Chapter 16 Organizer

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 16.1 **Primate Adaptation and Evolution** National Science Education Standards UCP.1-5; C.3, C.4, C.6; G.2, G.3 (1 session)	1. **Recognize** the adaptations of primates. 2. **Compare and contrast** the diversity of living primates. 3. **Distinguish** the evolutionary relationships of primates.	**Inside Story:** A Primate, p. 430 **MiniLab 16-1:** Comparing Old and New World Monkeys, p. 433 **Problem-Solving Lab 16-1,** p. 434 **Focus On** Primates, p. 436 **Earth Science Connection:** The Land Bridge to the New World, p. 448
Section 16.2 **Human Ancestry** National Science Education Standards UCP.2-5; A.1, A.2; C.3, C.6; E.1, E.2; G.1-3 (2 sessions)	4. **Compare and contrast** the adaptations of australopithecines with those of apes and humans. 5. **Summarize** the major anatomical changes in hominids during human evolution.	**MiniLab 16-2:** Compare Human Proteins with Those of Other Primates, p. 439 **Problem-Solving Lab 16-2,** p. 443 **Investigate BioLab:** Comparing Skulls of Three Primates, p. 446

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab
p. 446 metric ruler, protractor, copy of skull diagrams of *Australopithecus africanus, Gorilla gorilla,* and *Homo sapiens*

MiniLabs
p. 433 none
p. 439 calculator (optional)

Alternative Lab
p. 442 metric ruler or tape measure

Quick Demos
p. 432 skull models or photos
p. 441 video tape of sculptor doing paleoanthropological reconstruction

Key to Teaching Strategies

- L1 Level 1 activities should be appropriate for students with learning difficulties.
- L2 Level 2 activities should be within the ability range of all students.
- L3 Level 3 activities are designed for above-average students.
- ELL ELL activities should be within the ability range of English Language Learners.
- COOP LEARN Cooperative Learning activities are designed for small group work.
- P These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.

Primate Evolution

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 16.1 **Primate Adaptation and Evolution**	Reinforcement and Study Guide, pp. 69-70 L2 Concept Mapping, p. 16 L3 ELL BioLab and MiniLab Worksheets, p. 75 L2 Laboratory Manual, pp. 109-112 L2 Inside Story Poster ELL Content Mastery, pp. 77-80 L1	Section Focus Transparency 39 L1 ELL
Section 16.2 **Human Ancestry**	Reinforcement and Study Guide, p. 71-72 L2 Critical Thinking/Problem Solving, p. 16 L3 BioLab and MiniLab Worksheets, pp. 76-79 L2 Laboratory Manual, pp. 113-116 L2 Content Mastery, p. 77-80 L1 Tech Prep Applications, pp. 23-24 L2	Section Focus Transparency 40 L1 ELL Basic Concepts Transparency 23 L2 ELL Reteaching Skills Transparency 25 L1 ELL

Assessment Resources

Chapter Assessment, pp. 91-96
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 16 quiz

Additional Resources

Spanish Resources ELL
English/Spanish Audiocassettes ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Products Available From Glencoe
To order the following products, call Glencoe at 1-800-334-7344:
Curriculum Kit
GeoKit: Earth's History
Videodiscs
STV: Animals
STV: Biodiversity

Products Available From National Geographic Society
To order the following products, call National Geographic Society at 1-800-368-2728:
Videos
The Diversity of Life
Fossils: Clues to the Past

Index to National Geographic Magazine
The following articles may be used for research relating to this chapter:
"The Dawn of Humans: Redrawing Our Family Tree?" by Lee Berger, August 1998.
"Expanding Worlds: The Dawn of Humans," by Rick Gore, May 1997.
"The First Steps: The Dawn of Humans," by Rick Gore, February 1997.

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM ELL
Video: *Primate Characteristics*
BioQuest: *Biodiveristy Park*
Video: *Gorilla*
Videodisc Program
Primate Characersitics

The Infinite Voyage
The Keepers of Eden
The Dawn of Humankind

The Secret of Life Series
Gone Before You Know It: *The Biodiversity Crisis*
What's in Stetter's Pond: *The Basics of Life*
Homosapiens–Origin (a), (b)

Chapter 16

Getting Started Demo

Kinesthetic Instruct students to pick up pencils without using their thumbs, and use them to write their names. Then, ask students to describe how their thumbs differ from their other fingers.
L1 ELL

Theme Development

The main theme of this chapter is **evolution**. Students learn how the availability of human fossils and archaeological evidence affect the development of hypotheses about human evolution. Another theme, **unity within diversity**, is developed through descriptions of shared primate characteristics.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

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.

Getting Started

The Opposable Thumb

In this chapter you will study the opposable thumb. Move your thumb to the palm of your hand. Now, try to pick up various shaped objects.

interNET CONNECTION To find out more about primate evolution, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Humans are not the only animals that construct and use tools. This chimpanzee has broken off a twig to use like a fishing pole to catch termites, a favorite food.

Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

- ***Kinesthetic*** Getting Started Demo, p. 428; Project, p. 440
- ***Visual-Spatial*** Biology Journal, p. 432; Portfolio, p. 434; Meeting Individual Needs, p. 434; Reteach, pp. 435, 445; Quick Demo, p. 441; Enrichment, p. 444
- ***Interpersonal*** Project, pp. 437, 444
- ***Intrapersonal*** Biology Journal, p. 430; Meeting Individual Needs, p. 433
- ***Linguistic*** Meeting Individual Needs, pp. 437, 444; Biology Journal, p. 441
- ***Logical-Mathematical*** Portfolio, p. 436; Going Further, p. 447
- ***Naturalist*** Extension, p. 435

Section

16.1 Primate Adaptation and Evolution

SECTION PREVIEW

Objectives

Recognize the adaptations of primates.

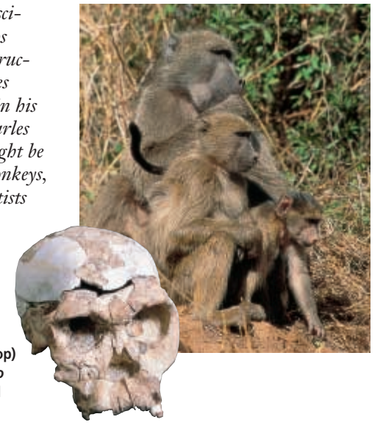
Compare and contrast the diversity of living primates.

Distinguish the evolutionary relationships of primates.

Vocabulary

primate
opposable thumb
anthropoid
prehensile tail

Monkeys have always fascinated humans, perhaps because of the many structural and behavioral similarities we share with them. In 1871, in his book The Descent of Man, *Charles Darwin proposed that there might be an evolutionary link among monkeys, apes, and humans. Today, scientists examine both living primates and primate fossils in the search for information about how primates may have evolved.*



Baboons (top) and a *Homo habilis* skull

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. A **primate** is 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.

What characteristic accounts for the complex behaviors of primates? Find out by reading the *Inside Story* on the next page. Perhaps the most distinctive trait of all primates is the rounded shape of their heads. They also have a flattened face when compared with faces of 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. For example, the primate skeleton is well adapted for movement among trees. All primates have relatively flexible shoulder and hip joints. These flexible joints are important for climbing and swinging among branches.

Assessment Planner

Portfolio Assessment
- **Problem-Solving Lab, TWE,** p. 434
- **Portfolio, TWE,** pp. 434, 436
- **MiniLab, TWE,** p. 439
- **BioLab, TWE,** p. 447

Performance Assessment
- **Problem-Solving Lab, TWE,** p. 443
- **Assessment, TWE,** p. 445
- **MiniLabs, SE,** pp. 433, 439
- **Alternative Lab, TWE,** pp. 442-443
- **BioLab, SE,** pp. 446-447

Knowledge Assessment
- **Assessment, TWE,** p. 432
- **Section Assessments, SE,** pp. 435, 445
- **Chapter Assessment, SE,** pp. 449-451

Skill Assessment
- **MiniLab, TWE,** p. 433
- **Assessments, TWE,** pp. 435, 442
- **Alternative Lab, TWE,** pp. 442-443

Prepare

Key Concepts

Students discover the shared characteristics of primates. The characteristics of each primate group are explored and the evolution of primates is discussed.

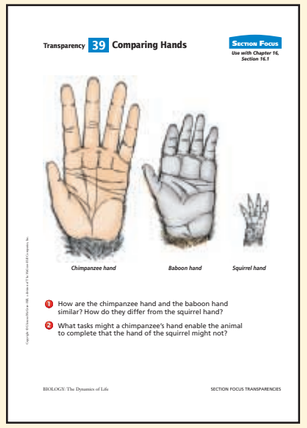
Planning

- Obtain a human skeleton and collect pictures or specimens of primate and nonprimate mammalian skeletons for the Visual Learning.
- Obtain pictures or models of prosimian and anthropoid skulls for the Quick Demo.
- Obtain slides or videos that show examples of each primate group for the Visual Learning.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 39** on the overhead projector and have students answer the accompanying questions.



