Chapter 16

Primate Evolution

What You'll Learn

- You will compare and contrast primates and their adaptations.
- You will analyze the evidence for the ancestry of humans.

Why It's Important

Humans are primates. A knowledge of primates and their evolution can provide an understanding of human origins.

Understanding the Photo

Humans are not the only animals that use tools. This chimpanzee is using a stone to crack a nutshell.

Biology Online

Visit bdol.glencoe.com to
- study the entire chapter online
- access Web Links for more information and activities on primate evolution
- review content with the Interactive Tutor and self-check quizzes

National Geographic Image Society Collection

CONTENTS

Section 16.1

Primate Adaptation and Evolution

SECTION PREVIEW

Objectives

Recognize the adaptations of primates.

Compare and contrast the diversity of living primates.

Distinguish the evolutionary relationships of primates.

Review Vocabulary

speciation: the process of evolution of a new species that occurs when members of similar populations no longer interbreed to produce fertile offspring (p. 409)

New Vocabulary

primate
opposable thumb
anthropoid
prehensile tail

FOLDABLES Study Organizer

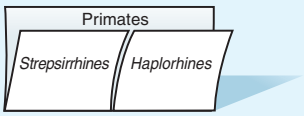
Investigating Primates Make the following Foldable to help you organize information about the two groups of primates.

STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 2 cm longer than the front edge.

STEP 2 **Turn** the paper so the fold is on the bottom. Then **fold** it in half.

STEP 3 **Unfold and cut** only the top layer along the fold to make two tabs.

STEP 4 **Label** the Foldable as shown.



Illustrate and Label As you read Chapter 16, identify the characteristics of each group of primates under the appropriate tab.

What is a primate?

Have you ever gone to a zoo and seen monkeys, chimpanzees, gorillas, or baboons? If you have, then you've observed some different types of primates. The **primates** are a group of mammals that includes lemurs, monkeys, apes, and humans. Primates come in a variety of shapes and sizes, but, despite their diversity, they share common traits. Learn more about primates on pages 1068–1069 in the *Focus On*.

What characteristics account for the complex behaviors of primates? Find out by reading ***Figure 16.1*** on the next page. Primates have rounded heads with flattened faces, unlike most other mammals. Fitting snugly inside the rounded head is a brain that, relative to body size, is the largest brain of any terrestrial mammal. Primate brains are also more complex than those of other animals. The diverse behaviors and social interactions of primates reflect the complexity of their brains.

The majority of primates are arboreal, meaning they live in trees, and have several adaptations that help them survive there. All primates have relatively flexible shoulder and hip joints. These flexible joints are important to some primates for climbing and swinging among branches.

INSIDE STORY

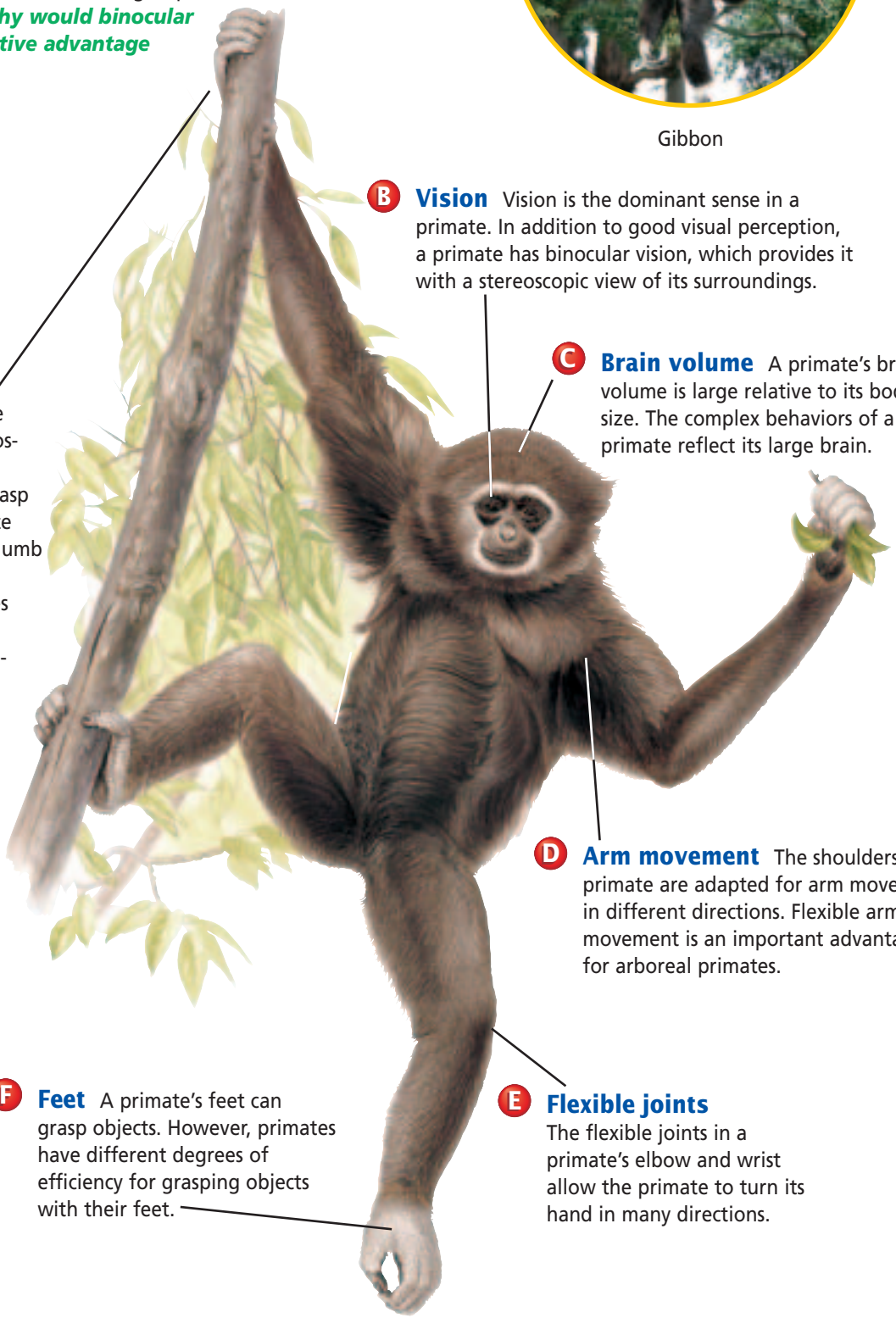
A Primate

Figure 16.1

Primates are a diverse group of mammals, but they share some common features. For example, you can see in the drawing of a gibbon that primates have rounded heads and flattened faces, unlike most other groups of mammals.

Critical Thinking ***Why would binocular vision be an adaptive advantage for primates?***

Gibbon



A Opposable thumbs The primate's opposable thumbs enable it to grasp and manipulate objects. The thumb is also flexible, which increases the primate's ability to manipulate objects.

B Vision Vision is the dominant sense in a primate. In addition to good visual perception, a primate has binocular vision, which provides it with a stereoscopic view of its surroundings.

C Brain volume A primate's brain volume is large relative to its body size. The complex behaviors of a primate reflect its large brain.

D Arm movement The shoulders of a primate are adapted for arm movement in different directions. Flexible arm movement is an important advantage for arboreal primates.

E Flexible joints The flexible joints in a primate's elbow and wrist allow the primate to turn its hand in many directions.

F Feet A primate's feet can grasp objects. However, primates have different degrees of efficiency for grasping objects with their feet.

Mack Henry/Visuals Unlimited

CONTENTS

Primate hands and feet are unique among mammals. Their digits, fingers and toes, have nails rather than claws and their joints are flexible. In addition, primates have an **opposable thumb**—a thumb that can cross the palm to meet the other fingertips. Opposable thumbs enable primates to grasp and cling to objects, such as the branches of trees. Primates can also hold and manipulate tools, as shown in ***Figure 16.2.***

Primates have a highly developed type of vision, called binocular vision. Primate eyes face forward so that they see an object simultaneously from two viewpoints, or through both eyes. This positioning of the eyes enables primates to perceive depth and thus gauge distances. As you might imagine, this type of vision is helpful for an animal jumping from tree to tree. Primates also have color vision that aids depth perception, enhances their ability to detect predators, and helps them find ripe fruits.

Reading Check **List** some common characteristics of primates.

Figure 16.2
Chimpanzees have opposable thumbs to help them grasp and cling to objects and manipulate them.

