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

Section	Objectives	Activities/Features
Section 17.1 **Classification** National Science Education Standards UCP.1, UCP.2, UCP.4; A.2; C.3, C.5; G.1-3 (1 session, 1/2 block)	1. **Evaluate** the history, purpose, and methods of taxonomy. 2. **Explain** the meaning of a scientific name. 3. **Describe** the organization of taxa in a biological classification system.	**MiniLab 17-1:** Using a Dichotomous Key, p. 456 **Problem-Solving Lab 17-1,** p. 457 **Focus On** Kingdoms of Life, p. 460 **Investigate BioLab:** Making a Dichotomous Key, p. 474
Section 17.2 **The Six Kingdoms** National Science Education Standards UCP.1, UCP.2, UCP.4, UCP.5; A.1, A.2; C.1, C.3, C.5, C.6; E.1, E.2; G.1-3 (3 sessions, 2 blocks)	4. **Describe** how evolutionary relationships are determined. 5. **Explain** how cladistics reveals phylogenetic relationships. 6. **Compare** the six kingdoms of organisms.	**MiniLab 17-2:** Using a Cladogram to Show Relationships, p. 467 **Problem-Solving Lab 17-2,** p. 470 **BioTechnology:** Molecular Clocks, p. 476

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

MATERIALS LIST

BioLab
p. 474 sample keys from guidebooks, metric ruler

MiniLabs
p. 456 miscellaneous leaves, dichotomous key for trees, paper, glue
p. 467 pencil, paper

Alternative Lab
p. 468 flasks, test tubes, beakers, stirring rods, thermometers, bottle stoppers, pipettes, droppers, funnels, petri dishes, graduated cylinders, bottles, jars

Quick Demos
p. 454 sponges, slime molds, mosses, mildew, lichens
p. 461 leaf, feather, moss, mushroom, seeds, seaweed, sponge, poultry wishbone
p. 468 organisms from the six kingdoms
p. 481 microscope, prepared slide of *Euglena*
p. 483 small mammal, cage

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.
- [block icon] These strategies are useful in a block scheduling format.

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 17.1 **Classification**	**Reinforcement and Study Guide,** p. 73-74 L2 **Concept Mapping,** p. 17 L3 ELL **Critical Thinking/Problem Solving,** p. 17 L3 **BioLab and MiniLab Worksheets,** p. 81 L2 **Laboratory Manual,** pp. 117-120 L2 **Tech Prep Applications,** pp. 25-26 L2 **Content Mastery,** pp. 81-82, 84 L1	**Section Focus Transparency 41** L1 ELL
Section 17.2 **The Six Kingdoms**	**Reinforcement and Study Guide,** pp. 75-76 L2 **Concept Mapping,** p. 17 L3 ELL **BioLab and MiniLab Worksheets,** pp. 82-84 L2 **Laboratory Manual,** pp. 121-124 L2 **Content Mastery,** pp. 81, 83-84 L1	**Section Focus Transparency 42** L1 ELL **Basic Concepts Transparency 24** L2 ELL **Reteaching Skills Transparency 26** L1 ELL

Assessment Resources

Chapter Assessment, pp. 97-102
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 17 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:
CD-ROMs
Mammals: A Multimedia Encyclopedia
NGS PictureShow: Classifying Plants and Animals
Curriculum Kits
GeoKit: Cells and Organisms
GeoKit: Fish, Reptiles, and Amphibians
GeoKit: Plants

Transparency Set
NGS PicturePack: Classifying Plants and Animals

Products Available From National Geographic Society
To order the following products, call National Geographic Society at 1-800-368-2728:
Books
National Geographic Book of Mammals
Field Guide to the Birds of North America
Video
Plant Classification

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life
CD-ROM ELL
BioQuest: *Biodiversity Park*
Video: *Museum Collections*
Exploration: *The Five Kingdoms*
Videodisc Program
Museum Collections

The Infinite Voyage
The Great Dinosaur Hunt
Insects: *The Ruling Class*
The Geometry of Life
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*
Using Cladistics

GETTING STARTED DEMO

Display a list of the six kingdoms and have students match each organism in the chapter opening photo with a kingdom. Ask students why there is no match for some kingdoms. *Most members of the Kingdoms Archaebacteria, Eubacteria, and Protista are microscopic.*

Theme Development

The theme of **evolution** underlies the phylogenetic basis of classification. The theme of **unity within diversity** emerges when the shared features of the species in each kingdom are described.

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 17 Organizing Life's Diversity

What You'll Learn

- You will both identify and compare various methods of classification.
- You will distinguish among six kingdoms of organisms.

