## Section 16.1 Primate Adaptation and Evolution

### Objectives
1. Recognize the adaptations of primates.
2. Compare and contrast the diversity of living primates.
3. Distinguish the evolutionary relationships of primates.

### Activities/Features
- 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

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## Section 16.2 Human Ancestry

### Objectives
1. Recognize and contrast the adaptations of australopithecines with those of apes and humans.
2. Summarize the major anatomical changes in hominids during human evolution.

### Activities/Features
- MiniLab 16-2: Compare Human Proteins with Those of Other Primates, p. 439
- Problem-Solving Lab 16-2, p. 443
- Investigative BioLab: Comparing Skulls of Three Primates, p. 446

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### Materials List
- BioLab p. 446 metric ruler, protractor, copy of skull diagrams of Australopithecus africanus, Gorilla gorilla, and Homo sapiens
- Quick Demos p. 432 skull models or photos
- p. 441 video tape of sculptor doing paleoanthropological reconstruction
- MiniLabs p. 433 none
- p. 439 calculator (optional)

### Alternative Lab
- p. 442 metric ruler or tape measure
- p. 447 video tape of sculptor doing paleoanthropological reconstruction

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

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## Primate Evolution

### Teacher Classroom Resources

### Section 16.1 Primate Adaptation and Evolution
- Reinforcement and Study Guide, pp. 69-70
- Concept Mapping, p. 16
- BioLab and MiniLab Worksheets, p. 75

### Section 16.2 Human Ancestry
- Reinforcement and Study Guide, p. 71-72
- Critical Thinking/Problem Solving, p. 16
- Laboratory Manual, pp. 76-79

### Assessment Resources
- Chapter Assessment, pp. 91-96
- MindJogger Videoquizzes
- Performance Assessment in the Biology Classroom
- BioLab and MiniLab Worksheets
- Inside Story Poster

### Additional Resources
- Spanish Resources
- English/Spanish Audiotapes
- Innovative Learning in the Science Classroom
- Lesson Plans/Block Scheduling

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### National Geographic Technology

### Products Available From Glencoe
- To order the following products, call Glencoe at 1-800-334-7344:
- Curriculum Kit GeoKat: 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:

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### Teacher’s Corner
- The following multimedia resources are available from Glencoe:
  - Biology: The Dynamics of Life
  - Video: Primate Characteristics
  - GeoQuest: Biodiversity Park Video: Gorilla
  - Videodisc Program Primate Characteristics
  - The Infinite Voyage
  - The Keepers of Eden
  - The Dawn of Humankind
  - Gone Before You Know It: The Biodiversity Crisis
  - What’s in Stetter’s Pond: The Basics of Life
  - Homosapiens-Origin (a), (b)
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 adaptive characteristics of living and extinct primates. A knowledge of primates and their evolution can provide an understanding of human origins.

Students learn how their thumbs and use them to write their names. Then, ask students to describe how their thumbs differ from their other fingers.

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

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 skull 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.

Multiple Learning Styles

- 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.
- Visual-Spatial: Use diagrams and visual aids to illustrate the anatomical and behavioral differences among primates.
- Interpersonal: Have students work in small groups to discuss the differences between primates and other animals.
- Naturalist: Encourage students to observe and describe the behavior of primates in their local zoo or wildlife park.

Multiple Assessments

- Portfolio Assessment: Problem-Solving Lab, TWE, pp. 434-436; Project, TWE, pp. 434-436; MiniLab, TWE, pp. 439; BioLab, TWE, pp. 447
- Performance Assessment: Problem-Solving Lab, TWE, pp. 441; Assessment, TWE, pp. 445; MiniLab, SE, pp. 432-439
- Alternative Lab, TWE, pp. 442-443; BioLab, SE, pp. 446-447; Knowledge Assessment, TWE, p. 432; Section Assessments, SE, pp. 435-445; Chapter Assessment, SE, pp. 449-451; Skill Assessment, TWE, pp. 432-439; MiniLab, TWE, pp. 433; Alternative Lab, TWE, pp. 442-443

Preparing for the Lesson

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

2. Observe the class during the lesson and make notes for the Assessment Planner.

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

Performance Assessment
- Problem-Solving Lab, TWE, pp. 443
- Assessment, TWE, pp. 445
- MiniLab, SE, pp. 432-439

Alternative Lab, TWE, pp. 442-443
- BioLab, SE, pp. 446-447
- Knowledge Assessment, TWE, p. 432
- Section Assessments, SE, pp. 435-445
- Chapter Assessment, SE, pp. 449-451
- Skill Assessment, TWE, pp. 432-439
- MiniLab, TWE, pp. 433
- Alternative Lab, TWE, pp. 442-443
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?

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

3. **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.

4. **Flexible joints** The flexible joint in a primate’s elbow allows the primate to turn its hand in many directions.