Primate Origins

The similarities among the many primates is evidence that primates share an evolutionary history. Scientists use fossil evidence and comparative anatomical, genetic, and biochemical studies of modern primates to propose ideas about how primates are related and how they evolved. Biologists classify primates into two major groups: strepsirrhines and haplorhines, as shown in ***Figure 16.3.***

Primates

Present-day strepsirrhines are small primates that include, among others, the lemurs and aye-ayes. Most strepsirrhines have large eyes and are nocturnal. They live in the tropical forests of Africa and Southeast Asia. The earliest fossils of strepsirrhines are about 50 to 55 million years old.

Word Origin

anthropoid from the Greek words *anthropos,* meaning "man," and *eidos,* meaning "shape"; The anthropoid apes resemble humans in their general appearance.

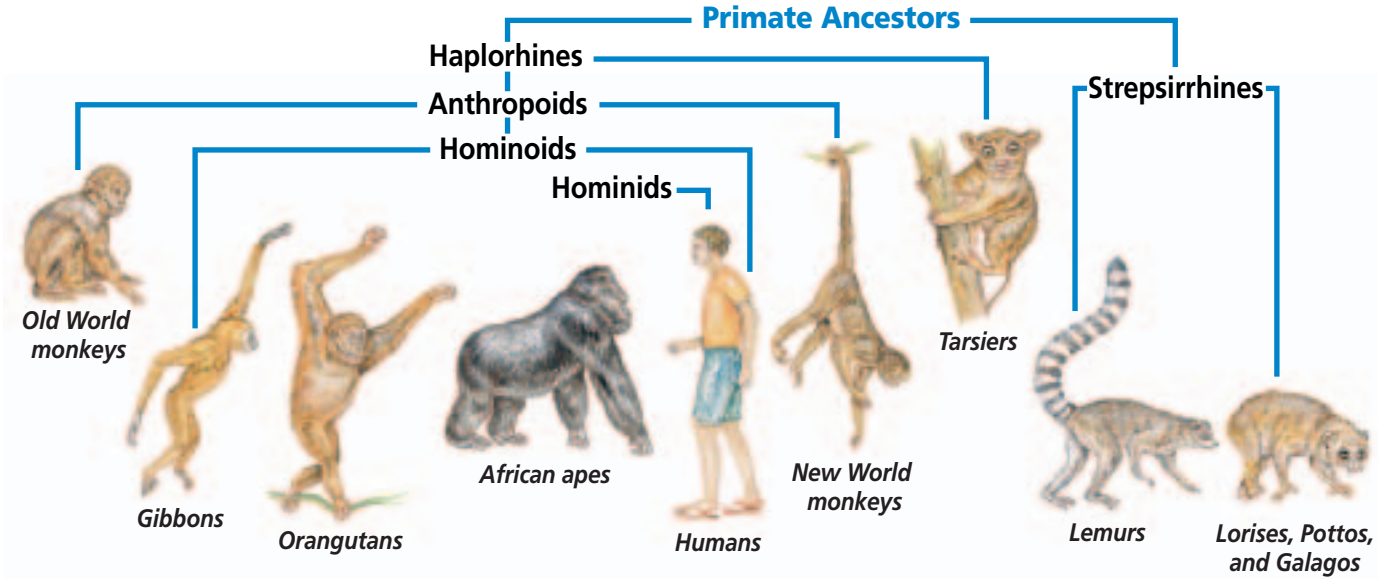


Figure 16.3
Primates are divided into two groups: the strepsirrhines and the haplorhines, which are subdivided into Old World monkeys, New World monkeys, and hominoids.

CONTENTS

Figure 16.4
Most basal primates are small, nocturnal animals that live in tropical environments.

A The aye-aye, a primate found in Madagascar, uses its long middle finger to dig for grubs.

B Tarsiers are primates that live in the Philippines, Borneo, and Sumatra.

Some scientists consider fossils of an organism called *Purgatorius* to be the earliest of primate fossils. *Purgatorius*, which probably resembled a squirrel, was a strepsirrhinelike animal that lived about 66 million years ago. Although there are no living species of *Purgatorius*, present-day strepsirrhines, ***Figure 16.4***, are quite similar.

Humanlike primates evolve

The remaining living primates are members of a group called haplorhines. This group consists of tarsiers and the **anthropoids** (AN thruh poydz), the humanlike primates. Anthropoids include hominoids and Old and New World monkeys, as shown in ***Figure 16.5***. In turn, hominoids include apes and humans.

Figure 16.5
Monkeys and hominoids are classified as anthropoids.

A Golden lion tamarins are arboreal New World monkeys that live in South America.

B This mandrill is an Old World monkey that lives in the forests of West Africa, and spends most of its time on the ground.

CONTENTS

Many features characterize anthropoids. Anthropoids have more complex brains than strepsirrhines. Anthropoids are also larger and have different skeletal features, such as a more or less upright posture, than strepsirrhines.

What are commonly called "monkeys" are classified as either New World monkeys or Old World monkeys. New World monkeys, which live in the rain forests of South America and Central America, are all arboreal. A long, muscular **prehensile** (pree HEN sul) **tail** characterizes many of these primates. They use the tail as a fifth limb, grasping and wrapping it around branches as they move from tree to tree. Among the New World monkeys are tiny marmosets and larger spider monkeys.

Old World monkeys are generally larger than New World monkeys. They include the arboreal monkeys, such as the colobus monkeys and guenons, the terrestrial monkeys, such as baboons, and monkeys, such as macaques, which are equally at home in trees or on the ground. Old World monkeys do not have prehensile tails. They are adapted to many environments that range from the hot, dry savannas of Africa to the cold mountain forests of Japan.

Hominoids are classified as apes or humans. Apes include orangutans, gibbons, chimpanzees, bonobos, and gorillas. Apes lack tails and have different adaptations for arboreal life from those of the strepsirrhines and monkeys. For example, apes have long, muscled forelimbs for climbing in trees, swinging from branches, and knuckle walking, or walking on two legs with support from their hands. Try the *MiniLab* shown here to investigate an adaptation for tree climbing. Although many apes are arboreal, most also spend time on the ground. Gorillas, the largest of the apes, live in social groups on the ground. Among the apes, social interactions indicate a large brain capacity.

Humans have an even larger brain capacity and walk upright. You will read more about human primates in the next section. Anthropologists have suggested that monkeys, apes, and humans share a common anthropoid ancestor based on their structural and social similarities. Use the *Problem-Solving Lab* on the next page to explore this idea. The oldest anthropoid fossils

MiniLab 16.1

Infer

How useful is an opposable thumb? Have you ever thought about what makes you different from other mammals as diverse as cows and dogs? One key difference between primates like you and the other mammals is that you have opposable thumbs. You may not live in trees like some other primates, but this adaptation is useful in a variety of additional ways. In this activity, you will explore the importance of your thumbs.

Procedure

1. Loosely wrap your dominant hand with tape so that your thumb points in the same direction as your fingers.
2. Try to pick up a pen and write a sentence.
3. Pick up your textbook and hand it to another student.
4. Pitch a tennis ball into an empty trash can two meters away.
5. Repeat steps 2–4 after unwrapping your hand.

Analysis

1. **Compare** Describe the results of your performance with the absence of an opposable thumb and with one.
2. **Infer** Why is an opposable thumb an important adaptation for primates?
3. **Use Models** Design models for completing three simple tasks without using your thumb, such as turning a doorknob or switching on a light.

Matt Meadows

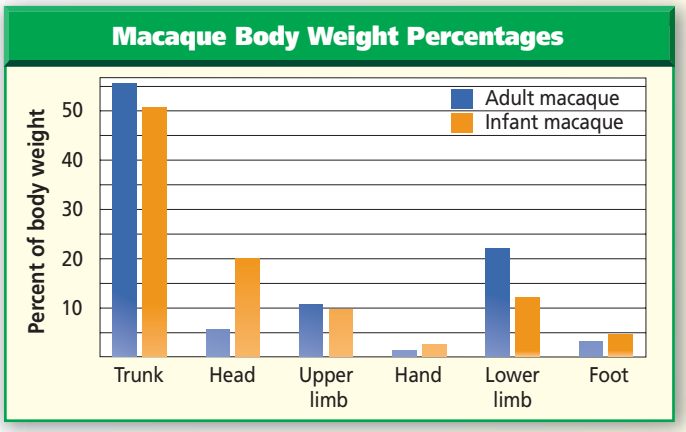
Problem-Solving Lab 16.1

Use Numbers

How do primate infants and adults compare? Some infant primates, such as macaques, cling to their mothers for their first few months of life. Therefore, muscles associated with clinging may represent a higher percentage of total body weight in infant macaques than in adult macaques.