2 Teach

INSIDE STORY

Purpose

Students examine traits common to primates.

Teaching Strategies

- Ask students why primates are popular zoo attractions and what makes primates unique. List responses on the chalkboard.
- Remind students that humans are primates and, although not arboreal, share these adaptations.
- Discuss each major primate characteristic, having students explain how each is an important human adaptation.

Visual Learning

- Display pictures or specimens of primate (including human) and other mammalian skeletons and teeth to compare and contrast them.
- Show how a human skeleton's hands, feet, and joints are similar to those of other primates.

Critical Thinking

Binocular vision allows primates to judge depth, a useful adaptation for arboreal species.

Resource Manager

Section Focus Transparency 39 and Master L1 ELL
Laboratory Manual, pp. 109-112 L2

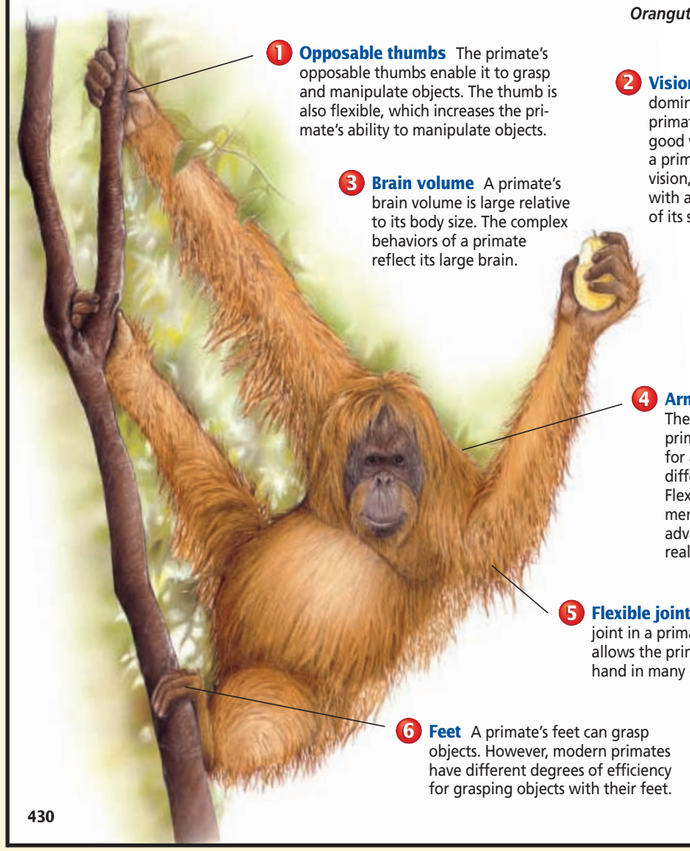
INSIDE STORY

A Primate

Primates are a diverse group of mammals, but they share some common features. For example, you can see in the drawing of an orangutan 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?***

Orangutans



1. **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.
2. **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.
3. **Brain volume** A primate's brain volume is large relative to its body size. The complex behaviors of a primate reflect its large brain.
4. **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.
5. **Flexible joints** The flexible joint in a primate's elbow allows the primate to turn its hand in many directions.
6. **Feet** A primate's feet can grasp objects. However, modern primates have different degrees of efficiency for grasping objects with their feet.

BIOLOGY JOURNAL

Observing a Primate

Intrapersonal Have students find the scientific name of a primate they have seen and then write answers to the following questions: Where did you first see the primate? What was it doing? What about the primate interested you? What more about the primate would you like to learn? L1

Internet Address Book

internet CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

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 adaptive **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, ***Figure 16.1.*** They also enable primates to manipulate tools.

Primates have a highly developed sense of vision, called binocular vision. Primate eyes face forward so that they see an object simultaneously from two viewpoints. This eye positioning 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.

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: prosimians and anthropoids, as shown in ***Figure 16.2.***

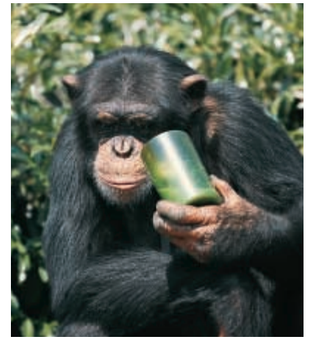


Figure 16.1
Notice the thumb of the chimpanzee. An opposable thumb helps a primate grasp and cling to objects and manipulate them.

WORD Origin

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

Prosimianlike primates evolved first

Prosimians are small, present-day primates that include, among others, the lemurs, aye-ayes, and tarsiers. Most prosimians have large eyes and are nocturnal. They live in the tropical forests of Africa and Southeast Asia, where they prowl through the leafy canopy in search of insects, seeds, and small fruits. The earliest

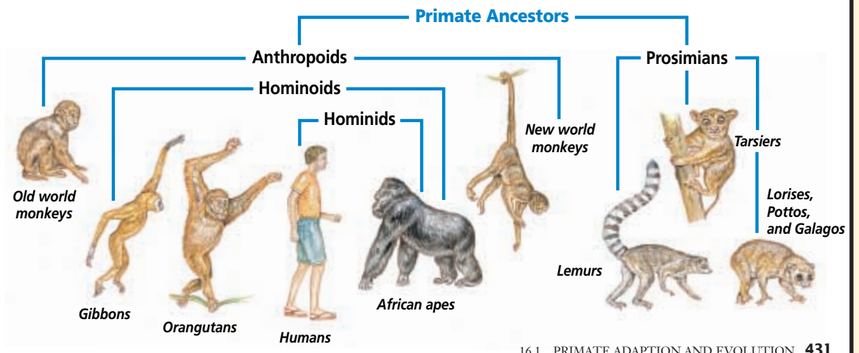


Figure 16.2
Primates are divided into two groups: the prosimians and the anthropoids, which are subdivided into monkeys and hominoids.

PROJECT

Interpreting Behavior

Paleoanthropologists use a variety of methods to interpret primate behavior from fossil evidence. Have student groups report on one of the following methods:

- Analyzing the wear on teeth to learn what extinct primates ate L2 ELL COOP LEARN
- Using cladistics to determine phylogeny L2 COOP LEARN
- Analyzing muscle function in living primates L3 COOP LEARN

Student reports should include one or two examples of how the method answered a question about primate evolution.

Concept Development

Primate hands are divided into three regions: the carpus, the metacarpus, and the phalanges. Point out each region and describe its anatomy. Explain that the wrist consists of eight or nine bones aligned in two rows. Between the two rows is the midcarpal joint that provides flexibility. The joints at the juncture of the metacarpals and most phalanges lack mobility. The joint at the thumb's base is extremely mobile.

Then, remind students that, although most primate hands have the same numbers of bones, the relative bone sizes vary with the species' needs for locomotion or manipulation. For example, the slow-climbing loris has a strong thumb and long, lateral digits for grasping branches. In contrast, gibbons and spider monkeys have long, slender digits that function almost like hooks as they hang under branches.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Primate Characteristics*
Disc 2

VIDEODISC
Biology: The Dynamics of Life
Primate Characteristics (Ch. 7)
Disc 1, Side 2, 47 sec.

Resource Manager

Concept Mapping, p. 16 L3 ELL

Assessment

Knowledge Have students write an essay about how their lives would be affected if their shoulder and hip joints moved only back and forth, like those of dogs and horses. L2

Tying to Previous Knowledge

Review the environmental conditions and the types of organisms living in the early Cenozoic Era, when primates evolved. Remind students that many mammalian groups diversified at this time. Discuss how these factors may have influenced primate evolution.

Quick Demo

Use photos, illustrations, models, or actual skulls to show the differences between prosimians and anthropoids. For example, contrast the fused frontal bone of anthropoids to the unfused one of prosimians.

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage:
The Keepers of Eden Extinction and the National Zoo's Tamarin Monkey Project (Ch. 4)
13 min. 30 sec.

Figure 16.3
Most prosimians are small, nocturnal animals that live in tropical environments.

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

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

fossils of prosimians are about 50 to 55 million years old.

Some scientists consider fossils of an organism called *Purgatorius* to be the earliest of primate fossils. *Purgatorius*, which probably resembled a squirrel, was a prosimianlike animal that lived about 66 million years ago. Although there are no living species of *Purgatorius*, present-day prosimians, ***Figure 16.3***, are probably quite similar.

Humanlike primates evolve

Humanlike primates are called **anthropoids** (AN thruh poydz). Anthropoids, some of which are shown in ***Figure 16.4***, include monkeys and hominoids. In turn, hominoids include apes and humans. Many features distinguish anthropoids from prosimians. In particular, anthropoids have more complex brains than prosimians. Anthropoids are also larger and have different skeletal features, such as a more or less upright posture, than prosimians.

