

CHAPTER 29

THE EVOLUTION OF HUMANS

WHAT IS A HUMAN?

A very meaningful question is to ask who or what is human. This question may seem relatively obvious or useless today, although various societies, promoting slavery, racism, or seizure of resources, have found ways to exclude one or another group from membership in the category of human. To a biologist, in spite of our very large variation in color, shape, and other characteristics, all nearly hairless apes capable of talking, forming societies, and of building elaborate tools belong to the species *Homo sapiens sapiens* by the criterion that we can interbreed freely and that all of our young, even those derived from the most diverse parents imaginable, are healthy, grow well, and are fertile. However, the question becomes more complicated as we move farther afield or delve into history. We may differ as to the rights and protections that an ape such as a chimpanzee should be accorded, but we have little difficulty in understanding that it is not human. But what about the fossils that we encounter?¹² We can evaluate them by many criteria: Did they walk fully upright? How large were their brains? What types of tools did they use? Can we determine what size colony they preferred? Did they build structures in which to dwell? Did they wear clothing? Did they use fire? Did they domesticate animals or plants? Did they have musical instruments? Did they have a sophisticated language? And, most importantly, did they leave any kind of artifact (artwork, statues, symbolic tools) that suggest that they thought about who they were and how they related to the earth? Did they care for wounded, deformed, or weak members of their society? Did they bury their dead or leave any indication that they had a sense of afterlife or a religion?

These questions have meaning when we consider our ancestors and most especially the ancestor that immediately preceded and to some extent overlapped with us. Current evidence indicates that the Neanderthal people—we will use that term—did not contribute to the population of humans that now covers the earth. Their DNA, insofar as it has been successfully analyzed, is too different from ours. And yet they met all or most of the criteria mentioned above. (There is still dispute, as described later in this chapter, as to whether or not they could have had a clear language.) In brief: they made tools, they buried their dead, perhaps with some

¹² See Wikipedia on Neanderthal, and Smithsonian (<http://www.si.edu>) on Shanidar cave (Neanderthal)

ceremony, they could control fire, they cared for their wounded, they decorated their bodies, and they apparently had musical instruments. And yet they did not survive.

Therefore the question becomes, what is the species we call *Homo sapiens sapiens*? Where did we come from, and how did we come to populate the world, as opposed to any other species similar to us or not? For this kind of analysis we look primarily to the fossil record, with some cross-referencing of our ability to interpret the record in our genes. For our purposes, we will use the following terms: *anthropoid* or human-ish: tailless apes that can stand erect on occasion; *hominid* (human-type): truly erect creatures with brain size larger than apes; *human*: truly erect large-brained creatures with sophisticated tool-making capability, the ability to control fire, and signs of culture. Our story begins approximately 4 million years ago (if one starts with the earliest creatures that resembled humans) 1,600,000 years ago (if one starts with creatures that were sufficiently like us to be considered within the genus *Homo*) or 160,000 years ago, if one considers those similar enough to us to be considered modern *Homo sapiens* with fragments of skeletons found in eastern Africa (Fig. 29.1). Because the skeletons are very fragmentary, much of what we understand about their lifestyles is inferential. In general, skulls or parts of skulls are more frequently preserved than other bones. Apes have sharp, tearing canine-like teeth, while modern humans have a mixture of grinding and more gently tearing teeth. Thus we can examine tooth structure. The size of the mandibles is also meaningful, since apes have more massive jaws. Although the intelligence of individuals does not correlate with brain size, in general populations of animals with larger brains are smarter than populations with smaller brains, and brain size has expanded very rapidly in human evolution. The vertebral column of humans follows an S-shaped curve, to balance the torso on the pelvis, and humans have

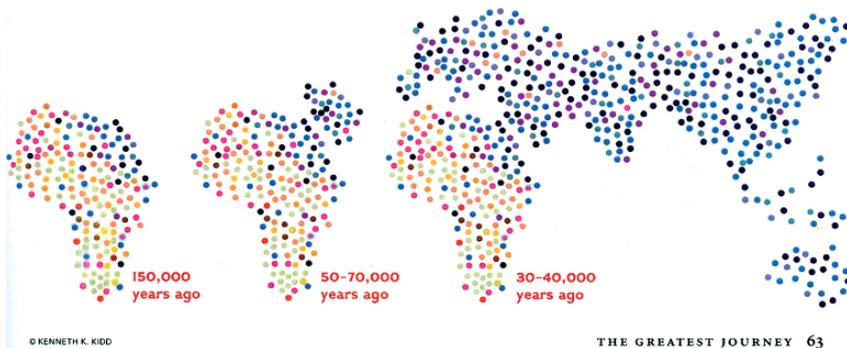


Figure 29.1a. Human migration, as determined by genetic diversity and traces of human activities. *Upper*: Genetic diversity. The colors indicate different primary genetic markers. *Lower*: Migration patterns as traced by earliest evidence of human activity. In general, blood types, genetic evidence, and general appearance (skin tone, hair color, hair form, extent of beard and hirsuteness) are consistent with these values. Credits: Shreeve, James, 2006, *The Greatest Journey*, National Geographic, March 2006

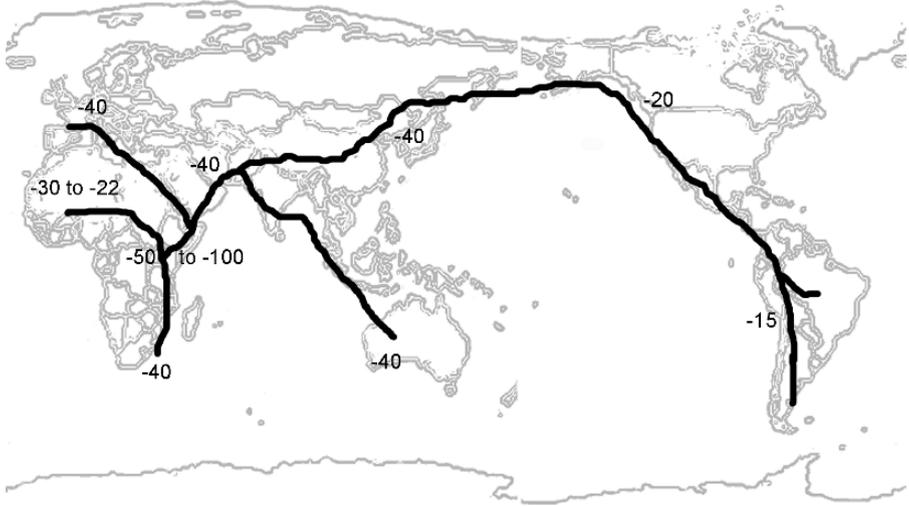


Figure 29.1b. (Continued)

