can be seen in the fossil record; (4) species change or go extinct in response to environmental change; (5) new species are the result of a portion of a population adapting to new or changed environmental conditions; (6) the same forces, such as volcanic eruptions, that operate today are those that shaped the earth and caused changes in the fossil record via extinctions and speciation events; and (7) layers and deposits are continually developing or eroding so that organisms are buried and fossils come to light, respectively. The idea that the same forces that operate today are those that shaped the earth and caused changes in the fossil record is termed **uniformitarianism**. Charles Lyell coined the term and is heralded as the father of modern geology. He greatly influenced Darwin and thus contributed to Darwin's synthetic view of the evolution of life on earth. Geologists use various methods to date fossils or fossil-containing sediments and have developed a **chronology** (i.e., a timeline) for the earth as a whole, as well as depositional layers in areas where fossils have been discovered.

Biologists and geneticists have refined the theory of **evolution by means of natural selection** by determining how traits are inherited. Scientists from a variety of disciplines have classified the known species of the world based on evolutionary relationships (also see Chapter 2).

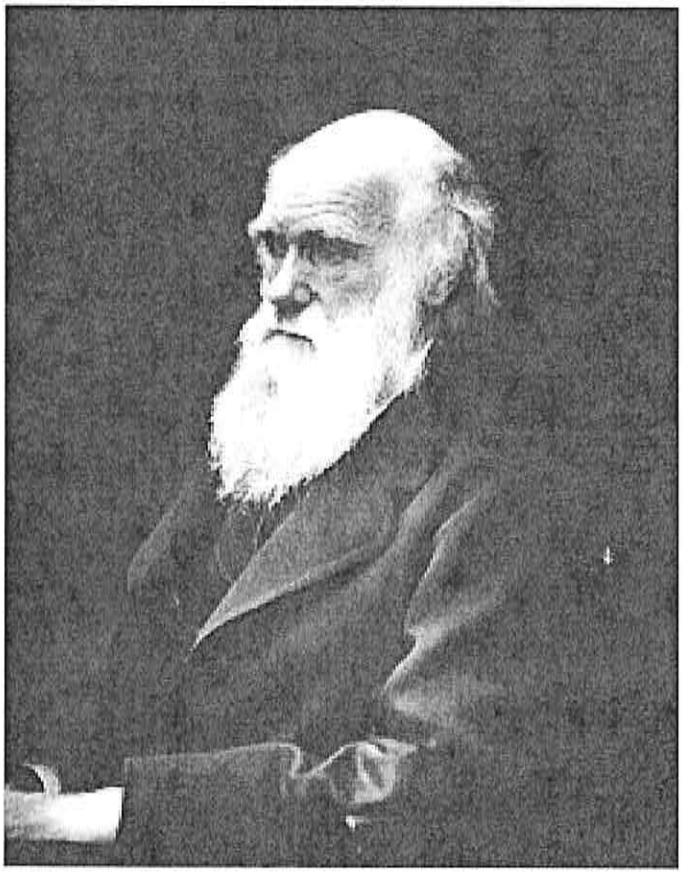


Figure 1.3 Charles Darwin. "Charles Darwin 01" by J. Cameron is in the public domain.

Archaeology has played and continues to play a strong role in paleoanthropology via the study of the **archaeological record**, that is, the record of past human activity via cultural remains and **anthropogenic** (human-induced) changes to the environment. Thomas Jefferson has been referred to as the first archaeologist, in that his methods were more scientific than his fellow **antiquarians.** Antiquarians tended to be after the "goods," without regard for careful interpretation of the archaeological record. Most would be considered looters by today's standards. They took items of great cultural and historical significance for personal or museum collections. Some items have been returned to their countries of origin, but the damage is done when the archaeological record is disturbed or destroyed. Once an item has been removed from the area where it was found, scientists can no longer learn from its context, for example, from associated artifacts or the location of the artifact in geographic space and time.

Archaeologists and geologists played a key role in recognizing that "stones and bones" were evidence of earlier hominin activities. In addition, the fact that some of the bones were from extinct animals supported the idea that humans had been around for a long time. Archaeological methods of excavation and analyses, such as the **provenience** (i.e., the three-dimensional location within a site) and association of **artifacts** (i.e., portable human-made or altered objects), help archaeologists and paleoanthropologists reconstruct past behavior. Just as taphonomy plays a role in determining how fossil assemblages came to be, it is also useful for archaeological assemblages.

Figure 1.4 Eugène Dubois. "Eugene Dubois" is in the public domain.

According to *Merriam-Webster Online*, the first known use of the term "paleoanthropology" occurred in 1916. However, the earliest paleoanthropologists were not labeled as such and came from a variety of occupations, such as anatomists and physicians. The first hominin fossils discovered were the neandertals in the 1800s. However, paleoanthropologists disagreed about whether neandertals were ancestors of humans or were modern humans. **Eugène Dubois** was the first person to intentionally search for a fossil hominin. He went to Asia with the sole purpose of finding evidence that humans evolved there, as was the reigning belief in Western Europe. In 1891, he discovered a skull cap (known as a **calotte**) and femur on the **Solo River** in **Trinil**, Java. More discoveries in China and Java during the first half of the 20th century supported the Asian origin theory until Raymond Dart and his contemporary, **Robert Broom**, began discovering much more ancient material in South African quarries and caves. Further discoveries by **Louis** and **Mary Leakey** in East Africa cemented Africa as the birthplace of humanity, and the race to find human origins and ancestors was on.

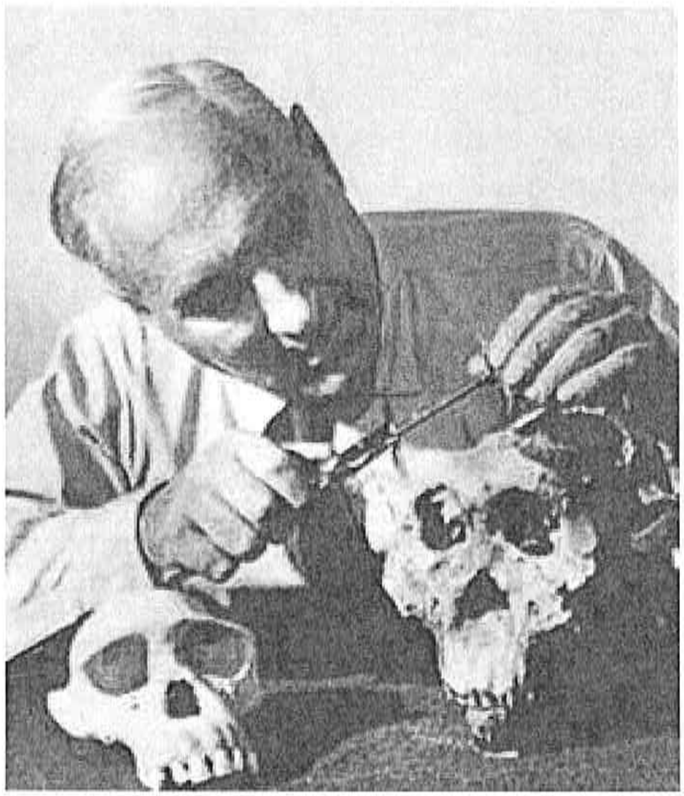


Figure 1.5 Louis Leakey. "Louis Leakey" is in the public domain.

RECONSTRUCTING PALEOENVIRONMENTS

A variety of tools can be used to determine the type of environment past species occupied. As mentioned, paleontologists can use floral and faunal analyses and what they know about ancient species or their extant relatives to determine environment type, for example, the presence of aquatic-, grassland-, and/or forest-dwelling species. Palynologists examine particulates in aquatic and terrestrial strata (i.e., layers or sediments) to do the same, primarily focusing on floral analyses. A variety of isotopic tools can be used to categorize flo-

Part III: Pliocene Epoch

THE PLIOCENE EPOCH (5.3–2.6 mya)

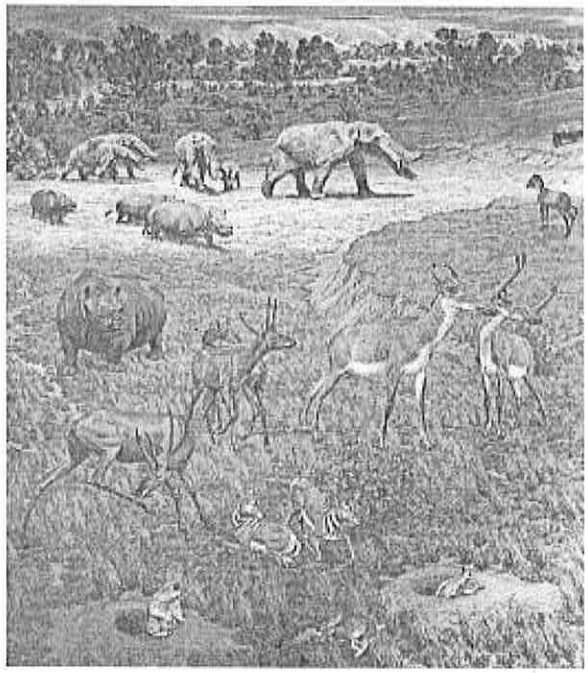


Figure III.1 Pliocene fauna of North America. "Pliocene" by Jay Matternes is in the public domain.

The Pliocene Epoch (~5.3–2.6 mya) was characterized by global cooling and weather disruptions due to the formation of the Panama land bridge and resultant changes in ocean currents. The polar ice caps were expanding and sea levels had already begun to drop, as the Pleistocene Epoch (~2.6 mya–11.7 kya) approached. The geologic record shows us that Africa was subject to cooling and drying trends, with seasons becoming more pronounced. Grasslands were expanding and thus forest cover was shrinking. Intermittent wet and dry periods changed the African landscape. Lakes formed and dried and filled once again. All of the ardipiths and most australopiths went extinct during this epoch and by ~2.0 mya genus *Homo* appeared in the fossil record. The most tantalizing question with regard to the earliest members of our genus is what drove the encephalization process. By the time of the more derived paranthropines [*Paranthropus boisei* (2.5–1.4 mya) and *robustus* (1.9–1.3 mya)] and genus: *Homo* (≥2 mya), cranial capacity had increased ~100 cc and 200 cc, respectively, from the earlier hominins. It has generally been hypothesized that competition for resources was the driving force, and while that may be so, recent research has illuminated just how radical climatic changes were in East Africa. The film *Becoming Human* (2009, Discovery Communications) provides a nice overview of how scientists have pieced together the Pliocene environment of that region of the world from the local geology.

PLIOCENE HOMININS

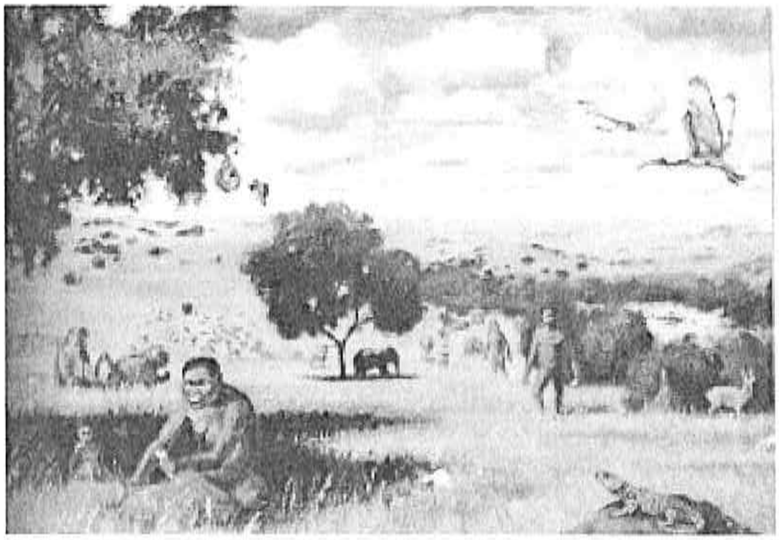


Figure III.2 Foraging paranthropines in South African grasslands. Artwork by Walter Voigt.

The Pliocene Epoch can be considered the time of the great **adaptive radiation of the hominins,** when more than a dozen species evolved in the **hominin corridor** from Ethiopia to South Africa. While the ardipiths died out, concurrent with the reduction in forest cover during the late Miocene and early Pliocene, many australopiths came and went over the course of almost 3 mya of the Pliocene. The australopith lineage may pre-date the Pliocene; there is possible australopith material (possibly *Australopithecus anamensis* or *afarensis*) from the late Miocene from several Kenyan sites (e.g. Lothagam and Tabarin) for which no taxonomic designation has been established. While there is debate as to how much time australopiths spent outside of forested environments, they certainly filled distinctive niches, as evidenced by changing craniofaciodental morphology as well as more versatile hands that afforded them greater manipulative abilities. As we discover more about australopith limb morphology, it is apparent that some were more adapted to an arboreal environment whereas others were less so. Of even greater interest is that the East African australopiths (i.e. *Australopithecus anamensis*, *afarensis*, and *garhi*) may represent a different clade than those from South Africa (i.e. *Australopithecus africanus* and *sediba*). The East African species may have been more adapted to a terrestrial environment, while the South African forms may have retained or reverted to more primitive climbing adaptations. The various species may have walked differently as well.

see The image on the next page

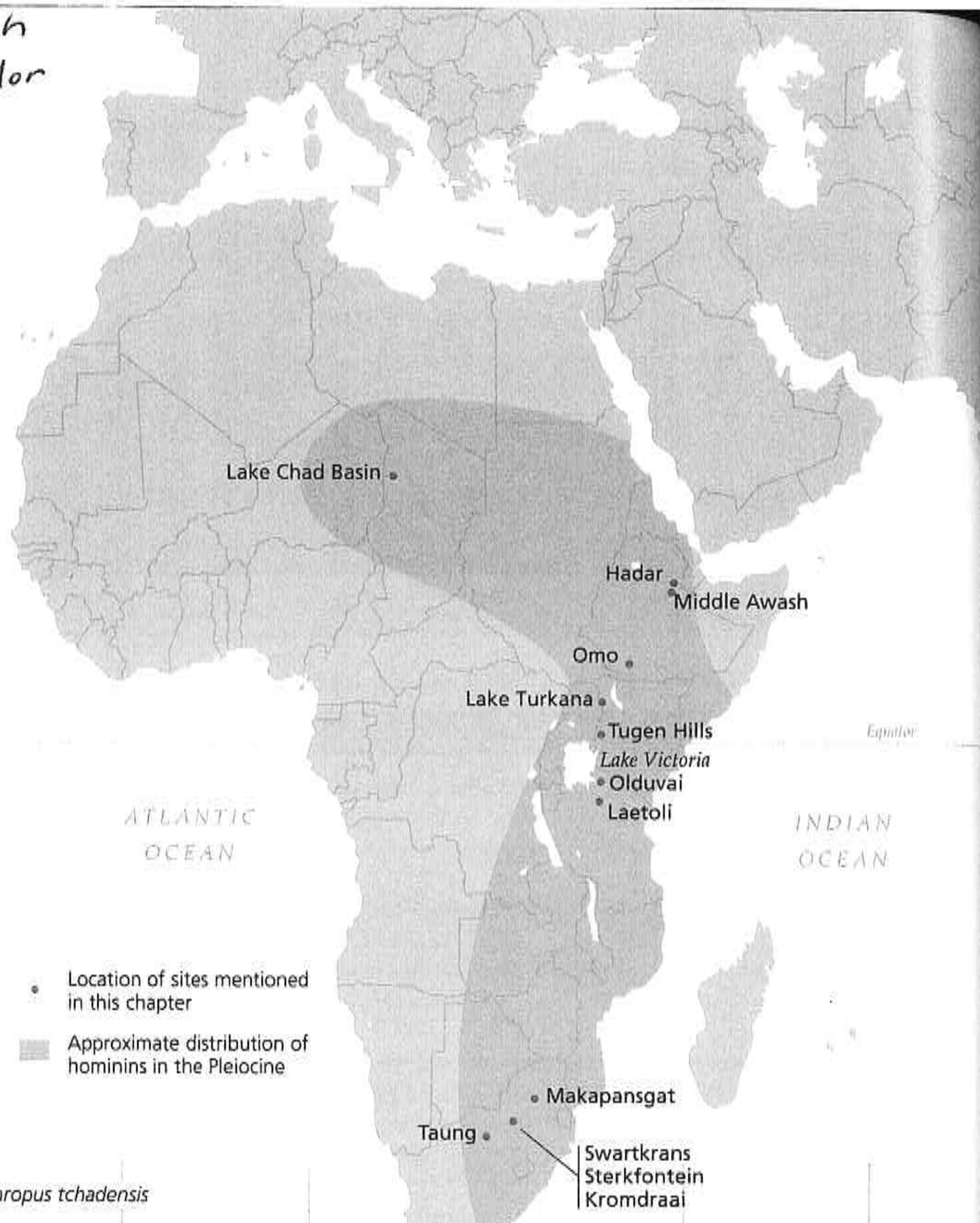
The question remains: from which group are we descended? Some researchers have suggested that *Au. sediba* from South Africa may be part of our lineage; this confounds matters for some researchers as to how the older East African species were seemingly less primitive in some ways than the more recent South African forms. We need to realize that we are only seeing part of the picture. Just as the ape population levels exploded on three continents in the Miocene, the same was apparently true for African hominins in the Plio-Pleistocene. Discoveries of new species of African apes and hominins are accelerating. We need to break out of our linear mindset and realize that there were numerous species adapting to localized conditions, so we should not expect to see uniform changes across time and geographic

