26.3 Primate Evolution

THINK ABOUT IT Carolus Linnaeus placed our species, *Homo sapiens*, in an order he named Primates, which means "first" in Latin. But what are primates "first" in? When primates appeared, there was little to distinguish them from other mammals, aside from an increased ability to use their eyes and front limbs together. As primates evolved, however, several other characteristics became distinctive.

What Is a Primate?

What characteristics do all primates share?

Primates, including lemurs, monkeys, and apes, share several adaptations for a life spent in trees. **In general, a primate is a mammal that has relatively long fingers and toes with nails instead of claws, arms that can rotate around shoulder joints, a strong clavicle, binocular vision, and a well-developed cerebrum.** The lemur in Figure 26–14 shows many of these characteristics. DOL•64

Fingers, Toes, and Shoulders Primates typically have five flexible fingers and toes on each hand or foot that can curl to grip objects firmly and precisely. This enables many primates to run along tree limbs and swing from branch to branch with ease. In addition, most primates have thumbs and big toes that can move against the other digits. This allows many primates to hold objects firmly in their hands or feet. Primates' arms are well suited for climbing because they can rotate in broad circles around a strong shoulder joint attached to a strong clavicle, or collar bone.

Binocular Vision Many primates have a broad face, so both eyes face forward with overlapping fields of view. This facial structure gives primates excellent binocular vision. **Binocular vision** is the ability to combine visual images from both eyes, providing depth perception and a three-dimensional view of the world. This comes in handy for judging the locations of tree branches, from which many primates swing.

Well-Developed Cerebrum In primates, the "thinking" part of the brain—the cerebrum—is large and intricate. This well-developed cerebrum enables more-complex behaviors than are found in many other mammals. For example, many primate species create elaborate social systems that include extended families, adoption of orphans, and even warfare between rival troops.

Key Questions

- ***What characteristics do all primates share?***
- ***What are the major evolutionary groups of primates?***
- ***What adaptations enabled later hominine species to walk upright?***
- ***What is the current scientific thinking about the genus* Homo?**

Vocabulary

binocular vision • anthropoid • prehensile tail • hominoid • hominine • bipedal • opposable thumb

Taking Notes

Outline Before you read, outline this lesson. As you read, add details to your outline.

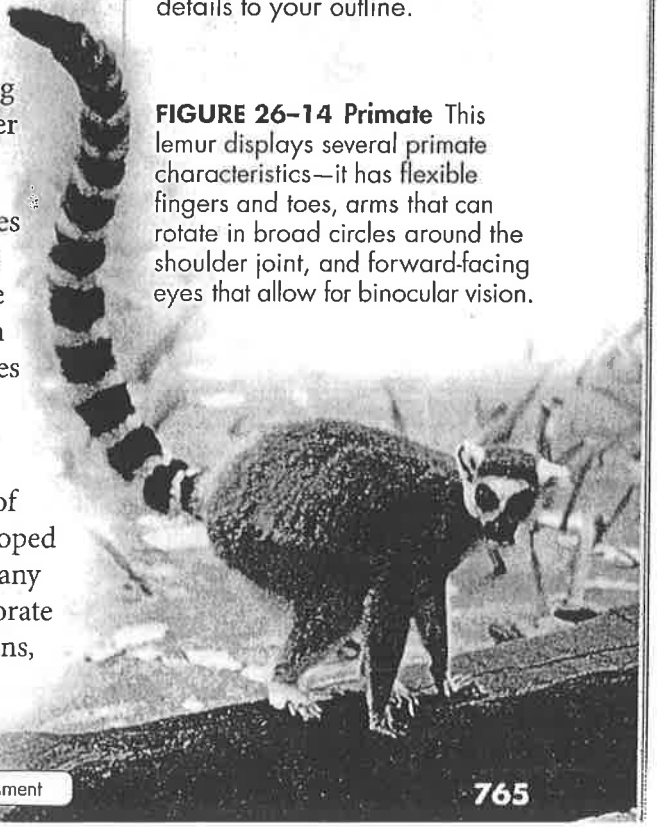


FIGURE 26–14 Primate This lemur displays several primate characteristics—it has flexible fingers and toes, arms that can rotate in broad circles around the shoulder joint, and forward-facing eyes that allow for binocular vision.

Quick Lab GUIDED INQUIRY

Binocular Vision

1. Throw a paper ball to your partner, who should try to catch the ball with one hand. Record whether your partner caught the ball.
2. Now have your partner close one eye. Repeat Step 1.

Analyze and Conclude

1. Use Tables and Graphs Exchange results with other groups. Make a bar graph for the class data comparing the results with both eyes open and one eye shut.

2. Draw Conclusions How is binocular vision useful to primates?

Evolution of Primates

What are the major evolutionary groups of primates?