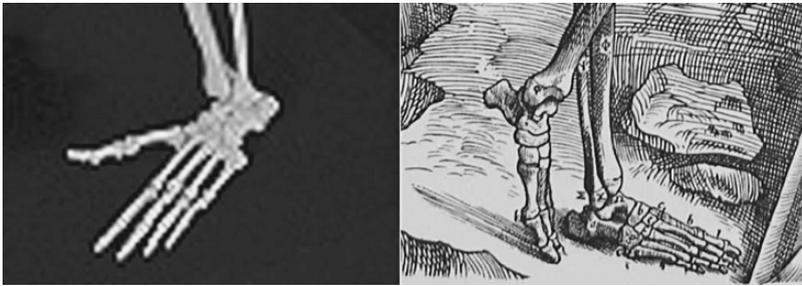


Figure 29.2. Feet of a chimpanzee (left) and human (right). Note that the big toe of the chimp is more adapted for grasping, and that the angle at which the leg meets the foot is slightly acute

flat walking feet unlike the prehensile (grasping) feet of many apes (Fig. 29.2). It has been of some interest to know when humans became fully erect, especially since some hypotheses consider that the increase in intelligence followed the free use of hands by our ancestors; but unfortunately vertebrae and feet are only rarely found. In fact, it was typical of earlier dioramas, or model displays of early human existence, that these individuals were shown in tall grass so that the shape of their feet would remain ambiguous. There are, however, clues that can provide indirect evidence. In truly erect humans, the skull must be balanced on the spine, with weight toward the back approximating the weight in the front, and the line of the eyes is at right angles to the spine. An ape's head sits at more of an angle to the skull. Thus the angle of attachment of the spine to the skull can be interpreted (Fig. 29.3). In a similar manner, the femur (thigh bone) of a four-legged animal



Figure 29.3. Skull and upper spine of chimpanzee (left) and human (right). Note the relative balance of the jaws vs the back of the skull, the position of the foramen magnum (where the spine meets the skull), and the angle of the spine relative to the skull. Using such criteria, it is possible to interpret the posture of fossils

rests naturally in the pelvis at approximately right angles to the spine, whereas in humans the femurs are almost aligned with the spine (Fig. 29.4). In the pelvis of an ape, which tends to “knuckle-walk” (move without putting its full weight on its front limbs, but using them for balance and to shift weight) the alignment of the pelvis is at an angle. In humans the pelvis is rotated relative to that of other animals to act as a basin for supporting the viscera. If a femur or a pelvis can be located, we can infer the posture of its owner. More recently, higher-resolution and reconstruction techniques have led to further inferences. For instance, an ape that climbs and swings from branches with its arms needs room for strong shoulder

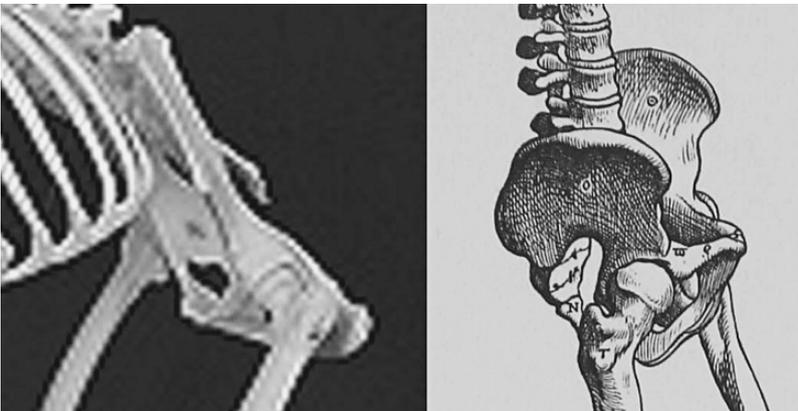


Figure 29.4. Angle of pelvis of chimpanzee (left) and human (right). Note that the angle of the pelvis to the spine, and of the legs to the pelvis, indicates that the chimp is clearly not erect

and forearm muscles. It therefore has a narrower, barrel-shaped chest than does a human, adapted for longer-endurance running and not particularly powerful arms.

THE IMPORTANCE OF LANGUAGE

Although all animals communicate with other members of their species, and some social animals cooperate to hunt, forage, or migrate (listen to migratory geese passing overhead) true language is much more powerful and much rarer. While porpoises seem to have a quite complex communication system, human language may be truly unique, and it is clearly much more efficient, creating the possibility of a species improving its probability of success by a means other than mutation. Consider, for instance, a pack of chimpanzees or wolves trying to encircle an animal that they hope to trap. Grunts or varying sounds and gestures may work well, but “Bill and Fred, go hide behind those bushes. Mike and I will drive the antelope toward you. When it gets to that rock, you should be able to spear it,” is far more effective.

Recent history has given us an example of how selection for intelligence—here, the ability to speak, address subtle concepts, and remember—might have functioned. Just after Christmas 2004, a severe earthquake off the coast of Indonesia generated a huge tsunami (“tidal wave”) in the Indian Ocean that devastated the coastline of Indonesia, India, Sri Lanka, Thailand, and other countries and resulted in well over 170,000 deaths. During the cleanup, rescuers assumed that the Moken people of the Andaman Islands, some low-lying islands directly in the path of the tsunami, had been lost. They were very startled to find that, although the villages were completely destroyed, most of the people had survived. What had happened was the following: First, the people of the islands derive from migrants who originated in southern Africa and who presumably populated the southern Indian Ocean coastlines, Melanesia, and Australia, where the descendants became the people known as the Melanesians and the Australian aborigines. They lead a simple life as fishermen in small villages, presumably similar to early human societies: they do not concern themselves with time, have no means of expressing how old individuals are in years, and have no words reflecting future and past. For instance, they have no word for “want”; if they desire something such as food, they simply “take” it. In their village life, they recount ancestral tales.

The water in a tsunami must come from somewhere and, because of the physics of wave motion in water, it pulls the water in from in front of the wave (Fig. 29.5). Thus a tsunami is preceded by what appears to be an extraordinarily low tide, most likely occurring at an unexpected time. For a tsunami of this size, generating waves up to 60 or 80 feet in height, the water withdrawal was enormous, and preceded the arrival of the wave by up to one hour. Many of the people who died in the tsunami had been intrigued by the surprising tide and had gone out to the suddenly-exposed beachfront to gather shellfish and stranded fish. Not so the people of the Andamans. When they saw the water retreat, they ran for the hills, and their fishermen who were at sea headed for the deepest water they could reach. Burmese fishermen