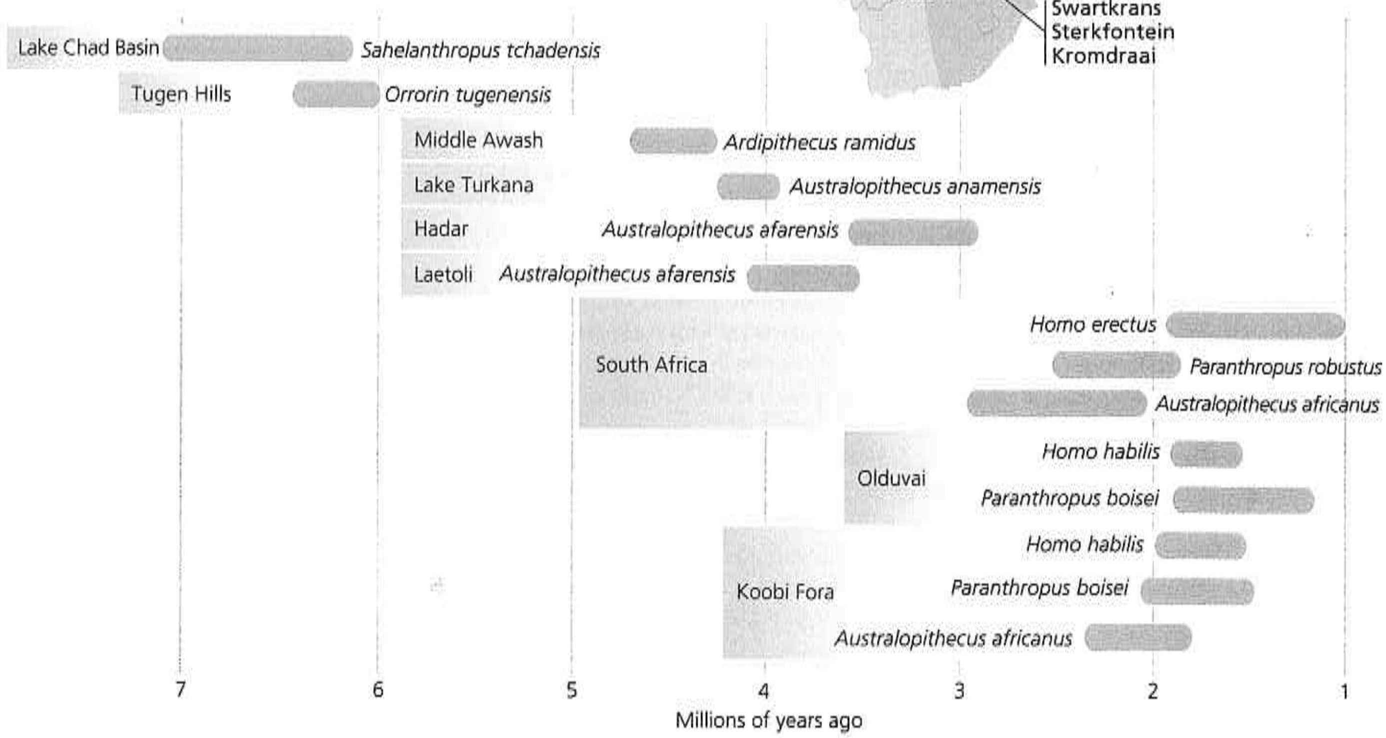
The hominin Corridor

Figure 2.5 Location of and timeline for early hominins in Africa.

In each great region of the world the living mammals are closely related to the extinct species of the same region. It is, therefore, probable that Africa was formerly inhabited by extinct apes closely allied to the gorilla and chimpanzee; and as these two species are now man's nearest allies, it is somewhat more probable that our early progenitors lived on the African continent than elsewhere.

—Charles Darwin (1871)





space. In addition, the same may hold true for grouping and mating practices. We should not jump to conclusions or get too caught up in how the various species were related and who begat whom! While everyone would like to be the person who found one of our long lost relatives, the history of paleoanthropology is fraught with those claims and debunks.

Figure III.3 Modern landscape of Olduvai Gorge. "Panoramic view of Olduvai Gorge" by רנדום *is licensed under CC BY-SA 3.0.*

Upper limb morphology suggests that australopiths retained adaptations for climbing trees that were likely used for food and safety. However, when on the ground, they were habitual bipeds, albeit with some differences from ourselves.

Concept

The Family Tree

The evidence and interpretation of our earliest biology

Human evolution—the changes in the skeleton and biology of our species over the past 7 million years—is a fascinating subject, but one for which there is only sparse evidence. In almost every instance, the fossil remains of our earliest hominin ancestors are very fragmentary, poorly preserved, and disturbed by natural forces—time and nature have taken their toll.

Since the initial work of the Swedish botanist Carolus Linnaeus during the mid-1700s, scientists have classified newly discovered members of the plant and animal kingdoms according to a system that organizes them into species, genus, family, order, class, phylum, and kingdom, from most specific to most general—a family tree of life. Modern humans are members of the family Homininae of the genus *Homo* and the species *sapiens*. Determining the genus and species of the fossil bones of early humans is very difficult. All the fragmentary early fossil finds represent only a few parts of a few hundred individuals. Determining the age of fossils is difficult, and questions remain about whether the species existed contemporaneously or sequentially. Not surprisingly, there are controversies over what to call these first hominin forms and how to identify them. As Richard Klein, of Stanford University, has noted, paleoanthropology is more like a court of law than a physics laboratory. It sometimes seems that whenever a new fragment is discovered, we have to reassess and even redraw our entire family tree. New fossils that modify current ideas are found almost every year. Disputes rage over the designation of species, the age of fossils, and the line of human ancestry.

Even the words to use to describe the category of early human ancestors are controversial. New fossil finds have forced a reconsideration of the terms because it becomes harder to distinguish the first humans from their closest relatives among the apes. The term **hominoid** refers to all present and past apes and humans. The word **hominid** has been used for many years as the

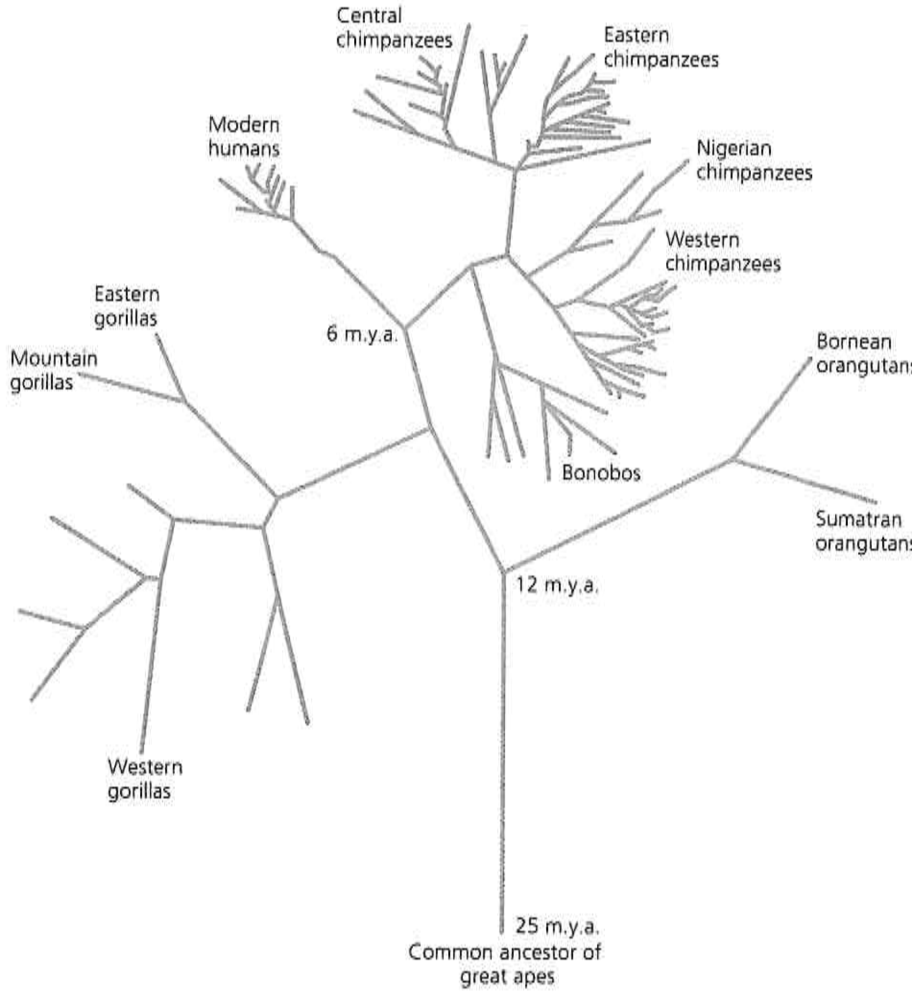


Figure 2.6 An evolutionary tree for the great apes based on modern genetic studies. The length of lines shows genetic distance from one group to another. The diagram shows that our closest relatives are the chimpanzees and the **bonobos** and that we are not very far apart compared with some of the other species. Three estimates for the time elapsed since separation are shown on the diagram. Fossil evidence suggests that the separation of humans and an ape relative may be somewhat earlier than 6 m.y.a.

bonobo A small species of chimpanzee, closely related to humans.

hominoid A descriptive term for any human or ape, past or present, characterized by teeth shape, the absence of a tail, and swinging arms.

hominid An obsolete term that refers to the human members of the primates, both fossil and modern forms.

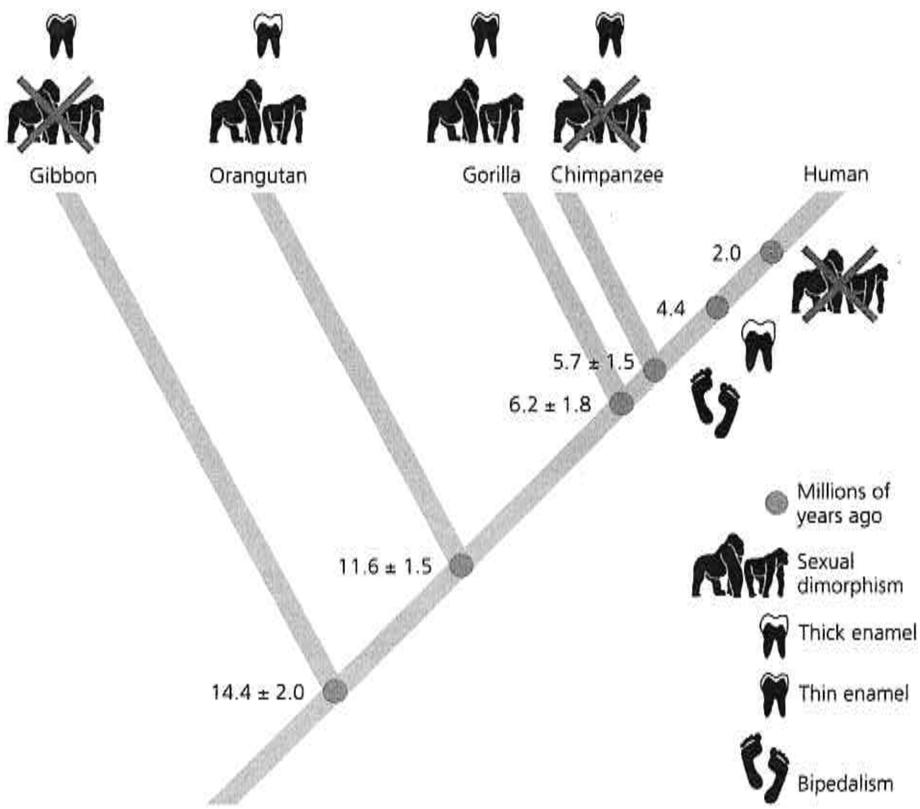


Figure 2.7 A diagram showing the speciation of the great apes with chronology and some distinguishing characteristics. Humans, for example, exhibit bipedalism, thick enamel, and little sexual dimorphism. The red X indicates reduced sexual dimorphism.

An ape-brained and small-canined creature, with dental enamel of unknown thickness. Large if male but smaller if female. May be spotted climbing adeptly in trees or walking bipedally on the ground. Last seen in Africa between 5 and 7 million years ago.

—Pat Shipman (2002), describing the earliest humans

hominin A current term that refers to the human, chimp, and gorilla members of the primates, both fossil and modern forms.

sexual dimorphism A difference in size between the male and female members of a species.

generic term for present and past humans. However, a new term, **hominin,** is now being used in place of *hominid.* Genetic studies have shown that not all apes descended from a common ancestor (Figure 2.6)—that chimps and gorillas share a more recent ancestor with humans than they do with the orangutan, for example. That means that, on the strict taxonomic level, chimps and gorillas are hominins. The term *hominins,* then, is used to describe those species clearly in the line of human evolution, not other apes. All hominins are hominids, but not all hominids are hominins. Confusing, isn't it?

Recent years have seen major changes in the field of paleoanthropology—new discoveries, new dates, new species, and new disagreements. A flurry of fossil finds has spurred these changes and once again rewritten our understanding of the evolution of our earliest ancestors. These discoveries have come from an important new locale in Chad, in central Africa, and from the usual places in East and South Africa. Features of the fossil material such as thickness of tooth enamel, evidence for bipedalism and tree climbing, and size differences between the sexes—**sexual dimorphism**—play an important role in the discussion (Figure 2.7).

In Chad, a new, very old, and controversial fossil species has been found in the blowing sands of the Late Miocene deposits in the Lake Chad basin. This new form is designated as *Sahelanthropus tchadensis.* Although it combines ape and human characteristics, a flat face and "habitual bipedalism" distinguish the Chad specimen as a human ancestor. Habitual bipedalism means the species normally moves on two feet (e.g., humans). Facultative bipedalism means that the species is able to move on two feet (e.g., chimpanzees and gorillas). Dates on this bipedal individual lie between 7 and 6 m.y.a., making it our oldest known ancestor.

In East Africa, a spate of finds documents the diversity of our early ancestors. In the Middle Awash area of Ethiopia, seventeen fossils, including teeth, skull, and arm bones, were found by a research team directed by Tim White of the University of California, Berkeley. These fossils lie directly under a volcanic deposit dating to 4.4 m.y.a. Designated *Ardipithecus ramidus,* the species exhibits a combination of human and chimpanzeelike features. Since the initial discovery, leg bones have been found that suggest that this earliest ancestor likely walked on two legs. Meave Leakey and her colleagues have named a new genus and species, *Kenyapithecus platyops,* which has a flat, humanlike face but an ape-size brain. This fossil probably dates to 3.5 m.y.a.