5. **Feet** A primate’s feet can grasp objects. However, modern primates have different degrees of efficiency for grasping objects with their feet.

Primate hands and feet are unique among mammals. Their digits, fingers, 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 position enables primates to perceive depth and thus gauge distances. As you might imagine, this type of vision is useful for a primate moving 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.

**Prime 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.

**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 canopies in search of insects, seeds, and small fruits. The earliest primates divided into two groups: the anthropoids and the prosimians, which are subdivided into monkeys and hominids.

**Primate Ancestors**

Anthropoids

Hominoids

Hominds

New world monkeys

Old world monkeys

African apes

Gibbons

Orangutans

Hamurs

Figure 16.1

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

**Visual Learning**

Display pictures or specimens of primates (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.

**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.

**Resource Manager**

Section Focus Transparency 39 and Master L1, L2, L3
Laboratory Manual pp. 109-112 L2

**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?

**Internet Address Book**

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

**PROJECT**

- **Using cladistics to determine phylogeny CoOP LEARN**
- **Analyzing muscle function in living primates CoOP LEARN**
- **Share of student reports should include one or two examples of how the method answered a question about primate evolution.**

**WORLD ORIGIN**

**Anthropoids**

From the Greek words anthropos, meaning “man,” and sauros, meaning “shaped.” The anthropoid ape resemblance bears the same relation to the horse family as the monkey resembles a dog family. The anthropoids are divided into monkeys and hominids.

**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 mid-carpal 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 lorises have a strong thumb and long, slender digits for grasping branches. In contrast, gibbons and spider monkeys have long, slender digits that function almost like hooks as they hang under branches.

**Resource Manager**

Concept Mapping, p. 16 L2 L3 L4

**GLENCOE BIOLOGY: THE DYNAMICS OF LIFE**

VIDEO DISC

Disc 1, Side 2, 47 sec.

CD-ROM

Biology: The Dynamics of Life

Prosimian Characteristics (Ch. 7)

Disc 1, Side 2, 47 sec.
The aye-aye, a primate found in Madagascar, uses its long middle finger to dig for grubs.

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

Humulike primates evolve
Humulike primates are called anthropoids (an thrush 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 (pre henz eel), 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, muscular forelimbs for climbing in trees and swinging from branches.

Hominooids 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, muscular forelimbs for climbing in trees and swinging from branches.
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 larger 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 about 15 to 17 million years old. Although New World monkeys probably evolved independently of 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.

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.

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, and use graphs, think critically, use numbers

Teaching Strategies

1. Explain to students that non-human infant primates typically go everywhere with their mother, clinging at first to her belly, and later to her back.

2. 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.

Portfolio

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

Problem-Solving Lab 16-1

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 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.

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.

New World Monkeys

Old World Monkeys

Gibbons

Chimpanzees

Ape and Baboon Evolution

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 their characteristics in their journals. Then, have students review their lists to compare and contrast the characteristics.

Meeting Individual Needs

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, lack prehensile tails. Old World monkeys have prehensile tails. Old World monkeys are generally larger, lack prehensile tails. Old World monkeys have prehensile tails. Old World monkeys are generally larger, 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.

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?

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.

Section Assessment

Check for Understanding

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

Reteach

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

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.

Assessment

Portfolio

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

4 Close

Discussion

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

Resource Manager

Reinforcement and Study Guide, pp. 69-70; Content Mastery, p. 78
Focus On
Primates

Purpose
Students will learn about the characteristics of the major pri-
mate groups.

Background
By investigating the functional relationships between primate features, such as size, tooth struc-
ture, 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.

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 mon-
keys evolved.

A jaw fragment discovered in eastern Africa is 8 million years old. Scientists sug-
gest 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.

PROJECT
All About a Primate

Interpersonal Have student groups make presentations about particu-
lar species of primates. Presentations can be models, posters, videos, or skits and must include behavior, anatomy, ecology, taxonomy, evolution, and importance to humans.

Meeting Individual Needs

English Language Learners

Linguistic Have students define the following terms: opposable thumb, binocular vision, prosimian, anthropoid.

Have students circle the word in the following group that does not belong: New World monkey, opposable thumb, Old World monkey, ape, prosimian.
before answering the accompanying questions.

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

1 Focus Bellringer

Prepare

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

1. Prepare on the overhead projector the section titled “Find the Australopithecine rek.” Have students copy the data table on a separate sheet of paper. 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. Calculate the percentage differences by dividing the numbers by 15 and multiplying by 100. Record the numbers in your data table.

Table 16.1 Amino Acid Sequences in Primates

<table>
<thead>
<tr>
<th>Primate</th>
<th>Amino acids different from human</th>
<th>Percent difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baboon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chimpanzee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gorilla</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemur</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure

Explain the molecular and biochemical methods used to determine phylogeny.