Why It's Important

Biologists use a system of classification to organize living things. Understanding classification helps you study organisms and their evolutionary relationships.

GETTING STARTED

Observing flowers

Carefully observe several flowers. *What characteristics distinguish the different flowers and let you separate them into groups?*

interNET CONNECTION To find out more about classification and taxonomy, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

Biologists have classified all the organisms you see in these photos as well as millions of others.

Section 17.1 Classification

SECTION PREVIEW

Objectives

Evaluate the history, purpose, and methods of taxonomy.

Explain the meaning of a scientific name.

Describe the organization of taxa in a biological classification system.

Vocabulary

classification
taxonomy
binomial nomenclature
genus
family
order
class
phylum
kingdom
division

Every day you see items that are grouped, and you group items yourself. In a supermarket, you find all the fresh produce in one area, baked goods in another, and dairy products in still another. In a music store, the type of music is the basis for shelving a CD. When you put away the dishes, you probably place the dinner plates on one shelf and the glasses on another. You group similar articles so often that you probably never think about why you do it. However, grouping things creates order, and grouping saves time and energy when you look for an item.

A display of fruit for sale

How Classification Began

Organizing items can help you understand them better and find them more easily. For example, you probably order your clothes drawers and your CD collection. Biologists want to better understand organisms so they organize them into groups. One tool that they use to do this is **classification**—the grouping of objects or information based on similarities. **Taxonomy** (tak SAHN uh mee) is the branch of biology that groups and names organisms based on studies of their different characteristics. Biologists who study taxonomy are called taxonomists.

Aristotle's system

The Greek philosopher Aristotle (384–322 B.C.) developed the first widely accepted system of biological classification. He classified all the organisms he knew into two groups: plants and animals. He subdivided plants into the three groups, herbs, shrubs, and trees, depending on the size and structure of a plant. He grouped animals according to where they lived or spent a great deal of time: on land, in the air, or in water.

The basis for Aristotle's groups was useful but did not group organisms according to their evolutionary history. According to his system, birds, bats, and flying insects are classified together even though they have

WORD Origin

taxonomy
From the Greek words *taxo*, meaning to "arrange," and *nomy*, meaning "ordered knowledge." Taxonomy is the science of classification.

Prepare

Key Concepts

Students will examine the history, purpose, and methods of classification and taxonomy. They will compare the contributions of Aristotle and Linnaeus and learn about taxonomic categories.

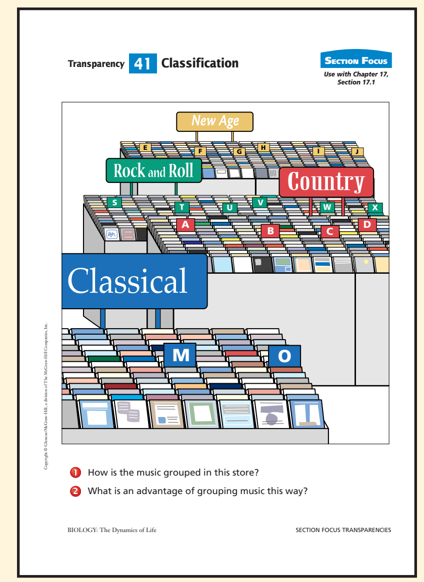
Planning

- Obtain samples of unusual organisms, such as some slime molds, moss, and lichens for the Quick Demo.
- Collect supermarket advertisements of produce sales for the Tech Prep.
- Collect leaves on lab day for MiniLab 17-1.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 41** on the overhead projector and have students answer the accompanying questions. L1 ELL



Multiple Learning Styles

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

Kinesthetic Building a Model, p. 458; Meeting Individual Needs, pp. 462, 467; Portfolio, p. 471

Visual-Spatial Portfolio, pp. 456, 458; Meeting Individual Needs, p. 465; Time Line, p. 469; Project, p. 471; Activity, p. 473

Interpersonal Activity, p. 465

Intrapersonal Tech Prep, pp. 455, 456; Reteach, p. 473

Linguistic Biology Journal, pp. 454, 458

Logical-Mathematical Meeting Individual Needs, p. 454

Naturalist Activity, pp. 455, 472; Biology Journal, pp. 457, 466; Reteach, p. 459; Extension, p. 459; Going Further, p. 475

Assessment Planner

Portfolio Assessment
Portfolio, TWE, pp. 456, 458, 471
Alternative Lab, TWE, pp. 468-469

Performance Assessment
MiniLab, SE, pp. 456, 467
MiniLab, TWE, pp. 456, 467
Assessment, TWE, pp. 458, 459, 473
Alternative Lab, TWE, pp. 468-469
BioLab, SE, pp. 474-475
BioLab, TWE, pp. 474-475

Knowledge Assessment
Problem-Solving Lab, TWE, p. 457
Section Assessment, SE, pp. 459, 473
Assessment, TWE, p. 466
Chapter Assessment, SE, pp. 477-479

Skill Assessment
Problem-Solving Lab, TWE, p. 470

2 Teach

Quick Demo

Provide each group of students with two unfamiliar organisms. Seal slime molds and mildews in a plastic bag because some students may have mold spore allergies. Ask students to classify each organism as a plant or animal and list their reasons. Explain that although plants and animals are often the most familiar organisms, there are four other major catagories of organisms.