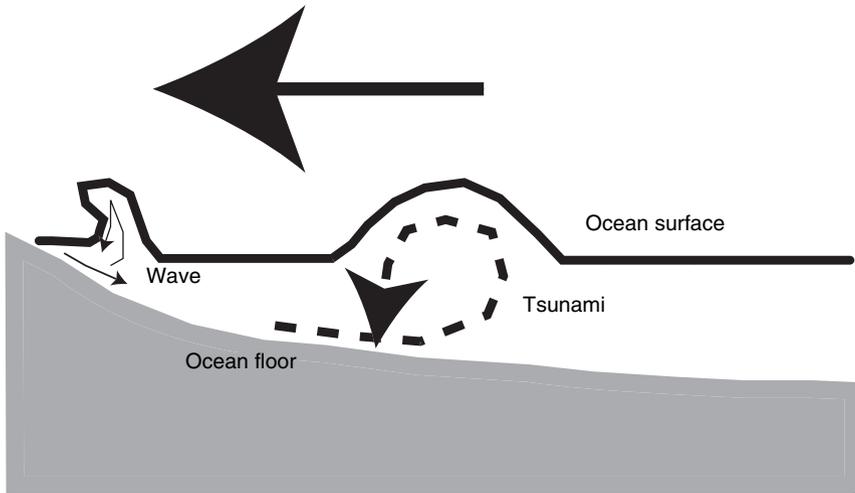


Figure 29.5. Mechanism of a tsunami. A wave is not a mass of water moving forward. Rather, it pulls in water from in front of it, and the water cycles through the wave and back under it. When a wave approaches the shore, the drag along the bottom slows the bottom relative to the top, and the wave builds height and finally falls over. Similarly, a tsunami draws the massive amount of water that it will take from in front of the wave, causing an unusually low tide or retreat of water from the coast, before it arrives

continued collecting squid and were lost, since the height of the tsunami is built in shallow water. (Watch how waves come in from the ocean: they get taller and finally break as their bottoms scrape the sand.)

Why did the Andaman people run? The tales that they told of their ancestors included stories of when the sea suddenly ran away and then came running back. It mattered little that they felt that the sea, responding to the spirits of their ancestors, was angry and came to eat the villages; the description in their legends was accurate, including the withdrawal of the sea and a first, smaller wave followed by a second, larger one. Geological records indicate that tsunamis had most recently occurred 40 and 200 years before, but the collective memory, explicitly described (as opposed to grunts) informed the people and allowed them to survive. The Andaman people lived very close to nature and observed it very well. Their comment about the Burmese fishermen was that the Burmese “were just looking at the squid, and were not looking at the water.” Picture an earlier time, when small groups of the first modern humans were spread widely in the region, and the total population was small. In this situation certainly and most likely in many similar situations, the only survivors would have been that group that was able to profit from the memory of the earlier experience. There are two elements here: good memory (which is also shared by some animals) and above all, ability to communicate that memory from one generation to another (possessed by very few if any other animals) would

have been an extremely influential factor in the evolution of the human race. It is probably quite meaningful that one human gene that has evolved quite rapidly and is very different from that of chimpanzees is a gene that is very important for the understanding and use of speech.

It is reported that some animals also fled to the hills. We are not aware that these animals were capable of communicating from one generation to another, for almost all species, adults do not interact with younger animals beyond the earliest phases of child-rearing. It is possible, however, that they could detect sounds lower or higher than humans can detect, or of lower intensity, and thus heard the incoming tsunami. They might have also detected other changes, such as in light or in magnetic fields; or they may simply have panicked in the face of a rapidly changing and unknown situation, not being as curious or self-assured as modern humans. At this point we do not know.

THE ORIGIN OF THE HUMAN SPECIES

Let us consider what we know about the origins of human beings. There are several lines of evidence. The oldest and most well-known evidence is that of fossil skeletons, or rather pieces of skeletons. These have been known, and in increasing numbers, since the mid 19th C. Other evidence includes traces of human activity in various parts of the world, coupled with radiometric and geologic dating; examination of the physical appearance of different groups of humans; consideration of the different versions of human language; and, today, several means of analyzing and comparing DNA from humans around the world. As has been discussed before, the evidence converges on common dates, and the convergence is a major basis for confidence in the hypothesis.

The physiology of humans and that of apes is extremely similar, as is the biochemistry. In fact, over 98% of human DNA is identical to that of the chimpanzee and slightly more to that of the pygmy chimpanzee or bonobo. To understand human evolution, we must first agree on how humans and apes differ and, hopefully, identify means by which those differences can be detected. The obvious differences include the size of the brain in humans, which is approximately three times that of chimpanzees; the relative hairlessness of humans, which cannot be measured in the fossil record (but can be surmised by the evolution of lice—see below); the fact that humans are truly erect and bipedal, whereas apes are not; humans are much more omnivorous than apes, which tend to eat more fruit and less meat, and their dentition (shape of teeth) is correspondingly different; and the skulls of apes differs in that they have pronounced brow ridges, slanting foreheads, a flat nose, massive mandibles and prognathous jaws (with the teeth jutting well in front of the nose). In terms of soft tissue, apes do not have lips (outwardly turned tissues in the mouth), and apes cannot talk. This latter point indicates soft tissue changes, since the much lower position of the human larynx permits the complex changes in shape of the throat muscles to generate all the sounds that humans make. Apes cannot make the several dozen individual sounds that humans can, but on the other hand the

lowered larynx makes it possible for humans to choke on food. Unfortunately soft tissue like the larynx is not preserved in fossils, though several anthropologists have attempted to infer from the structure of skulls (indications of where jaw muscles inserted) whether or not any of the fossils were able to talk.

There are many more subtle consequences of the differences in lifestyle between and humans and apes. To walk easily and efficiently on two legs requires, for balance and conservation of energy, longer legs. Arms of animals that can swing from trees require strong muscles, leading to a chest that is narrower at the top (to allow for the muscles) than the bottom. Even the spines on the vertebrae serve for attachment of back muscles, giving indication of the size of, and demands on, these muscles. Thus it is possible to extrapolate from fragments of bones to an image of the creature from whence the bones came.

There are also indications of intelligence that, at a higher level, may be recognized. Apes can use primitive tools: Orangutans can strip leaves from twigs and use the resulting sticks as probes to retrieve insects from nests; the preparation of the twig indicates foresight and deliberate intent. Chimpanzees can use rocks to break open large seeds or to throw at a predator or other threat, and they may even protect their feet with shoes of leaves if they walk over thorns or other sharp terrain, but none of these uses leaves identifiable remnants. Early humans learned to split rocks to get sharp edges. Later they learned to hit specific types of rocks to create thin, sharp blades and even to sharpen the blade when it got dull. The use of tools to scrape meat from bones can be identified from the marks left on the bones. Even later humans used fire to create metal tools. All of these activities leave remnants that can be identified, and fire leaves its own traces. More sophisticated tools such as throwing tools (spears, javelins) and fishhooks can be identified by their shape. Creatures that can control fire also have access to far wider ranges of food, since many plant and animal products are indigestible to humans unless they are cooked. Some of the diet may be inferred from the shells and scraps left by the eaters—early humans had a rather sloppy lifestyle, resulting in the collection of middens, or trash heaps, that can be explored—and indigestible materials in fossilized feces give further clues. Finally, art—organized markings, even if their purpose is not understood—is characteristic of all truly modern humans. Anthropologists and evolutionists delve through all of these cues to trace the origin of humans (Fig. 29.6).