Monkeys are classified as New World monkeys or Old World monkeys. Try the *MiniLab* to compare some characteristics of these two groups of monkeys.

New World monkeys, which live in the rain forests of South America and Central America, are all arboreal. A long, muscular **prehensile tail** (pree HEN sul), 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.

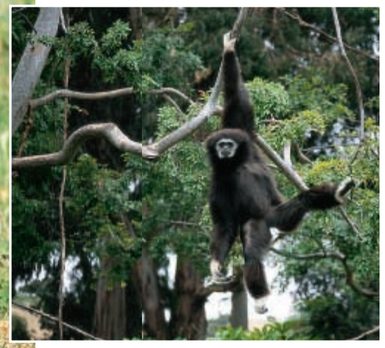
Old World monkeys are generally larger than New World monkeys. They include the arboreal monkeys, such as the colobus monkeys and guenons, the terrestrial monkeys, such as baboons, and monkeys, such as macaques, which are equally at home in trees or on the ground. Old World monkeys do not have prehensile 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 gibbons, orangutans, chimpanzees, bonobos, and gorillas. Apes lack tails and have different adaptations for arboreal life from those of the prosimians and monkeys. For example, apes have long, muscled forelimbs for climbing in trees and swinging from branches.

Figure 16.4
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.



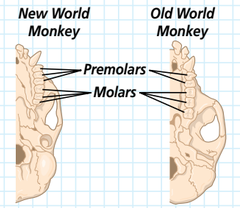
C Gibbons are small apes that live in Southeast Asia. They have long arms and long, curved fingers.

MiniLab 16-1 Comparing and Contrasting

Comparing Old and New World Monkeys In this activity, you will gather and then compare data about Old World monkeys and New World monkeys.

Procedure

1. Copy the data table.
2. Examine the diagrams.
3. Complete the data table.



Nostrils far apart and open up

Nostrils close and open down

Tail can grasp

Tail cannot grasp

Analysis

1. Why would a low body weight be helpful for an animal with an arboreal life style?
2. Which group appears to be more closely related to humans? Explain your answer. (Note: Humans have eight premolars, twelve molars, and a total of 32 teeth.)

Data Table

Characteristic	New World monkey	Old World monkey
Number of premolars ($\frac{1}{4}$ jaw)		
Number of molars ($\frac{1}{4}$ jaw)		
Total teeth in mouth		
Nostril position		
Tail		
Body weight	0.14 to 11 kg	1.2 to 30 kg

Biology Journal

Cartoon Evolution

Visual-Spatial Ask students to collect some cartoons that relate to human evolution. Have them work in groups to develop their own cartoons. L1 ELL COOP LEARN

TechPrep

Training Animals

Ask students to suppose that they train animals for people who have visual, auditory, and physical challenges. Have them list the tasks that they could train monkeys, but not dogs, to perform. L1

Meeting Individual Needs

Gifted

Intrapersonal Many unanswered questions about primate evolution remain. Have students report on one of the following topics. L3

- What group gave rise to the primates?
- What is the phylogeny of tarsiers?
- How did New World monkeys reach South America?

NATIONAL GEOGRAPHIC

VIDEODISC
GTV: Planetary Manager
Animal, Side 2

MiniLab 16-1

Purpose
Students will compare and contrast traits of Old World and New World monkeys.

Process Skills
compare and contrast, analyze information, draw a conclusion, think critically

Teaching Strategies

- Explain the meaning of the term "prehensile."
- Review the number and type of human teeth. Ask students to count their teeth. Discuss any differences, such as unerupted molars.
- Use photos of Old World and New World monkeys to illustrate their nostrils.

Expected Results
Number of premolars (1/4 jaw) =3, 2; number of molars (1/4 jaw)=3, 3; total teeth in mouth=36, 32; nostril position=up, down; tail=prehensile, not prehensile.

Analysis

1. It would allow for efficient movement in trees.
2. Old World monkeys share more traits with humans.

Assessment

Skill Ask students to visit a zoo and determine if the monkeys are Old World or New World by their features. Use the Performance Task Assessment List for Making Observations and Inferences in **PASC**, p. 17. L2

Resource Manager

BioLab and MiniLab Worksheets, p. 75 L2

Problem-Solving Lab 16-1

Purpose

Students will observe that the weights of several body regions of an infant and adult primate correlate with different percentages of their body weights.

Process Skills

analyze information, compare and contrast, draw a conclusion, make and use graphs, think critically, use numbers

Teaching Strategies

- Explain to students that nonhuman infant primates typically go everywhere with their mother, clinging at first to her belly, and later to her back.
- Remind students that, unlike a primate's other organs, its brain does not grow much after birth.

Thinking Critically

1. Major changes in brain size do not occur during growth.
2. The percentage decreases because the need for strong muscles to continually grasp their mothers diminishes. No. Human infants do not cling to their mothers.

Assessment

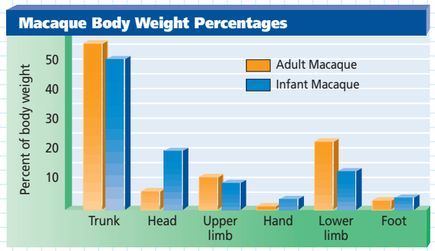
Portfolio Ask students to prepare a graph similar to the one they just used. The graph should compare the percent body weights for a human infant and adult. Use the Performance Task Assessment List for Graph from Data in **PASC,** p. 39. L2 P

Problem-Solving Lab 16-1 Using 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.

Analysis

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



Thinking Critically

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

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 and long-term parental care 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* to explore this idea. The oldest anthropoid fossils 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 16.5,*** you can see the worldwide geographic distribution of monkeys and apes.

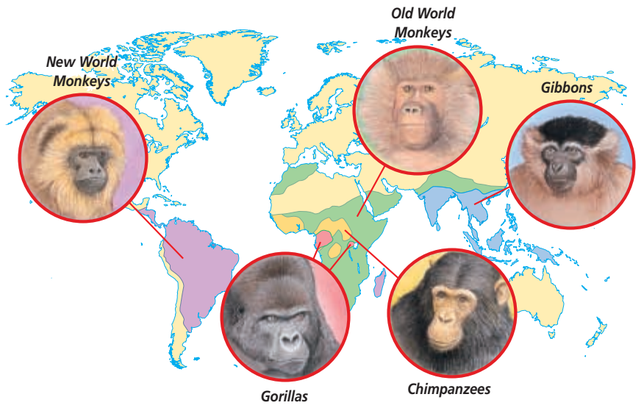


Figure 16.5 The present-day, worldwide distribution of monkeys and apes suggests that they probably evolved a long time ago from a common ancestor.

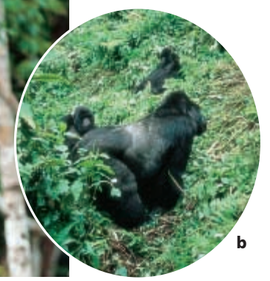


Figure 16.6 Modern apes are diverse, and fossils indicate that ancient apes were even more diverse. Orangutans are arboreal apes that live in the forests of Borneo and Sumatra (a). Gorillas are ground-dwelling African apes that live in small social groups (b).

Old World monkeys probably 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. At about the same time, the Old World monkeys evolved and became adapted to this climatic cooling. Fossils indicate how the apes adapted and diversified. You can see the modern-day diversity of apes in ***Figure 16.6.***

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 to evolve, followed by the orangutans that are found in southeast Asia. Finally, the African apes, chimpanzees, and gorillas evolved. Some anthropologists suggest that one of the groups of African apes was the ancestor of modern humans.

Section Assessment

Understanding Main Ideas

1. What adaptations help primates live in the trees?
2. Describe how hominoids are classified.
3. What features distinguish anthropoids from prosimians?
4. What is the major physical difference between Old World monkeys and New World monkeys?

Thinking Critically

5. 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

6. **Classifying** 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 *Organizing Information* in the **Skill Handbook.**

Portfolio

Ape and Baboon Evolution

Visual-Spatial Have students draw the probable events in baboon and ape evolution. Their illustrations should include the time period and the environmental factors that may have influenced ape and baboon evolution. L3 ELL P

Meeting Individual Needs

Learning Disabled

Visual-Spatial Give students photographs, illustrations, or videos of each group of primates. Have students write the names of each group and at least five of its characteristics in their journals. Then, have students review their lists to compare and contrast the characteristics. L1 ELL

Section Assessment

1. Opposable thumbs, digits with nails, and flexible feet help primates grip branches. Flexible skeletons and binocular vision enable them to gauge depth and distance.
2. Hominoids are classified as apes or humans.
3. Anthropoids have larger brains, different skull and skeletal structures, and larger sizes than prosimians.
4. New World monkeys have prehensile tails. Old World monkeys are generally larger and lack prehensile tails.
5. Observations could include the presence of an opposable thumb, a large brain size, nails rather than claws, binocular vision, and flexible joints.
6. Check student lists for accuracy and understanding of the main concepts.