Expected Results

The human, chimpanzee, and gorilla sequences are identical. Baboons differ by 3 percent and lemurs by 4 percent.

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.

2 Teach

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

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 stretches of amino acids of a protein among groups of primates to determine their evolutionary history.

Table 16.1 Amino Acid Sequences in Primates

<table>
<thead>
<tr>
<th>Primate</th>
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<th>Percent difference</th>
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Analysis

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Data Table

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<td>Gorilla</td>
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<tr>
<td>Lemur</td>
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</tr>
</tbody>
</table>

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 3 percent and lemurs by 4 percent.

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.

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

Figure 16.7

MiniLab 16.2

MiniLab 16.2

MiniLab 16.2

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.

Resource Manager

Bioblend and MiniLab Worksheets, p. 74

Resource Manager

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.

Resource Manager

GLENCOE TECHNOLOGY

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

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Resource Manager

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.
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.

Visual Learning

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

young hominid with an apelike brain-case 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 afarensis (af-ah-fuh-rih-nis), meaning “ancient, antropos, meaning “human,” and af, meaning “towards.” Paleon-thropology is the study of human fossils. A. afarensis

Figure 16.8 Some skeletal features of an australopithecine are intermediate between those of modern apes and humans. Compare the skull and pelvis bone of Australopithecus afarensis (A) with those of the chimpanzee (B) and the human (C).

Chimpanzee
Ancient Hominid
Humans

Visual-Spatial

The Infinite Voyage: Dawn of Humankind, The Origin of the Species, and the Discovery of Lucy

PRIMATE EVOLUTION

Australopithecus 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.

Recent Discoveries

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

Mistaken Identity

“Why, if humans evolved from apes, are there still apes alive today?” This question represents a common misconception that students have about human evo-lution. Explain that humans evolved from ancestors of apes, which were neither humans nor apes. Reiterate that the common ancestor of the two groups prob-ably 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 paleon-thropologists by applying their knowledge of anatomy and anthropology to reconstruct the flesh and bones of extinct humans, such as the Neanderthals.

BIOLOGY JOURNAL

What’s in Stetter’s Pond: The Basics of Life

440 PREHISTORIC EVOLUTION

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440 INTIMATE EVOLUTION

16.1. HUMAN ANCESTRY

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.

Figure 16.9 Louis and Mary Leakey discovered many fossils in the Olduvai Gorge area of Tanzania, Africa.
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 brow ridge? A thicker browridge more apelike or humanlike characteristics? Explain your judgment.
3. What clues do fossils such as spear points and hand axes, shells 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 350,000 to 100,000 years ago in Europe, Asia, and the Middle East.

Problem-Solving Lab 16-2

Purpose

Students will compare Neanderthals and modern humans.

Process Skills

think critically, apply concepts, compare and contrast, draw conclusions, 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. Neanderthals has the apelike features of a thick brow ridge and a protruding jaw.
3. They were probably hunters and had religious values.

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 for Scientific Drawing in PASC, p. 55.

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.

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 $H. erectus$.

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.

Figure 16.11

An almost complete Homo erectus skeleton of a 12-year-old male was discovered in East Africa in 1969. $H. erectus$ had a brain volume of about 500 cm$^3$ and long legs like modern humans.

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 $H. erectus$, 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.

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

Notes

Figure 16.12

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

Figure 16.10

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

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 about 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.

**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.

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

### 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 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.

### 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.

### INVESTIGATE

**Comparing Skulls of Three Primates**

1. **Problem**
   - How do skulls of primates provide evidence for human evolution?

2. **Objectives**
   - In this BioLab, you will:
     - Determine how paleoanthropologists study early human ancestors.
     - Compare and contrast the skulls of australopithecines, gorillas, and modern humans.

3. **Materials**
   - metric ruler
   - protractor
   - copy of skull diagrams

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

### DATA TABLE

<table>
<thead>
<tr>
<th>Gorilla</th>
<th>Australopithecus</th>
<th>Modern human</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Face area in cm²</td>
<td>23 cm²</td>
<td>22 cm²</td>
</tr>
<tr>
<td>2. Brain area in cm²</td>
<td>35 cm²</td>
<td>33 cm²</td>
</tr>
<tr>
<td>3. Is brain area smaller or larger than face area?</td>
<td>Smaller</td>
<td>Larger</td>
</tr>
<tr>
<td>4. In brain area 3 times larger than face area?</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Cranial capacity in cm³</td>
<td>600 cm³</td>
<td>600 cm³</td>
</tr>
<tr>
<td>6. Jaw angle</td>
<td>120°</td>
<td>110°</td>
</tr>
<tr>
<td>7. Does lower jaw stick out in front of nose?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8. Is sagittal crest present?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>9. Is browridge present?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### 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?