Humans and other primates evolved from a common ancestor that lived more than 65 million years ago. One recently discovered fossil, *Carpolestes,* which lived 56 million years ago in Wyoming, has been proposed as an example of the first primate. Early in their history, primates split into two groups. **Primates in one of these groups look very little like typical monkeys. This group contains the lemurs and lorises. The other group includes tarsiers and the anthropoids, the group that includes monkeys, great apes, and humans.** Refer to **Figure 26–15** as you read about the evolutionary relationships between these groups.

Lemurs and Lorises With few exceptions, lemurs and lorises are small, nocturnal primates with large eyes adapted to seeing in the dark. Many have long snouts. Living members include the bush babies of Africa, the lemurs of Madagascar, and the lorises of Asia.

Tarsiers and Anthropoids Primates more closely related to humans than to lemurs belong to a different group, members of which have broader faces and widely separated nostrils. This group includes the tarsiers of Asia and the anthropoids. **Anthropoids** (AN thruh poydz), or humanlike primates, include monkeys, great apes, and humans. Anthropoids split into two groups around 45 million years ago, as the continents on which they lived moved apart.

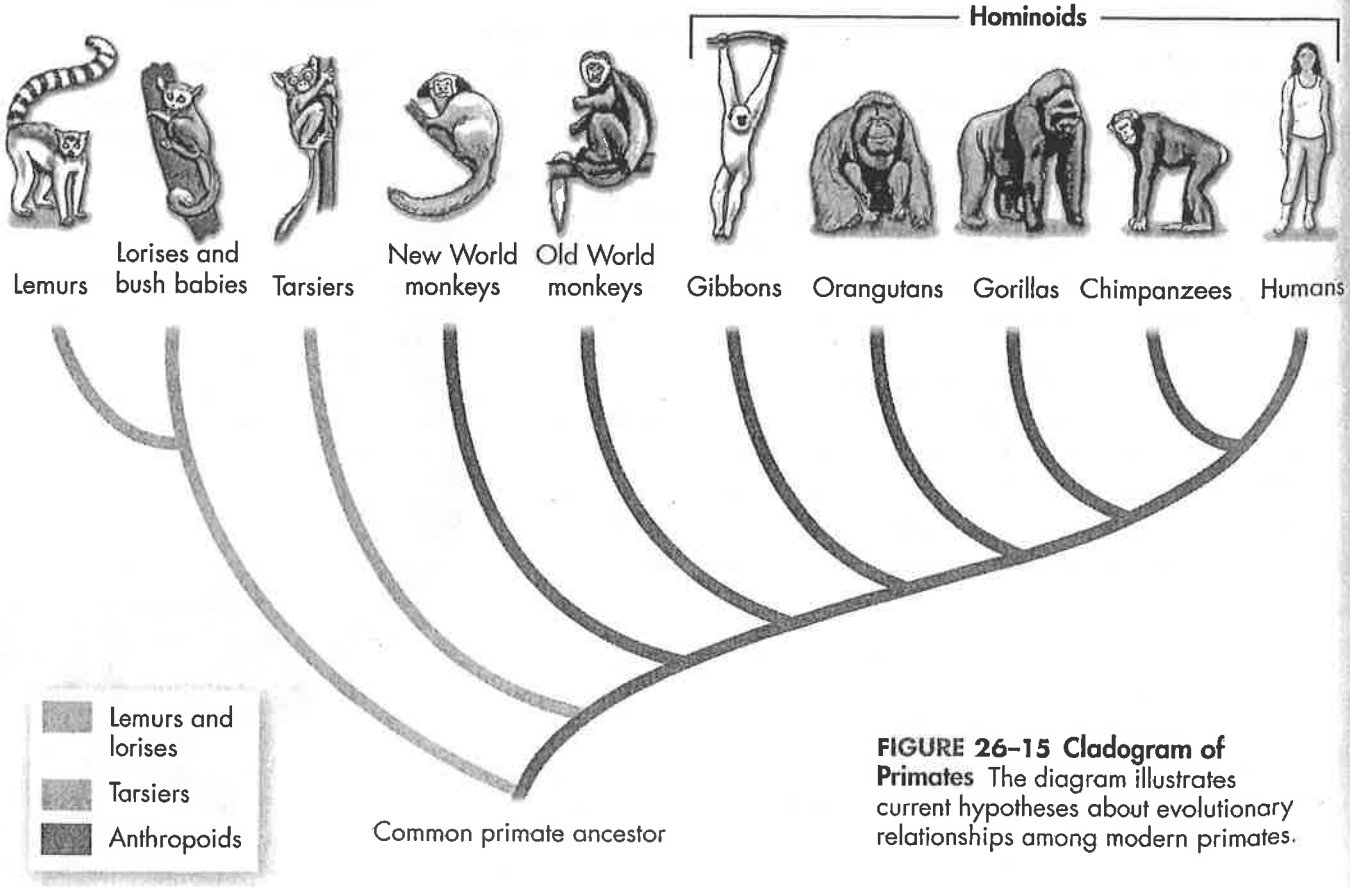


FIGURE 26–15 Cladogram of Primates The diagram illustrates current hypotheses about evolutionary relationships among modern primates.