3 Assess

Check for Understanding

Have students write the shared characteristics of primates and describe beside each its adaptive significance. L1

Reteach

Visual-Spatial Give students outline maps of the world. Have them develop a key to show where the groups of primates live. L1 ELL

Extension

Naturalist Have students prepare a primate phylogenetic tree that contains the name of each primate group, when the group evolved, and the group's unique characteristics. L2 ELL

Assessment

Skill Have students create in their journals a diagram that shows the possible evolutionary relationships of the primate groups. L2 ELL

4 Close

Discussion

Review the highlights of primate evolution. Have students identify the major evolutionary developments. L1

Resource Manager

Reinforcement and Study Guide, pp. 69-70 L2
Content Mastery, p. 78 L1

Focus On

Primates

Purpose

Students will learn about the characteristics of the major primate groups.

Background

By investigating the functional relationships between primate features, such as size, tooth structure, bone shape, and behavioral habits, the probable evolution of many anatomical differences can be better understood.

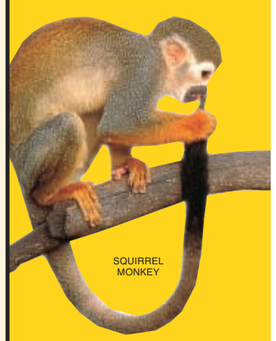
Teaching Strategies

- Discuss the characteristics of each group, emphasizing how each adaptation is important for its environment.
- Guide students to hypothesize how natural selection may have affected the groups' evolution.
- Discuss some of the methods used to analyze primate fossils, such as biomechanical studies to infer locomotion and scanning-electron microscopy to infer diet.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
BioQuest: *BioDiversity Park*
Disc 3, 4

VIDEOTAPE
The Secret of Life
Gone Before You Know It: The Biodiversity Crisis


SQUIRREL MONKEY

FOCUS ON Primates

Catch the gaze of an orangutan and you'll be staring into a face very much like your own. Similarities between apes and humans are striking—expressive eyes, fingers that can grasp, keen intelligence, and complex social systems. The resemblance is no coincidence. Apes and other primates are humans' closest relatives. The Primate order is made up of 13 families, including *Hominidae,* to which *Homo sapiens,* our species, belongs.

PROSIMIANS ▶

These small, tree-dwelling prosimians look least like other primates. Their triangular faces, set off by large round eyes, lack muscles needed to make facial expressions that other primates use for communication. They can be as small as a mouse or as big as a large house cat. Perhaps the best known prosimians are the lemurs (right), which live only in Madagascar and neighboring islands off the coast of eastern Africa.


AYE-AYE

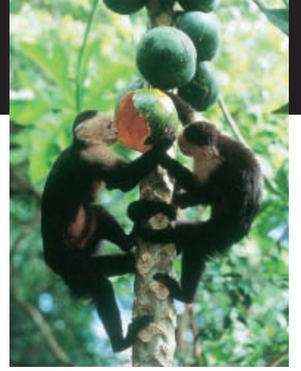
RING-TAILED LEMUR

OLD WORLD MONKEYS


MANDRILL

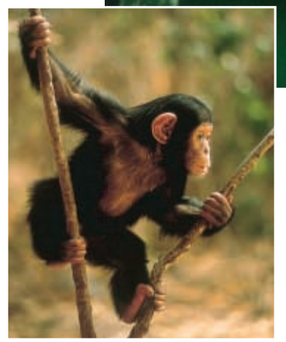
Monkeys found in Europe, Asia, and Africa are called Old World monkeys. They grow larger than their New World relatives and have no prehensile tail for grasping. Pads of tough skin on their rumps cushion them while they are seated. Among Old World monkeys, the mandrill (above) wins the prize for the most colorful face. The Japanese macaque (right), or snow monkey, lives farther north than any other species of monkey.

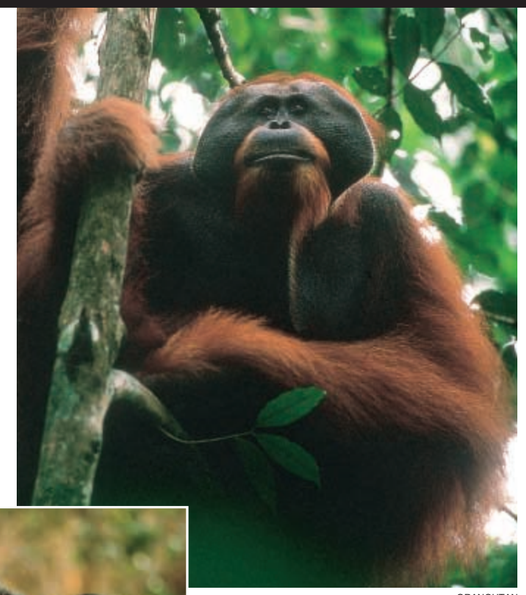

JAPANESE MACAQUES


CAPUCHINS

NEW WORLD MONKEYS ▲

Unlike their Old World counterparts, New World monkeys have prehensile tails. Sometimes compared to an extra hand, the tail can wrap around a tree limb and support the monkey's weight. Thus, the animal can dangle upside down to eat. The capuchins (above) of Central and South America have thumbs that can move to touch other fingers and help them pick up food.


CHIMPANZEE


ORANGUTAN

APES

Unlike monkeys, apes have no tails, and they are usually larger than monkeys. While monkeys run on all fours, apes walk on two legs with support from their hands. Chimpanzees (left), gibbons, gorillas, and orangutans (above) are all apes. Living in Africa and Asia, these primates have large brains and are considered to be more like humans than any other animal. They are subject to many of the same diseases as humans, can use simple tools, and some have been taught to communicate with humans using sign language.

EXPANDING Your View

1. **THINKING CRITICALLY** Examine the photo of New World monkeys. How is having a tail an adaptive advantage for these primates?
2. **COMPARING AND CONTRASTING** Which of the species in this feature probably live in trees? Explain your answer.

Portfolio

Fossil Problems

Logical-Mathematical Have students solve the following problems.

- A fossil skeleton of a primate known as *Apidium* is discovered in Egypt. It is 31 million years old and shows similarities to New World monkeys. Could this animal be an ancestor of New World monkeys? *It is unlikely because the fossil is from the same period when the New World monkeys evolved.* L2 P
- A jaw fragment discovered in eastern Africa is 8 million years old. Scientists suggest that it might be from the common ancestor of African apes and humans. What tests might you perform to verify this idea? *analysis of skeletal structures and brain size* L2 P

PROJECT

All About a Primate

Interpersonal Have student groups make presentations about particular species of primates. Presentations can be models, posters, videos, or skits and must include behavior, anatomy, ecology, taxonomy, evolution, and importance to humans. L3 ELL COOP LEARN

MEETING INDIVIDUAL NEEDS

English Language Learners

Linguistic Have students define the following terms: opposable thumb, binocular vision, prosimian, anthropoid, and ape. Have students circle the word in the following group that does not belong: New World monkey, *opposable thumb*, Old World monkey, ape, prosimian L1 ELL

Visual Learning

- Prepare a video or slide presentation of one or more species of each primate group to provide detail about the groups' behaviors and ecologies.
- Show pictures of primate fossils and discuss how each fossil provides evidence of primate evolution.

Answers to Expanding Your View

1. The tail aids in balance and allows them to grasp a branch and keep their hands free.
2. Long-tailed primates probably live in trees: prosimians, New World monkeys, and some Old World monkeys.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Gorilla*
Disc 4

Prepare

Key Concepts

Students will study the archaeological evidence of human evolution. They will investigate ideas about the behavior of different groups of probable human ancestors and how cultural adaptations, such as the use of tools, fire, and language, may have originated.

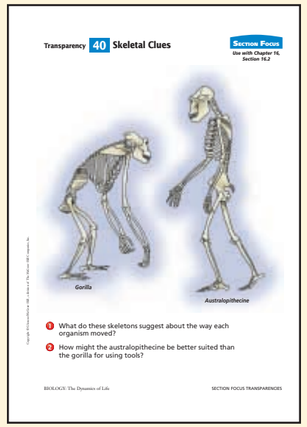
Planning

- Gather several round stones to use as tools for the Project.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 40** on the overhead projector and have students answer the accompanying questions.



SECTION PREVIEW

Objectives

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

Summarize the major anatomical changes in hominids during human evolution.