An even earlier and more important find, from the Tugen Hills of Kenya, are fossils—named *Orrorin tugenensis*—that date to 6 m.y.a. A CAT scan of the fossil femur (thighbone) indicated habitual bipedalism. Like those of *Ardipithecus,* the arm bones suggest tree-climbing adaptations, but the two species differ in enamel thickness. *Orrorin* has thick enamel like a human's, whereas *Ardipithecus* has thin enamel more closely resembling that of other chimps and gorillas.

In South Africa, the big news is dating. New techniques have redated the deposits at several sites where varieties of **australopithecines** have been found and have pushed back the dates to almost 4 million years, twice as long ago as previously believed. These fossils are now easily as old as their counterparts in East Africa.

These recent fossil finds have pushed the antiquity of humans and their ancestors back to the end of the Pliocene into the Late Miocene, the oldest more than 7 m.y.a., aging our presence on the planet by several million years (Figure 2.8). The new finds have turned the tree of human evolution into more of a bush with a number of branches at the bottom as well. In addition, the finds have provided important new information on habitat, diet, and posture. The older fossil forms appear to have lived in forested environments, in contrast to the more open savanna that is thought to have been the habitat of the australopithecines. It now seems that bipedalism first appeared in the context of the forest rather than the plain.

Changes in diet are apparent in the fossil teeth. Relatively small molar size in chimps, *Ardipithecus*, and *Orrorin* indicates a diet primarily of fruit and vegetation. *Homo erectus* and *Homo sapiens* also have small molars relative to body size. Tooth enamel is thin in chimps, medium in *Ardipithecus*, and thick in *Orrorin*, *Australopithecus*, and *Homo*. Canine teeth in chimps and *Orrorin* are large, sharp, and V-shaped in cross section; canines are small, more rounded, and diamond shaped in *Ardipithecus* and later forms. The combination of thick enamel, large molars, and smaller canines first seen in the australopithecines is thought to show a change in diet from fruits and leaves to more roots, tubers, insects, and other small animals.

Microscopic analysis of wear patterns on fossil teeth by Alan Walker, of Pennsylvania State University, indicates that the tooth enamel among early hominins more closely resembles that of herbivores than that of carnivores (Figure 2.9). Examination of the anatomy of the wrist, shoulder, pelvis, and thigh of the early australopithecines indicates a pattern of movement, or **locomotion**, different from that of both the modern apes and humans. Henry McHenry, of the University of California–Davis, noting the curvature visible in hand and foot bones, concludes that these creatures must have spent some time in the trees. Sexual dimorphism was greatly reduced in *Homo erectus* and may reflect the emergence of monogamous mating systems, in which males and females each have a single mate for long periods of time.

Australopithecus anamensis, a transitional form between *A. ramidus* and *A. afarensis*, has recently been found at Lake Turkana, Kenya, dating to 4 m.y.a. Sometime around 3.9 m.y.a., *A. anamensis* evolved into *Australopithecus afarensis*, well known from Hadar, Laetoli, and elsewhere in East Africa (Table 2.1). *A. afarensis* exhibits more humanlike teeth and unquestionably walked upright, as seen in the footprints at Laetoli and in the fossil bones themselves.

The next series of fossil finds comes from a period generally referred to as the **Plio-Pleistocene**. This is a combined term for the late Pliocene

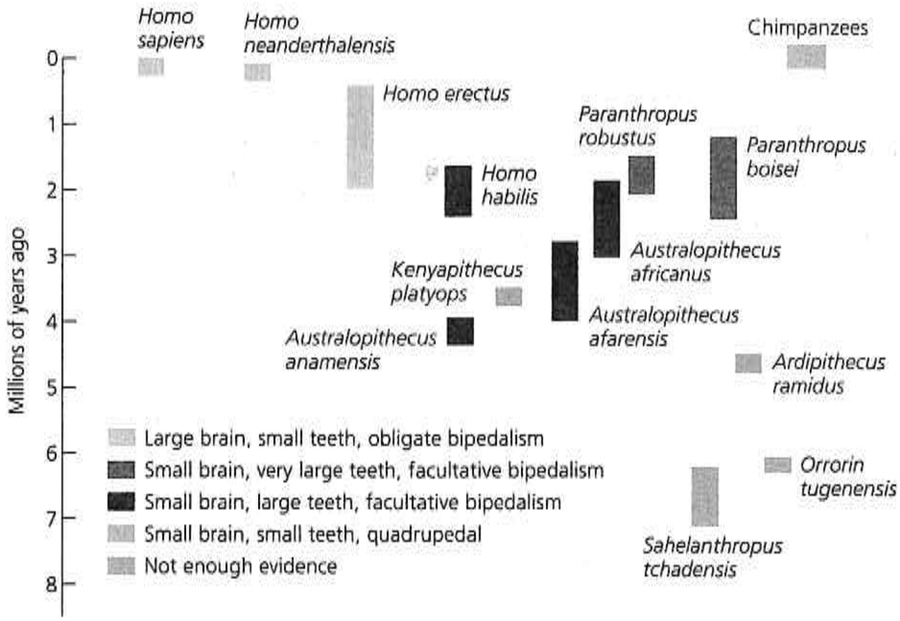


Figure 2.8 Hominin evolution over the past 7 million years. The diagram shows only some of the major species and their major characteristics: brain size, tooth size, and bipedalism.

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www.mhhe.com/priceip6e

For a Web-based activity on the various hominin species, see the Internet exercises on your online learning center.

What advantages could bipedalism have provided for our ape ancestors?

australopithecine The generic term for the various species of the genus *Australopithecus*, including *A. ramidus*, *A. afarensis*, and *A. africanus*.

locomotion A method of animal movement, such as bipedalism.

Plio-Pleistocene A generic term for the period of the Pliocene and early Pleistocene, used to describe the age of fossil finds, approximately 3–1 m.y.a.

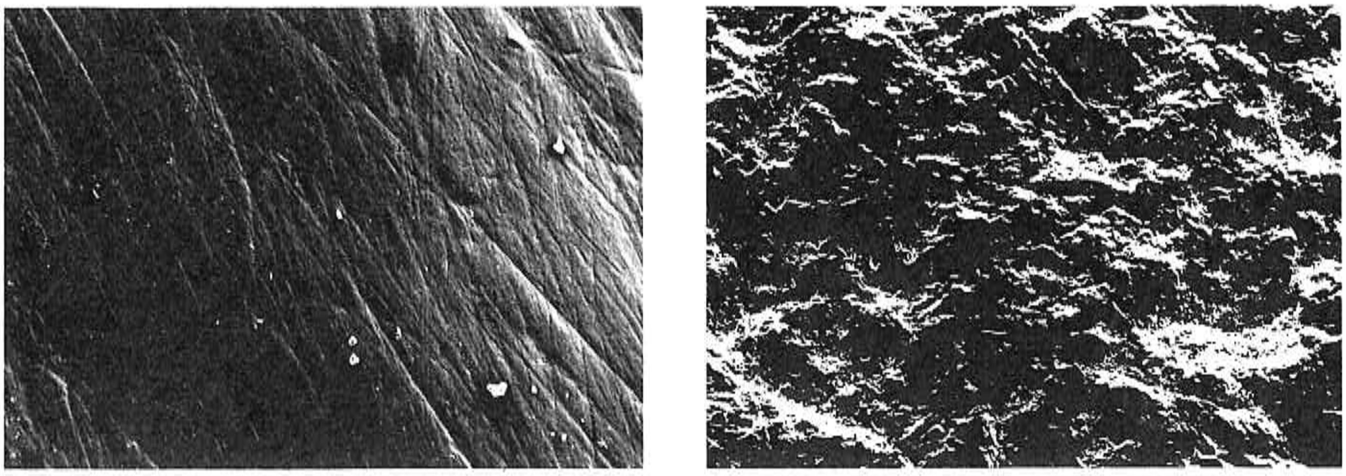


Figure 2.9 Electron microscope photos of tooth wear on early hominins. The scratched surface from *Australopithecus africanus* (left) contrasts with the rough and irregular surface of the enamel of *Paranthropus* (right), thought to have eaten harder gritty foods such as roots and nuts.

Stunning new fossils of hominins that lived three to four million years ago. . . . During this time, we're dealing with a warmer, wetter Africa that it seems was spawning hominins from the shores of Lake Chad to the caves of Sterkfontein.

—Philip Tobias (2002)

Paranthropus Genus of early hominins, contemporary with *Australopithecus,* that includes *boisei* and *robustus* as species.

and early Pleistocene, approximately 3–1 m.y.a. The generally accepted picture is that sometime between 3 and 2.5 m.y.a., *A. afarensis* split into two separate lineages. One of those lineages continued as the australopithecines (a generic term for various forms of *Australopithecus*). This line included both gracile and robust forms. The gracile form, with smaller teeth, skull, and body size, known as *Australopithecus africanus,* appeared shortly after 3 m.y.a. The robust forms, with big teeth and heavy jaws for chewing plant foods, are designated as genus ***Paranthropus.*** Several species have been identified, including *aethiopithecus, robustus,* and *boisei.* The robust forms have been found in both East and South Africa and eventually became extinct around 1 m.y.a.

The other lineage led to *Homo habilis,* the first members of our own genus. The earliest *H. habilis* is known from around 2.5 m.y.a. and is recognized by a clear increase in brain size. (The first *H. habilis* is very close in time to the earliest known stone tools; see "The First Tools," p. 63.) The 1986 discovery by Johanson and White of over 300 pieces of a skeleton in beds at Olduvai Gorge dating to 1.8 m.y.a. has filled in part of the picture of *Homo habilis.* For the first time, there were enough fragments of the arms and legs of an *H. habilis* creature to provide an indication of height and the proportions of the limbs. Surprisingly, this female *H. habilis* was less than 1 m (about 3 ft) tall and had very long arms, similar to Lucy and other australopithecines. Such evidence suggests that (1) *H. habilis* may still have been spending part of its life in the trees, (2) sexual dimorphism was still very pronounced, and (3) major changes in behavior and habitat of the early hominins may have taken place in the period between 2 and 1.5 m.y.a. Thus, it appears that *Homo habilis* "represents a mosaic of primitive and derived features, indicating an early hominin which walked bipedally . . . but also retained the generalized hominoid capacity to climb trees" (Susman and Stern, 1982, p. 931).

Richard Leakey, Alan Walker, and a few others suggest a different scenario. Louis Leakey always argued that the genus *Homo* had its roots deep in the Pliocene, and he eventually discovered several early *Homo* specimens at Olduvai and elsewhere. This view is maintained by his son Richard and others who would push the evolutionary split from a common ancestor of the *Australopithecus* and *Homo* lines much further back in time, perhaps near the beginning of the Pliocene, around 6 m.y.a. They imagine that two or more different australopithecine groups (*P. robustus* and *A. africanus*) and one line of *Homo* (*H. habilis*) evolved at this time.

The next stage in our family tree is relatively straightforward and uncon-

TABLE 2.1 Major Characteristics of the Plio/Pleistocene Hominins

	Australopithecus ramidus	*Australopithecus anamensis*	*Australopithecus afarensis*	*Australopithecus africanus*	*Paranthropus robustus*	*Paranthropus boisei*	*Homo habilis*
Dates	4.5–4.3 m.y.a.	4.3–4.0 m.y.a.	4.2–2.8 m.y.a.	3–1.8 m.y.a.	2.2–1.5 m.y.a.	2.2–1 m.y.a.	2.5–1.6 m.y.a.
Sites	Middle Awash	Lake Turkana	Hadar Omo Laetoli	Taung Sterkfontein Makapansgat Lake Turkana (?) Omo (?)	Kromdraai Swartkrans	Olduvai Lake Turkana Omo	Olduvai Lake Turkana Omo Sterkfontein Swartkrans
Cranial Capacity	Unknown (400–450 cc?)	Unknown	380–500 cc; average = 440 cc	435–530 cc; average = 450 cc	520 cc (based on one specimen)	500–530 cc; average = 515 cc	500–800 cc; average = 680 cc
Size	100 lb?	5' 110 lb (♂) 4'3" 70 lb (♀)	3'6" 50 lb (♀) (♂ to 100 lb?)	Similar to *A. afarensis*	5'+ 150 lb	5'+ 150 lb	Limited evidence; may have been size of *A. afarensis*
Skull	Large pointed canines, small molar crowns, thinner enamel; foramen magnum forward	Teeth and jaw hominin, but some similarities to chimpanzee	Very prognathous, receding chin, large teeth, pointed canines with gap, arcade between ape and human, hint of crest	Less prognathous than *A. afarensis;* jaw more rounded; large back teeth; canines smaller than *A. robustus,* larger than *A. afarensis;* no crest	Heavy jaws, small canines and front teeth, large back teeth, definite crest	Very large jaws, very large back teeth, large crest	Flatter face, less sloping forehead, teeth similar to *A. africanus,* no crest
Postcranial Skeleton	Arm bones with characteristics intermediate between great apes and hominins	Joints on leg bones indicate bipedal gait	Long arms, short thumb, curved fingers and toes, bipedal	—	Hands and feet more like modern humans', retention of long arms	—	Limited evidence, retention of long arms, maybe retention of primitive features of hand and foot

Source: Adapted from Feder and Park, 1997.

tested. *Homo erectus* evolved from *Homo habilis* about 1.9 m.y.a., again in Africa. The earliest fossils of *H. erectus* are known from the eastern shore of Lake Turkana in northern Kenya. *H. erectus* is also the first early human form found outside Africa, in Asia and probably in Europe. In fact, a controversial date of 1.8 m.y.a. for an *H. erectus* fossil from China would suggest a very rapid spread of this species out of Africa. *Homo erectus* walked upright and had a brain size midway between that of *Australopithecus* and fully modern humans. The time period of *H. erectus* covers more than 1.5 million years, and there were a number of changes in the species during that period. In fact, there is some controversy today about the reliability of the *H. erectus* species designation.

Remarkably, and probably relatedly, a major innovation in the technology of stone tools, the appearance of the handaxe and other bifacial tools, occurred almost simultaneously with *Homo erectus* in Africa (see "The Acheulean Handaxe," Chapter 3, p. 99). The distribution of *Homo erectus* fossils and the archaeological evidence they produced are the subject of the next chapter.

Homo erectus gradually evolved in Africa and Asia, exhibiting slowly increasing brain size, for a million years, eventually expanding into Europe. *Erectus* forms evolved into *Homo heidelbergensis* after 600,000 years ago. At some point after, perhaps, 200,000 years before the present (B.P.), *Homo sapiens* began to appear. Suffice it to say here that *Homo erectus* is the ancestor of the first *Homo sapiens*—and ultimately of ourselves.

There is a great deal we don't know about our early ancestors. What would you like to know?

11. Australopithecus afarensis

Australopithecus afarensis (4.2 mya)

("southern ape" / Afar region of Ethiopia)

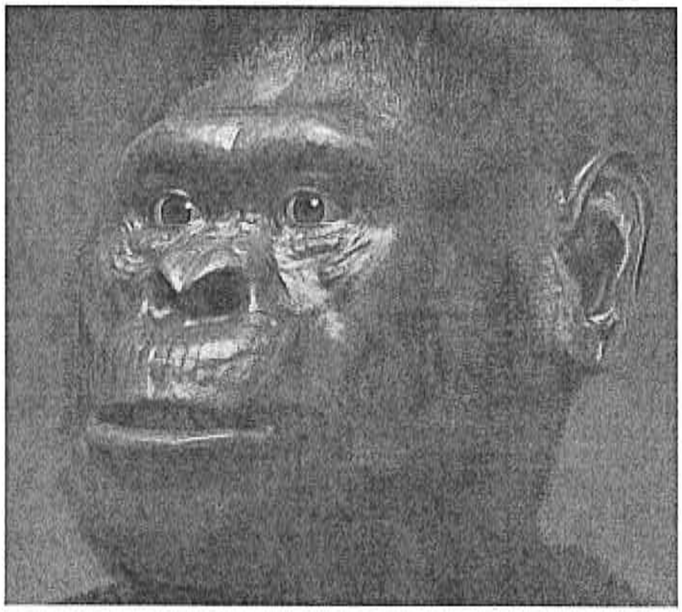


Figure 11.1 Forensic facial reconstruction of Australopithecus afarensis. "Australopithecus afarensis" by Cicero Moraes is licensed under CC BY-SA 3.0.