▶ ***New World Monkeys*** Members of one anthropoid branch, the New World monkeys, are found in Central and South America. (Europeans used the term *New World* to refer to North and South America.) Members of this group, which includes squirrel monkeys and spider monkeys, live almost entirely in trees. They have long, flexible arms that enable them to swing from branch to branch. New World monkeys also have a long, **prehensile tail** that can coil tightly enough around a branch to serve as a "fifth hand."

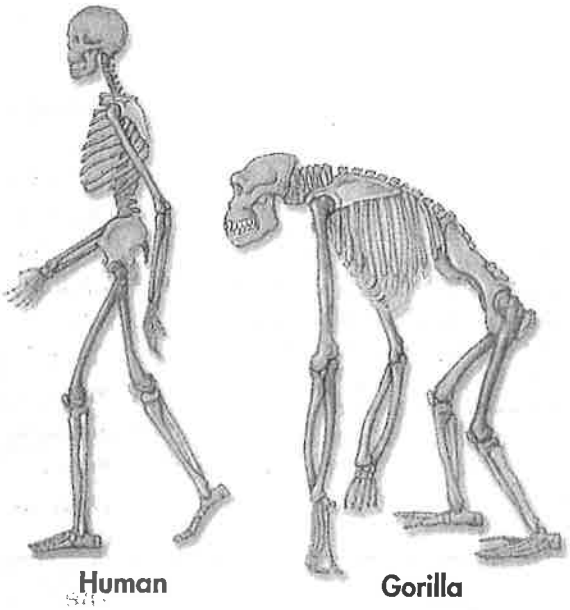
▶ ***Old World Monkeys and Great Apes*** The other anthropoid branch, which evolved in Africa and Asia, includes the Old World monkeys and great apes. Old World monkeys, such as langurs and macaques (muh KAHKS), spend time in trees but lack prehensile tails. Great apes, also called **hominoids,** include gibbons, orangutans, gorillas, chimpanzees, and humans. Recent DNA analyses confirm that, among the great apes, chimpanzees are humans' closest relatives.

Hominine Evolution

What adaptations enabled later hominine species to walk upright?

Between 6 and 7 million years ago, the lineage that led to humans split from the lineage that led to chimpanzees. The hominoids in the lineage that led to humans are called **hominines.** Hominines include modern humans and all other species more closely related to us than to chimpanzees. Hominines evolved the ability to walk upright, grasping thumbs, and large brains. **Figure 26–16** shows some ways in which the skeletons of modern humans differ from those of hominoids such as gorillas. **The skull, neck, spinal column, hip bones, and leg bones of early hominine species changed shape in ways that enabled later species to walk upright.** The evolution of this **bipedal,** or two-footed, locomotion was very important, because it freed both hands to use tools. Meanwhile, the hominine hand evolved an **opposable thumb** that could touch the tips of the fingers, enabling the grasping of objects and the use of tools.

Hominines also evolved much larger brains. The brains of chimpanzees, our closest living relatives, typically range in volume from 280 to 450 cubic centimeters. The brains of *Homo sapiens,* on the other hand, range in size from 1200 to 1600 cubic centimeters! Most of the difference in brain size results from a radically expanded cerebrum.



Comparing Human and Gorilla Skeletons

Feature	Human	Gorilla
Skull	Atop S-shaped spine	Atop C-shaped spine
Spinal cord	Exits at bottom of skull	Exits near back of skull
Arms and hands	Arms shorter than legs; hands don't touch ground when walking	Arms longer than legs; hands touch ground when walking
Pelvis	Bowl-shaped	Long and narrow
Thigh bones	Angled inward, directly below body	Angled away from pelvis

FIGURE 26–16 Comparison of Hominoids Modern hominines walk upright on two legs; gorillas use all four limbs. The diagrams show many of the skeletal characteristics that allow hominines to walk upright. **Compare and Contrast** ***According to the chart and illustrations, what are the other skeletal differences between humans and gorillas?***