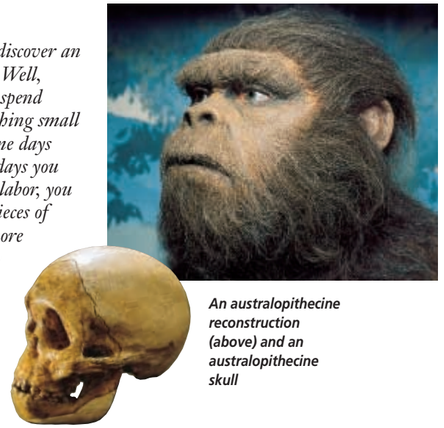
Vocabulary

hominid
bipedal
australopithecine
Neanderthal
Cro-Magnon

Section

16.2 Human Ancestry

What would it be like to discover an ancient primate skull? Well, you'd probably have to spend weeks at the excavation site brushing small sections of the area each day. Some days you'd find a piece of bone; other days you wouldn't. After weeks of tedious labor, you might be ready to assemble the pieces of bone in your laboratory. After more weeks of work, you might finally be looking into the empty orbits of a very human-looking skull that generates more questions than answers. What organism was this? How did it live?



An australopithecine reconstruction (above) and an australopithecine skull

Hominids

Some scientists propose that between 5 and 8 million years ago in Africa, a population that was ancestral to the African apes and humans diverged into two lines. According to this hypothesis, one line evolved into the African apes—gorillas and chimpanzees. The other line evolved into modern humans. These two lines are collectively called the **hominids** (hoh MIHN udz)—primates that can walk upright on two legs and include gorillas, chimpanzees, bonobos, and humans. Hominids do not include the other types of apes—the gibbons and orangutans.

There are relatively few fossils to support this hypothesis, but DNA studies of the modern hominids provide data that support the idea. You can work with some of these data in the *MiniLab* on the next page.

Some anthropologists suggest that the divergence of the African population of ancestral hominids might have occurred in response to environmental changes that forced some ancestral apes 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 apes to be **bipedal,** meaning able to walk on two legs. In addition to speed, walking on two legs leaves the arms and hands free for other activities, such as hunting, feeding, protecting young, and using tools. Therefore, apes with the ability to walk upright better and more often than others probably survived more successfully on the ground and lived to reproduce and pass the characteristic to offspring. According to this reasoning, the bipedal organisms that evolved might have been the earliest forms of a hominid.

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 16.7,*** you see a South African anatomist, Raymond Dart, who, in 1924, discovered a skull of a

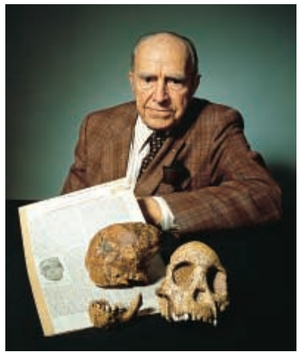


Figure 16.7
Raymond Dart discovered the first australopithecine fossil, the Taung child, *Australophithecus africanus.* The skull has features of both apes and humans.

MiniLab 16-2 Analyzing 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 amino acids of a protein among groups of primates to determine their evolutionary history.

Table 16.1 Aminio 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. Copy the 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. Which primate is most closely related to humans? Least closely related?
2. Construct a diagram of primate evolutionary relationships that most closely fits your results.

Data Table

Primate	Amino acids different from humans	Percent difference
Baboon		
Chimpanzee		
Gorilla		
Lemur		

2 Teach

The BioLab at the end of the chapter can be used at this point in the lesson.

INVESTIGATE BioLab

MiniLab 16-2

Purpose
Students will learn how comparing amino acid sequences indicates phylogenetic relationships.

Process Skills
compare and contrast, make and use tables, interpret data

Teaching Strategies
- Explain the molecular and biochemical methods used to determine phylogeny.

Expected Results
The human, chimpanzee, and gorilla sequences are identical. Baboons differ by 33 percent and lemurs by 47 percent.

Analysis
1. gorilla and chimpanzee; lemur
2. Baboons should branch off lemurs. Gorillas, chimpanzees, and humans should be close together.

Assessment

Portfolio Ask students to summarize this activity. Have them predict the results of analyzing another protein. Use the Performance Task Assessment List for Lab Report in **PASC,** p. 47 L1 P

Resource Manager

BioLab and MiniLab Worksheets, p. 76 L2
Tech Prep Applications, p. 23 L2

Resource Manager

Section Focus Transparency 40 and Master L1 ELL
Laboratory Manual, pp. 113-116 L2

GLENCOE TECHNOLOGY

VIDEODISC **The Infinite Voyage:** *The Dawn of Humankind, Dating Fossils: Effects of Dating Methods and Interbreeding Theories* (Ch. 5) 4 min.

DNA Studies Create Controversy (Ch. 7) 3 min. 30 sec.

Cultural Diversity

The Hominid Gang

Linguistic Finding human fossils is difficult and requires considerable expertise. Introduce the contributions of Kenyan fossil expert Kamoya Kimeu, the leader of a team of fossil hunters known as the Hominid Gang. Since the 1960s, Kimeu's work has led to the discovery of many important hominid fossils, including "Lucy" and the 12-year-old *Homo erectus* male, the "Strapping Youth."

Have students read sections from *Origins Reconsidered* by Richard Leakey and Roger Lewin or other similar books to learn more about Kimeu and the techniques involved in finding human fossils. L3

Chalkboard Activity

Visual-Spatial On a section of the chalkboard that you do not have to erase for a while, begin a time line of hominid to human evolution as it is described in this section. Encourage students to insert the time periods, such as 3-5 million years ago for *A. afarensis*, on the time line as they read about each group. L1 ELL

Visual Learning

Figure 16.8 Discuss the observable differences in the three sets of bones. Ask students what characteristics *A. afarensis* shared with humans. *bipedal* What characteristic is apelike? *the jawbone and the size of the facial area*

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage: *The Dawn of Humankind, Human Origins: Unexpected Finds in South Africa* (Ch. 6)
5 min.

Resource Manager

Critical Thinking/Problem Solving, p. 16 L3
Reteaching Skills Transparency 25 and Master L1 ELL

young hominid with an apelike braincase and facial structure. 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 PIHTH uh kus • af ruh KAHN us), which means "southern ape from Africa." The skull that Dart found has been dated at about 1 to 2 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 a nearly complete australopithecine skeleton that he called "Lucy" after a popular song of the time. Radiometric dating shows that Lucy probably lived about 3.5 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 5 million years ago, making it the earliest known hominid species.

Although the fossils show that *A. afarensis* individuals had apelike shoulders and forelimbs, the structure of the pelvis, as shown in ***Figure 16.8,*** 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.

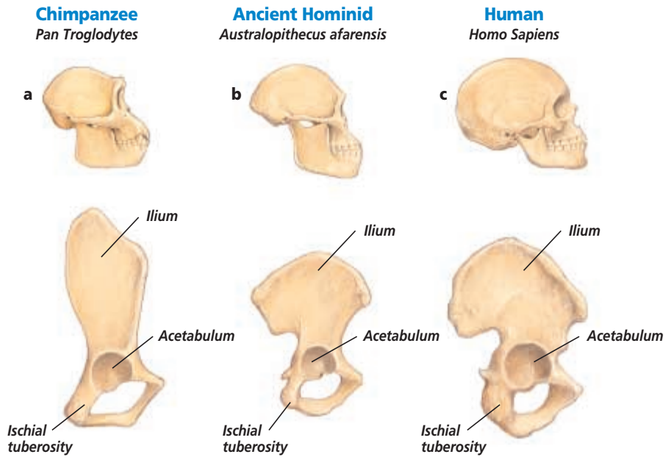


Figure 16.8
Some skeletal features of an australopithecine are intermediate between those of modern apes and humans. Compare the skull and pelvic bone of *Australopithecus afarensis* (b) with those of the chimpanzee (a) and the human (c).

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 two, or perhaps three, other species of australopithecines have been found. These other species, discovered at sites in East Africa and South Africa, are dated about 1 to 2.5 million years old. Overall, the later species are similar to the earlier ones. However, these later hominids are grouped into the genus *Paranthropus* because their fossils suggest that the individuals were more robust and had larger teeth and jaws than earlier species.

The evolutionary relationships among australopithecines are not clear from the fossil record. However, the genus disappears from the record at about 1 million years ago. Although australopithecines became extinct, some paleoanthropologists propose that an early population of these hominids might have been ancestral to modern hominids.

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 16.9
Louis and Mary Leakey discovered many fossils in the Olduvai Gorge area of Tanzania, Africa.

Early members of the genus *Homo* made stone tools

In 1964, anthropologists Louis and Mary Leakey, ***Figure 16.9,*** 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 *Homo habilis* lived between about 1.5 and 2 million years ago. It is the earliest known hominid to make and use stone tools. These tools suggest that *Homo 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.

Misconception

"Why, if humans evolved from apes, are there still apes alive today?" This question represents a common misconception that students have about human evolution. Explain that humans evolved from ancestors of apes, which were neither humans nor apes. Reiterate that the common ancestor of the two groups probably lived in the Miocene period.

Using Science Terms

Reinforce the idea that *Homo habilis*, meaning "handy man," was so named because evidence indicates that this hominid used tools. Have students correlate this with the term handyman today as it refers to people who use tools to make household or mechanical repairs.