SITES
Ethiopia: Afar Depression (e.g., Hadar and Dikika) **Tanzania:** Laetoli **Chad:** Bahr el Ghazal
PEOPLE
Donald Johanson, Mary Leakey, Zeresenay Alemseged

INTRODUCTION

Australopithecus afarensis, or the "southern ape from Afar," is a well-known species due to the famous "Lucy" specimen. It has been extensively studied by numerous famous paleoanthropologists. As mentioned, it is categorized as a gracile form of australopith. The species survived for over a million years in the changing East African landscape, covering a broad geographic range. The famous Laetoli footprints are attributed to *Au. afarensis* (see Figures 11.5 and 11.6). They provided support for the then controversial idea of habitual bipedalism, as well as the species' presence in a more open environment.

PHYLOGENY

The most logical ancestor for *Au. afarensis* is *Au. anamensis*. The two species overlapped in time and geographic space. Some paleoanthropologists have always believed that genus: *Homo* is descended from *Au. afarensis*. Over time, others have changed their taxonomic scenarios from *Au. africanus* to *Au. afarensis* (which would formerly have been a sister lineage to *Au. africanus*) as our ancestor, and made *Au. africanus* a side branch of the robust forms. Part of the argument for classifying *Au. afarensis* outside of our lineage had to do with aspects of their anatomy being more derived than our own, e.g. the lateral flare of their ilia (the plural of ilium). Since the discovery of *Au. sediba* (Chapter 21), some scholars are back to favoring *Au. africanus* in our ancestry.

Figure 11.2 "Laetoli recreation." "Laetoli recreated" by Wapondaponda is licensed under CC BY-SA 3.0.

DISCOVERY AND GEOGRAPHIC RANGE

The geographic range of *Au. afarensis* extends over 1,600 km from the site of Hadar in the Afar Depression of Ethiopia to the Laetoli site in Tanzania (see Figure 11.3). The **holotype** comes from Laetoli. There is conjecture as to whether the Ethiopian and Tanzanian material should be attributed to the same species, since the sites are distant from one another and separated in time by 800 kya. In addition, if *Au. bahrelghazali* is included as a geographic variant of the species, their range expands 2,500 km westward into Chad (McHenry 2015). Thus this species was very successful at exploiting a variety of environments.

With the discovery of "**Lucy**" (3.2 mya) (see Figure 11.7) in 1974 by **Donald Johanson's** crew at the site of **Hadar** in the Afar Depression of Ethiopia, paleoanthropology gained

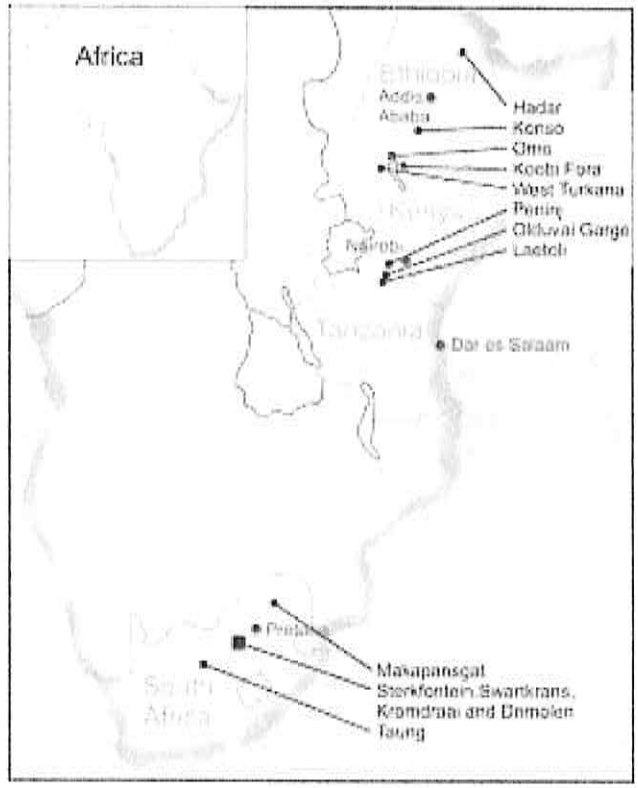


Figure 11.3 Map showing the major fossil sites where specimens of Australopithecus and Paranthropus have been found. From Clement and Hillson (2013), licensed under CC BY 3.0.

momentum and the rush was on in East Africa to find more evidence of human origins. Certainly **Louis** and **Mary Leakey** recognized the importance of the Great Rift Valley, but Johanson "upped the ante" with his 3.2 mya find. In addition, since Lucy's skeleton was almost 40% complete (making it one of the six most complete fossilized hominin skeletons older than 100 kya), much could be said about her anatomy and locomotor capabilities.

Site **AL 333** at Hadar yielded remains of 13 individuals, referred to as the "**First Family**." Some researchers speculated that they may have died together and thus possibly represent a social group. However, recent examination of the deposition pattern at the site suggests otherwise (see Behrensmeyer 2008).

The more recently discovered "**Dikika Baby**" (3.3 mya) (see Figure 11.4), also known as "Selam" (meaning "peace" in the Afar language) has contributed greatly to our knowledge of development in early hominins. Dikika, meaning "nipple" in the Afar language, is the name of the nipple-shaped hill at the site of her discovery. Discovered by Zeresenay Alemseged in 2000, the three-year-old female has also been dubbed "Lucy's Baby" due to its proximity to Hadar where Lucy was discovered. Selam is now the oldest, most complete fossil hominin. It took five years to extract the fossils from the surrounding sandstone matrix in which they were embedded. Thus we can see that not only is there difficulty in locating fossils, along with their living conditions in the desert environments of East Africa, the fossils may take years to process before all of their secrets can be revealed.

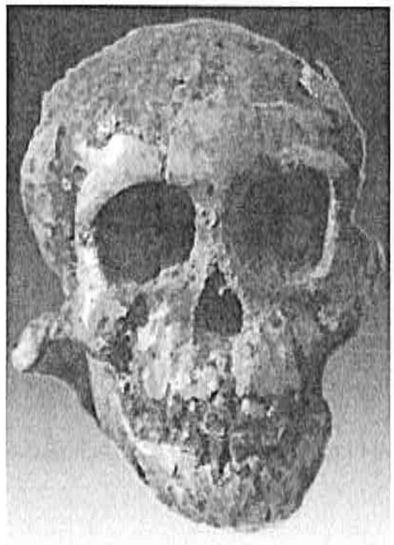


Figure 11.4 Dikika Baby. "SelamAustralopithecus" by Jlorenz1 is licensed under CC BY-SA 3.0.

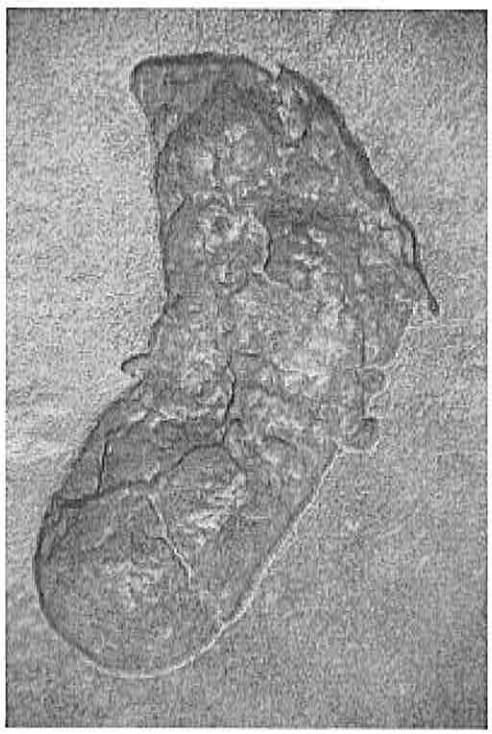


Figure 11.5 Laetoli footprint cast. "Australopithecus afarensis footprint" by Tim Evanson is licensed under CC BY-SA 2.0.

- Semi-sectorial premolar.
- Monomorphic canines.
- Precision grip adaptation in hands.
- Bipedal hips and lower limbs.
- Prolonged juvenile dependency and brain growth.

ENVIRONMENT AND WAY OF LIFE

This species inhabited a mixed woodland environment that is thought to have been more open than previous hominin habitats. They could thus have exploited arboreal resources and moved between trees and forested areas in a fairly efficient manner. They are considered to have been scavenger-foragers, collecting wild plant foods, opportunistically hunting animals, and scavenging large game from carnivore kills. There is evidence of stone tool use at the Dikika, Ethiopia, site. Since *Au. afarensis* are the only known hominin from that time and location, the tool use has been attributed to them. Researchers found cut marks on bones of two large animals that were dated to 3.4 mya. Even more exciting is the recent discovery of 3.3 mya tools in association with hominin fossil material at the West Lake Turkana, Kenya, site of Lomekwi 3. While it was commonly accepted that australopiths used tools, this is the first evidence that they made them. The tools have been designated as the **Lomekwian** industry and have displaced the Oldowan as the earliest tool industry, preceding it by 700,000 years (Harmund et al. 2015). The tools consist of anvils, cores (stones from which flakes for cutting are removed), and flakes (see *Homo habilis*: "Environment and Way of Life" for more information on stone tools and their production). Like extant great apes, they also would almost certainly have used biodegradable materials for tools, such as wooden, ivory, or antler digging sticks.

Au. afarensis exhibited premolar molarization and thick molar enamel for masticating a tougher, more dry-adapted diet, such as tubers (large edible roots, e.g. yams). However, they were not yet able to grind their food as well as later hominins whose jaws could move laterally due to the reduction in canine size.

The brain of Selam shows that the juvenile dependency period was prolonged relative to chimps and hence the chimp/hominin ancestor. In addition, once infants could not hang on with their feet, mothers would have had to put their babies down periodically. Dean Falk has suggested that this pattern of mother-infant care may have led to language, in the form of what she refers to as "motherese" (Falk 2009).

It is interesting that female chimps use tools more often than do males. In addition, "woman the gatherer" should share the limelight with "man the hunter," as women in most traditional societies collected a larger share of their family's food. Is it possible that women invented tools? How about language? For how long have we heard about the male provisioning model for the evolution of bipedalism, "man the toolmaker," "man the hunter," men romancing women with the first language? Let's stir up that cooking pot!!!

As mentioned, we are unsure of their mating and thus grouping pattern. Regardless of whether the First Family died together and represented a social group, *Au. afarensis* likely lived in groups for protection and possibly cooperation. Males were much larger than fe-

Figure 11.9 Selam reconstruction at the National Museum of Addis Ababa, Ethiopia. "Selam" by Highrey is licensed under CC BY-SA 3.0.

males but had lost the large canines and honing complex of *Au. anamensis*. Thus while the degree of sexual dimorphism was much greater than in our own species, their monomorphic teeth suggest that they were transitioning toward pair-bonding while retaining polygynous tendencies. While females may have mated polyandrously, like a fair proportion of females in our own species, it may have been in their best interest to stick with their mate for help in raising their offspring, and not jeopardizing their safety with extra-pair copulations.

Figure 11.10 Lucy by Keenan Taylor.

Site

Laetoli

Conclusive evidence of our first steps

The study of fossil origin and evolution is a kind of mystery play, acted out in remote antiquity, in many scenes and in many places. The players have long ago departed the stage, and left their all too sparsely distributed and brittle bones buried deep in the rocks in a cave. The walking shadows, the poor players who have strutted and fretted their brief hours on the stage, have in most cases been heard from no more.

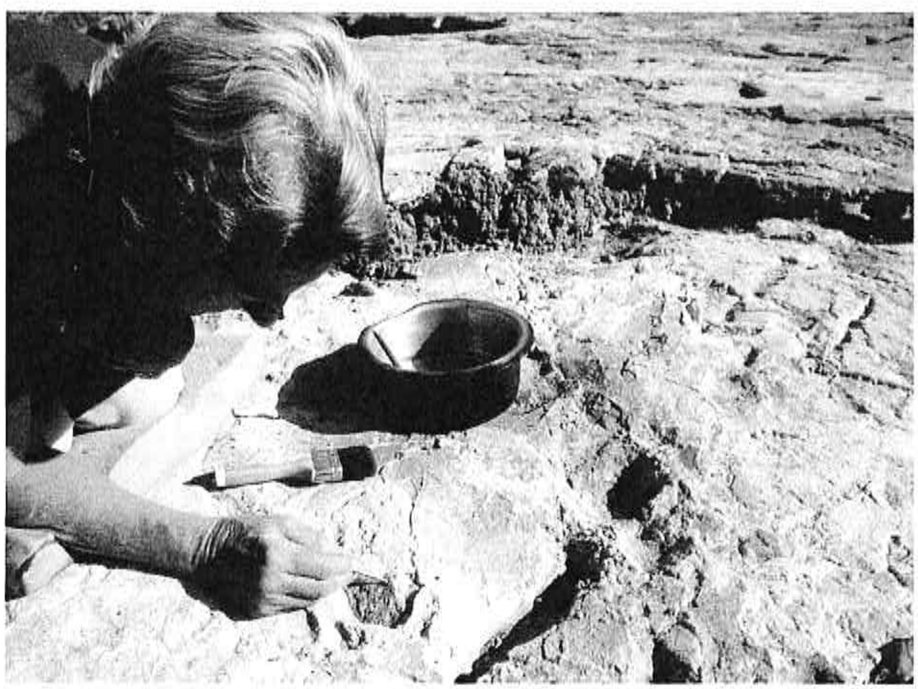
—Ashley Montague (1964)

As we have noted, the three distinctive characteristics of being human are upright posture, a large brain, and tool use. The question of which came first has been dramatically answered by a discovery in East Africa. The evidence for this new posture comes not only from the fossil bones, however, but also from actual footprints preserved at the site of Laetoli (lay-TOE-lee) in Tanzania, discovered by Mary Leakey in 1976 (Figure 2.16). Laetoli is located about 70 km (40 mi) southeast of Olduvai Gorge. Sometime around 3.6 m.y.a., an active volcano near Laetoli covered the area with a layer of volcanic ash. Following a light rain shower, various animals moved across the damp layer of ash. A chemical reaction between rainwater and the ash quickly hardened their tracks; even the impressions of the raindrops are preserved in some areas at the site. Hares, birds, extinct elephants, pigs, buffalo, rhinos, a saber-toothed tiger, and many baboons left their footprints.

The numerous sets of tracks do not often overlap one another, suggesting that this layer of footprints was quickly buried by more ash, ensuring its preservation. Radiopotassium dating determined that the age of the ash layers, and therefore the footprints, was between 3.8 and 3.5 million years (see "Dating Methods," p. 48).

Early hominins walked across the fresh ash as well (Figure 2.17). The 70 or so human footprints continued over a distance of more than 6 m (20 ft) and were made by three individuals. The longest track contains about 30 prints of an individual walking on two feet with a stride and balance that is clearly human. A second, smaller individual followed in the footprints of the first, and a third set of prints lies alongside the first. The footprints look human, with a well-defined arch and an absence

Figure 2.16 Mary Leakey recording the 3.6-million-year-old footprints of Laetoli.