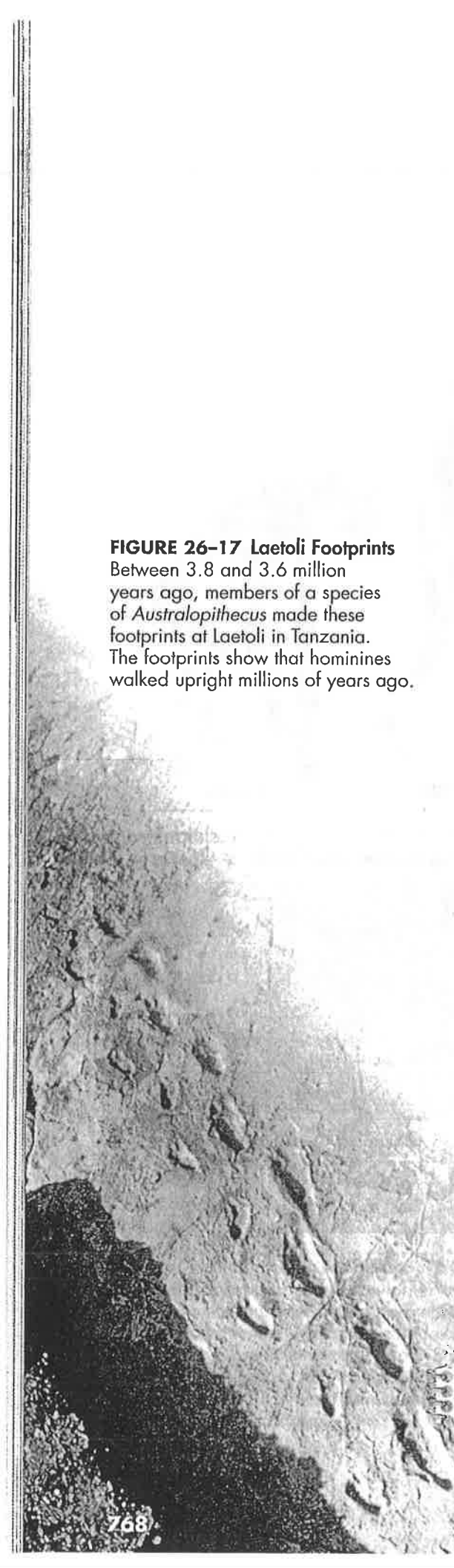


FIGURE 26–17 Laetoli Footprints Between 3.8 and 3.6 million years ago, members of a species of *Australopithecus* made these footprints at Laetoli in Tanzania. The footprints show that hominines walked upright millions of years ago.

New Findings and New Questions The study of human ancestors is exciting and constantly changing. Since the 1990s, new discoveries in Africa have doubled the number of known hominine species. Those discoveries also doubled the length of the known hominine fossil record—from 3.5 million years to 7 million years, a time that corresponds closely to the time at which DNA studies suggest that the lineage that led to humans split from the lineage that led to chimpanzees. These new data have enhanced the picture of our species' past. Questions still remain as to how fossil hominines are related to one another—and to humans. In fact, the field is changing so rapidly that all we can present here is a sampling of current hypotheses.

Relatives Versus Ancestors Most paleontologists agree that the hominine fossil record includes seven genera—*Sahelanthropus, Orrorin, Ardipithecus, Australopithecus, Paranthropus, Kenyanthropus,* and *Homo*—and at least 20 species. These diverse hominine fossils stretch back in time roughly 7 million years. All these species are *relatives* of modern humans, but not all of them are human *ancestors.* To understand that distinction, think of your family. Your relatives may include aunts, uncles, cousins, parents, grandparents, and great-grandparents. All of these folks are your relatives, but only your parents, grandparents, and great-grandparents are your ancestors. Distinguishing relatives from ancestors in the hominine family is an ongoing challenge.

The Oldest Hominine? In 2002, paleontologists working in north-central Africa discovered a fossil skull roughly 7 million years old. This fossil, called *Sahelanthropus,* is a million years older than any known hominine. *Sahelanthropus* had a brain about the size of that of a modern chimp, but its short, broad face was more like that of a human. Scientists are still debating whether this fossil represents a hominine.

Australopithecus Some early hominine fossil species seem to belong to the lineage that led to modern humans, while others formed separate branches off the main hominine line. One early group of hominines, of the genus *Australopithecus,* lived from about 4 million to about 1.5 million years ago. These hominines were bipedal apes, but their skeletons suggest that they probably spent at least some time in trees. The structure of their teeth suggests a diet rich in fruit.

The best-known of these species is *Australopithecus afarensis,* which lived from roughly 4 million to 2.5 million years ago. The humanlike footprints in **Figure 26–17,** about 3.6 million years old, were probably made by members of this species. *A. afarensis* fossils indicate the species had small brains, so the footprints show that hominines walked bipedally long before large brains evolved. Other fossils of this genus indicate that males were much larger than females. You can see artists' conceptions of young female and adult female *A. afarensis* in **Figure 26–18.**

In Your Notebook *How long ago does DNA evidence suggest that the human lineage split from the chimpanzee lineage?*