Visual Learning

Figure 17.1 Ask students to identify features they could use to classify these flowers. *Possible answers include the numbers and arrangements of petals or male and female reproductive organs.*

GLENCOE TECHNOLOGY

VIDEOTAPE
The Secret of Life
Gone Before You Know It: The Biodiversity Crisis
What's in Stetter's Pond: The Basics of Life

Resource Manager

Section Focus Transparency 41 and Master L1 ELL

WORD Origin

binomial nomenclature
From the Latin words *bi,* meaning "two," *nomen,* meaning "name," and *calatus,* meaning "list." The system of binomial nomenclature assigns two words to the name of each species.

little in common besides the ability to fly. As time passed, more organisms were discovered and some did not fit easily into Aristotle's groups, but many centuries passed before Aristotle's system was replaced.

Linnaeus's system

In the late eighteenth century, a Swedish botanist, Carolus Linnaeus (1707–1778), developed a method of grouping organisms that was more useful than Aristotle's. Linnaeus's system was based on physical and structural similarities of organisms. For example, he might use the similarities in flower parts as a basis for classifying flowering plants, ***Figure 17.1.*** As a result, the groupings revealed the relationships of the organisms.

Eventually, some biologists proposed that structural similarities reflect the evolutionary relationships of species. For example, although bats fly like birds, they also have hair and produce milk for their young. Therefore, bats are classified as mammals rather than as birds, reflecting the evolutionary history that bats share with other mammals. This way of organizing organisms is the basis of modern classification systems.

Two names for a species

Modern classification systems use a two-word naming system called **binomial nomenclature** that Linnaeus developed to identify species. In this system, the first word identifies the genus of the organism. A **genus** (JEE nus) (plural, genera) consists of a group of similar species. The second word, which often describes a characteristic of the organism, immediately follows the genus name. Thus, the scientific name for each species is a combination of the genus and descriptive names. For example, the scientific name of modern humans is *Homo sapiens.* Modern humans are in the genus *Homo,* and one of their characteristics is intelligence. The Latin word *sapiens* means "wise."

Figure 17.1
Linnaeus classified flowering plants according to their flower structures.

Latin is the language of scientific names. Taxonomists are required to give each newly discovered species a Latin scientific name. They use Latin because the language is no longer used in conversation and, therefore, does not change. Scientific names should be italicized in print and underlined when handwritten. The first letter of the genus name is uppercase, but the first letter of the descriptive name is lowercase.

Although a scientific name gives information about the relationships of an organism and how it is classified, many organisms have common names just like you and your friends might have nicknames. However, a common name can be misleading. For example, a sea horse is a fish, not a horse. In addition, it is confusing when a species has more than one common name. The bird in ***Figure 17.2*** lives not only in the United States but also in several countries in Europe. In each country it has a different common name. Therefore, if an English scientist publishes an article about the bird's behavior and uses the bird's English common name, a Spanish scientist looking for information might not recognize the bird as the same species also living in Spain.

Biological Classification

Expanding on Linnaeus's work, today's taxonomists try to identify the underlying natural relationships of organisms and use the information as a basis for classification. They compare the external and internal structures of organisms, as well as their geographical distribution and chemical makeup to reveal their probable evolutionary relationships. Grouping organisms on the basis of their evolutionary relationships makes it easier to understand biological diversity.

Figure 17.2
In the United States and England, this bird is called the house sparrow, in Spain the gorrion, in Holland the musch, and in Sweden the hussparf. However, the bird has only one scientific name, *Passer domesticus.*

Taxonomy: A framework

Just as similar food items in a supermarket are stacked together, taxonomists group similar organisms, both living and extinct. Classification provides a framework in which to study the relationships among living and extinct species.

For example, biologists study the relationship between birds and dinosaurs within the framework of classification. Are dinosaurs more closely related to birds or reptiles? The bones of some dinosaurs have large internal spaces like those in birds. Some paleontologists who study dinosaur fossils propose that some dinosaurs may have been endothermic—able to maintain a constant body temperature—which is a characteristic of all birds. Because of such evidence, they suggest that dinosaurs are more closely related to ostriches, which are birds, than to lizards, which are reptiles.