Quick Demo

Visual-Spatial Show students videos that describe how sculptors help paleoanthropologists by applying their knowledge of anatomy and anthropology to reconstruct the flesh and bones of extinct humans, such as the Neanderthals. L1 ELL

GLENCOE TECHNOLOGY

VIDEOTAPE
The Secret of Life
What's in Stetter's Pond: The Basics of Life

PROJECT

Using Stone Tools

Kinesthetic Provide groups of students with simple stone tools and have them put on lab aprons and safety goggles. You can make the tools from quartz or flint stones. Hit one stone against the other to remove flakes and then use both the flakes and the cores as tools. Have students design experiments to test the effectiveness of the tools for different tasks, such as cutting meat, cutting branches, or breaking open fresh beef bones. Have them write a report of their findings. L1 ELL

BIOLOGY JOURNAL

Australopithecines in Primate Evolution

Linguistic Have students write a short essay about the significance of australopithecines in primate evolution. They can conclude their essays with some unanswered questions about australopithecines. L2

Recent Discoveries

Linguistic Have students research current hominid discoveries, the evolution of human speech, or the relationship between Neanderthals and Cro-Magnons. Have them write a summary of their findings. L3

Assessment

Skill Modern primates with large molars eat tough foods such as plant stems, seeds, and fruits. Living gorillas have an average molar area of 1011 mm^2 and humans average 500 mm^2. *A. africanus* had an average molar area of 901 mm^2 and *H. erectus* averaged 656 mm^2. Have students use the data to infer the diets of *A. africanus* and *H. erectus.* L1

TECHPREP

Doing Field Work

Ask students to imagine that they are studying evidence of *Homo erectus* in a cave. Have them make a list of evidence-gathering rules that include ways of protecting the site and assuring accurate measurements, map-making, and information recording in a database. L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage: *The Dawn of Humankind*

Evolution of Early Man (Ch. 2) 6 min.

Cave Art: Religious and Cultural Significance (Ch. 1) 6 min. 30 sec.

Figure 16.10
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.

You can see a *Homo habilis* skull in ***Figure 16.10.***

Hunting and using fire

Some anthropologists propose that a *H. habilis* population gave rise to another species about 1.6 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 16.11,*** 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 300 000 and 500 000 years ago. However, some scientists propose that more human-looking hominids might have arisen from *H. erectus* before it disappeared.

Figure 16.11
An almost complete *Homo erectus* skeleton of a 12-year-old male was discovered in East Africa in 1985. *H. erectus* had a brain volume of about 900 cm^3 and long legs like modern humans.

Culture developed in modern humans

The incomplete fossil record and the inaccuracies of dating fossils produce controversy about dating the emergence of modern humans. However, paleoanthropologists have enough evidence to propose possible paths to the origin of the modern human species, *Homo sapiens*. A description of one such path follows.

The fossil record indicates that the species *H. sapiens* appeared in Europe, Africa, the Middle East, and Asia about 100 000 to 400 000 years ago. The early forms of the species are called archaic *H. sapiens* because their skulls resemble those of *H. erectus* but have less prominent browridges, more bulging foreheads, and smaller teeth. Also, the braincases of archaic *H. sapiens* are larger than those of *H. erectus*, and can contain a brain volume of 1000 to 1400 cm^3, which is within the modern human range.

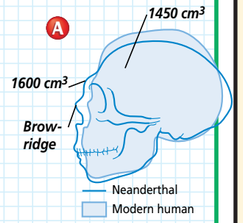
Best known among these archaic *H. sapiens* were Neanderthals (nee AN dur tawlz), illustrated in ***Figure 16.12.***

Problem-Solving Lab 16-2 Applying Concepts

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

Analysis

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



Thinking Critically

1. How much larger is a Neanderthal brain than a human brain? Express the value as a percentage.
2. 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. 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 Neanderthals?

You can compare the sizes of two skulls of the genus *Homo* in the *Problem-Solving Lab* on this page.

The **Neanderthals** lived from about 35 000 to 100 000 years ago in Europe, Asia, and the Middle East.

Figure 16.12
Neanderthals were skilled hunters. They had many tools, including spears, scrapers, and knives.

Alternative Lab

Measuring Human Variation

Purpose

Students will analyze variations in three human traits.

Materials

metric ruler or tape measure

Procedure

Give students the following directions.

1. Prepare a data table with the following headings: Height (cm), Length of left index finger (cm), and Length of left forearm (cm).
2. Working with a partner, measure in centimeters your height, the length of your left index finger, and length of your left forearm (elbow to wrist). Record the results in your data table and on a class data table. Calculate a class average for each measurement.
3. Divide the class measurements for each trait into five equal intervals. Count the number of students within each interval. Make bar graphs for each measurement.

Expected Results

The data will vary. Students will note a wide range of variation in each trait.

Analysis

1. What is the average height of your class members? The average forearm length? The average finger length? *Answers depend on measurements.*
2. Explain the variations. *Traits and growth rates vary among humans.*
3. How might the data change if you measured the same traits of a group of adults? *fewer extreme measurements*

Assessment

Skill Have students develop hypotheses about how natural selection may act on the variability of these three traits in the future. Use the Performance Task Assessment List for Formulating a Hypothesis in **PASC,** p. 21. L2

Problem-Solving Lab 16-2

Purpose

Students will compare Neanderthals and modern humans.

Process Skills

think critically, apply concepts, compare and contrast, draw a conclusion, interpret scientific illustrations, observe and infer

Teaching Strategies

- Review percentage.
- Illustrate brain volume using two beakers filled respectively with 1600 mL and 1450 mL of colored water. A cm^3 and mL are comparable

Thinking Critically

1. 150 cm^3 larger—9.4 % larger
2. Neanderthal has the apelike features of a thick brow ridge and a protruding jaw.
3. They were probably hunters and had religious values.

Assessment

Performance Ask students to redraw the outlines of both skulls and reconstruct the appearance of both heads by drawing the locations of skin and muscle. Use the Performance Task Assessment List for Scientific Drawing in **PASC,** p. 55. L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC

The Infinite Voyage: *The Dawn of Humankind*

Development of Modern Man (Ch. 4), 10 min.

Visual Learning

Figure 16.14 illustrates two possible phylogenetic trees of human evolution. Point out that some paleoanthropologists have suggested alternative phylogenies.

Enrichment

Visual-Spatial Have students draw probable evolutionary pathways of humans that include time periods and three characteristics of each species. L3

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Homo sapiens—Origin (a)
Homo sapiens—Origin (b)
The Infinite Voyage: *The Dawn of Humankind, Bridging of Fossils and Genetic Research* (Ch. 9), 2 min. 30 sec.
Evolution of the Mind (Ch. 10) 4 min.

Resource Manager

Basic Concepts Transparency 23 and Master L2 ELL
Reinforcement and Study Guide, pp. 71-72 L2
Content Mastery, pp. 77, 79-80 L1

Figure 16.13
The dwelling sites of Cro-Magnons, full of cave paintings, detailed stone and bone artifacts, and tools, have been excavated in Europe.

Fossils reveal that Neanderthals had thick bones and large faces with prominent noses. The brains of Neanderthals were at least as large as those of modern humans.

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

What happened to Neanderthals?

Could Neanderthals have evolved into modern humans? 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 16.13.*** 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 Neanderthals evolve into Cro-Magnons? Current genetic and archaeological evidence indicates that this is unlikely. Current dates for hominid fossils suggest that modern *H. sapiens* appeared in both South Africa and the Middle East about 100 000 years ago, which was about the same time the Neanderthals 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 Neanderthals were most likely a side branch of *H. sapiens*, and not an ancestral branch of modern humans. Look at ***Figure 16.14*** to see two proposed evolutionary paths to modern humans.

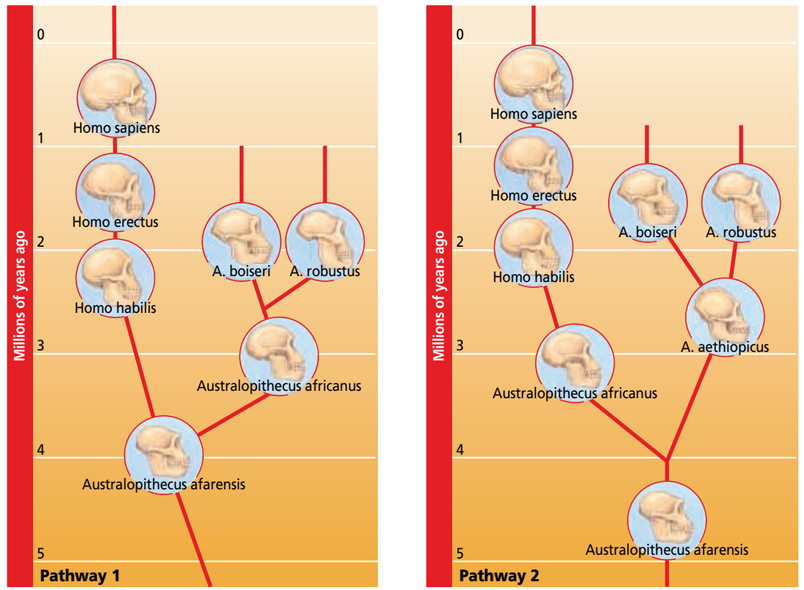


Figure 16.14
These diagrams represent two possible pathways for the evolution of *Homo sapiens.*

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, about 12 000 years ago, evidence shows that they crossed a land bridge into North America. You can read more abouth this event in the *Earth Science Connection* at the end of the chapter. By 8000 to 10 000 years ago, Native Americans had built permanent settlements and were domesticating animals and farming.