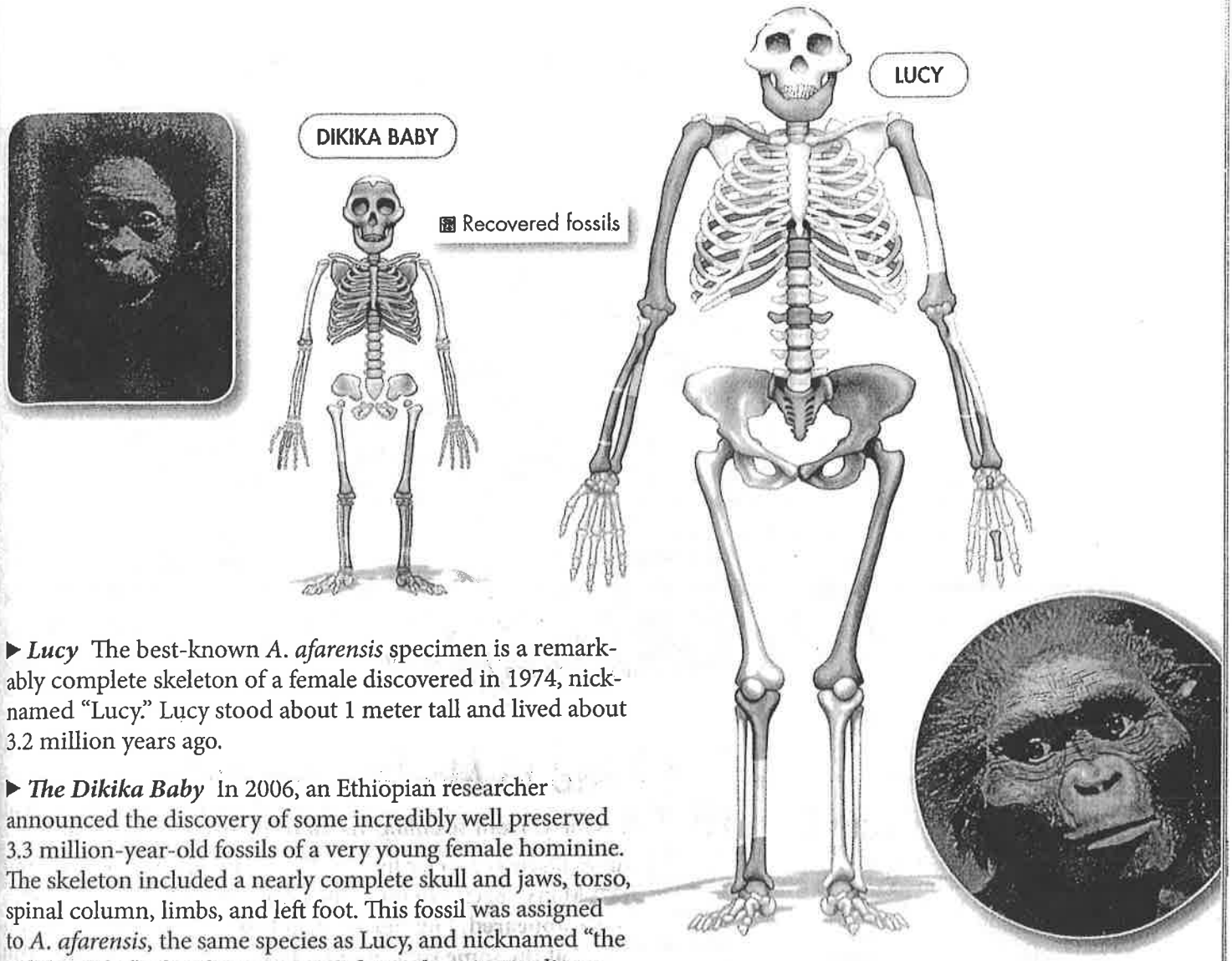


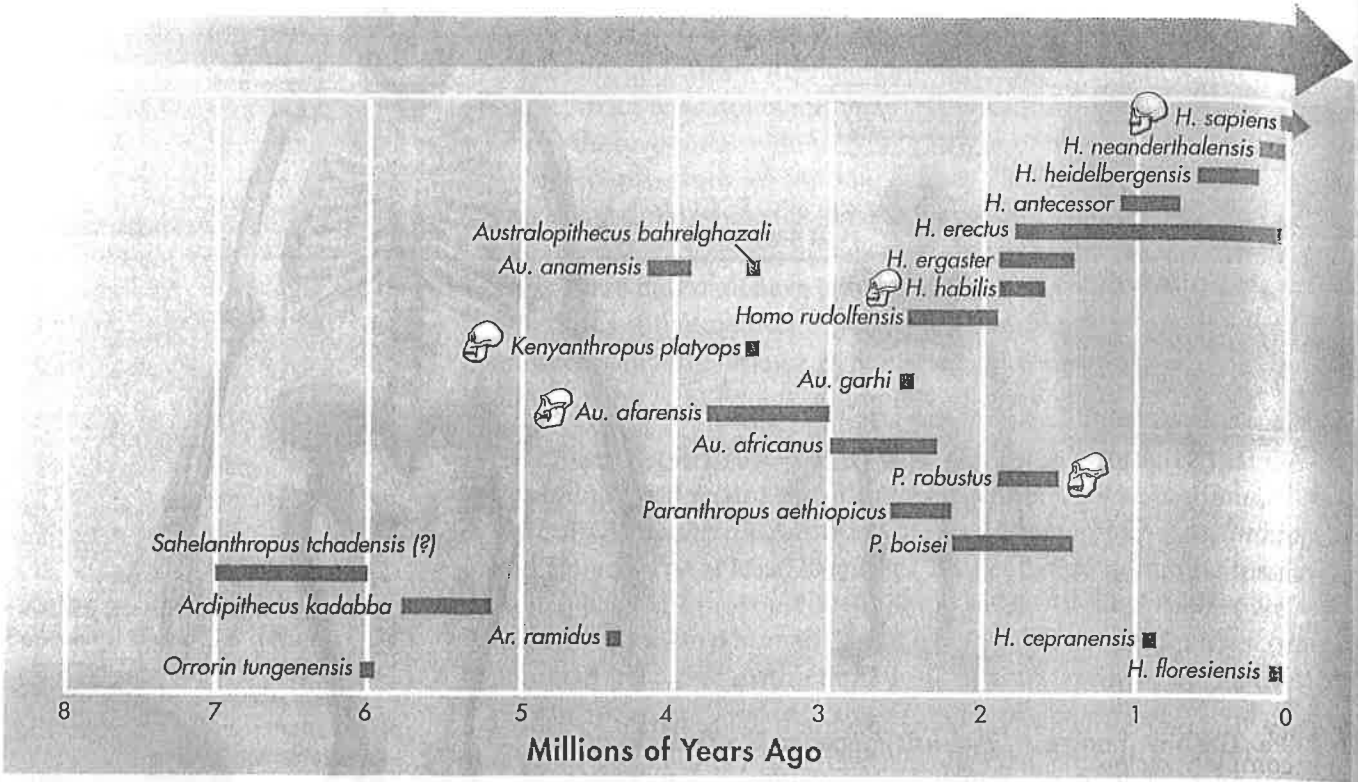
FIGURE 26–18 Lucy and the Dikika Baby "Lucy" and "the Dikika Baby" are nicknames of two very important fossils of the hominine *A. afarensis*. Lucy is a partial skeleton of an adult female. The Dikika Baby is the most-complete fossil yet found of this species. These two fossils were discovered just 6 miles apart in Ethiopia. **Interpret Visuals** ***Given the fossils recovered, which face shape would you expect scientists to be more confident about—the Dikika Baby's or Lucy's?***

▶ ***Lucy*** The best-known *A. afarensis* specimen is a remarkably complete skeleton of a female discovered in 1974, nicknamed "Lucy." Lucy stood about 1 meter tall and lived about 3.2 million years ago.

▶ ***The Dikika Baby*** In 2006, an Ethiopian researcher announced the discovery of some incredibly well preserved 3.3 million-year-old fossils of a very young female hominine. The skeleton included a nearly complete skull and jaws, torso, spinal column, limbs, and left foot. This fossil was assigned to *A. afarensis*, the same species as Lucy, and nicknamed "the Dikika Baby," after the region in Africa where it was discovered. Leg bones confirmed that the Dikika Baby walked bipedally, while her arm and shoulder bones suggest that she would have been a better climber than modern humans. Researchers will be extracting information from these bones for years.

Paranthropus Three more-recent species, which grew to the size of well-fed football linebackers, have been placed in their own genus, *Paranthropus*. These *Paranthropus* species had huge, grinding back teeth. Their diets probably included coarse and fibrous plant foods like those eaten by modern gorillas. Paleontologists now place *Paranthropus* on a separate, dead-end branch of our family tree.