Primates have existed for approximately 60 million years. The least evolved primates are small tree-dwelling creatures called lemurs, pottos, lorises, and tarsiers. They are very cute animals because of their forward-facing eyes and opposable thumbs (thumbs that can touch the opposite side of their paws, or hands). Both of these characteristics are adaptations to scampering through trees, the forward-facing eyes giving binocular vision (see Chapters 3 and 4) and the opposable thumb and big toe allowing the animals to grasp branches. Likewise, unlike many other mammals, they rely more on vision than on smell, and they have color vision. All primates retain these characteristics. The so-called New World monkeys are similar but are monkeys (anthropoids, with more human-like body shapes and faces) but



Figure 29.6. (left) Right-tailed lemur, from Madagascar. (right): Tarsier from Philippines. These two creatures are prosimians, lower primates. Credits: Ring-tailed Lemur - Wikimedia commons (photographer; Adrian Pingstone), Philippine tarsier - Wikipedia.org

have an interesting adaptation, in that many have tails that can be controlled and used to hold onto branches (prehensile tails). Monkeys like these have been around for about 35 million years. A little over 20 million years ago, in Africa, arose a different version of monkey, one which was also at ease on the ground, could stand and sometimes run on two legs, and whose tail might serve for balance but was not effective for grasping and climbing. All of these monkeys are very social and move around during the day as opposed to night. These are the so-called Old World monkeys. About 15 million years ago, the true apes or hominoids arose. These mostly large monkeys are tailless, and although two apes, the orangutan and gibbon, are almost entirely arboreal, the others, which also include chimpanzees, bonobos (pigmy chimpanzees), and gorillas, are reasonably comfortable on the ground. These “higher” primates have another characteristic that is relevant to the story of the evolution of humans. Almost all female mammals have “estrus” cycles. In an estrus cycle—the word derives from the Latin for “excitement”—the female accepts advances of a male only when she is ovulating, and otherwise actively drives him away, and after ovulation her ovaries do not produce progesterone (an early hormone of pregnancy) unless she has mated and is likely to become pregnant. Female higher primates have menstrual cycles. In a menstrual cycle the female may accept the advances of a male at any time, and after ovulation the ovary produces progesterone for about two weeks after ovulation, preparing the uterus for a potential pregnancy. If pregnancy does not ensue, the tissues in the uterus break down and are released, producing a true “period”. These latter characteristics of course apply to humans, linking humans to the higher primates. The continuous

sexual receptivity of the higher primate female plays an important behavioral role in keeping the males in proximity, allowing for pairing or, minimally, the organization of troupes in which the babies are protected. In most of the apes, males are much larger than females (more about this later.) Thus the question arises, when did humans become distinct from apes, and what evolutionary mechanisms led to the appearance of humans?

The DNA of humans differs from that of chimpanzees and bonobos by less than two percent. It is important to understand that these DNA sequences are measured on current, living, animals, not ancestral animals. Also, genes can differ by being turned on and off at different times, as well as producing different proteins. Since humans in many respects appear to be apes that are sexually mature while retaining many characteristics of infants (prolonged growth of legs, hairlessness, curiosity and capacity for play), much of the difference between humans and apes may reside in the timing of when genes become active. Biochemically we may not be very different but, if we are the equivalent of sexually active juveniles, our behaviors may be very different.

About 30 million years ago, the great forests of eastern Africa were beginning to dry up. India was pushing its way into Asia, and the uplift of the Himalayas in addition to the appearance of a new landmass in the area changed the weather pattern, and the forest gave way to an expanding savannah. By 6 to 7 million years ago, the savannahs were fully established. An ape that could easily move across grasslands would be able to move from one wood to another, and otherwise expand beyond the forests. Thus at about this period we find a type of skull that differs from that of most apes in interesting ways. They have smaller canine, or tearing, teeth, and their faces may have been a bit flatter. The position of the foramen magnum, the hole at the base of the skull where the spinal cord enters the skull, is a bit farther forward than in apes, suggesting that the skull is more balanced on the spine, meaning that the creature is more comfortably balanced in a vertical position. Thus what defines these creatures as being related to the human line is the suggestion that they were more fully bipedal than other apes and that they were eating a more varied diet. Unfortunately, the feet, which are grasping with opposable big toes in apes and flat in humans, are typically lost in the fossil record.

The story begins to get much more interesting about 4 million years ago. Reliable dating of the soils in which they are found indicates that various members of the genus named *Australopithecus* (Southern ape) lived between 4 and 2 million years ago. These creatures were fully bipedal and had teeth much more similar to those of humans. Their brains were still relatively small, about the size of an orange. This is equivalent to the brain of a chimpanzee, which is of similar size to these creatures. "Lucy," a 40% complete skeleton found by the Leaky family in Ethiopia, was an *Australopithecus* who lived 3 ¼ million years ago. Her arms were still relatively long, suggesting that she could easily climb trees, but the pelvis and the remnants of the skull argue for an upright posture and bipedal locomotion. Even more convincing was the discovery of 3.5 million year old bipedal footprints in what

is now Tanzania. These footprints were made as a presumptive *Australopithecus* walked across newly-fallen ash from a nearby volcano. The ash subsequently was wet, probably by rain that was “seeded” by the ash in the atmosphere, and solidified into rock. Even more convincing and touching is a detail about these footprints: They start out as two sets, an adult and a child. About half way along, the adult picked up the child, as evidenced by the disappearance of the child’s footprints and the deeper impressions made by the prints of the adult.

At approximately this time we encounter some very important fossils, not of humans but of animals found in Ethiopia. What is interesting about these fossil bones, from about 2 ½ million years ago, is that they have marks on them that indicate that the flesh was scraped from the bones by stone tools. Thus we have the first tool use. Thus *Australopithecus* appears to have been a bipedal, upright, tool-using creature.

Between 2.5 and 1.6 million years ago, fossils appear that are similar enough to humans to warrant the genus designation *Homo* (man, or [the] same [as us]). How do they differ from the *Australopithecus* type? They have skulls that can accommodate larger brains, about half the size of modern humans. Associated with these skeletons are well-made and sharp stone tools, enough that the first of these type of fossils were given the name *Homo habilis* (“handy man”). Meanwhile, other hominids persisted along the *Australopithecus* line, continuing with small brains and prognathous (jaw forward) face. This was previously a considerable source of confusion, as long as people imagined a direct lineage from the most primitive anthropoids directly to modern humans. Today we recognize that, similar to other sequences of evolution, there were many branches to the line that led to humans, most of which finally petered out. Thus, contemporaneous with *Homo* were several other hominoids with one or more characteristics approaching those of modern humans, but these were not part of our ancestral line and ultimately the lines died out.