Taxonomy: A useful tool

Classifying organisms is a useful tool for scientists who work in agriculture, forestry, and medicine. For

Activity

Naturalist Have students list the species names of organisms whose common names they know, such as your state flower, tree, animal, etc. Have them identify each organism's common name. L1

Visual Learning

Figure 17.2 Ask the students to explain why the common name of *Passer domesticus* is house sparrow. *This bird nests in the eaves of houses in both rural and urban areas.*

Brainstorming

Have students brainstorm why taxonomy reflects evolutionary relationships. *When taxonomy reflects phylogeny, an organism's name provides information about the organism.*

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage:
The Great Dinosaur Hunt, Dinosaur Tracks: Footprint Analysis (Ch. 6), 5 min.

Newborns: Examining Dinosaur Eggs (Ch. 7), 8 min. 30 sec.

New Dinosaur Discoveries and Their Link with Today (Ch. 10) 8 min.

MEETING INDIVIDUAL NEEDS

Learning Disabled

Logical-Mathematical Ask students how they would find the phone number of a music store whose name they'd forgotten in the yellow pages. Then ask how they would use the white pages to do the same thing. Have them name other situations in which classification is useful. L1

BIOLOGY JOURNAL

Using Binomials

Linguistic Have students reread the paragraphs titled "Two names for a species" and use the information to write the names of their family members as binomials. L1 ELL

TECHPREP

Using Scientific Names

Intrapersonal Provide supermarket advertisements of produce sales and ask students to rewrite the ads using the scientific names of the sale items. Have them exchange their rewritten ads and try to identify the sale items. L2

Internet Address Book

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

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

MiniLab 17-1

Purpose
Students will use a dichotomous key to identify organisms.

Process Skills
classify, observe and infer, compare and contrast

Teaching Strategies
- Have students wash their hands after touching the leaves.
- Use Keys that identify trees and shrubs by leaf structure.
- Obtain leaves on the day students will do the activity.
- Make a transparency of a key to demonstrate the key's use.

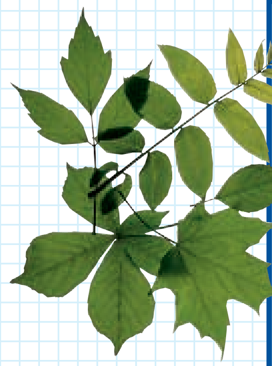
Expected Results
Students will identify trees and shrubs based on leaf structure.

Analysis
1. identification of organisms
2. vein and margin structure, leaf shape and size, number of lobes
3. more specific

Assessment
Performance Provide students with several algae and a dichotomous key. Ask them to examine, diagram, and then identify the algae. Use the Performance Task Assessment List for Making and Using a Classification System in **PASC,** p. 49. L3

Resource Manager
BioLab and MiniLab Worksheets, p. 81 L2
Tech Prep Applications, pp. 25-26 L2
Laboratory Manual, pp. 117-120 L2

MiniLab 17-1 Classifying



Using a Dichotomous Key How could you identify a tree growing in front of your school? You might ask a local expert, or you could use a manual or field guide that contains descriptive information and keys about trees. A key is a set of descriptive sentences that is subdivided into steps. A dichotomous key has two descriptions at each step. You follow the steps until the key reveals the name of the tree.

Procedure
1. Using a few leaves from local trees and a dichotomous key for trees of your area, identify the tree from which each leaf came. To use the key, study one leaf. Then choose the one statement from the first pair that most accurately describes the leaf. Continue following the key until you identify the leaf's tree. Repeat the process for each leaf.
2. Glue each leaf on a separate sheet of paper. For each leaf, record the tree's name.

Analysis
1. What is the function of a dichotomous key?
2. List three different characteristics used in your key.
3. As you used the key, did the characteristics become more general or more specific?

example, suppose a child eats berries from the holly plant that you see in *Figure 17.3.* The child's parents would probably rush the child and some of the plant and its berries to the nearest hospital. Someone working at a poison control center could identify the plant, and the physicians would then know how to treat the child.

Anyone can learn to identify many organisms. The *MiniLab* on this page will guide you through a way of identifying some organisms in your own neighborhood. Then try the *BioLab* at the end of this chapter.

Taxonomy and the economy

It often happens that the discovery of new sources of lumber, medicines, and energy results from the work of taxonomists. The characteristics of a familiar species are frequently similar to those found in a new, related species. For example, if a taxonomist knows that a certain species of pine tree contains chemicals that make good disinfectants, it's likely that another pine species will also contain these useful substances.