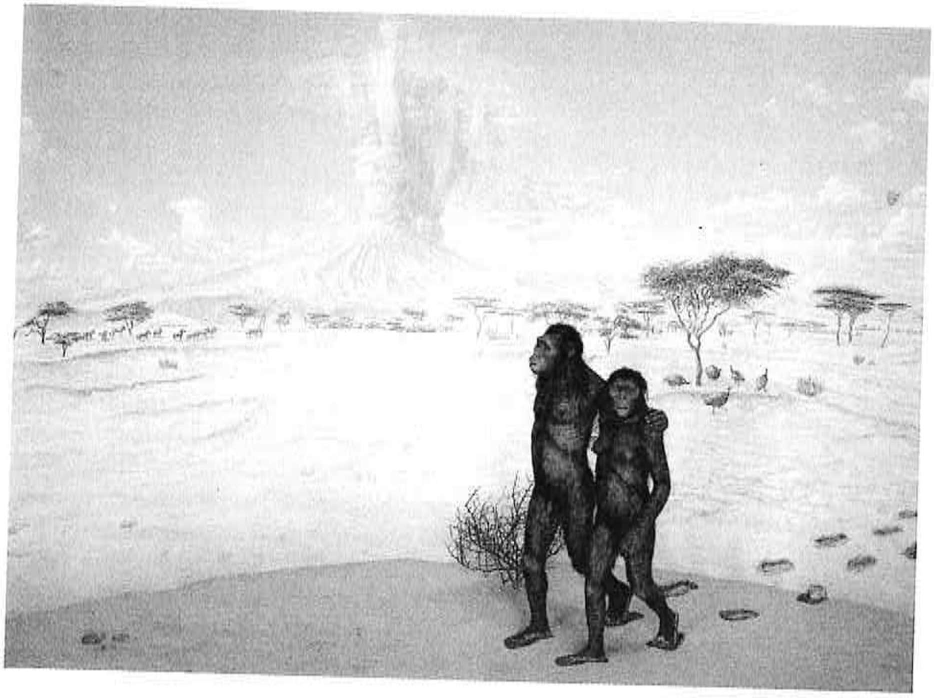


Figure 2.17 An artist's reconstruction of the early hominins at Laetoli, walking across the volcanic ash 3.6 m.y.a.

of the diverging toe that is characteristic of great apes. Studies of the size and depth of the prints suggest that two of the individuals were approximately 1.4 m (4 ft, 8 in) tall, and the third 1.2 m (4 ft) tall. The footpath of the second individual indicates that this early hominin stopped briefly and turned slightly to the left before continuing. Mary Leakey, the excavator of these fossil footprints, speculated about the scene:

This motion—the pause, the glance to the left—seems so intensely human, it transcends time. Three million six hundred thousand years ago, a remote ancestor—just as you or I—experienced a moment of doubt. (quoted in Lewin, 1988, p. 57)

The brain of these earliest hominins from the Pliocene was no larger than that of modern apes, nor had their teeth changed a great deal from those of their ape ancestors. Fossil remains, particularly fragments of skulls from Laetoli and elsewhere in East Africa, demonstrate that the human brain had not yet begun its major expansion. No stone tools have been found in deposits of this age at Laetoli; such equipment was apparently not yet part of the human repertoire. What was different, however, was a shift to a new form of movement.

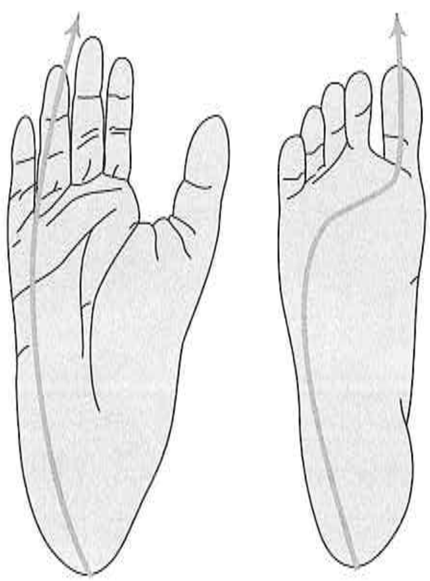


Figure 2.18 The footprints at Laetoli are clearly from bipedal individuals. The weight distribution in ape feet is along the side of the foot (left). The big toe on apes is for grasping and does not carry weight. In humans, the weight is carried from the heel, along the side, and across the ball of the foot to the big toe (right).

The earliest human fossils give evidence of **bipedalism**—they walked on two feet, with a stride very similar to our modern one (Figure 2.18). In fact, these earliest humans might best be portrayed with the head and face of an apelike creature atop a small, upright human body, stepping into the future. As Mary Leakey went on to say, "The outstanding evolutionary question now is: What was the selection pressure that produced bipedalism?" (quoted in Lewin, 1988, p. 57).

They are the most remarkable find I have made in my entire career. . . . When we first came across the hominid prints I must admit that I was skeptical, but then it became clear that it could be nothing else. They are the earliest prints of man's ancestors, and they show us that hominids . . . walked upright with a free-striding gait, just as we do today.

—Mary Leakey
(quoted in R. Leakey, 1981)

bipedalism The human method of locomotion, walking on two legs.

Part IV: Pleistocene Epoch

THE PLEISTOCENE EPOCH (~2.6 mya – 11.7 kya)

Figure IV.1 East African grassland and a local. Photo by the author.

The Pleistocene Epoch is commonly known as the Ice Age. The climate of Africa continued on the trajectory that began in the late Miocene and continued throughout the Pliocene (see Figures IV.2 and IV.3). While the Pleistocene was characterized as a period of global cooling, glacial advances, and dropping sea levels, the cold periods were interspersed with interglacial periods when the ice retreated and sea levels rose (see Figures IV.2, IV.3, and IV.4). Even within glacial periods, the climate varied. Animals in northern areas that were not adapted to arctic conditions went extinct or moved south when temperatures dropped and vice versa. They pushed in and out of Africa, in response to those climatic pulses.

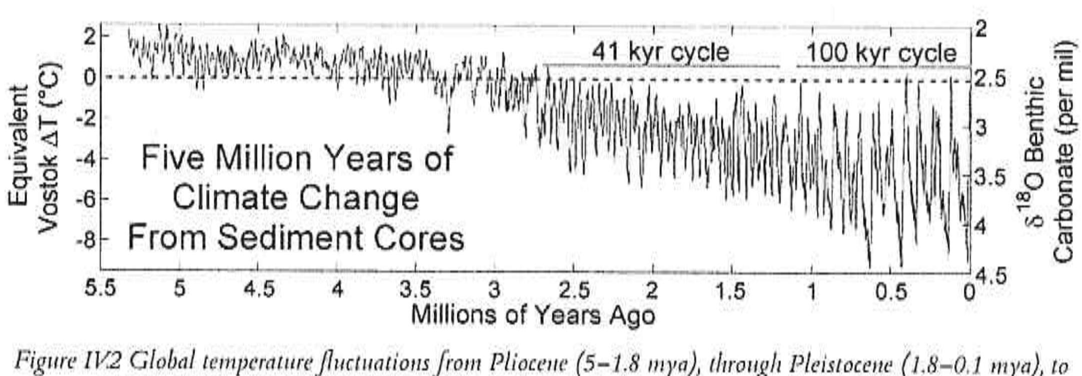


Figure IV.2 Global temperature fluctuations from Pliocene (5–1.8 mya), through Pleistocene (1.8–0.1 mya), to present. "Five Myr Climate Change" by Robert A. Rohde is licensed under CC BY-SA 3.0.

Site

Olduvai

A trail of biological and behavioral evolution from the early Pleistocene to the recent past

Flying low across northern Tanzania, one crosses an enormous wilderness of grassland and solitary trees, a region filled with herds of wildebeest, giraffes, elephants, and many other animals. This is the fabled Serengeti (ser-in-GET-ee) Plain—the place of safari. The level surface of the plain results from the long, gradual accumulation of geological sediments, especially volcanic materials such as ash and lava. Two million years ago, this area was a large bowl-shaped basin, ringed by a series of volcanic mountains and uplands.

Active volcanoes filled the air with ash and covered the ground with molten lava, which hardened into new rock. The basin trapped rainfall, forming lakes and wetlands during the beginning of the Pleistocene. Silts and sands, carried by running water, were deposited in these lakes, which grew or disappeared over time as rainfall amounts varied with changes in cli-

Figure 2.22 Olduvai Gorge, cutting 100 m into the Serengeti Plain and 2 million years into human evolution.

mate. Along the shores of these lakes, creatures of the early Pleistocene in East Africa found food, reproduced, and died; occasionally, their bones were buried and preserved in the accumulating layers of sediment.

The richness of the lakeshore environment is represented by the abundance of fossil animal bones that are found there. Antelope, giant buffalo, and wild sheep occur in large numbers, along with aquatic animals, such as the giant crocodile, the hippopotamus, and various species of fish and fowl. The layers of lava, ash, and lake deposits continued to build up until the basin became relatively level, resulting in the surface of the Serengeti Plain today.

About 200,000 years ago, a particularly violent series of earthquakes and volcanic activity opened a crack in the surface. Seasonal streams cut and eroded a large gully into the layers of sediment. Gradually, a canyon, some 40 km (25 mi) long and almost 100 m (325 ft) deep, wound its way from the top of the Serengeti Plain through the layer cake of deposits. This canyon is Olduvai (ol-dew-VIE) Gorge, one of the most famous prehistoric sites in the world (Figure 2.22). Each step down into the gorge takes us back 6000 years in time, toward the layer of basalt at the very bottom, dating to 1.9 m.y.a. (Figure 2.23).

Along the steep sides of this gorge, two archaeologists—Louis and Mary Leakey—began an extended vigil, in quest of the remains of the earliest humans. Starting in 1931, Louis and, later, Mary Leakey made the arduous journey from Nairobi each summer to spend several weeks at the rugged exposures of Olduvai. Accompanied by their dogs, and later their several children, they searched for fossil hominins. Louis Leakey had found numerous crude stone tools in the

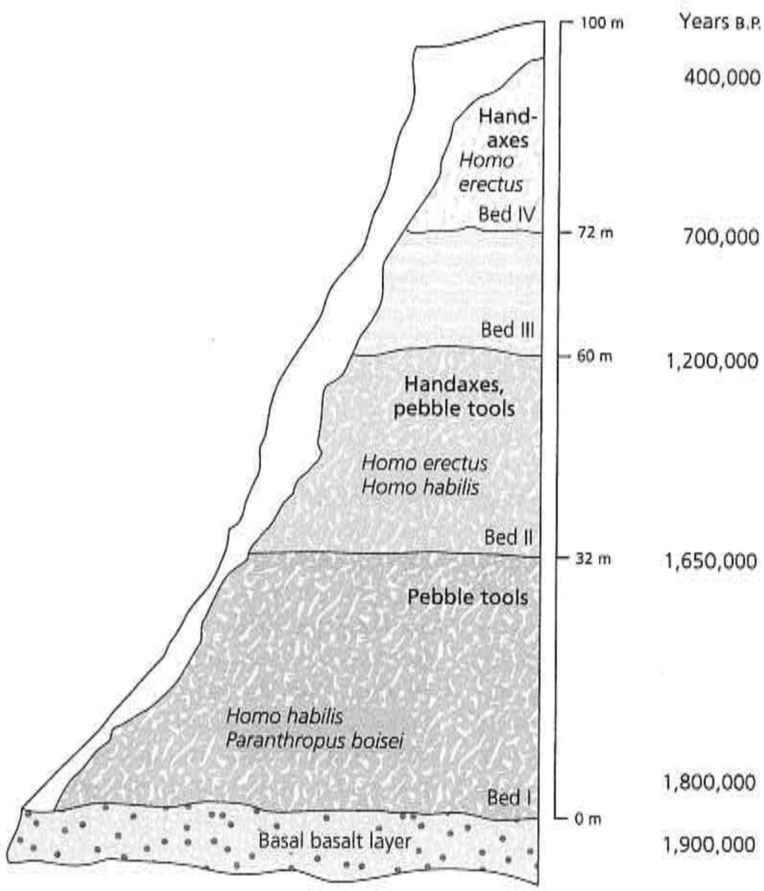
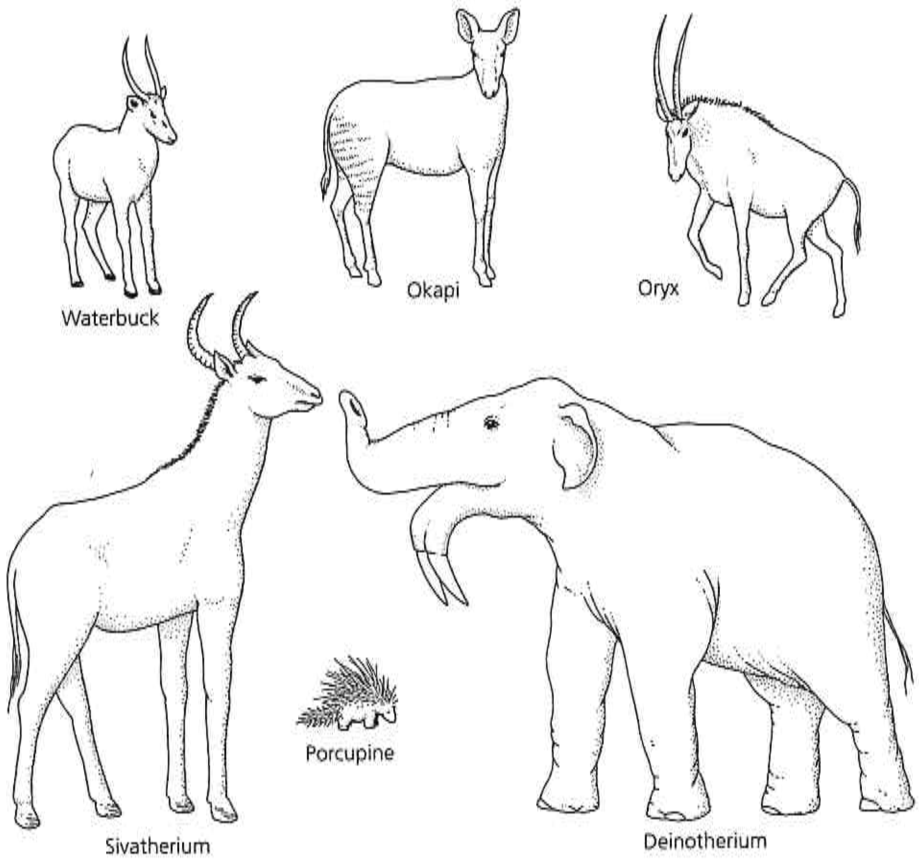


Figure 2.23 A schematic cross section through the 100 m of deposits at Olduvai Gorge, naming the various fossil forms and types of stone tools, with approximate ages.

Figure 2.24 Some of the more common early Pleistocene animal species at Olduvai Gorge.



lower layers at the gorge and was convinced that the bones of the toolmakers would also appear in this remarkable series of deposits. Not until 1959, however, 28 years after Louis' first visit, was the persistence of the Leakeys rewarded by Mary's discovery of a very early fossil, initially named *Zinjanthropus*. At the time, the fossil was thought to be approximately 1 million years old—twice the age of the then-earliest-known remains from Java. Zinj, as this fossil is affectionately known (or *Paranthropus boisei*, as it is scientifically termed), actually dates closer to 2 million years old.

The Leakeys' discovery brought the search for the first humans to Africa and eventually back into the Pliocene epoch. Their discovery of Zinj also brought world recognition for their efforts in the form of acclaim and funding, which supported more extensive investigations at Olduvai. With that funding, the Leakeys were able to examine a larger area of the gorge in 2 years than had been possible in the previous 20 years. That intensive work paid off in the discovery of more fossils and a whole series of archaeological sites.