The *Homo* line gave rise, between 1.9 and 1.6 million years ago, to a very interesting new variant, named *Homo ergaster* (working man). This creature now had a brain 70% of modern size (900 cc compared to 1300 cc). Skeletons of *H. ergaster* indicated tall, long-legged individuals with hips clearly structured for straightforward, long strides. Perhaps related to their ability to walk long distances, skeletons of *H. ergaster* are found over much wider areas and in more arid lands. Their teeth were of a more generalized style, indicating a wider variety of food. Their fingers were too short and straight for them to have been good climbers. Their stone tools were sharpened with skill. Unlike the male/female size ratio of 1.5 of *Australopithecus*, in *H. ergaster* the ratio is 1.35, much closer to the ratio for modern humans of 1.2. The decreasing ratio suggests less male-male competition for females and therefore more pairing of partners. (Logically, it would seem more sensible to have females bigger than males, but in the way that the world is constructed, males frequently fight over females and, not only does the larger male often win, the female often prefers the larger male. Thus, where there is competition among males, there is heavy selection in favor of increased size of males.) One

driving force may have been a longer period required for infant care. (Human babies take twice as long to reach puberty, and therefore twice as long to increase their knowledge before becoming independent—no jokes please—as do chimpanzees. This slowing of maturation is important and is probably related to the relatively juvenile appearance of humans as apes, and may also be part of the process that gradually lengthened human lifespan to approximately double that of apes.)

A more recent version of the genus *Homo*, *Homo erectus*, is considered by some to be simply a late version of *H. ergaster* and by others to be a different species. It may be nearly a semantic argument, since *H. erectus* survived into much more recent times—from 1.8 million years ago to as recently as 200,000 years ago, but *H. erectus* continued the trend and was the first hominoid to leave Africa. Remains of *H. erectus* have been found in the Republic of Georgia, and in Indonesia.

Finally, in 1856 a most curious hominid skeleton was found in a cave in the valley of the Neander River in Germany. Named the Neander Valley, or Neanderthal, skeleton, it was very human in many respects. For instance, it had a brain size equal to or exceeding that of modern humans (approximately 1300 cc). On the other hand, the Neanderthal people were much more heavily boned than modern humans; they had heavy, massive jaws; and they had pronounced brow ridges (Fig. 29.7). Their hip sockets were a bit different from ours, indicating that they walked with a more waddling gait. However, based on the material found among them, they did many things that were essentially human in style. Since the period in which they existed, 200,000 to 40,000 years ago, was an ice age in Europe, they had to use and control fire, and it is difficult to imagine how they could have coped with the winters unless they had clothing. There is evidence that they constructed wooden homes, or nests if you prefer, on platforms beside lakes in Switzerland. Some of their dead have what appears to be jewelry or other indications of planned burial. They honed stones into very effective hand axes.

However, what may be missing is definitive evidence of artwork. Although for at least one cave modern results suggest otherwise, for the most part these people left no statuettes, drawings, or markings on stones to suggest that their thoughts surpassed the immediate and the practical. Because of these lacks, we cannot be certain that we know or recognize these people. If subsequent research for the Grotte des Fées (Grotto of the Fairies) in southern France confirms the recent findings, we will have to reassess this judgment and reevaluate the issue of why these people disappeared approximately 40,000 years ago.

Late in the period of the Neanderthals, starting according to DNA approximately 200,000 years ago, a different variety of hominid appeared in Africa. Other than the dry Rift Valley of Ethiopia, the African continent is not very conducive to preserving the remains of hominids, and we have little physical evidence of what was going on. What we do know is that, approximately 100,000 years ago, a new type of hominid appeared in the Middle East. This hominid had the full modern brain capacity of 1200–1300 cc, nearly absent brow ridges and a high brow, modern, multi-purpose teeth, a flattened face that had receded behind the nose; and its skeleton was lighter-weight and more delicate than that of the Neanderthals. In short, this was a modern

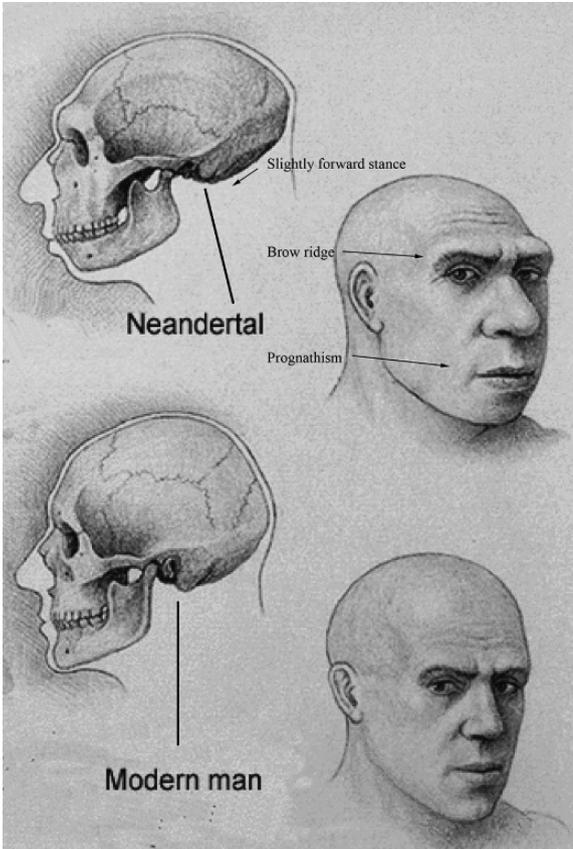


Figure 29.7. Interpretation of appearance of *Homo erectus* compared to *Homo sapiens*. Skin color and relative level of hirsuteness are of course totally speculative. Such images help us to understand that, the similarity of these people would have been enough to confuse us, the differences were such that they would not have moved in our societies without evoking a double-take. Their ability to speak is also in question. Credit: <http://sapphire.indstate.edu/~ramanank/heads-sk.gif>

human who would not stand out in a crowd today. We do not know the colors of their skins or the form of their hair, though we might speculate, but they were modern humans. Their tools were far superior to those of the Neanderthals, in that they used one rock to shape another and, rather than simply cracking a rock to get a sharp edge, they had learned to break off thin blades, suitable for arrowheads and knives, from flint. Most importantly, they left traces of their passage in the form of odd geometric patterns carved onto bone and stone, curious figurines often in the shape of obese, possibly pregnant, women termed Venuses (Fig 29.8), and paintings on the walls of the caves that they inhabited. When they buried their dead, they surrounded them with tools, stones or shells that appear to have been necklace jewelry, and red-colored dirt that may have been symbolic or may have