Solve the Problem

The graph shows the percentages of body weight for specific body parts of adult and infant macaques.



Thinking Critically

1. **Compare** Explain the difference between the percentage of body weight of infant heads and adult heads.
2. **Hypothesize** Explain why the percentage of body weight for hands and feet changes as macaques mature. Would you expect the same pattern in humans? Explain your answer.

are from Africa and Asia and date to about 37 to 40 million years ago.

Anthropoids evolved worldwide

The oldest monkey fossils are of New World monkeys and are 30 to 35 million years old. Although New World monkeys probably share a common anthropoidlike ancestor with the Old World monkeys, they evolved independently of the Old World monkeys because of geographic isolation. In ***Figure 16.6,*** you can see the worldwide geographic distribution of monkeys and apes.

Old World monkeys evolved more recently than New World monkeys. Scientists suspect this is true because the oldest fossils of Old World monkeys are only about 20 to 22 million years old. The fossils indicate that the earliest Old World monkeys were arboreal like today's New World monkeys.

Hominoids evolved in Asia and Africa

According to the fossil record, there was a global cooling when the hominoids evolved in Asia and Africa. Important changes in vegetation,

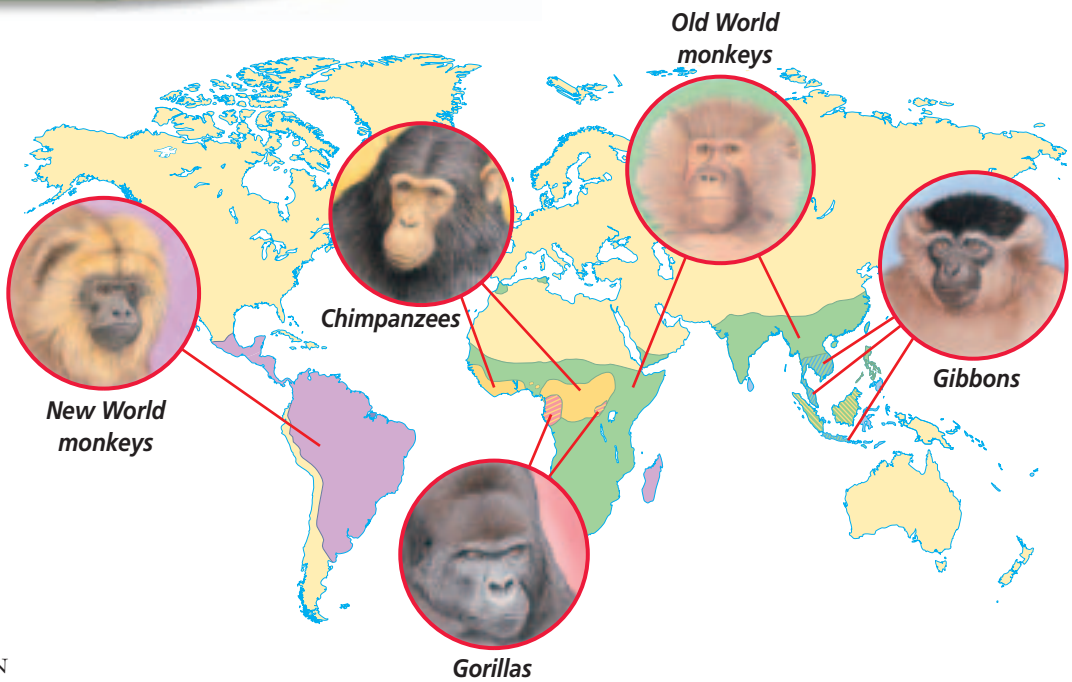


Figure 16.6
The present-day, worldwide distribution of monkeys and apes shows they have adapted to a wide range of habitats. **Interpret Scientific Illustrations** ***Which group has the widest modern distribution? The most restricted distribution?***

CONTENTS

Figure 16.7
Modern apes are diverse, and fossils indicate that ancient apes were even more diverse. Orangutans are arboreal apes that live in the forests of Borneo and Sumatra **(A).** Gorillas are ground-dwelling African apes that live in small social groups **(B).**

such as the evolution of grass, also occurred. At about the same time, the Old World monkeys became adapted to this climatic cooling. Fossils indicate how the apes adapted and diversified. You can see two examples of the present-day diversity of apes in ***Figure 16.7.***

Remember that hominoids include the apes and humans. By examining the DNA of each of the modern hominoids, scientists have evaluated the probable order in which the different apes and humans evolved. From this type of evaluation, it appears that gibbons were probably the first apes that evolved, followed by the orangutans that are found in southeast Asia. Finally, the African apes, gorillas and chimpanzees, evolved. Morphological and molecular data suggest that chimpanzees share the closest common ancestor with modern humans.

Section Assessment

Understanding Main Ideas

1. What adaptations help primates live in the trees?
2. What features distinguish anthropoids from strepsirrhines?
3. Draw a concept map to illustrate one possible pathway for the evolutionary history (phylogeny) of hominoids.

Thinking Critically

4. Imagine you are a world famous primatologist, a scientist who studies primates. An unidentified, complete fossil skeleton arrives at your lab. You suspect that it's a primate fossil. What observations would you make to determine if your suspicions are accurate?

Skill Review

5. **Get the Big Picture** Make a table listing the different types of primates, key facts about each group, and how the groups might be related. For more help, refer to *Get the Big Picture* in the **Skill Handbook.**

CONTENTS

Section 16.2

Human Ancestry

SECTION PREVIEW

Objectives

Compare and contrast the adaptations of australopithecines with those of apes and humans.

Identify the evidence of the major anatomical changes in hominids during human evolution.

Review Vocabulary

fossil: evidence of an organism that lived long ago that is preserved in Earth's rocks (p. 370)

New Vocabulary

hominoid
bipedal
hominid
australopithecine
Neandertal
Cro-Magnon

Solving a Puzzle

Using Prior Knowledge Have you ever tried to put together a jigsaw puzzle and found that some of the pieces were missing? If several pieces are lost, it is difficult to figure out what the puzzle is a picture of. Sometimes it depends on which part of the puzzle is missing. If the puzzle is a picture of a famous person and pieces of the face are missing, it's hard to tell who it is. But if the missing pieces are part of the background, you can still identify the person. Scientists who study human ancestry try to fit together a puzzle from scattered pieces of fossils—a puzzle with most of the pieces missing!

Homo habilis skull

Infer *What parts of a skeleton do you think would provide scientists with the most information? Explain your answer.*

Hominids

Some scientists propose that between 5 and 8 million years ago in Africa, a population that was ancestral to chimpanzees and humans diverged into two lines. According to this hypothesis, one line evolved into chimpanzees, and the other line eventually evolved into modern humans. These two lines are collectively called the **hominoids** (HAH mih noydz)—primates that can walk upright on two legs and include gorillas, chimpanzees, bonobos, and humans. There are relatively few fossils to support this hypothesis, but DNA studies of the modern hominoids provide data that support the idea. You can work with some of these data in *MiniLab 16.2* on the next page.

Some scientists suggest that the divergence of the population of ancestral hominoids might have occurred in response to environmental changes that forced some ancestral hominoids to leave their treetop environments and move onto the ground to find food. In order to move efficiently on the ground while avoiding predators, it was helpful for the hominoids to be **bipedal,** meaning able to walk on two legs. **Hominids** (HAH mih nudz) are bipedal primates that include modern humans and their direct ancestors. In addition to increased speed, walking on two legs leaves the arms and hands free for other activities, such as feeding, protecting young, and using tools. Therefore, hominoids with the ability to walk upright probably survived more successfully on the ground.

CONTENTS

These individuals then lived to reproduce and pass the characteristics to their offspring. According to this reasoning, the bipedal organisms that evolved might have been the earliest hominids.

Although the fossil record is incomplete, more hominid fossils are found every year. The many fossils that scientists have found reveal much about the anatomy and behavior of early hominids. Fossils of skulls provide scientists with information about the appearance and brain capacity of the early hominid types. Complete the *BioLab* at the end of the chapter to learn more about the kinds of information scientists gather from skulls of hominids.

Early hominids walked upright

In ***Figure 16.8***, you see a South African anatomist, Raymond Dart, who, in 1924, discovered a skull of a young hominoid with a braincase and facial structure similar to those of an ape.