Section Assessment

Understanding Main Ideas
1. What evidence supports the idea that species of australopithecines were intermediate forms between apes and humans?
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. Describe the evidence that supports the idea that Neanderthals 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. **Interpreting Scientific Illustrations** Draw a time line to show the evolution of hominids. Indicate each species of hominid that evolved and where it evolved. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

MEETING INDIVIDUAL NEEDS

English Language Learners

Linguistic Have students supply the hominid species name for each of the following descriptions: (1) earliest maker of stone tools, (2) chimpanzee-sized brain and bipedal, (3) earliest hominid to move out of Africa, (4) thick-boned and maker of diverse tools. L1 ELL

PROJECT

Social Behavior in Early Hominids

Interpersonal Have small groups of students develop a project for studying nonhuman primates to infer social behavior in early hominids. L2 COOP LEARN

Section Assessment

1. They have a brain capacity larger than apes and smaller than humans. They climbed trees like apes, but walked like humans.
2. Bipedalism allowed hominids to better scan the horizon for predators and freed their forelimbs for carrying objects.
3. *Homo habilis* was the first hominid to purposefully construct stone tools.
4. Genetic and archaeological evidence suggests that Neanderthals were not the ancestors of Cro-Magnon people.
5. If *H. habilis* were scavengers, bones that contain little meat, such as ribs, would be at their sites. If they were hunters, there would be meat-containing bones at their sites.
6. Evaluate the time lines for accuracy.

3 Assess

Check for Understanding

Visual-Spatial Have students construct a time line of the following events; use of fire, bipedal movement, tool use, language, art, burial of the dead. L1 ELL

Reteach

Visual-Spatial Have students make a bar graph showing the evolution of human brain size. L2

Extension

Have students illustrate a human phylogenetic tree. L3

Assessment

Performance Have students give an oral report about a day in the life of a hominid species. L1 ELL

4 Close

Discussion

Discuss what future paleoanthropologists might determine about today's humans. Have students identify probable artifacts and their information. L1

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage: *The Dawn of Humankind, "Out-of-Africa" vs. Multiregional Debate on Origination of Modern Man* (Ch. 8)
6 min.

INVESTIGATE BioLab

Time Allotment
One class period

Process Skills
observe and infer, measure in SI, hypothesize, compare and contrast, make and use tables

Preparation

- Give each student a copy of the skull diagrams from the BioLab and MiniLab Worksheets book to use in this BioLab. These skulls are one-half natural size.
- Alternatively, copy the skull art on this student edition page and increase it by 50% for students to use.

Analyze and Conclude

1. Humans have a small facial area compared with brain area. Apes have a large facial area compared with brain area. Australopithecines were intermediate between apes and humans but closer to apes.

Resource Manager
BioLab and MiniLab Worksheets, pp. 77-78 L2

INVESTIGATE BioLab

Comparing Skulls of Three Primates

Australopithecines are 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.

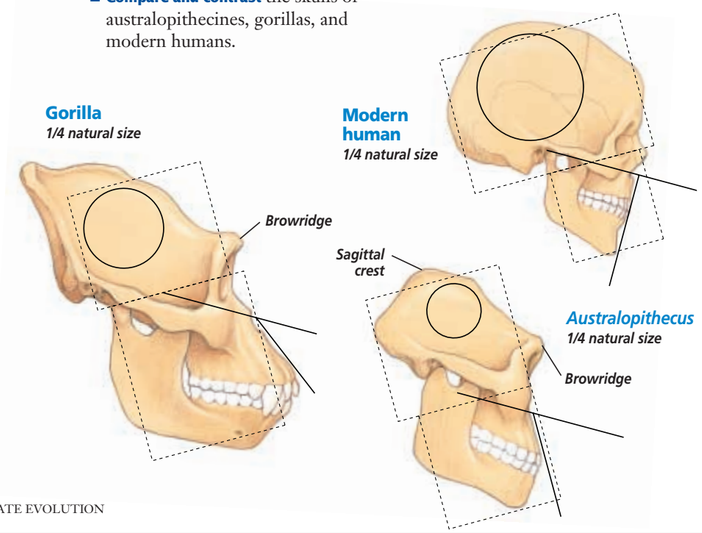
Preparation

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
Use the **Skill Handbook** if you need additional help with this lab.



Procedure

1. Your teacher will provide copies of the skulls (1/2 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 heavy lines projected on the skulls are used to measure how far forward the jaw protrudes. Use your protractor to measure the outside angle (toward the right) 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. **Comparing and Contrasting** How would you describe the similarities and differences in face-to-brain area in the three primates?
2. **Interpreting Observations** How do the cranial capacities compare among the three skulls? How do the jaw angles compare?
3. **Drawing Conclusions** Based on your findings, what statements can you make about the placement of australopithecines in human evolution?

Going Further

Application Different parts of the australopithecine skeleton are also intermediate between apes and humans. Obtain diagrams of primate skeletons to determine the similarities and differences.

internet CONNECTION To find out more about primate evolution, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

INVESTIGATE BioLab

2. Apes have a small cranial capacity, whereas humans have a large cranial capacity, and that of australopithecines was intermediate but closer to the apes. An ape has a small jaw angle, and a human has a large jaw angle. The jaw angle of australopithecines was intermediate but closer to that of the ape.
3. Many australopithecine skull traits were intermediate between those of apes and humans, and some were more similar to those of apes. Australopithecines represent very early human ancestors.

Assessment
Portfolio Have students formulate three hypotheses about the natural selection pressures that may have taken place during australopithecine evolution. Have them place their hypotheses in their portfolios. Use the Performance Task Assessment List for Formulating a Hypothesis in **PASC**, p. 21. L2 P

Going Further

Logical-Mathematical Obtain illustrations or actual fossil casts of australopithecine limb bones, hands, or feet. Have students compare measurements and other observations of the postcranial skeletons of apes, humans, and australopithecines. L1

Procedure

Teaching Strategies

- Remind students that australopithecines existed between 1 and 5 million years ago, around the time that African apes and humans probably diverged. Because of their age, australopithecines were probably primitive anatomically.
- To estimate cranial capacities, students should draw circles just inside each skull on the worksheets provided or on the copied and enlarged skulls from the student edition page.
- Estimating cranial capacity by multiplying by the factor of 200 is suitable only for these drawings because the factor is based on the scale of the drawings at one-half natural size.

Data Table

	Gorilla	Australopithecus	Modern human
1. Face area in cm^2	32 cm^2	19 cm^2	12 cm^2
2. Brain area in cm^2	23 cm^2	23 cm^2	40 cm^2
3. Is brain area smaller or larger than face area?	Smaller	Larger	Larger
4. Is brain area 3 times larger than face area?	No	No	Yes
5. Cranial capacity in cm^3	600 cm^3	600 cm^3	1060 cm^3
6. Jaw angle	35°	55°	90°
7. Does lower jaw stick out in front of nose?	Yes	Yes	No
8. Is sagittal crest present?	Yes	Yes	No
9. Is browridge present?	Yes	Yes	No

Earth Science Connection

Purpose

Students will learn about the types of evidence that paleoanthropologists use to propose how modern humans entered the New World.

Teaching Strategies

- Use the illustration on this page, along with a world map or globe, to discuss how human ancestors might have migrated from their African place of origin to the Americas.
- Review radiometric dating.
- Students can prepare wet mounts of pollen from a variety of flowers and, after viewing, draw and label each pollen type.
- Ask students to imagine that they are in the first group of humans crossing the Bering Land Bridge. Have them write an essay about their experiences. L2

Connection to Biology

Prehistoric humans may have used boats to enter the New World.

Earth Science Connection

The Land Bridge to the New World

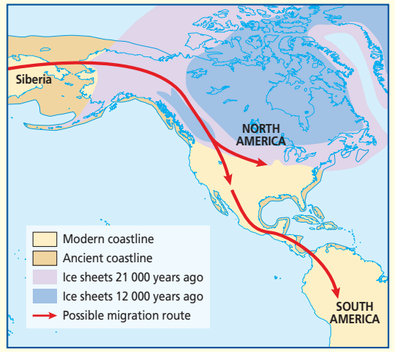
The Bering Land Bridge, or Beringia, is a strip of land that connects Asia and North America. During the last Ice Age, Beringia was dry land above sea level. Human ancestors may have walked across this land to reach North America.