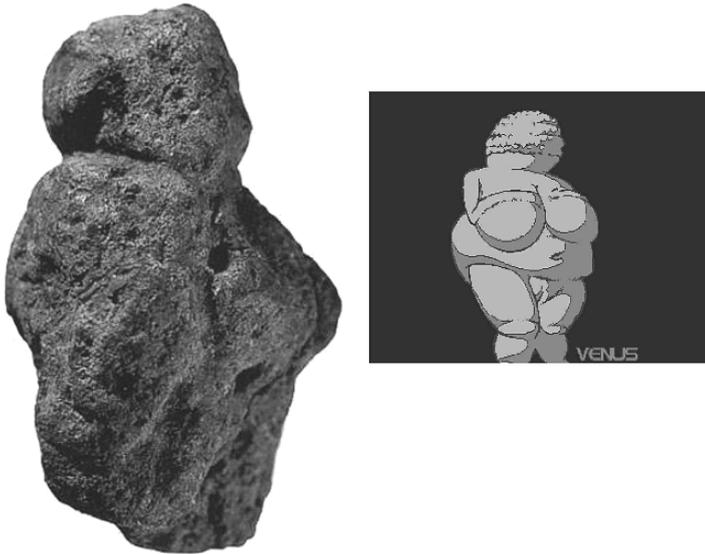


Figure 29.8. Left: A controversial Venus apparently over 100,000 years old and therefore at a time at which no Homo sapiens fossils have been found. DNA evidence (see page 392) suggests that Homo sapiens may have appeared by this time. It appears to be a human artifact rather than a remarkable natural formation, and the dating appears to be correct. If so, it would indicate that this species also had a representative (religious?) art. Right: The Venus of Willenburg, typical of the earliest known art (approximately 50,000 years ago). Although Venuses were not the only figures made, they are frequently found. Their purpose is unknown. Credits: Venus, Berekhat-ram - Wikimedia Commons. This image has been released into the public domain by its author, Locutus Borg, Venus, Willendorf - Venus of Willendorf Source first published at de.wikipedia as de:Bild:VenusWillendorf.jpg Date 2004 Author Photo taken by de:Benutzer:Pip at the Naturhistorisches Museum Wien

been used to make them more alive-looking. Though we do not know what they intended by the carvings and the art, it is clear that the important word is “intended”: these people thought and could formulate concepts, almost certainly with a sense of future and past. They understood the concept of a symbol, and they may have attempted to control their fate with the use of these symbols. They were modern humans and, though their presumptions were undoubtedly very different from ours, we could have understood how they reasoned. Although most of the caves are now closed to the public because visitors bring in new microorganisms and the lights allow algae to grow, several websites offer innovative tours that are well worth a visit. They are listed in the references section.

These people moved quickly around the world. Though the first exploration as far as Israel does not seem to have survived, by 70,000 years ago a second wave again reached the Middle East. By 50,000 years ago, the first humans had reached Australia, presumably traveling along the coasts past India and island-hopping thereafter—obviously by boat. They also migrated toward the northeast and northwest, appearing in both Europe and central Asia between 40,000 and 30,000

years ago, crossing the Bering Strait during an ice age when there were land bridges and, apparently following the coastlines, reaching southern South America approximately 15,000 years ago. Movement inland in the Americas was a bit slower, so that the earliest non-coastal settlements date from 19,000 to 12,000 years ago. All of these people left skeletons, burial grounds, campsites, weapons, and artwork along their trails, allowing a fairly accurate and well-confirmed record.

Though for a species this speed of expansion is quite remarkable, in terms of what we see in current human behavior it was not a headlong rush. This expansion could have been accomplished if, in each generation, the outermost family decided to move out of sight, out of earshot, or out of the hunting range of its neighbors. One or two miles per generation would have been adequate. What the movement does suggest is a desire to seek more game or more resources or to keep away from perhaps competing tribes, together with a resourceful life style that is able to overcome geographical and geological barriers. We know that these people were resourceful and that they hunted resources; in some areas of Europe there is evidence that they could dig substantial distances into the ground to locate good flint for arrowheads.

There are many worthy questions that are worth asking. Among these questions of course are, what happened to the Neanderthals, where modern humans came from, how we know their origins, and how the world ended up with different races.

The Neanderthal (*H. neanderthalensis*) population had been declining, but the Neanderthals disappeared from Europe at approximately the time that the Cro-Magnon population (*H. sapiens*, named from the cave in France from which they were first clearly distinguished from *H. neanderthalensis*) spread through Europe. Although skeletons of *H. neanderthalensis* do not display wounds indicating attack by humans, the question of whether *H. sapiens* fought with them, made them uncomfortable enough to cause them to retreat, or interbred with them, ultimately diluting them out of existence, is of interest to scientists and most amateurs.

The lack of evidence of battles between *H. neanderthalensis* and *H. sapiens* led most researchers to favor the hypotheses of displacement or interbreeding, but advancing technology gave a much clearer answer. It became possible to collect DNA from first one, then a second specimen of *H. neanderthalensis* and compare the DNA to that of modern humans. More specifically, it was mitochondrial DNA that was analyzed. Mitochondrial DNA, a remnant of the presumed bacterial origin of mitochondria (Chapter 18, page 266), is more conserved than nuclear DNA and, since there is only one nucleus but hundreds of mitochondria in each cell, there is more mitochondrial DNA available.

If we assume that changes in some DNA bases will not markedly influence evolution (“neutral mutations”) and that the probability of these mutations appearing is random, one can estimate both the evolutionary distance between two subjects and the age of their last common ancestor. From the specific sequences, one can suggest a probable lineage (page 118, Chapter 9). From the sequences established from the *neanderthalensis* and several samples of *sapiens* mitochondrial DNA, it

is clear that the two are similar: of 360 bases, 335 are identical and only 25 are different. But this is not really the surprise. When the same regions of DNA are compared from humans all over the globe, the DNAs differ by no more than 8 bases. All human DNA differs by less than 0.1%. By comparison, humans and chimpanzees differ by 55 bases. What this means is that the evolutionary distance between *H. neanderthalensis* and *H. sapiens* is at least three times the distance that separates the most different modern humans, and half the distance that separates humans from chimps. In other words, Neanderthals were very different from us. Furthermore, the similarity between Neanderthal and European DNA is no greater than the similarity between Neanderthal and Asian, Native American, Australian, or Oceanic DNA, arguing against the hypothesis that Neanderthals interbred with Europeans. The conclusion drawn from this evidence is that Neanderthals did not interbreed with modern humans. Furthermore, the last ancestor shared by Neanderthals and modern humans existed over 200,000 years ago. More recently, the DNA of a second Neanderthal, found in the Caucasus Mountains in Russia, was analyzed. This sample was extremely similar to that of the first Neanderthal, notwithstanding a distance of approximately 1000 miles and a difference in age of as much as 70,000 years; and it, likewise, was not similar to that of that of modern humans. More recent analysis of Y-chromosome DNA has confirmed these initial findings.