Hominine Relationships Researchers once thought that human evolution took place in relatively simple steps in which hominine species, over time, became gradually more humanlike. But it is now clear that a series of hominine adaptive radiations produced a number of species whose relationships are difficult to determine. As a result, what once looked like a simple hominine "family tree" with a single main trunk now looks more like a shrub with multiple trunks.



VISUAL SUMMARY

HOMININE TIME LINE

FIGURE 26–19 The diagram shows hominine species known from fossils and the time ranges during which each species probably existed. These time ranges may change as paleontologists gather new data. At this writing, several competing hypotheses present different ideas about how these species are related to one another and to *Homo sapiens*. So far, there is no single, universally accepted hypothesis, so we present these data as a time line, rather than as a cladogram. The fossil record shows that hominine evolution did not proceed along a simple, straight-line transformation of one species into another. Rather, a series of adaptive radiations produced a number of species, several of which display a confusing mix of primitive and modern traits. **Interpret Graphs** ***According to this time line, which species in the genus* Homo *lived at the same time?***

The Road to Modern Humans

***What is the current scientific thinking about the genus* Homo?**

The hominines discussed so far lived millions of years before modern humans. **Many species in our genus existed before our species, *Homo sapiens*, appeared. Furthermore, at least three other *Homo* species existed at the same time as early humans.** Paleontologists still do not completely understand the relationships among species in our own genus.