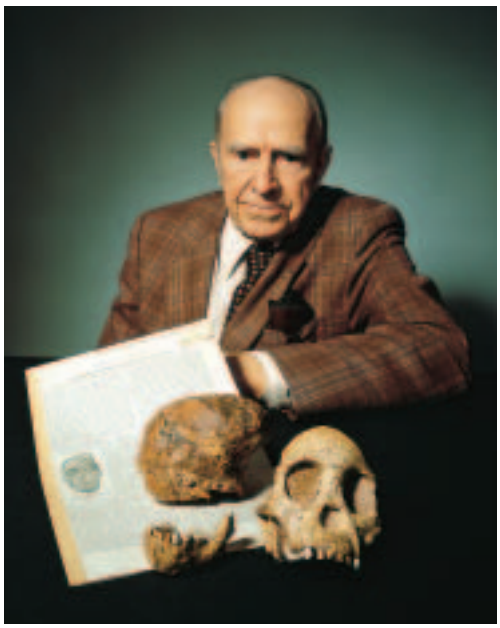


Figure 16.8
Raymond Dart discovered the first australopithecine fossil, the Taung child, *Australopithecus africanus.* The skull has features of both apes and humans.

MiniLab 16.2

Analyze Information

Compare Human Proteins with Those of Other Primates

Scientists use differences in amino acid sequences in proteins to determine the evolutionary relationships of living species. In this activity, you'll compare representative short sequences of the amino acids of a specific protein among groups of primates to determine their evolutionary history.

Amino Acid Sequences in Primates

Baboon	Chimp	Lemur	Gorilla	Human
ASN	SER	ALA	SER	SER
THR	THR	THR	THR	THR
THR	ALA	SER	ALA	ALA
GLY	GLY	GLY	GLY	GLY
ASP	ASP	GLU	ASP	ASP
GLU	GLU	LYS	GLU	GLU
VAL	VAL	VAL	VAL	VAL
ASP	GLU	GLU	GLU	GLU
ASP	ASP	ASP	ASP	ASP
SER	THR	SER	THR	THR
PRO	PRO	PRO	PRO	PRO
GLY	GLY	GLY	GLY	GLY
GLY	GLY	SER	GLY	GLY
ASN	ALA	HIS	ALA	ALA
ASN	ASN	ASN	ASN	ASN

Procedure

1. Prepare a data table.
2. For each primate listed in the table above, determine how many amino acids differ from the human sequence. Record these numbers in the data table.
3. Calculate the percentage differences by dividing the numbers by 15 and multiplying by 100. Record the numbers in your data table.

Analysis

1. **Interpret Data** Which primate is most closely related to humans? Least closely related?
2. **Formulate Models** Construct a diagram of primate evolutionary relationships that most closely fits your results.

However, the skull also had an unusual feature for an ape skull—the position of the *foramen magnum*, the opening in the skull through which the spinal cord passes as it leaves the brain.

In the fossil, the opening was located on the bottom of the skull, as it is in humans but not in apes. Because of this feature, Dart proposed that the organism had walked upright. He classified the organism as a new primate species, *Australopithecus africanus* (aw stray loh PIH thuh kus • a frih KAH nus), which means "southern ape from Africa." The skull that Dart found has been dated at between 2.5 and 2.8 million years old.

Since Dart's discovery, paleoanthropologists, scientists who study human fossils, have recovered many more australopithecine specimens. They describe an **australopithecine** as an early hominid that lived in Africa and possessed both apelike and humanlike characteristics.

Word Origin

paleoanthropology from the Greek words *paleo,* meaning "ancient," *anthropo,* meaning "human," and logos, meaning "study"; Paleoanthropology is the study of human fossils.

Early hominids: Apelike and humanlike

Later, in East Africa in 1974, an American paleoanthropologist, Donald Johanson, discovered one of the most complete australopithecine skeletons that he called "Lucy." Radiometric dating shows that Lucy probably lived about 3.2 million years ago. Johanson proposed that the Lucy skeleton was a new species, *Australopithecus afarensis.* Other fossils of *A. afarensis* indicate that this species probably existed between 3 and 4 million years ago.

Although the fossils show that *A. afarensis* individuals had apelike shoulders and forelimbs, the structure of the pelvis, as shown in ***Figure 16.9,*** indicates that these individuals were bipedal, like humans. On the other hand, the size of the braincase suggests that their brains had a small, apelike volume and not a larger human volume.

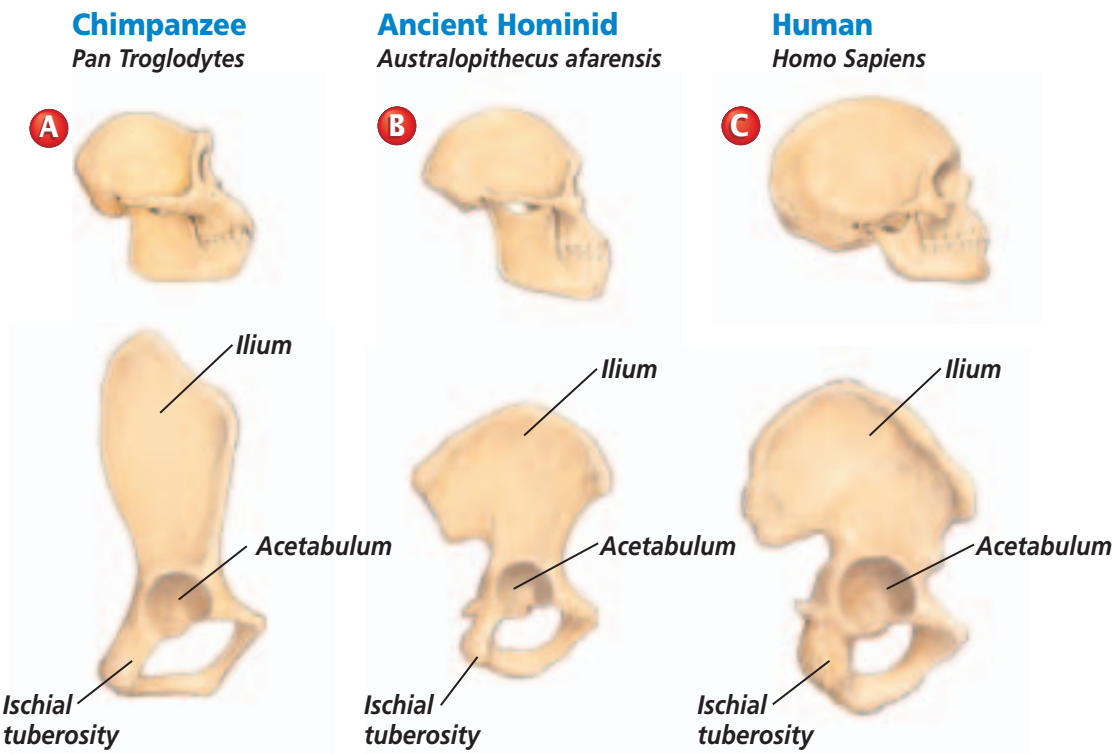


Figure 16.9
Some skeletal features of an australopithecine are intermediate between those of modern apes and humans. Compare the skull and pelvic bone of *Australopithecus afarensis* **(B)** with those of the chimpanzee **(A)** and the human **(C).**

CONTENTS

You may be wondering what life was like for hominids like Lucy. Because of the combination of apelike and humanlike features, one idea is that *A. afarensis* and other species of australopithecines might have lived in small family groups, sleeping and eating in trees. But, to travel, they walked upright on the ground. The fossil record indicates that an *A. afarensis* individual rarely survived longer than 25 years.

In addition to fossils of *A. afarensis* and *A. africanus*, fossils of three or perhaps four other species of australopithecines have been found. These other species, discovered in East Africa and South Africa, are dated from about 2.5 to 4.3 million years old. Three other species of hominids have been found that are similar to australopithecines. These earlier hominids are grouped into the genus *Paranthropus* because their fossils suggest that they had larger teeth and jaws and sturdier bodies than australopithecines.

The relationships among australopithecines are not entirely clear from the fossil record. However, the genus disappears from the record between 2.0 and 2.5 million years ago. Although australopithecines became extinct, some paleoanthropologists propose that an early population of these hominids might have been ancestral to modern humans.

Reading Check **Identify** the differences in fossil hominid species using anatomical evidence.

The Emergence of Modern Humans

Any ideas about the evolution of modern hominids must include how bipedalism and a large brain evolved. Australopithecine fossils provide support for the idea that bipedalism evolved first. But when did a large brain evolve in a hominid species? When did hominids begin to use tools and develop culture?