Thus the Neanderthals, after a reign on earth approximately three times that of modern humans, disappeared. With, like us, the physiology of a tropical animal, they were capable of withstanding the rigors of an ice age in Europe. They had considerable skills and may have had conceptual thought and buried their dead. Were they driven further, into less hospitable territory, by the more capable, skilled modern humans? Did modern humans bring in diseases that they could not resist? Could they speak? Did they have a religion? We do not know, but the book is still open. What we do know is that they were sufficiently different from modern humans that there apparently was no effort to interbreed, or no success at it.

Concerning the migration of modern humans, certainly we can impute the sequence of events from the appearance of peoples before modern migrations began to mix the races once again. Likewise, we can look for common features to suggest the appearance of the earliest modern humans. For instance, chimpanzees and most groups of humans have straight black hair and moderately pigmented skin. Thus deviations from these patterns are probably more recent innovations. Humans, but not apes, have light colored soles and palms, perhaps used like the tails of white-tailed deer as markers by which adults could signal children or be seen by children as they walk away. Finally, again by DNA analysis, headlice seem to have differentiated from pubic lice approximately 70,000 years ago, suggesting that these humans were sufficiently hairless at that time to make the migration of lice between the two sites a difficult excursion.

Again, DNA analysis both adds precision and adds a surprising twist. First, there is much greater diversity of DNA in Africa than elsewhere, dating back 150,000

years, suggesting that, as the fossil record suggests, modern humans arose there. All human DNA shows similarity to a presumed ancestral DNA, especially in the DNAs that are normally passed on without modification, the mitochondrial DNA

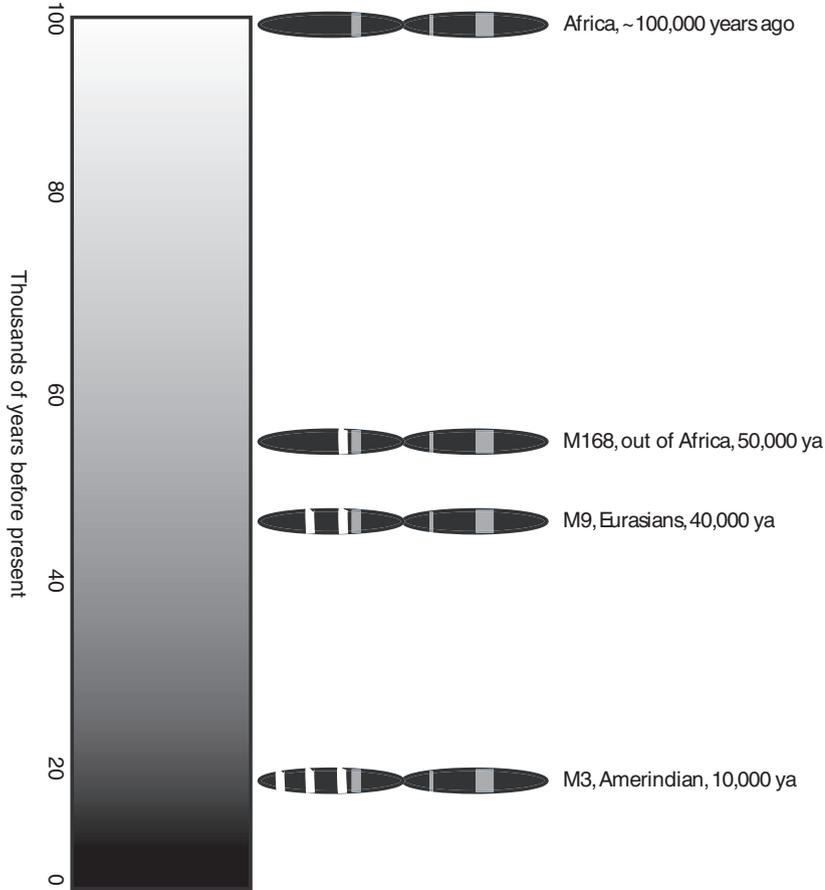


Figure 29.9. Human lineage as traced by Y chromosome markers. All human men, including those in Africa, Eurasia, and the Americas, share a pattern detectable by the use of specific stains (gray markings). These markings therefore are ancestral. The pattern has been stable for approximately 100,000 years. New markers (white) have arisen among the migrants, indicating their paths. The M168 mutation is found in all men whose origin is outside of Africa before the beginning of slave trading. Therefore the migrants from Africa carried this trait, and the ancestral form is African. It is approximately 50,000 years old. The M9 mutation appeared about 40,000 years ago and is common among Eurasians, especially those from the Middle East through Central Asia, marking this migratory route. The M3 mutation is found only in natives of the Americas. It appeared about 10,000 years ago, after this population had become established in the New World

passed on from mother to child and the Y chromosome DNA passed from father to son. Somewhere between 150,000 and 100,000 years ago lived a mitochondrial Eve and a Y chromosome Adam, who gave rise to everyone we now consider to be human. However, they lived in Africa, not the Garden of Eden (Iraq), and—despite the conceits of European artists (Fig. 29.9) more likely looked like the San of southwestern Africa. Note that this does not necessarily mean that there was only one Adam and one Eve, but that only one or very few of the original chromosomes have survived to this day.

The DNA of humans outside of Africa comes from a subset of these types, arguing that a small band of humans left Africa 50-70,000 years ago and spread through Asia, Europe, and Australia by 30-40,000 years ago. Again, the sequence of mutations confirms the migratory patterns suggested by the fossil record and physical similarities (Figs. 29.1 and 29.10).

These sequences have helped us to understand human evolution and underscore some other points as well. The genetic similarity of all humans is remarkable and completely consistent with the history: We are essentially milli-cousins, or second cousins 1000 times removed. We are approximately 2000 generations separated from the first migration from Africa. In fact, there is less difference between any two humans than between chimpanzees from the East Coast and the



Figure 29.10. Contrary to the conceits of European artists (left: Adam and Eve as drawn by Albrecht Durer in 1504) the original humans almost certainly did not look like Europeans. They may have looked more like this San Bushwoman from South Africa, as the San are one of the groups, all in Africa, who seem to have the largest number of ancestral genes. Judging from the apes, it may be more likely that the original human hair was straight. Credits: Durer - Albrecht Dürer (German, 1471–1528) Adam and Eve, Bushmen - <http://www.rightlivelikelihood.org/gallery/2005-first-people-of-the-kalahari.htm> See home website: www.survival-international.org

West Coast of Africa, and more variation within a presumed “racial” group than between one group and another. All of this reflects on various attempts to display human evolution as a linear (hierarchical), as opposed to branched, process (see Chapter 5). Second, the wide variation in human appearance argues for evolution in small groups at relatively high selection pressure (Chapter 27). This would be consistent with our impression that humans have always lived in relatively small tribes.