The Genus *Homo* About 2 million years ago, a new group of hominine species appeared. Several of these fossils resemble modern human bones enough that they have been classified in the genus *Homo*. One set of fossils from this time period was found with tools made of stone and bone, so it was named *Homo habilis* (HAB uh luhs), which means "handy man" in Latin. The earliest fossils that most researchers agree can be definitely assigned to the genus *Homo* have been called *Homo ergaster*. *H. ergaster* was larger than *H. habilis* and had a bigger brain and downward-facing nostrils that resemble those of modern humans. *Homo rudolfensis* appeared before *H. ergaster*, but some researchers choose to classify it in the genus *Australopithecus* instead of *Homo*.

Out of Africa—But When and Who? Researchers agree that our genus originated in Africa and migrated from there to populate the world. But many questions remain. When did hominines first leave Africa? Did more than one species make the trip? Which of those species were human ancestors and which were merely relatives? You can see some of the current hypotheses in **Figure 26–20.**

▶ ***The First to Leave*** Fossil and molecular evidence suggest that some hominines left Africa long before *Homo sapiens* evolved. It also appears that more than one *Homo* species made the trip in waves. Again, researchers differ as to the identity of various fossils, but agree that hominines began migrating out of Africa at least 1.8 million years ago. Hominine remains from that period were found in the Republic of Georgia, which is north of Turkey and far from Africa. Some researchers who have examined those remains argue that they might belong to a smaller-brained *Homo* species, *Homo habilis*.

▶ **Homo erectus *in Asia*** According to some researchers, groups of *Homo erectus* left Africa and traveled all the way across India and through China to Southeast Asia. In fact, some of the oldest known specimens of *H. erectus* were uncovered on the Indonesian island of Java. This suggests that these ancient wanderers spread very rapidly once they left Africa. These *H. erectus* populations continued to survive and evolve across Asia for as long as 1.5 million years.

▶ ***The First* Homo sapiens** Paleontologists have long debated where and when *Homo sapiens* arose. One hypothesis, called the multiregional model, suggests that, in several parts of the world, modern humans evolved independently from widely separated populations of *H. erectus*. Another hypothesis, the "out-of-Africa" model, proposes that modern humans evolved in Africa about 200,000 years ago, migrated out of Africa through the Middle East, and replaced the descendants of earlier hominine species.

Recently, molecular biologists analyzed mitochondrial DNA from living humans around the world to determine when they last shared a common ancestor. The estimated date for that African common ancestor is between 200,000 and 150,000 years ago. More recent DNA data suggest that a small subset of those African ancestors left northeastern Africa between 65,000 and 50,000 years ago to colonize the world. These data strongly support the out-of-Africa model.

BUILD Vocabulary

MULTIPLE MEANINGS The word *sapient* means "wise." It is also used as an adjective referring to *Homo sapiens*.