Figure 16.10
Mary and Louis Leakey discovered many fossils in the Olduvai Gorge area of Tanzania, Africa. **Describe** ***Why was the Leakeys' discovery of* Homo habilis *important?***

Early members of the genus *Homo* made stone tools

In 1964, anthropologists Louis and Mary Leakey, ***Figure 16.10,*** described skull portions belonging to another type of hominid in Tanzania, Africa. This skull was more humanlike than those of australopithecines. In particular, the braincase was larger and the teeth and jaws were smaller, more like those of modern humans. Because of the skull's human similarities, the Leakeys classified the hominid with modern humans in the genus *Homo*. Because stone tools were found near the fossil skull, they named the species *Homo habilis*, which means "handy human."

Radiometric dating indicates that *H. habilis* lived between about 1.5 and 2.5 million years ago. It is the earliest known hominid to make and use stone tools. These tools suggest that *H. habilis* might have been a scavenger who used the stone tools to cut meat from carcasses of animals that had been killed by other animals. You can see a *H. habilis* skull in ***Figure 16.11*** on the next page.

CONTENTS

Figure 16.11
The average brain volume of *Homo habilis* was 600 to 700 cm^3, smaller than the average 1350 cm^3 volume of modern humans, but larger than the 400 to 500 cm^3 volume of australopithecines.

Hunting and using fire

Some anthropologists propose that a *H. habilis* population or another species, *Homo ergaster*, gave rise to a new species about 1.5–1.8 million years ago. This new hominid species was called *Homo erectus*, which means "upright human." *H. erectus* had a larger brain and a more humanlike face than *H. habilis*. However, it had prominent browridges and a lower jaw without a chin, as shown in ***Figure 16.12***, which are apelike characteristics.

Some scientists interpret the stone tools called hand axes that they find at some *H. erectus* excavation sites as an indication that *H. erectus* hunted. In caves at these sites, they have also found hearths with charred bones. This evidence suggests that these hominids used fire and lived in caves.

The distribution of fossils indicates that *H. erectus* migrated from Africa about 1 million years ago. Then this hominid spread through Africa and Asia, and possibly migrated into Europe, before becoming extinct between 130 000 and 300 000 years ago. However, some scientists propose that more human-looking hominids might have arisen from *H. erectus* before it disappeared.

A

B

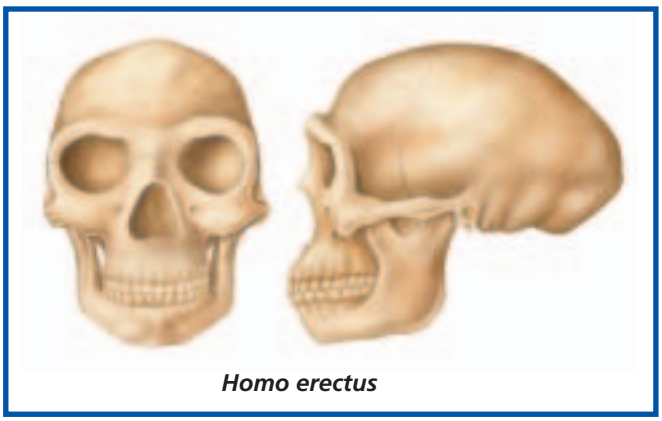


Figure 16.12
A nearly complete *Homo erectus* skeleton of a young male was discovered in East Africa in 1985 **(A).** *H. erectus* had a brain volume of about 1000 cm^3 and long legs like modern humans **(B).**

CONTENTS

Culture developed in modern humans

Many hypotheses have been suggested to explain how modern humans, *Homo sapiens*, might have emerged. These hypotheses were formed after studying evidence from fossil bones and teeth, and from studies of certain types of DNA. A description of the most popular hypothesis follows.

The fossil record indicates that the species *H. sapiens* appeared in Europe, Africa, the Middle East, and Asia about 100 000 to 500 000 years ago. The forms that are thought to precede *H. sapiens* are placed by most scientists into one of two groups—*H. antecessor* or *H. heidelbergensis* (hi duhl berg EN sus). It is not yet clear which of these species represents the direct ancestor to *Homo sapiens*. More fossil evidence and additional research into fossil DNA sequences still are needed. These early forms have skulls that resemble *H. erectus* or *H. ergaster* but have less prominent browridges, more bulging foreheads, and smaller teeth. Also, the braincases are larger than *H. erectus*, with brain volumes of 1000 to 1650 cm^3, which is within the modern human range. A well-known *Homo* species was the Neandertals (nee AN dur tawlz), illustrated in ***Figure 16.13.***

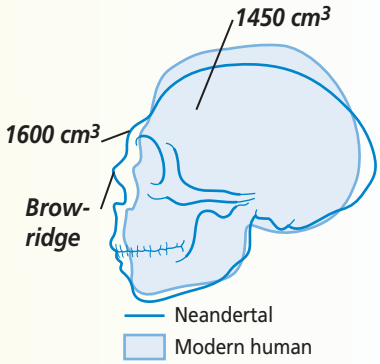
Problem-Solving Lab 16.2

Apply Concepts

How similar are Neandertals and humans? Fossil evidence can provide clues to similarities and differences between Neandertals and humans.

Solve the Problem

Examine the diagram of a human skull superimposed on a Neandertal skull. The cranial capacities (brain size) of the two skulls are provided.



Thinking Critically

1. **Measure** How much larger is a Neandertal brain than a human brain? Express the value as a percentage.
2. **Interpret Scientific Illustrations** Which skull has the more protruding jaw? A thicker browridge? Are a protruding jaw and thick browridges more apelike or humanlike characteristics? Explain your judgment.
3. **Identify** What clues do fossils such as spear points and hand axes, shelters made of animal skins, and flowers and animal horns at burial sites provide about the lifestyle of Neandertals?

Figure 16.13
Neandertals *(Homo neanderthalensis)* were skilled hunters. They had many tools, including spears, scrapers, and knives.