Very old standardized objects of human manufacture (stone artifacts) appeared in the lower layers at Olduvai. Olduvai provided the first clear documentation that crude stone tools and the bones of very early hominins occurred at the same point in geological time. Over 70 prehistoric localities with stones or bones, or both, have been recorded in the geological layers of the gorge to date; perhaps 10 of these represent actual living areas where tools were made and used. Some of the stones are unmodified and may have been used as anvils and for other purposes. Other stones were in-

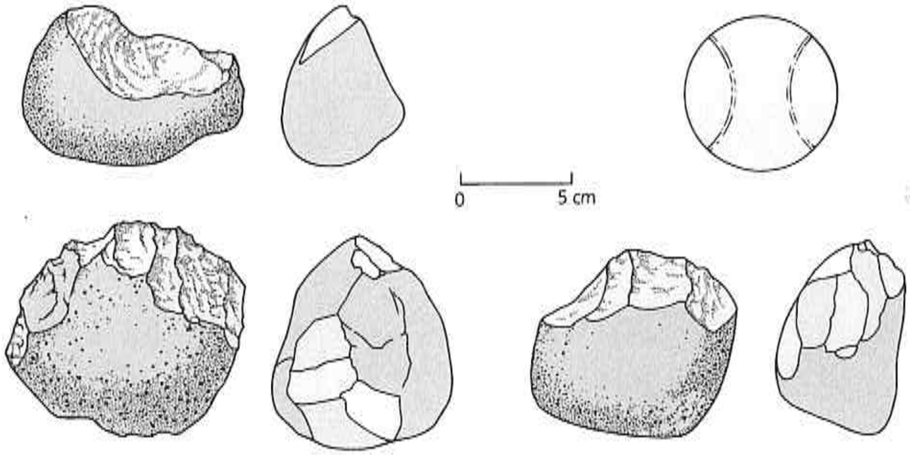


Figure 2.25 Typical Oldowan pebble tools, shown with a tennis ball for scale.

tentionally bashed with another stone to shape and manufacture tools (Figure 2.25). These stone artifacts had strong, sharp edges, providing cutting equipment for a species lacking sharp teeth or claws.

The materials for these artifacts were often brought from the rocky hills some 10 km (6 mi) away. Raw materials were selected on the basis of specific properties. Fine-grained stone was used to make small cutting tools, and basalt and quartz were used for heavy chopping equipment. Tools described as choppers, spheroids, and discoids were created by knocking off flakes of stone from a rounded cobble or large pebble. These sharp-edged cobbles are about the size of a tennis ball and are known as **Oldowan** pebble tools, named after the gorge itself. The flakes that had been struck off these pebble tools also had sharp edges and were likely used as tools.

One of the Olduvai sites contains a large quantity of broken and fragmented bone, along with stone tools. Many of the bone fragments are clustered in an area of about 5 × 10 m (16 × 33 ft, the size of a large room), with an empty zone several feet wide surrounding this concentration. Perhaps a thorn hedge or barricade was placed in this area to protect the inhabitants in the center.

At another site in Olduvai Gorge is a group of several hundred rocks in a roughly circular arrangement, surrounded by the bones of giraffes, hippopotamuses, antelopes, and elephants (Figure 2.26). The reason for such concentrations is unknown; it is not even clear whether early hominins were responsible for killing the animals represented by the bones. However, the hominins almost certainly collected the bones. Two other sites at Olduvai are known to have been places of animal butchering. At one of the sites, known as FLK North, the bones of an elephant lie scattered on the ground along with stone artifacts. The elephant would have been much too heavy to move and was very likely butchered at the spot where it died. Most of the bones from the elephant are present, disarranged by the butchering and surrounded by stone tools and flakes. Striations and cutmarks on the bones document the use of stone flakes to remove meat from the skeleton. (The issue of whether the hominins at Olduvai actually hunted these animals was discussed earlier; see "Hunters or Scavengers?" on p. 55.)

Other evidence suggests that most of the living floors at Olduvai were occupied during the wet season. Tortoises hibernate during the dry season, making them difficult to capture, yet their remains are common at most of

Oldowan The name given to the assemblages of early pebble tools and flakes belonging to the Basal Paleolithic, derived from *Olduvai*.

Figure 2.26 The plan of part of an excavated deposit at Olduvai, containing a concentration of elephant and other bones, with stone tools shown in solid black. This site likely represents the place where parts of these animals were butchered.

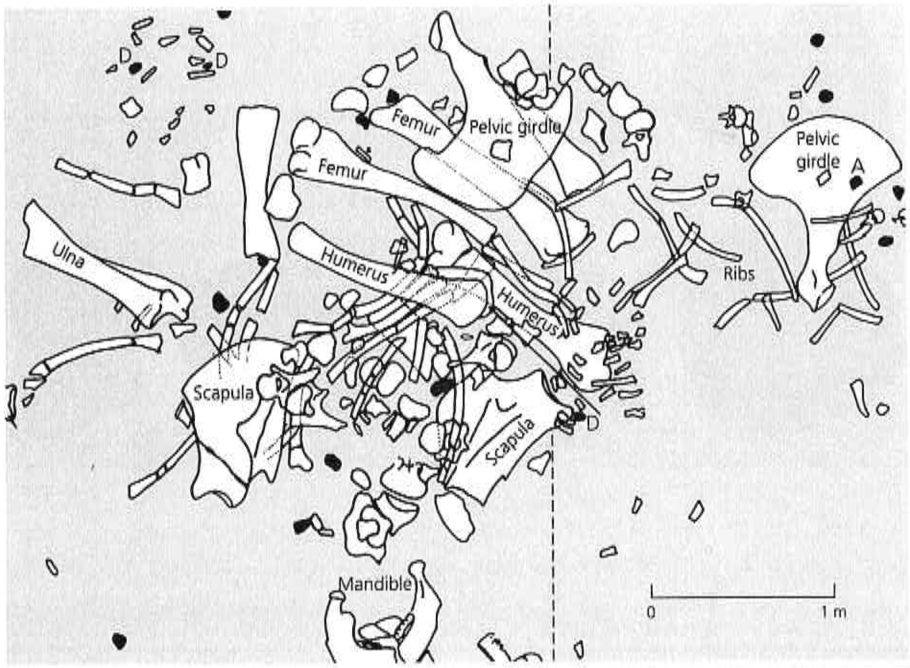
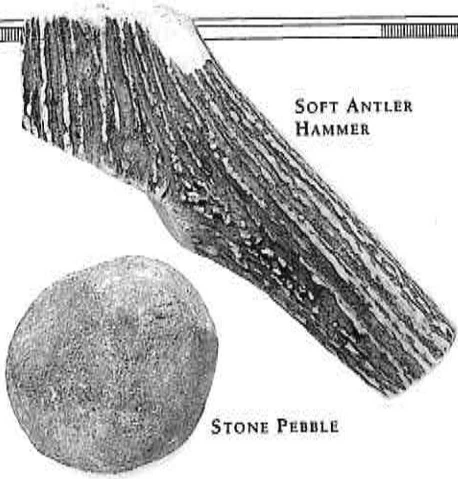


Figure 2.27 The Leakey family at work in Olduvai Gorge, ca. 1960.

the sites at Olduvai. Such information suggests that our early ancestors may have been absent from the Olduvai lakeshore during the dry season, pursuing other activities and perhaps game elsewhere in the region.

Olduvai will remain one of the most important archaeological sites in the world because it contains the information that helps answer many questions—the human fossils, the early Pleistocene deposits, the association of human bone and stone artifacts, and the fact that these materials are sometimes found where they were dropped by our early ancestors.



AX-MAKING TOOLS

In some cases, the hammers used to make tools are found with the tools themselves. Stone hammers survive well, whereas antler, which was often used to "pressure-flake" – remove flakes by pushing instead of striking the stone – survives less well.

STONE TOOLS

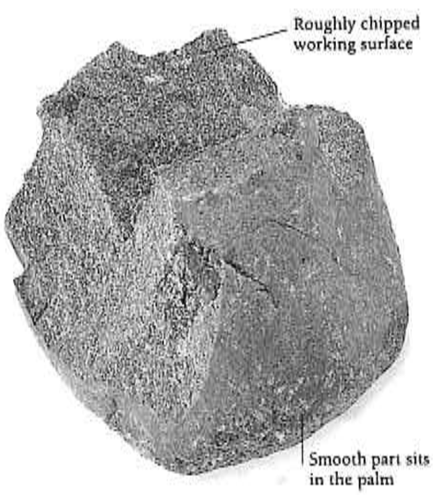
BY COMPARING A RANGE OF TOOLS from different time periods, archaeologists can begin to understand more about the technological capabilities of different societies. In the case of stone tools, there is often a period of more than 100,000 years between distinctive changes in types of tool. Each new stage of development tends to be characterized by a more sophisticated technique of production, particularly with regard to the relative length of usable cutting edge produced from a single piece of flint. Another way of analyzing a group of tools would be to imagine the amount of work taken to create each implement. It takes only a few strikes of stone against stone to create an Oldowan chopper, whereas to produce a flaked and ground ax takes considerably longer. One of the most significant stone-tool developments is the change from using just a core, with the flakes removed, to using the flakes themselves, reworked into a variety of implements.

OLDOWAN CHOPPER

1.9 MILLION YEARS AGO

Some of the earliest stone tools discovered to date are those found in the Olduvai Gorge in Tanzania, dating to 1.9 million years ago. These types of tools were simple pebbles with occasional flakes knocked off them to create a cutting edge. The smaller pieces that had been chipped off were probably used for cutting and scraping. These tools were used by *Homo habilis*, one of the ancestors of modern humans. The simple nature of these tools often makes it difficult to distinguish them from naturally broken and cracked pebbles in the field. A wide variety of types of stone were used to make these tools, including quartzite and volcanic rocks.

1.9 MYA



KEY CHARACTERISTICS

Pebbles used as the raw material.
Smooth part to sit in the palm.
Chipped and flaked cutting edge.

PALEOLITHIC HAND-AX

1.5 MILLION YEARS AGO

Around this time a newly evolved species of human called *Homo erectus* spread from Africa to the rest of the world, excluding the Americas. These people carried a new kind of stone tool with them that is now described as being of the "Acheulian" type. This style of hand-ax is characterized by being flaked on both sides.

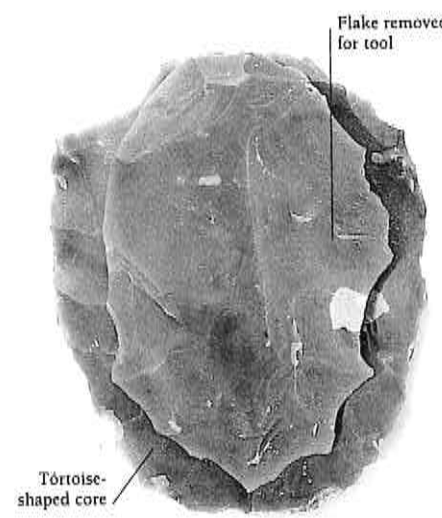
KEY CHARACTERISTICS

Defined cutting edge.
Flaked all over to produce two faces.
Distinct and elongated ovate shape.

LEVALLOIS AX

200,000 YEARS AGO

Homo sapiens emerged about 200,000 years ago, and a new form of tool (named after the Levallois region of France, where it was first recognized) is associated with this period. This new technique created a tortoise-shaped core surrounded by a series of sharp facets all around the edge. From the end of this core, one large flake is skillfully detached. This flake is shell-shaped – bulbous in the center, with sharp edges – which gives it great strength. This technique, still in use until about 35,000 years ago, enabled the maker to predict and control the exact shape of the final flake.

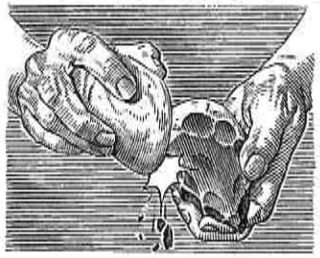


KEY CHARACTERISTICS

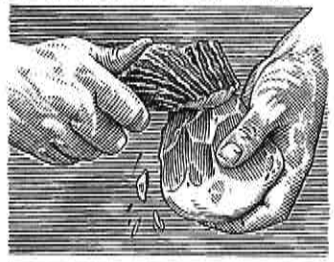
Tortoiselike shape from core preparation.
Ax is one large flake struck from core.
Cutting edge is chipped for strength.

Knapping a Paleolithic Ax

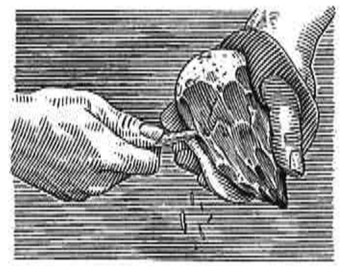
Making (or knapping) a stone ax is a job that requires great skill and patience. The skill lies in striking the core (a specifically selected stone of the correct weight and dimensions) at exactly the right place each time, so that the fracture produced creates a flake of the size and shape required. Even after thousands of years, the results of this process are often still visible on individual axes. This is because the place of impact, called the point of percussion, and the ripple fractures, created by the blow, are often well preserved.



1 A fine-grained, faultless stone that will fracture easily is selected. The stone core is prepared using a hard hammer stone. Major flakes are removed by striking the core to fracture it, and a rough ax shape is produced.



2 Once the stone is roughly the correct shape, a soft bone hammer is used to chip off specific areas of the stone in a controlled manner. This stage, which is known as "secondary flaking," requires patience and precision.

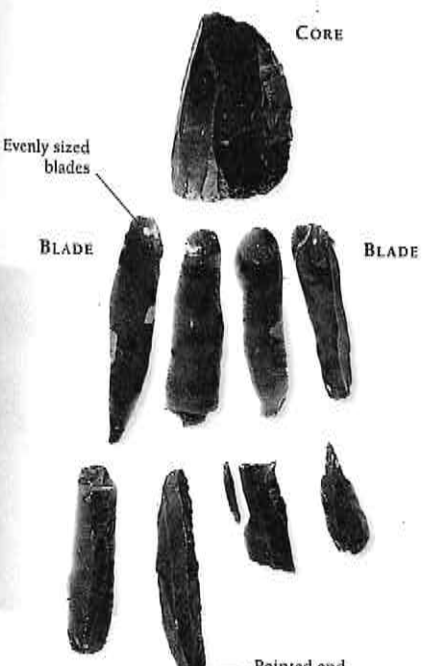


3 Once the stone is ax-shaped, the knapper can begin to shape the ax further by "pressure flaking" – pushing not striking – the ax with a chisel. This task requires a leather hand cover to protect the palm.

Upper Paleolithic Blades

40,000 YEARS AGO

Around 40,000 years ago, an advanced form of the core technique was developed, in which a series of blades were struck from one core. After they had been secondary flaked (the removal of flakes from each edge) the blades were used to make knives and scrapers. This method created the maximum length cutting edge from one core.



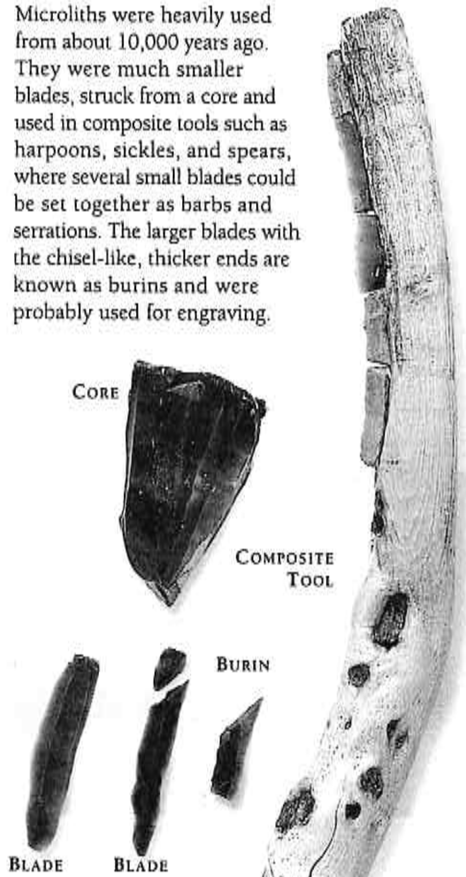
Key Characteristics

Parallel-sided blades.
Pointed or chisel ends.
One core produces many blades.

Microliths

10,000 YEARS AGO

Microliths were heavily used from about 10,000 years ago. They were much smaller blades, struck from a core and used in composite tools such as harpoons, sickles, and spears, where several small blades could be set together as barbs and serrations. The larger blades with the chisel-like, thicker ends are known as burins and were probably used for engraving.