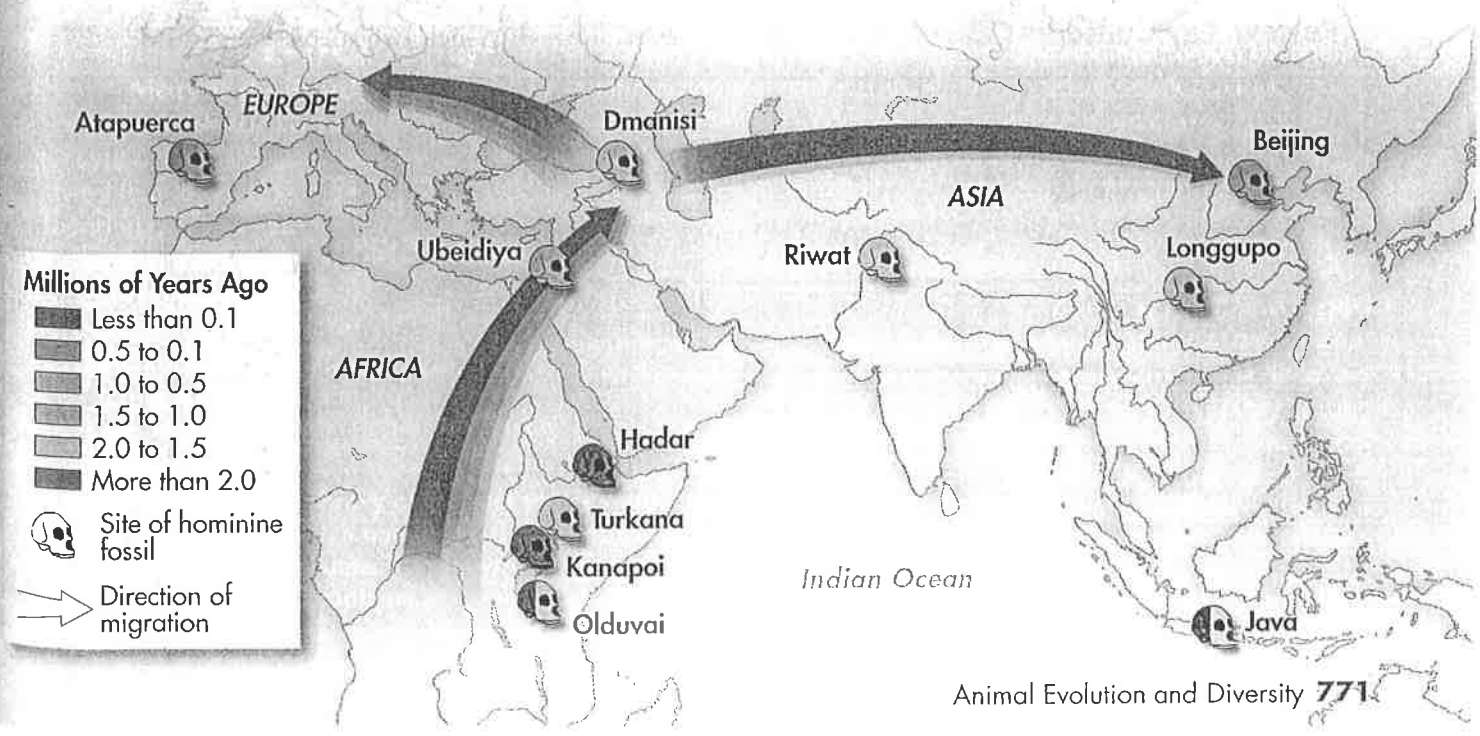


FIGURE 26–20 Out of Africa Data show that relatives and ancestors of modern humans left Africa in waves. But when—and how far did they travel? By comparing the mitochondrial DNA of living humans and by continuing to study the fossil record, scientists hope to improve our understanding of the complex history of *Homo sapiens*. (Note: Skulls on the map do not indicate that skulls were found at each location.)

FIGURE 26–21 Cro-Magnon Art This ancient cave painting from France shows the remarkable artistic abilities of Cro-Magnons. **Infer** ***How might these painted images be related to the way in which these early humans lived?***

Modern Humans The story of modern humans over the past 200,000 years involves two main species in the genus *Homo*.

▶ **Homo neanderthalensis** Neanderthals flourished in Europe and western Asia beginning about 200,000 years ago. Evidence suggests that they made stone tools, lived in complex social groups, had controlled use of fire, and were excellent hunters. They buried their dead with simple rituals. Neanderthals survived in parts of Europe until about 28,000 to 24,000 years ago.

▶ ***Modern* Homo sapiens** Anatomically modern *Homo sapiens*, whose skeletons look like those of today's humans, arrived in the Middle East from Africa about 100,000 years ago. By about 50,000 years ago, *H. sapiens* populations were using new technology to make more sophisticated stone blades. They also began to make elaborately worked tools from bones and antlers. They produced spectacular cave paintings and buried their dead with elaborate rituals. In other words, these people, including the group known as Cro-Magnons, began to behave like modern humans.

When *H. sapiens* arrived in the Middle East, they found Neanderthals already living there. Neanderthals and *H. sapiens* lived side by side in the Middle East for about 50,000 years. Groups of modern humans moved into Europe between 40,000 and 32,000 years ago. There, too, *H. sapiens* coexisted alongside Neanderthals for several thousand years. For the last 24,000 years, however, our species has been Earth's only hominine. Why did Neanderthals disappear? Did they interbreed with *H. sapiens*? No one knows for sure. What we d know is that our species, *Homo sapiens*, is the only surviving member of the once large and diverse hominine clade.

26.3 Assessment

Review Key Concepts

1. a. Review What are the characteristics of primates?

b. Apply Concepts How does each characteristic benefit primates?

2. a. Review List the two major groups of primates.

b. Sequence At what point did the two groups of anthropoids split, and why?

3. a. Review Which early hominine bones changed shape over time, allowing later hominines to walk upright?

b. Relate Cause and Effect How was bipedal locomotion important to hominine evolution?

4. a. Review Which two species are considered humans?

b. Compare and Contrast List two ways in which *Homo neanderthalensis* differed from *Homo sapiens*.

WRITE ABOUT SCIENCE

Creative Writing

5. Create a "Lost Hominine" poster for *Homo neanderthalensis*. Include its known characteristics and approximately when and where it was last seen. Illustrate the poster with a drawing or clipping.