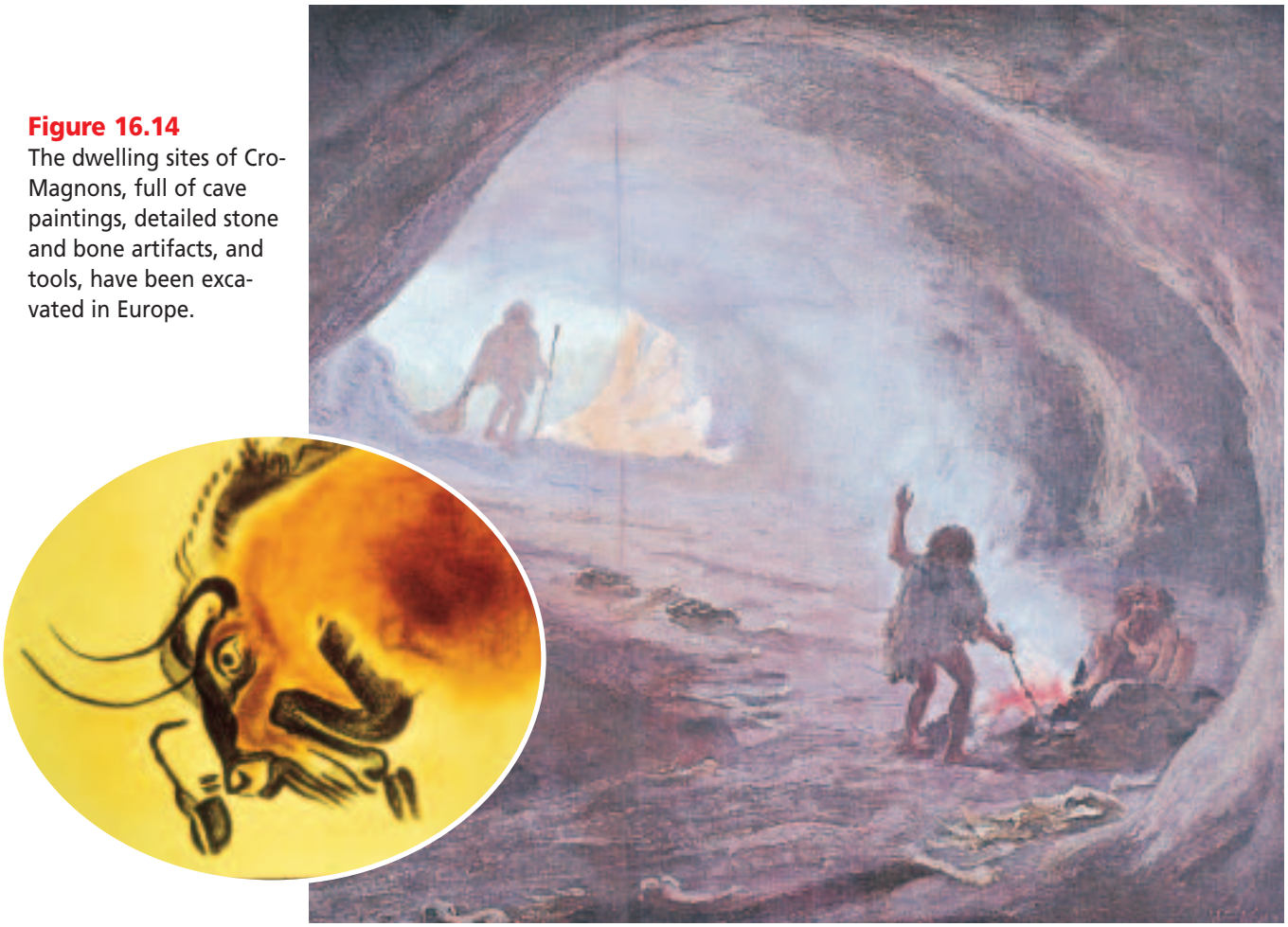


Figure 16.14
The dwelling sites of Cro-Magnons, full of cave paintings, detailed stone and bone artifacts, and tools, have been excavated in Europe.

The **Neandertals** lived from about 35 000 to 100 000 years ago in Europe, Asia, and the Middle East. Fossils reveal that Neandertals had thick bones and large faces with prominent noses. The brains of Neandertals were at least as large as those of modern humans.

The fossil records also indicate that Neandertals lived in caves during the ice ages of their time. In addition, the tools, figurines, flowers, pollen, and other evidence from excavation sites, such as burial grounds, suggest that Neandertals may have had religious views and communicated through spoken language.

What happened to Neandertals?

Could Neandertals have evolved into modern humans? No, the fossil record shows that a more modern type of *H. sapiens* spread throughout Europe between 35 000 to 40 000 years ago. This type of *H. sapiens* is called Cro-Magnon (kroh MAG nun). **Cro-Magnons** were identical to modern humans in height, skull structure, tooth structure, and brain size. Paleoanthropologists suggest that Cro-Magnons were toolmakers and artists, as shown in ***Figure 16.14.*** Cro-Magnons probably also used language, as their skulls contain a bulge that corresponds to the area of the brain that is involved in speech in modern humans.

Did Neandertals evolve into Cro-Magnons? Current genetic and archaeological evidence indicates that this is not the case. Current dates for hominid fossils suggest that modern

CONTENTS

H. sapiens appeared in both South Africa and the Middle East about 100 000 years ago, which was about the same time the Neandertals appeared. In addition, genetic evidence supports the idea of an African origin of modern *H. sapiens*, perhaps as early as 200 000 years ago. This idea suggests that the African *H. sapiens* migrated to Europe and Asia.

Most fossil evidence supports the idea that Neandertals were most likely a sister species of *H. sapiens*, and not an ancestral branch of modern humans. Look at ***Figure 16.15*** to see one possible evolutionary path to modern humans.

Fossil evidence shows that humans have not changed much anatomically over the last 200 000 years. Humans probably first established themselves in Africa, Europe, and Asia. Then evidence shows that they crossed either by sea or using a land bridge into North America. You can read more about the land bridge theory in the *Connection to Earth Science* at the end of the chapter. By about 10 000 to 8000 years ago, Native Americans had built permanent settlements and were domesticating animals and farming.

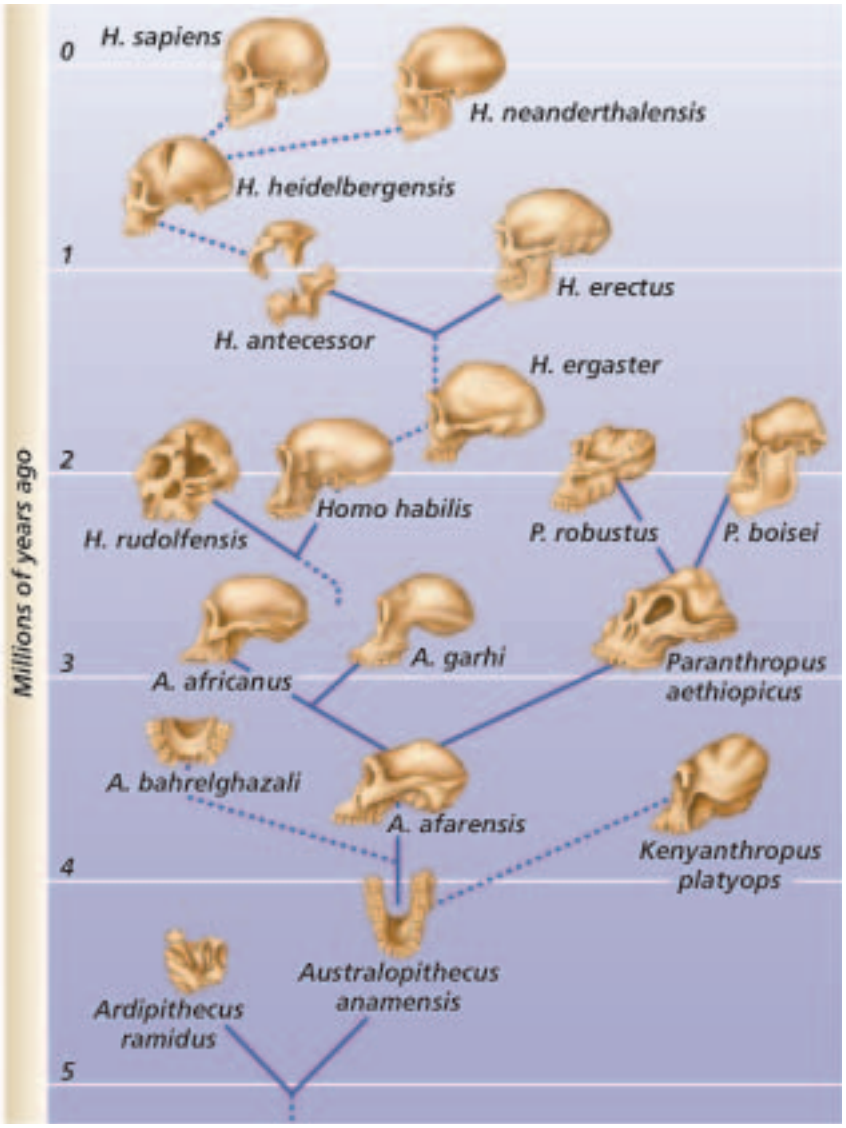


Figure 16.15
This diagram represents one possible pathway for the evolution of *Homo sapiens.* Not all scientists agree on the evolutionary pathway.

Section Assessment

Understanding Main Ideas

1. Describe the history of at least three major discoveries that led to our current understanding of hominid evolution.
2. Why was the development of bipedalism a very important event in the evolution of hominids?
3. What evidence supports the idea that *H. habilis* was an ancestor of *H. erectus?*
4. Identify and describe the evidence that supports the idea that Neandertals were not the ancestors of Cro-Magnon people.

Thinking Critically

5. What kind of animal bones might you expect to find at the site of *Homo habilis* remains if *H. habilis* was a scavenger? A hunter?

Skill Review

6. **Interpret Scientific Illustrations** Draw a time line to show results of natural selection in the phylogeny or the evolutionary history of hominids. For more help, refer to *Interpret Scientific Illustrations* in the **Skill Handbook.**

INVESTIGATE

BioLab

Comparing Skulls of Three Primates

Before You Begin

Australopithecines are one of the earliest hominids in the fossil record. In many ways, their anatomy is intermediate between living apes and humans. In this lab, you'll determine the apelike and humanlike characteristics of an australopithecine skull, and compare the skulls of australopithecines, gorillas, and modern humans. The diagrams of skulls shown below are one-fourth natural size. The heavy black lines indicate the angle of the jaw.

Preparation

Problem

How do skulls of primates provide evidence for human evolution?