### PROCEDURE

1. Your teacher will provide copies of the skulls (1/2 natural size) of Australopithecus afarensis, 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 x width).
3. Measure the diameters of the circles in each skull. Multiply these numbers by 200 cm². 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.

### RESOURCES

- Resource Manager
  - BioLab and MiniLab Workbooks, pp. 77-78

- 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.

- 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.

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162 HUMAN ANCESTRY 447
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 1510 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 11,310 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 on 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 on the Bering and Chukchi Seas. Today, the Chukchi Sea is covered with sea ice during the winter months. During the summer, the ice is about 1.9 m thick, and in areas such as Karluk Light Bay, the ice is as thick as 4 m. The land bridge is about 267 meters below the ocean’s surface.

An alternate route
In addition to these findings, recent archaeological 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 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 archaeological 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 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.

The fossil record
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.

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

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.

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

Chapter 16 Assessment
Main Ideas
1. 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.
2. There are two groups of primates: prosimians, such as lemurs and tarsiers; and anthropoids, which include monkeys and hominoids.
3. 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
anthropoids (p. 432) opposable thumb (p. 433)
prosimians (p. 431) primate (p. 442)

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

Connection to Biology
Prehistoric humans may have used boats to enter the New World.
5. Primates native to the area indicated by the map below are _______.
   a. Old World monkeys
   b. New World monkeys
   c. apes
   d. prosimians

6. The science of studying the fossils of humans is ________.
   a. palaeoanthropology
   b. palaeontology
   c. paleontology
   d. anthropology

7. The dominant sense in primates is ________.
   a. vision
   b. taste
   c. smell
   d. hearing

8. Which of these is NOT a primate?
   a. human
   b. squirrel
   c. lemur
   d. orangutan

9. The earliest primates were most like ________.
   a. apes
   b. monkeys
   c. prosimians
   d. New World monkeys

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 ________.
    a. prosimians
    b. New World monkeys
    c. Old World monkeys
    d. hominoids

12. The term used to describe the tails of New World monkeys is ________.
    a. prehensile
    b. tufted
    c. prehensile
    d. not tufted

13. Which group appears to have the greatest range of intermembral distance? ________
    a. Gibbon
    b. Orangutan
    c. Chimp
    d. Gorilla

14. The dominant sense in primates is ________.
    a. vision
    b. hearing
    c. smell
    d. taste

15. The term used to describe the tails of New World monkeys is ________.
    a. prehensile
    b. tufted
    c. prehensile
    d. not tufted

16. Hominoids walked upright before they had ________.
    a. .
    b. large brains
    c. medium brains
    d. small brains

17. Organisms that walk upright on two legs are ________.
    a. prosimians
    b. New World monkeys
    c. Old World monkeys
    d. hominoids

18. The term used to describe the tails of New World monkeys is ________.
    a. prehensile
    b. tufted
    c. prehensile
    d. not tufted

19. The earliest primates were most like ________.
    a. apes
    b. monkeys
    c. prosimians
    d. New World monkeys

20. African hominids who possessed apelike and humanoid qualities are classified as ________.
    a. hominoids
    b. hominids
    c. prosimians
    d. Old World monkeys

21. Suppose that you were told that a scientist found a 21 000-year-old arrowhead in Arizona. How would you respond? ________.
    a. Yes, it is in the range shown.
    b. New World monkeys
    c. Old World monkeys
    d. hominoids

22. Which group appears to have the narrowest range of intermembral distance? ________.
    a. prosimians
    b. New World monkeys
    c. Old World monkeys
    d. hominoids

23. Some scientists suggest that Neanderthals evolved into modern humans. What information should they gather to support their idea? ________.
    a. DNA of modern humans and that of Neanderthals
    b. acid sequences in apes
    c. evidence of physical traits
    d. spoken language were ________.

24. How is the evolution of apes an example of ________?
    a. science of studying the fossils of humans
    b. science of studying the fossils of humans
    c. science of studying the fossils of humans
    d. science of studying the fossils of humans

25. Observing and Inferring: How could you tell from the position of the foramen magnum that an animal walked upright? ________.

26. Formulating Hypothesis: How would you test the idea that opposable thumbs are beneficial adaptations for arboral 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? ________.

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

Table 16.2 Comparisons of Amino Acid Sequences

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage amino acid sequence difference from humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibbon</td>
<td>3.7</td>
</tr>
<tr>
<td>Orangutan</td>
<td>5.2</td>
</tr>
<tr>
<td>Chimp</td>
<td>6.4</td>
</tr>
<tr>
<td>Gorilla</td>
<td>7.8</td>
</tr>
<tr>
<td>Modern human</td>
<td>100</td>
</tr>
</tbody>
</table>

29. 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? ________.

CD-ROM: For additional review, see the assessment options for this chapter found in the Biology: The Dynamics of Life Interactive CD-ROM and on the Glencoe Science Web Site.

www.glencoe.com/sec/science