Key Characteristics

Small tool size.
Long thin blades.
Used in composite tools.

Neolithic Ax

4000 BC

Ground and polished stone axes appear in the Neolithic period (see pp. 24–33). These larger axes, strengthened by grinding the cutting edge with another stone, represent a large expenditure of human time and effort. As a result, they were often symbolic as well as utilitarian objects.

Key Characteristics

Regular shape.
Sharp, ground edge.
Smooth, polished surface.

23. Homo habilis

Homo habilis (2.3 mya)

("same" / "handy," "able," etc.)

SITES
Ethiopia: Hadar (and possibly Omo)
Kenya: Koobi Fora
Tanzania: Olduvai Gorge
South Africa: Swartkrans and Sterkfontein
PEOPLE
Mary and Louis Leakey, Donald Johanson, Tim White, and others

Figure 23.1 Scientific reconstruction of Homo habilis. "Homo habilis" by Lillyundreya is licensed under CC BY-SA 3.0.

Of the two species of Early *Homo*, *Homo habilis* is the favored ancestor of *Homo ergaster* and all subsequent hominin species.

PHYLOGENY

While the origin of *Homo habilis* has been in a state of flux in recent years, the discovery of *Au. sediba* has raised more questions about the origin of our genus. The discovery of Lucy in the early 1970s led some researchers to turn away from *Au. africanus* in favor of *Au. afarensis* as the ancestor of genus: *Homo*. In recent years, the idea that a cladistic event had occurred with *Au. afarensis*, leading to *Au. africanus* and the more derived robust forms on the one hand and genus *Homo* on the other, gained in popularity. *Au. sediba* now seems to have bridged the gap between the australopiths and genus *Homo*, sharing characteristics with *Au. africanus*, *H. habilis*, and *H. ergaster*. The similarities with the two *Homo* species may help resolve the problem as to which of the two species of "Early *Homo*" gave rise to *H. ergaster*. There are proponents in support of each of the evolutionary scenarios, with their share of pros and cons.

Figure 23.2 KNM-ER 1813, Koobi Fora, Kenya. "Homo habilis-KNM ER 1813" by Locutus Borg is in the public domain.

DISCOVERY AND GEOGRAPHIC RANGE

Louis and Mary Leakey discovered the first fossil material in 1960 at their site in Olduvai Gorge, Tanzania. Louis had been recovering stone tools from the site for years, but the manufacturer of those tools had previously eluded him. He named the species *Homo habilis* or "handy-man." Fossils attributed to *H. habilis* have also been found at Hadar (and possibly Omo), Ethiopia; Koobi Fora, Kenya (see Figure 23.2); and the South African sites of Swartkrans and Sterkfontein.

PHYSICAL CHARACTERISTICS

H. habilis exhibited a high degree of sexual dimorphism, with males and females weighing 114 and 70 lb and standing 5′2″ and 4′1″, respectively. Their skull, face, and dentition were more gracile than the australopiths. Their teeth and dental arcades were very human-like. The skull base was flexed, as seen in *Au. africanus* and the more derived robust australopiths and, relative to past species, the skull was rounder and higher, reflecting architectural changes in the brain. Cranial capacity ranged from 500 to 800 cc with a mean of 631 cc. This gave them an EQ of 3.1–3.5. At this point in hominin evolutionary history, we see increased asymmetry in the two hemispheres of the brain, termed lateralization or left hemispheric dominance. The left side of our brain is involved with language and analytical processes. Like all Old World monkeys and apes, *H. habilis* possessed Broca's area, which is involved with language production. However, it was larger than in past hominin species, and they also possessed Wernicke's area, which plays a role in language comprehension. They thus had the neural capacity for language. The left hemisphere is also related to right-handedness. They may have exhibited our tendency to hold objects with our left hand while working on them with our right. The frontal lobe, important in association processes, was expanded and resulted in more of a vertical forehead. The enlarged brain may have been facilitated by a decrease in gut volume, combined with a higher-quality diet that resulted from increased cognitive capabilities and an expanded technology base.

H. habilis had a smaller supraorbital torus and its face was more orthognathic than its supposed ancestor, *Au. africanus*, but they retained some prognathism in the lower face. They had fairly large ape-like incisors, but their canines, premolars, and molars were reduced in size. The mandible was more gracile, reflecting their reduced masticatory capabilities.

Like the majority of the australopiths, *H. habilis* possessed elongated arms, possibly suggesting continued reliance on an arboreal environment. While the digits were still curved, they had increased gripping capabilities for tool manufacture and use, as evidenced by the pronounced attachment site for the *flexor pollicis longus* muscle, which acts to flex the thumb.

The femoral head was enlarged and the neck shortened. Those changes are thought to have been the result of increased strain generated by an expanded pelvis for birthing larger-brained infants. However, no fossilized pelvic fossils have been found. Their foot was more modern, in that the hallux was no longer divergent but rather aligned with the lateral four digits, and the toes were shorter. They had less mobility in their feet, in that the foot had become more of a support structure like our own. The metatarsals were thick relative to modern feet, and the morphology of the third metatarsal suggests that they did not yet exhibit the degree of weight transfer and propulsive capabilities seen in modern humans.

Review of Primitive Characteristics

- Some prognathism.
- Large incisors.
- Curved phalanges.
- Long arms and short legs.
- Thick metatarsals.

Review of Derived Characteristics

- Gracile craniofaciodental characteristics:

  - Thin skull vault.
- More globular cranium.
- Expanded frontal lobe.
- Left hemispheric dominance.
- Enlarged Broca's and Wernicke's areas.
- Reduced supraorbital torus.
- Smaller mandible, canines, and cheek teeth.
- Parabolic dental arcade.
- Increased manual dexterity.
- Larger femoral head (and hence acetabulum) and shorter neck.
- More stable foot:
  - Loss of divergent hallux.
  - Shorter toes.

ENVIRONMENT AND WAY OF LIFE

Certainly one of the most interesting things about *H. habilis* is the appearance of a much more extensive archaeological record. The cultural period at that time, and extending through *Homo erectus*, is termed the **Early Paleolithic**, or the early portion of the Old Stone Age. While other species apparently preceded *H. habilis* in the manufacture of tools, it was thought for many years that they were the first to do so. The **Oldowan** or **Olduwan tradition** (**industry** and **technology** are also used synonymously with "tradition"), named after Olduvai Gorge, consisted of simple core tools and flakes. The technique involved the selection of a **cobble** (a workable-sized rock), followed by the use of a **hammerstone** to remove the outer rough surface (see Figure 23.3) or "**cortex**" and then to shape it into a **core tool**, by the removal of **flakes**. The flakes that are removed may be suitable for cutting and slicing. The process is called hard percussion, and the shaping is known as lithic reduction. "**Lithic**" refers to stone and is also used to denote a stone tool. Stone resources for the manufacture of tools were chosen for their suitability and transported across the landscape. Of course, this indicates a level of cognitive complexity, but we must remember that chimps and orangutans choose sticks and grass of particular widths and strengths, trim them to the appropriate length, and transport them in their mouths to their site of intended use. Apes learn by trial and error, innovation and imitation, and cultural transmission, i.e. traits spread throughout a group by observation. Cultural transmission of innovations is even seen in monkeys, e.g. Japanese macaques washing sweet potatoes, skimming grain kernels floating on the surface to separate them from beach sand, and bathing in volcanic springs. While we do not know which species was the first to invent stone tools that were modified from their original form via lithic reduction and shaping, we can see the precursors of innovation and cultural transmission in our primate relatives. The real skill comes with having the manual dexterity to do so, making a tool that can accomplish a variety of uses, and the ability to teach others. I would argue that the earliest members of our genus had "**theory of mind,**" i.e. the realization of another's thoughts. There is only one example of teaching in nonhuman primates and that was a mother chimp in the Tai Forest of the Ivory Coast that helped her daughter crack a nut, using their unique hammer and anvil technique. Our closest relatives, with all of their intelligence, symbolic capabilities as demonstrated in language studies, and similarities to our own behavior, do not know enough to teach their children. They are not capable of realizing that "I know something that you don't know" and vice versa. We go on and on about encephalization in the hominin lineage and technological advancements in the archaeological record over time, but what may have been the true dividing line between ourselves and the apes, whether bipeds or not, was the ability to teach our young, kin, and other group members and thus increase their chance of survival. The vehicle for developing a theory of mind is language. Human children develop a theory of mind at three or four years of age. Prior to that time, they do not realize that they or others may have incomplete information. Here is a fun anecdotal account that I always relay to my students:

My brother Michael was visiting my brother Jimmy. Jimmy was nowhere to be found when Michael realized that Jimmy's 18-month-old son had messed his diaper. Jimmy's older son must have been about three years old at the time. He helped Michael find everything that he needed to clean the baby. After Jimmy had reappeared and Michael had left for the day, the older boy remarked to his dad, "Uncle Mike is so dumb!" When asked what he meant by that, he replied, "He didn't know where the towels were; he didn't even know how to use the Diaper Genie® [a gizmo that turns dirty diapers into self-contained plastic coated links—truly magical!]."

This indicates that my nephew had not developed a theory of mind. He did not understand that Michael did not know things that he knew.

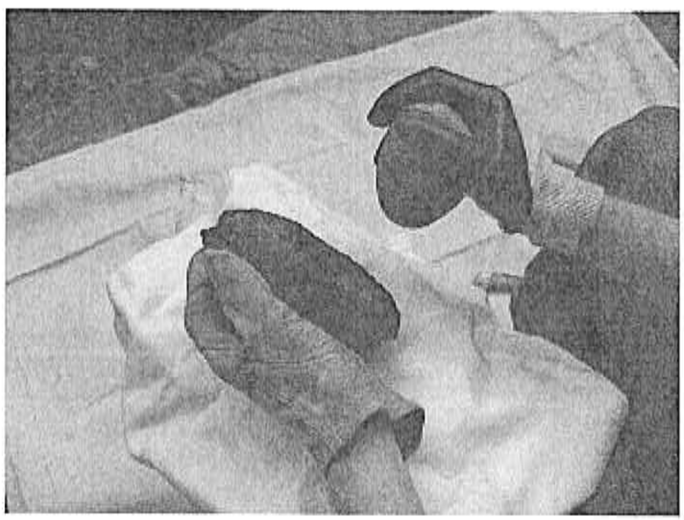


Figure 23.3 Hard hammer percussion. "Hard Hammer" by ZenTrowel is in the public domain.

Homo habilis was the first species to exhibit enlarged Broca's and Wernicke's areas. They thus may have had the motor control that allowed more lingual activity and the ability to comprehend the resulting sounds they could produce. Great apes can comprehend symbols, i.e. *this* stands for *that* even though *this* bears no resemblance to *that*. They have been taught American Sign Language, various computer languages, and spoken language. Where they fall short is in syntax—they cannot string together symbols into meaningful sentences. I firmly believe that the descendant species of Early *Homo*, i.e. *Homo ergaster*, had theory of mind, based on their stereotypical production of tools. There had to be teaching, learning, and training involved in order to produce an implement that is readily recognized as an

Acheulian hand axe (see Figure 23.4). Thus, since we see an earlier stage of tool production in Early *Homo*, I would argue that they had rudimentary language and theory of mind.

Figure 23.4 Acheulian hand axe. "Bifaz en mano" by José-Manuel Benito Alvarez is licensed under CC BY-SA 2.5.

The Oldowan tradition lasted from approximately 2.5 to 1.5 mya but survived in some areas until 600 kya. Tools consisted of crude choppers (see Figure 23.6) and scrapers, as well as simple flake tools, some of which indicate that they were "retouched," i.e. secondarily shaped and/or sharpened. In addition, there is evidence of possible wooden digging sticks or spears at the site of Koobi Fora, in the East Lake Turkana region of Kenya and possible bone tools at Olduvai Gorge.

Tools were likely used for acquiring and processing both animal (scavenging, butchering, disarticulation, skinning, cutting flesh, chopping bones open, etc.) and plant (digging tubers, cutting stalks, pounding to break down fiber, etc.) foods. Indications of hominins having butchered and scavenged animals comes from several lines of evidence. First, tools have been found with *H. habilis* remains. Second, there are concentrations of tools and fossilized animal bones that exhibit signs of cutting, disarticulation, and marrow extraction. Mary Leakey mapped one such area with a high accumulation of stone tools and bones, known as site DK. Third, the high frequency of particular bones at some sites is indicative of the hominins having "brought back the good stuff," i.e. skulls for brain and limb bones for meat and marrow. Fourth, microscopic analyses indicate that cut marks on some bones overlay predators' teeth marks, showing that the hominins arrived afterward. How they got meat away from scary scavengers is anyone's guess. Finally, experiments with modern-made stone tools in the Oldowan style reveal (1) that it is possible to butcher an elephant and (2) wear patterns that result from the butchering process match those found on ancient tools.

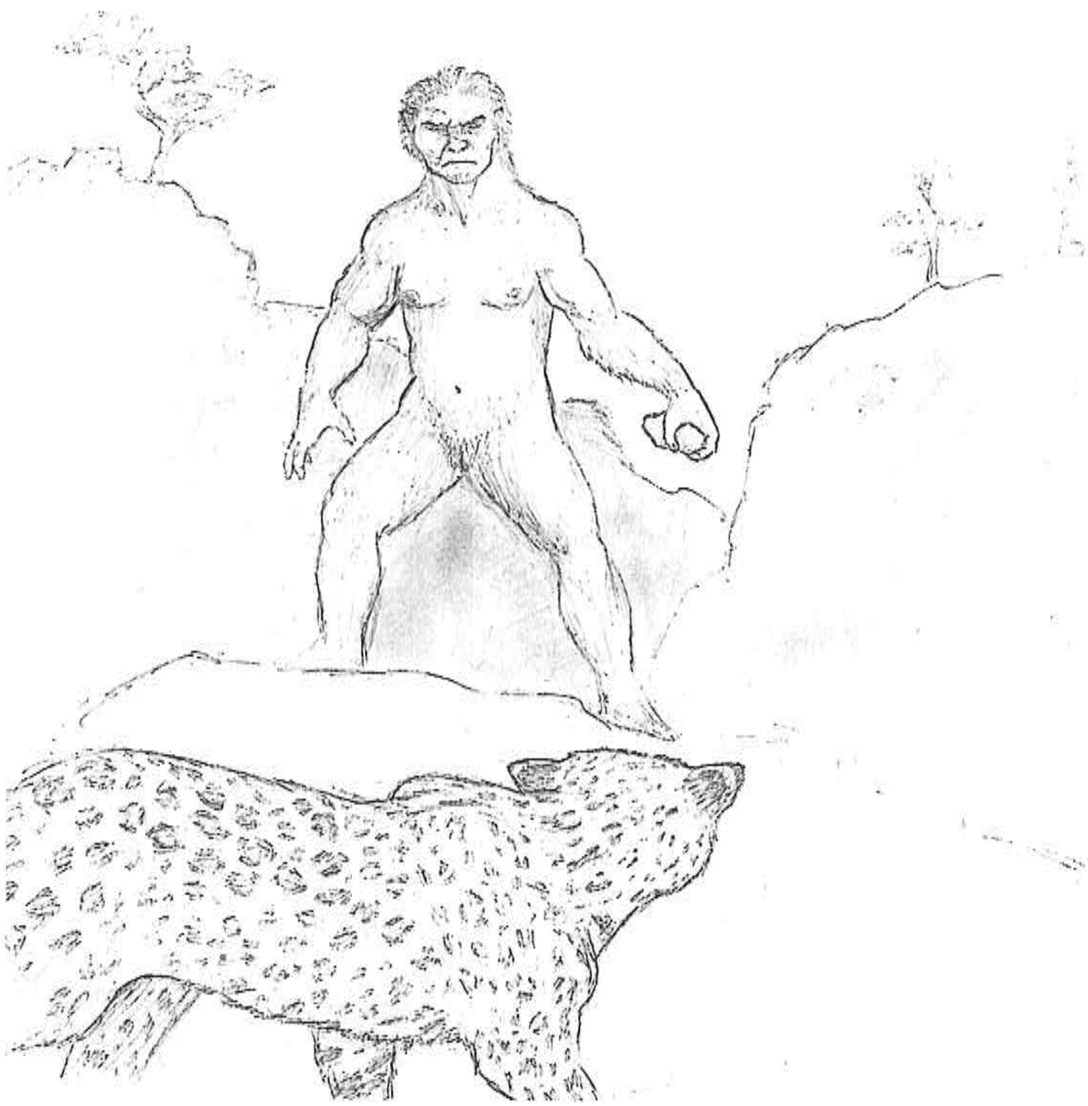


Figure 23.5 Homo habilis Leopard Confrontation by Keenan Taylor.