Of the order of 5,000 years ago, a major change occurred in human style. Humans in the Middle East and in Asia learned to control the breeding of certain plants and animals, thus achieving domestication. Shortly thereafter, MesoAmerican and South American peoples marched down the same road. Domestication of plants tied populations to the agricultural fields and provided potentially stable sources of food, as chronicled in the story of Joseph and the Pharaoh (Genesis 39-42) and similar stories in other cultures, while domestication of animals provided sources of milk and meat, as well as the power to undertake large-scale building projects and the speed to move rapidly over great distances. As is described by Jared Diamond, these achievements made possible the rise of cities and perhaps led to selection that made these groups so successful.

Think of what has happened to take us to this stage (Table 29.1 and Fig. 29.11). If the entire history of the earth were encompassed in the space of one hour, the length of time that we have had any understanding of the process would take place in less time than the sound of a single clap of the hands. If the entire history of the

Table 29.1. History of the Earth

Date (years ago)	Event	Percent of Age of Earth
-6,000,000,000	Origin of universe	133
-4,500,000,000	Origin of earth	100
-3,500,000,000	Origin of life	77
-1,000,000,000	Multicellular fossils	22
-600,000,000	Origin of animals	13
-500,000,000	Cambrian explosion	11
-350,000,000	Land vertebrates	8
-150,000,000	Origin of mammals; age of dinosaurs	3
-65,000,000	End of dinosaurs	1.4
-5,000,000	Humans, chimps emerge	0.1
-1,600,000	Genus <i>Homo</i>	0.04
-200,000	Genetic evidence for origin of <i>Homo sapiens</i>	0.004
-70,000	<i>H. sapiens</i> , jewelry	0.0015
-30,000	First art	.0007
-15,000	Humans reach new world	0.0003
-10,000	Domestication of cattle	0.0002
-5,000	First cities	0.0001
-3,000	First writing	0.00007
-150	First understanding of evolution	0.000008

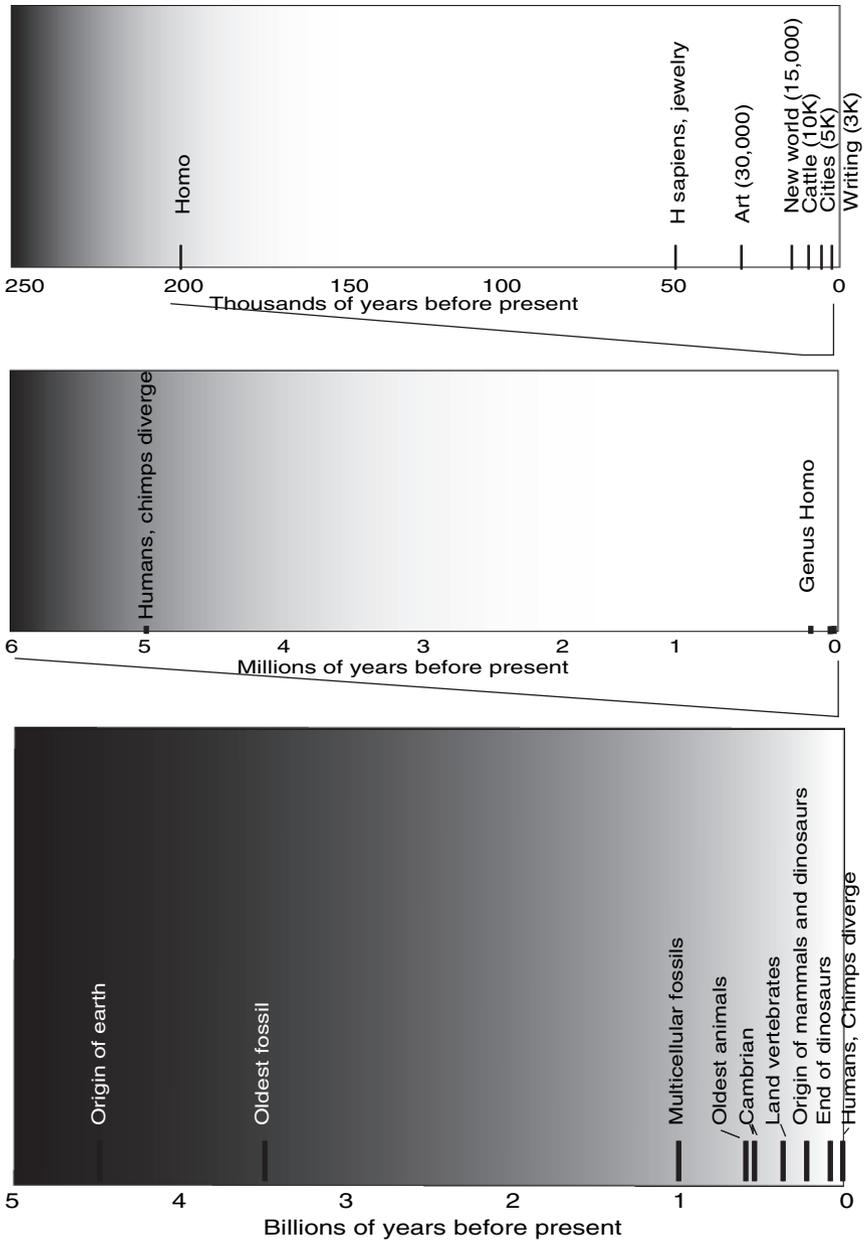


Figure 29.11. Scale of human evolution. Note that the time scales differ from each other by a factor of 1000. Humans have been on this planet for an infinitesimal amount of time since the beginning of the earth. In that time, we have been able to write about our history for a period of less than 3% of our existence, and for 99.9% of that time we have had very little to no idea of how it came about. The comment “Genus Homo” refers to the appearance of the large-brained modern versions, *H. neanderthalensis* rather than the earliest, much smaller-brained *H. ergaster*, who appeared approximately 1.6 million years ago.

earth were encompassed in the space of one day, our understanding would have appeared in the last 25 seconds.

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<http://www.hominids.com/donsmaps/galgenbergvenus.html> (Venus of Brassempouy 28,000 BC?)
<http://www.hominids.com/donsmaps/ukrainevenus.html> (Berekhat Ram, Israel: ~800,000 to ~233,000 years ago)

STUDY QUESTIONS

1. Would you consider *Homo neanderthalensis* (Neanderthals) human? Why or why not?
2. Would *Homo neanderthalensis* have all the rights and privileges of citizens of free countries? Or would they be treated as apes? Why or why not?
3. In your opinion, what was the major change that led to the appearance and success of modern humans?
4. What characteristics define progress to becoming human?
5. At what stage do you think that humans learned to use fire? Why?
6. Look at the websites featuring the caves. What do you think that the drawings mean, and why do you think that they were put there?
7. What would have determined which way humans migrated, and where they could and could not go?
8. Is there any contradiction between the DNA evidence for human migration and other evidence, for instance physical appearance of humans or distribution of languages?
9. To what extent is skin color a reliable marker of lineage?