Objectives

In this BioLab, you will:

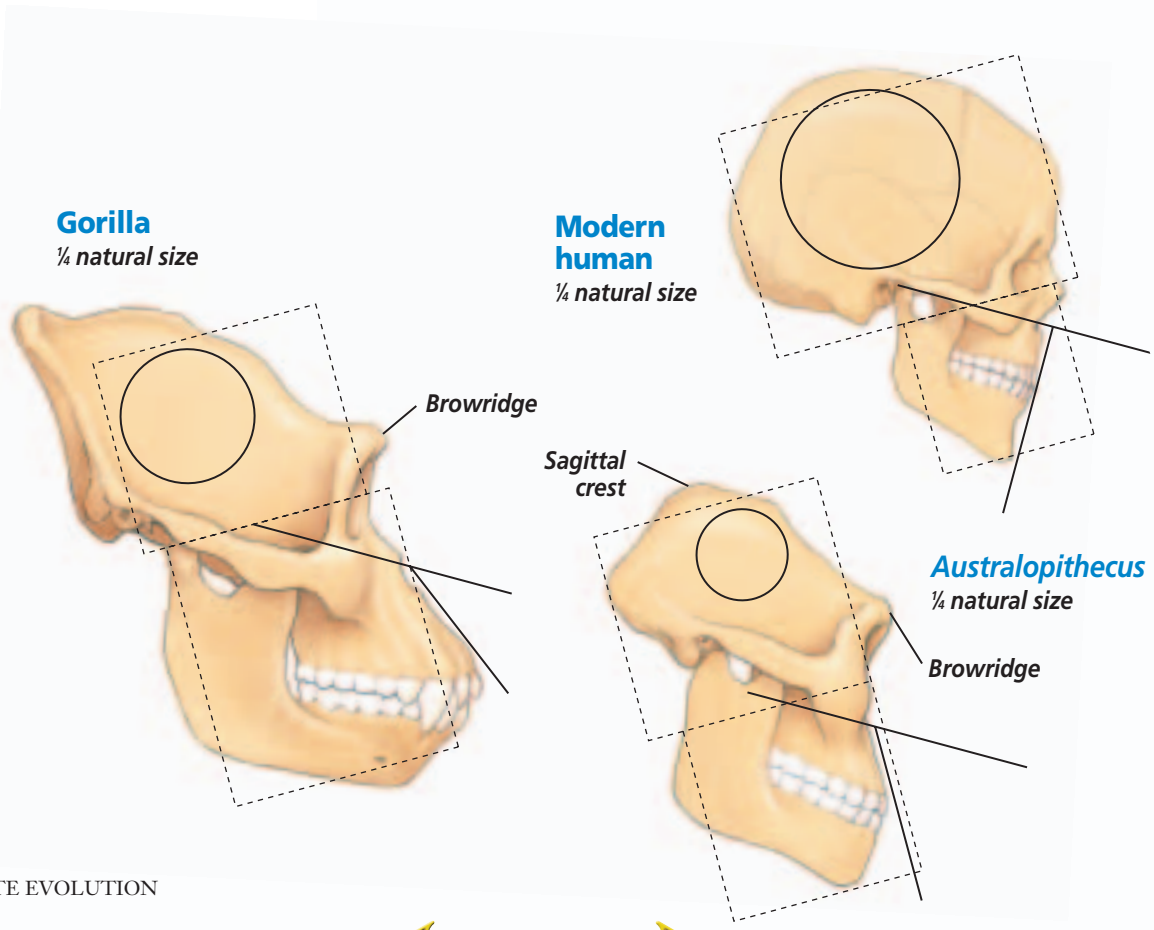
- **Determine** how paleoanthropologists study early human ancestors.
- **Compare and contrast** the skulls of australopithecines, gorillas, and modern humans.

Materials

metric ruler
protractor
copy of skull diagrams

Skill Handbook

If you need help with this lab, refer to the **Skill Handbook.**



Procedure

1. Your teacher will provide copies of the skulls (¼ natural size) of *Australopithecus africanus*, *Gorilla gorilla*, and *Homo sapiens*.
2. The rectangles drawn over the skulls represent the areas of the brain (upper rectangle) and face (lower rectangle). On each skull, determine and record the area of each rectangle (length × width).
3. Measure the diameters of the circles in each skull. Multiply these numbers by 200 cm^2. The result is the cranial capacity (brain volume) in cubic centimeters.
4. The two lines projected on the skulls are used to measure how far forward the jaw protrudes. Use a protractor to measure the acute angle formed by the two lines.
5. Complete the data table.

Data Table

	Gorilla	*Australopithecus*	Modern Human
1. Face area in cm^2			
2. Brain area in cm^2			
3. Is brain area smaller or larger than face area?			
4. Is brain area 3 times larger than face area?			
5. Cranial capacity in cm^3			
6. Jaw angle			
7. Does lower jaw stick out in front of nose?			
8. Is sagittal crest present?			
9. Is browridge present?			

Analyze and Conclude

1. **Compare and Contrast** How would you describe the similarities and differences in face-to-brain area in the three primates?
2. **Interpret Observations** How do the cranial capacities compare among the three skulls? How do the jaw angles compare?
3. **Interpret Data** Identify evidence of the change in the species using anatomical similarities.
4. **Error Analysis** What are the possible sources of error in your analysis?

Apply Your Skill

Use Models Obtain diagrams of primate skeletons to determine the similarities and differences using other parts of the skeletons.

Web Links To find out more about primate evolution, visit bdol.glencoe.com/primate_evolution

connection to Earth Science

The Land Bridge to the New World

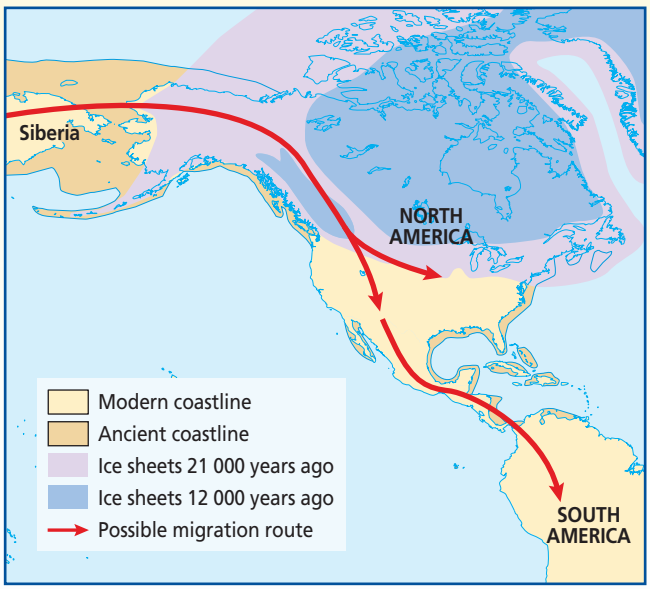
The Bering Land Bridge, or Beringia, was a strip of land that connected Asia and North America. During the last Ice Age, the Bering Land Bridge was dry land above sea level. The ancestors of Native Americans walked across this land to reach North America.

The 1500 km–wide piece of land known as the Bering Land Bridge is located between the Bering and Chukchi Seas and links northeastern Siberia and northwestern North America. Today, the land bridge is about 267 meters below the ocean's surface. However, during the last ice age, sea level was much lower than it is today. At that time, this land bridge was above the water's surface. Humans could have migrated from Asia to North America across this land bridge. Recent evidence indicates that such a human migration probably occurred about 12 000 years ago.

Dating the land bridge Anthropologists compared two kinds of data to determine the 11 000-year date for human migration across the Bering Land Bridge. They used radiometric dating methods on fossils and gathered information on sea level changes over time. Both data reveal that the Bering Land Bridge was last above sea level about 11 000 years ago.

Pollen reveals plant life Pollen found in sediments dredged from the bottoms of the Bering and Chukchi Seas indicates that the land bridge and the surrounding areas were tundra ecosystems. Willows, birch, sedge tussocks, and spring flowers were the dominant plants of the area, and caribou probably roamed over the frozen soil.

The pollen studies also showed that the temperature at the time was warmer than it is in present-day Alaska. Scientists have used this finding to propose that perhaps the ice age was ending. The glaciers would have melted in a warming climate and the sea level would have risen, covering the land bridge with water.



A controversial idea Archaeologists have unearthed what they believe to be human artifacts dating back to more than 12 000 years ago in several states. Some archaeologists believe that these artifacts, such as stone spearheads, suggest that humans occupied North America before the land bridge migration. Other archaeologists disagree, citing that no human fossils have been found, contamination of sites could have occurred, and that published reports confirming the dates and documenting the details of most of the sites have not been completed.

Writing About Biology

Infer Study the map shown above. Suggest in a short report another way that prehistoric humans might have entered the New World.