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 11 330 to 11 000 years ago.

Dating the land bridge Anthropologists compared two kinds of data to determine the 11 000-year date for human migration across Beringia. They used radiometric dating methods on fossils and data tables that indicate the sea levels at different times in geological history. Both data reveal that Beringia was last above sea level about 11 000 years ago, which is about 4000 years earlier than previous calculations had determined.

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.



An alternate route In addition to these findings, recent archeological studies in South America have uncovered new information about human migration to the New World. Researchers from the University of Illinois have discovered evidence that prehistoric humans lived in Brazil about 12 800 years ago. The question paleoanthropologists now ask is did humans enter the New World only via the Bering Land Bridge, or was there another route to the Americas?

Connection to Biology

Study the map shown above. Suggest another way that prehistoric humans might have entered the New World.

interNET CONNECTION To find out more about human origins, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Internet Address Book

interNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

Chapter 16 Assessment

Summary

Section 16.1

Primate Adaptation and Evolution

Main Ideas

- 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: prosimians, such as lemurs and tarsiers; and anthropoids, which include monkeys and hominoids.
- Fossils indicate that primates appeared on Earth about 65 to 70 million years ago. Major trends in primate evolution include an increasing brain size and walking upright.

Vocabulary

anthropoid (p. 432)
opposable thumb (p. 431)
prehensile tail (p. 433)
primate (p. 429)

Section 16.2

Human Ancestry

Main Ideas

- One idea about the evolution of humans is that the earliest hominids arose in Africa approximately 5 to 8 million years ago. Australopithecine fossils indicate that these individuals were bipedal, but also climbed trees.
- The fossil record indicates that humans developed over time. Their brain and body size gradually increased, bipedalism became more efficient, and their jaws and teeth decreased in size.
- The appearance of stone tools in the fossil record coincided with the appearance of the genus *Homo* about 2 million years ago. The use of fire and language, as well as the development of culture, probably developed in more recent *Homo* species.

Vocabulary

australopithecine (p. 440)
bipedal (p. 438)
Cro-Magnon (p. 444)
hominid (p. 438)
Neanderthal (p. 443)

Understanding Main Ideas

1. Which living primate group is probably the most similar to the earliest primates?
   a. apes **c.** prosimians
   b. monkeys **d.** hominids
2. The first *Homo sapiens* were _____.
   a. Cro-Magnon people
   b. *Homo erectus*
   c. *Australopithecus afarensis*
   d. Neanderthals
3. Which of the following pairs of terms is most closely related?
   a. primate—squirrel
   b. arboreal—gorilla
   c. prosimian—hominid
   d. Cro-Magnon—*Homo sapiens*
4. Because the eyes of primates face forward, they _____.
   a. have color vision
   b. have binocular vision
   c. can climb trees well
   d. see well to the sides

GLENCOE TECHNOLOGY

VIDEOTAPE
MindJogger Videoquizzes
Chapter 16: *Primate Evolution*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

Chapter Assessment, pp. 91-96
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 16 quiz

Chapter 16 Assessment

Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site:
www.glencoe.com/sec/science

THE PRINCETON REVIEW

All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.

Understanding Main Ideas

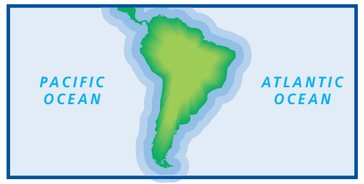
1. c
2. d
3. d
4. b

5. b
6. a
7. a
8. b
9. b
10. d
11. bipedal
12. prehensile
13. Neanderthals
14. australopithecine
15. primates
16. *Homo*
17. Cro-Magnon humans
18. binocular vision
19. opposable thumb
20. australopithecines

Applying Main Ideas

21. Yes. The first evidence of humans in the Americas dates from about 12 000 years ago. A 25 000-year-old arrowhead would more than double the time that humans are known to be in North America.
22. The adaptations that evolved in nonhuman primates laid the groundwork for adaptations that arose during hominid evolution.
23. Answers could include that scientists might compare the DNA of modern humans and that of Neanderthals, if such DNA exists. Or scientists could compare the skulls or skeletons of Neanderthals and modern humans.
24. Apes evolved their unique traits as a result of adapting to conditions in the environments they inhabited.

5. Primates native to the area indicated by the map below are _____.
   a. Old World monkeys **c.** apes
   b. New World monkeys **d.** prosimians



6. The science of studying the fossils of humans is _____.
   a. paleoanthropology **c.** paleontology
   b. geology **d.** anthropology
7. The dominant sense in primates is _____.
   a. vision **c.** smell
   b. taste **d.** hearing
8. Which of these is NOT a primate?
   a. human **c.** lemur
   b. squirrel **d.** orangutan
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
11. Organisms that walk upright on two legs are _____.
12. The term used to describe the tails of New World monkeys is _____.
13. An early group of humans who may have been the first to develop religious views and a spoken language were _____.
14. The fossil of the Taung child represents the first _____ skull ever discovered.
15. A group of mammals that includes lemurs, monkeys, apes, and humans is _____.
16. Humanlike hominids are grouped in the genus _____.
17. Toolmakers and artists who lived in Europe about 30 000 years ago were the _____.
18. _____ enables primates to perceive depth and thereby gauge distances.
19. The primate structure that allows for the grasping of objects is _____.
20. African hominids who possessed apelike and humanlike qualities are classified as _____.

Applying Main Ideas

21. 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?
22. Why is it important for a paleoanthropologist to know about all primates?
23. Some scientists suggest that Neanderthals evolved into modern humans. What information should they gather to support their idea?
24. How is the evolution of apes an example of adaptive radiation?

Test-Taking Tip

THE PRINCETON REVIEW

Dress Comfortably

Loose, layered clothing is best. Whatever the temperature, you're prepared. Important test scores do not take climate into consideration.

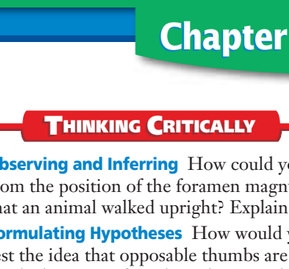
Thinking Critically

25. **Observing and Inferring** How could you tell from the position of the foramen magnum that an animal walked upright? Explain.
26. **Formulating Hypotheses** How would you test the idea that opposable thumbs are beneficial adaptations for arboreal mammals?
27. **Interpreting Data** The data in ***Table 16.2*** are from an experiment comparing amino acid sequences in apes. What conclusions can you draw from such data?

Table 16.2 Comparisons of Amino Acid Sequences

Primate	Percentage amino acid sequence difference from humans
Gibbon	5.2
Orangutan	3.7
Chimpanzee	1.8
Gorilla	2.1

28. **Concept Mapping** Complete the concept map by using the following vocabulary terms: australopithecine, hominids, Cro-Magnon, bipedal, Neanderthal, opposable thumbs



CD-ROM

For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

The intermembral index is the ratio of forelimb length to hindlimb length. Primates with a high index are good branch swingers. Primates with a low index tend to walk on all four legs.

Table 16.3 Intermembral Index of Some Primates

Species	Intermembral Index $\frac{\text{FORELIMB LENGTH}}{\text{HINDLIMB LENGTH}} \times 100$
Prosimians	
Indri	64
Slow loris	88
New World monkeys	
Squirrel monkey	80
Black spider monkey	105
Old World monkey	
Pig-tailed macaque	92
Hanuman langur	83
Hominoids	
Orangutan	139
Common chimpanzee	103

Interpreting Data Study ***Table 16.3*** and answer the following questions.

1. Which group appears to have the greatest range of intermembral distance?
   a. prosimians
   b. New World monkeys
   c. Old World monkeys
   d. hominoids
2. Which group appears to have the narrowest range of intermembral distance?
   a. prosimians
   b. New World monkeys
   c. Old World monkeys
   d. hominoids
3. **Interpreting Data** To which group might a primate with an intermembral index of 92 belong? Explain your answer.

Thinking Critically

25. For an animal to walk erect, its spinal cord must enter the skull at its base. The foramen magnum would be located more toward the back of the skull than at its base in an animal that used four appendages for locomotion.
26. Students can design an experiment to test and compare the success of two arboreal animals, a primate and a nonprimate, in a situation unique to arboreal life, such as obtaining fruit at the ends of branches.
27. Chimpanzees are the most closely related to humans, then gorillas, then orangutans, and finally gibbons.
28. 1. Hominids; 2. Bipedal; 3. Opposable thumbs; 4. Australopithecine; 5. Neanderthal; 6. Cro-Magnon

Assessing Knowledge & Skills

1. d
2. c
3. An intermembral index of 92 could place this new primate with Old World monkeys. It could also place the primate with New World monkeys as 92 is in the range shown. More information would be needed to correctly place this new primate.