The following sites contain evidence of stone tools and their manufacture:

- Lomekwi 3, Lake Turkana region, Kenya (3.3 mya): cores, anvils, and flakes.
- Gona, Ethiopia (>2.5 mya): 3,000 stone artifacts.
- Hadar, Ethiopia (2.4 mya): tools were found with a *H. habilis* mandible.
- Olduvai Gorge, Tanzania (1.8 mya): numerous tools.
- Koobi Fora, Kenya: high concentration of flakes suggesting repeated use.

H. habilis are thought to have been forager-scavengers that collected wild plant foods, hunted small animals opportunistically, and scavenged carcasses from large predators. While there is evidence of "**repeated-use**" sites, meaning that individuals returned to particular areas to meet, they are not thought to have settled in any one area but rather moved about

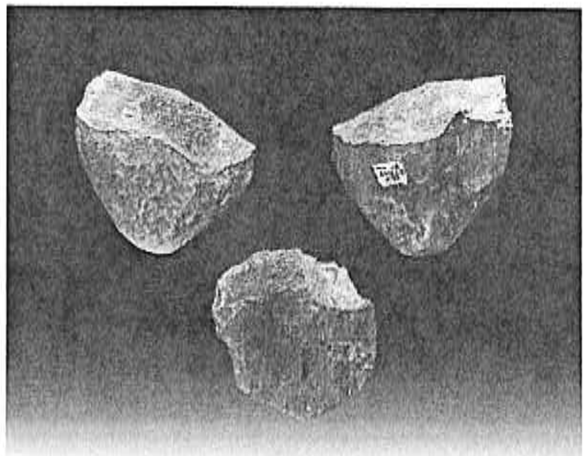


Figure 23.6 Oldowan choppers. "Pierre taillée Melka Kunture Éthiopie fond" by Didier Descouens is licensed under CC BY-SA 4.0.

the landscape in their quest for food. They may have made use of those sites for a variety of communal or individual activities, such as grouping for "central place foraging" activities (from the animal literature, meaning to move out from and possibly return to a particular place), making new and/or using cached tools, butchering carcasses, sharing food, etc. Mary Leakey believed that her Site DK was indicative of a home base. While it is a romantic notion to look to modern hunter-gatherers with modern intelligence and advanced weaponry as being able to stay in one place until resources became scarce, it is not likely that those primitive hominins were camped out on a lake shore. It would have been a very dangerous place to be for long periods of time.

While they could have climbed trees and made sleeping nests in trees or on the ground, we do not know how much time they spent in the two microenvironments.

THE FIRST FAMILY OF PALEOANTHROPOLOGY: THE LEAKEYS

Louis Leakey (1903–1972) was born to British missionary parents residing in Kenya. He and his wife Mary made names for themselves with their pioneering work, searching for and discovering fossil hominins in East Africa. Louis is credited with the discovery of three hominin species, the first of which is considered to be a possible **basal** or **stem** ape, *Proconsul africanus* ("before Consul" [a famous chimp at the London Zoo]/"from Africa"). Louis was an early believer in an African human origin (Cartmill and Smith 2009). He became interested in the search for ancient hominins after his discovery of stone tools that he attributed to human ancestors. The Leakeys worked at Olduvai Gorge in Tanzania for many years. When Mary discovered the robust australopith that she named *Zinjanthropus boisei* (later to be changed to *Australopithecus boisei* and later to *Paranthropus boisei*), Louis proclaimed to the world that they had found his predicted "man the toolmaker." According to legend, he was ridiculed by some because they felt that "Zinj" (also known as "Dear Boy" or "Nutcracker Man"), as the specimen came to be known, was an herbivorous ape that would not have had the mental capabilities to manufacture the tools that became known as the **Oldowan technology**. Louis was later rewarded with the discovery of fossils of a more derived hominin with a larger cranial capacity. He named the species *Homo habilis* ("Handy man") as the first tool makers. There was and still is some controversy surrounding the classification of the species. He and his colleagues were accused of using cultural versus physical attributes to justify their inclusion of the fossil material in our genus *Homo*. Some still believe the species should be assigned to genus: *Australopithecus*. Regardless of the controversies, Louis made a name for himself and added to our knowledge of human ancestry. At Olduvai, he also discovered the cranium (missing its face) of a 1.2 mya *H. ergaster* individual. Another great accomplishment was sending the three "grand dames" of ape primatology into the field. He correctly believed that we can learn about ourselves from our closest relatives. He thus funded Jane Goodall to study the chimps of Gombe, Tanzania; Dian Fossey for her work with mountain gorillas in the Virunga Volcano region of Rwanda; and Biruté Galdikas to study the orangutans of Borneo.

Mary Leakey (née Mary Douglas Nikol, 1913–1996) is described on the Leakey website (www.leakey.com) as "one of the world's most distinguished fossil hunters." She is credited with the discovery of two species of early hominins, *Au. afarensis* at Laetoli and *P. boisei* at Olduvai, as well as the Laetoli footprints. (Laetoli is also in Tanzania.) Mary had an early interest in archaeology and, like Louis, excavated stone tools; in her case in France as a mere child. By age 17, she was auditing university courses in archaeology and geology. She met Louis in 1933 and accompanied him to Kenya to illustrate stone tools for a book he was writing. They married several years later and had three sons, Jonathan, Richard, and Philip. Jonathan hunted fossils along with his parents and discovered the first *H. habilis* specimen, a mandible known as "Jonny's Child." Richard moved into Kenya to work at sites around Lake Turkana, and his team discovered the oldest *H. ergaster* specimen (1.75 mya) in the West Lake Turkana region. In addition to his paleoanthropological work, he is a champion of wildlife conservation. His wife Meave is a renowned paleoanthropologist with several hominin species discoveries to her credit, and their daughter, Louise, is well on her way to making a name for herself (www.leakey.com).

29. Homo erectus

Homo erectus (1.8 mya)

("same" / "upright")

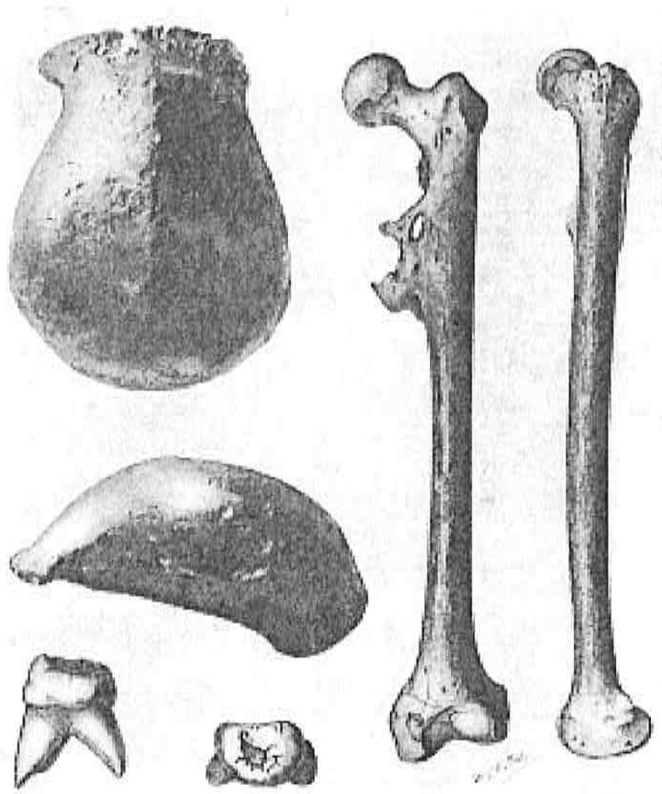


Figure 29.1 Drawing of Trinil material. "Pithecanthropus-erectus" by 120 is in the public domain.

SITES

Java: Trinil, Modjokerto, Sangiran, Ngandong

China: Zhoukoudian, Taiwan, and sites in Yunxian, Hexian, and Lantian counties

India: Narmada

Turkey: Kocabas

PEOPLE

While there are many people associated with *Homo erectus*, I have listed a few of the historic names.

Java: Eugène Dubois

China: J. Gunnar Andersson, Davidson Black, Franz Weidenreich

INTRODUCTION

Homo erectus is the genus and species combination that was retained for all mainland Asian, Taiwanese, and Javanese fossil material.

PHYLOGENY

The most popularly held notion is that *Homo erectus* is derived from *H. ergaster* or a pre-*ergaster* form that "quickly" moved out of Africa into Eastern Europe and Southeast Asia. However, *H. georgicus* is another possibility for the ancestor of *H. erectus*.

DISCOVERY AND GEOGRAPHIC RANGE

Eugène Dubois discovered the first *H. erectus* material at the Trinil site (see Figure 29.1) on the Solo River in Java in 1891. While there are problems with the dates, the oldest material from the Javanese site of Modjokerto may be "contemporary" with African and Georgian material at 1.8 mya. Other famous Javanese sites are Sangiran, Ngandong, and Trinil. Java is part of the Sunda shelf, and when initially colonized by *H. erectus*, it was connected to mainland Asia (see Figure 29.2). After reaching Java and possibly other areas of Southeast Asia, later groups of *H. erectus* moved north into China. The earliest Chinese fossils are dated to 1 mya. First assigned to the genus *Sinanthropus* ("Chinese man"), the material was later included in our own genus after Franz Weidenreich pointed to the similarities between the various assemblages of *erectus*-like fossils and other extinct and modern humans. The first fossils were discovered at the now famous site of Zhoukoudian (formerly Choukoudian), near Beijing (formerly Peking and hence the term, "Peking Man"). The local people called them "dragon bones" and were using them for medicinal purposes. Material from Zhoukoudian spans a time period of over 200,000 years, from 460 to 230 kya, with three distinct cultural periods thought to be in evidence.

One of the great mysteries of paleoanthropology surrounds the Zhoukoudian material. Weidenreich and his predecessors, Davidson Black and J. Gunnar Andersson, had amassed an unprecedented amount of fossil material from the site. Due to the imminent Japanese invasion, Weidenreich packed up the fossil material in 1941 with the intent of having it shipped to the United States. However, the material disappeared, and all that remains are Weidenreich's notes, drawings, and some casts of the original fossils.

Other Chinese sites are found in the counties of Lantian, Yunxian, and Hexian. A new discovery on the island of Taiwan has been linked to *H. erectus*, with the closest resemblance to the Hexian remains (Chang et al. 2015). Finally, the Narmada site in India has been a topic of debate for a long time but it has now been decided, at least by a portion of the paleoanthropological community, as being *Homo erectus*.

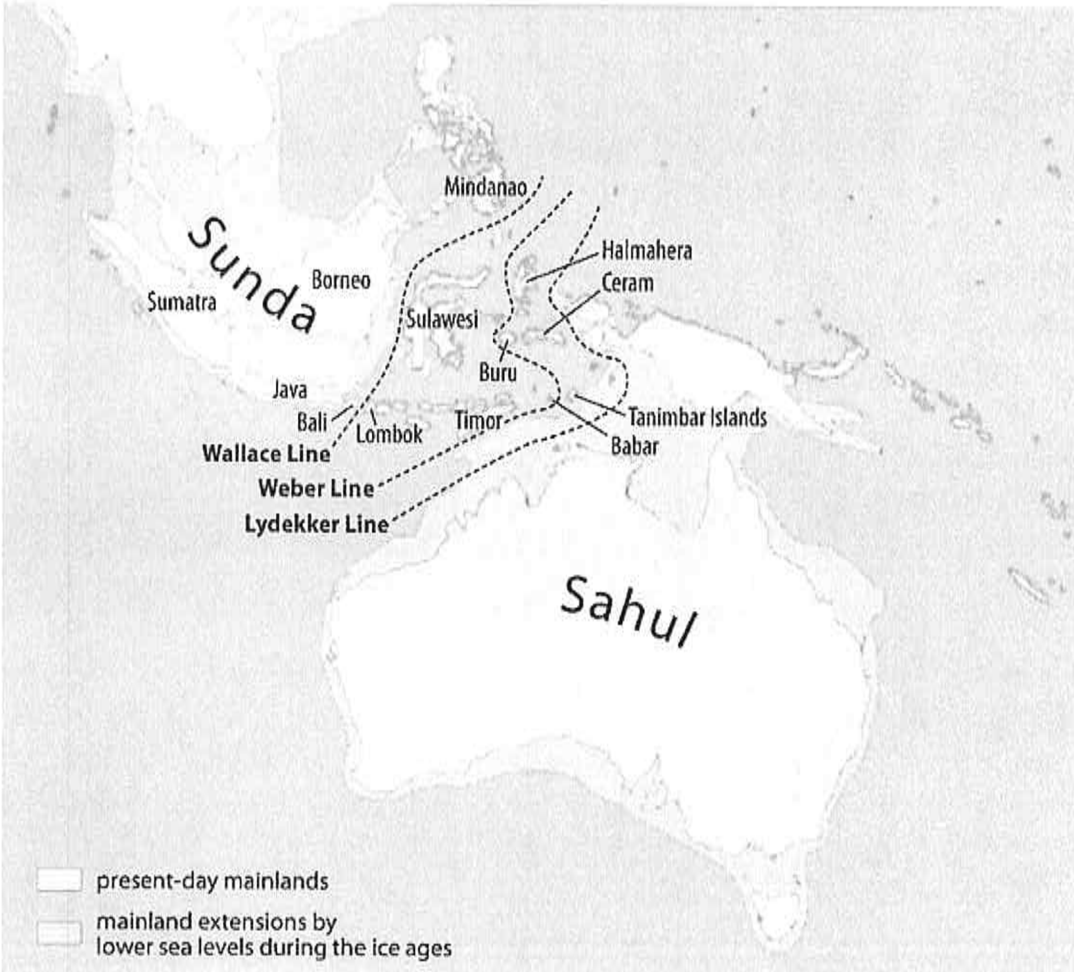


Figure 29.2 Sundaland (northwest of the Wallace Line). "Map of Sunda and Sahul" by Maximilian Dörrbecker is licensed under CC BY-SA 3.0.

PHYSICAL CHARACTERISTICS

While many of the physical characteristics of *H. erectus* are similar to *H. ergaster*, the Asian species is unique in a number of ways. Asian forms exhibit a thickening along the sagittal suture, termed a sagittal keel. The keel gives the skull a pentagonal shape in cross-section. It is unknown whether the keel served a function.

Their incisors were shoveled, an adaptation that increases the stress resistance of teeth, especially when using them as tools. The molar enamel was characterized by a unique wrinkling pattern. Both of those dental characteristics are found in modern people of Asia and Asian ancestry and are interpreted by some scholars as evidence of regional continuity; in other words, there was a gradual evolution from *erectus*-like forms through archaic human populations and into modern populations in multiple areas via gene flow.

Figure 29.3 Homo erectus by Keenan Taylor.

Review of Derived Characteristics

- Sagittal keel.
- Shoveled incisors.
- Wrinkled molar enamel.

Figure 29.4 Homo erectus: Peking Man by Keenan Taylor.

ENVIRONMENT AND WAY OF LIFE

Javanese sites in the early Pleistocene would have been conducive to tropical-adapted animals like *Homo erectus*. The area was part of the land bridge that was exposed beginning ~2.5 mya, making it accessible by land. Pleistocene Java was a mix of environments consisting of a variety of forest types, freshwater lakes and rivers, brackish marshes, and grasslands (Blain 2012).