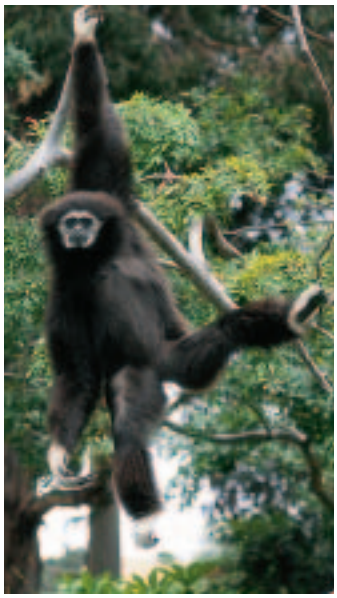
To find out more about human origins, visit bdol.glencoe.com/earth_science

Chapter 16 Assessment

Study Guide

Section 16.1

Primate Adaptation and Evolution



Key Concepts

- Primates are primarily an arboreal group of mammals. They have adaptations, such as binocular vision, opposable thumbs, and flexible joints, that help them survive in trees.
- There are two groups of primates: strepsirrhines, such as lemurs; and haplorhines, which include tarsiers, monkeys, and hominoids.
- There are two groups of monkeys: New World monkeys and Old World monkeys. New World monkeys live in South America and Central America. Many New World monkeys have a prehensile tail. Old World monkeys are larger and do not have prehensile tails.
- Hominoids are primates that include gorillas, chimpanzees, bonobos, gibbons, orangutans, and humans.
- Fossils indicate that primates appeared on Earth about 66 million years ago. Major trends in primate evolution include an increasing brain size and walking upright.

Vocabulary

anthropoid (p. 424)
opposable thumb (p. 423)
prehensile tail (p. 425)
primate (p. 421)

Section 16.2

Human Ancestry

Key Concepts

- The earliest hominids arose in Africa approximately 5 million years ago. Australopithecine fossils indicate that these individuals were bipedal, but also climbed trees.
- The first hominid to be classified in the genus *Homo* was discovered in Africa in 1964 by Mary and Louis Leakey. The fossil was named *Homo habilis* or "handy human." *Homo habilis* has been radiometrically dated at between 1.5 and 2.5 million years old.
- The appearance of stone tools in the fossil record coincided with the appearance of the genus *Homo* about 2 million years ago.

Vocabulary

australopithecine (p. 430)
bipedal (p. 428)
Cro-Magnon (p. 434)
hominid (p. 428)
hominoid (p. 428)
Neandertal (p. 434)

FOLDABLES Study Organizer

To help you review primate evolution, use the Organizational Study Fold on page 421.

CONTENTS

Chapter 16 Assessment

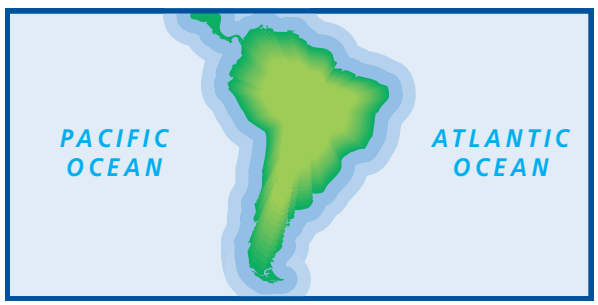
Vocabulary Review

Review the Chapter 16 vocabulary words listed in the Study Guide on page 439. Determine if each statement is true or false. If false, replace the underlined word with the correct vocabulary word.

1. New World monkeys have prehensile tails.
2. Hominids include humans and the apes.
3. Early hominids that lived in Africa and possessed both apelike and humanlike characteristics are called primates.
4. Bipedal organisms walk upright on two legs.

Understanding Key Concepts

5. The first *Homo sapiens* were _____.
   - **A.** Cro-Magnon people
   - **B.** *Homo erectus*
   - **C.** *Australopithecus afarensis*
   - **D.** Neandertals
6. Which of the following pairs of terms is most closely related?
   - **A.** primate—squirrel
   - **B.** arboreal—gorilla
   - **C.** strepsirrhine—hominid
   - **D.** Cro-Magnon—*Homo sapiens*
7. Primates native to the area indicated by the map below are _____.
   - **A.** Old World monkeys
   - **B.** New World monkeys
   - **C.** apes
   - **D.** strepsirrhines



8. The science of studying the fossils of humans is _____.
   - **A.** paleoanthropology
   - **B.** geology
   - **C.** paleontology
   - **D.** anthropology
9. The earliest primates were most like _____.
   - **A.** 
   - **C.** 
   - **B.** 
   - **D.** 
10. The study of the fossil Lucy helped scientists determine that _____.
    - **A.** both primates and hominids have color vision
    - **B.** hominids are primates with opposable thumbs
    - **C.** hominids had large brains before they walked upright
    - **D.** hominids walked upright before they had large brains

Constructed Response

11. **Open Ended** Suppose that you were told that a scientist found a 25 000-year-old arrowhead in Arizona. Would you be surprised? Why or why not?
12. **Open Ended** Why is it important for a paleoanthropologist to know about all primates?
13. **Open Ended** Some scientists suggest that Neandertals evolved into modern humans. What information should they gather to support their idea?

Thinking Critically

14. **REAL WORLD BIOCHALLENGE** Almost every year the discovery of new fossils provides evidence for the evolution of human ancestors. Visit bdol.glencoe.com to find out about some of the newest fossil discoveries. When and where were the fossils found? Write an essay to describe how the fossils add to our understanding of primate evolution.

bdol.glencoe.com/chapter_test

CONTENTS

Chapter 16 Assessment

15. **Observe and Infer** How could you tell from the position of the foramen magnum that an animal walked upright? Explain.

16. **Formulate Hypotheses** How would you test the idea that opposable thumbs are beneficial adaptations for arboreal mammals?

17. **Compare and Contrast** Compare and contrast strepsirrhines and haplorhines.

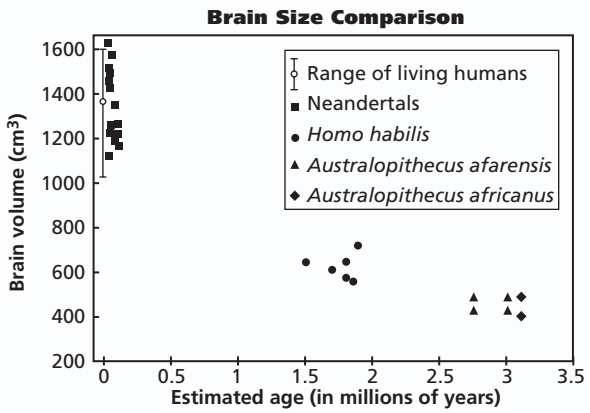
18. **Hypothesize** Explain why you think there can be different interpretations for the possible pathways of hominid evolution.

Standardized Test Practice

All questions aligned and verified by The Princeton Review

Part 1 Multiple Choice

Use the graph below to answer question 19.



19. According to the graph, which of the following is a true statement?

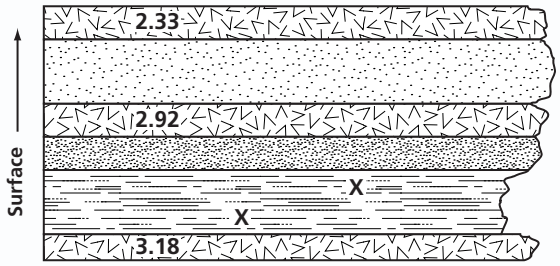
A. Hominid brains appear to increase in size as you go back in time.

B. Hominid brains appear to have remained about the same size for the last million years.

C. Hominid brains of the same species are all the same size.

D. Hominid brains have been increasing in size for at least three million years.

Read the following paragraph and use the illustration to answer questions 20 and 21.



Scientists have determined radiometric ages for volcanic materials located near hominid fossils. A cross section showing layered volcanics and sediments containing the fossils is shown above. The location of each hominid fossil is indicated with an "X." Ages of volcanic layers are given as numbers in millions of years ago.

20. Which of the ages represents a maximum age for the fossil hominids? In other words, which is the oldest age that the fossils could be?
A. 233 million years **C.** 2.33 million years
B. 2.92 million years **D.** 3.18 million years

21. A minimum age for the fossils is indicated by which age?
A. 233 million years **C.** 2.33 million years
B. 2.92 million years **D.** 3.18 million years

Part 2 Constructed Response/Grid In

Record your answers on your answer document.

22. **Open Ended** Which characteristics are common to all primates? Include in your answer the major function of each characteristic.

23. **Open Ended** Suppose you found a skull in an area where both Neandertals and Cro-Magnons lived. Explain the types of data you would use to determine which species the skull was from.