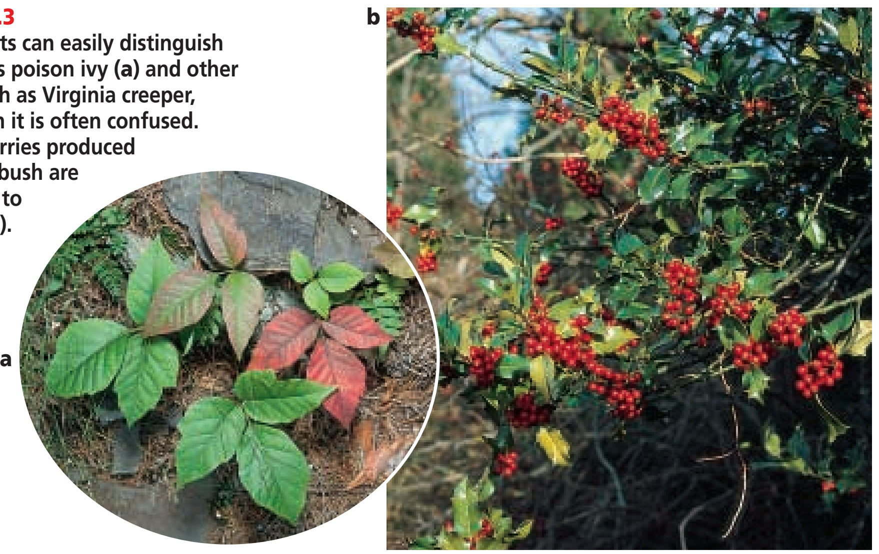


Figure 17.3
Taxonomists can easily distinguish among this poison ivy (a) and other plants, such as Virginia creeper, with which it is often confused. The red berries produced by a holly bush are poisonous to humans (b).

TECHPREP
Classification in Daily Life
Intrapersonal Provide students with newspaper classified ads. Ask them to describe their dream car and explain where they would find it listed in the ads. L1

Portfolio
Zoo and Garden Classification
Visual-Spatial Send students to a nearby zoo or botanical garden to find an example of classification in use. Have them make a photo or video essay of the example for their portfolios. L2 ELL P

How Living Things Are Classified

In any classification system, items are categorized, making them easier to find and discuss. For example, in a newspaper's classified advertisements, you'll find a section listing autos for sale. This section frequently subdivides the many ads into two smaller groups—domestic autos and imported autos. In turn, these two groups are subdivided by more specific criteria, such as different car manufacturers and the year and model of the auto. Although biologists group organisms, not cars, they subdivide the groups on the basis of more specific criteria. Any group of organisms is called a taxon (plural, taxa).

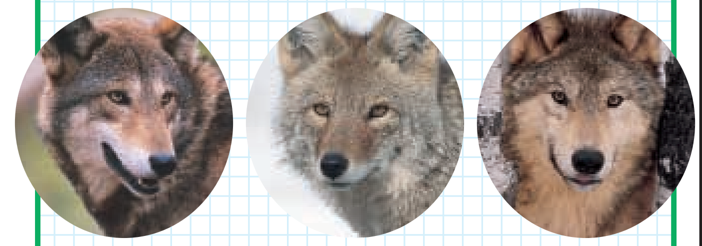
Taxonomic rankings

Organisms are ranked in arbitrary taxa that range from having very broad characteristics to very specific ones. The broader a taxon, the more general its characteristics, the more species it contains. You can think of the taxa as fitting together like nested boxes of increasing sizes. You already know about two taxa. The smallest taxon is that of species. Organisms that look alike and successfully interbreed belong to the same species. The next largest taxon is a genus—a group of similar species that have similar features and are closely related.

It is not always easy to determine the species of an organism. For example, over many years, taxonomists have debated how to classify the red wolf, the coyote, and the gray wolf. Some biologists wanted to classify them as separate species, and others wanted to classify them as a single species. Use the *Problem-Solving Lab* on this page to explore the evidence for and against classifying these three organisms as separate species.

Problem-Solving Lab 17-1 Drawing a Conclusion

Is the red wolf a separate species? The work of taxonomists results in changing views of species. This is due to both the discovery of new species and the development of new techniques for studying classification.



Red wolf — Coyote — Gray wolf

Analysis
A. The red wolf *(Canis rufus)* can breed and produce offspring with both the coyote *(Canus latrans)* and the gray wolf *(Canis lupus).* Despite this fact, the three animal types have been classified as separate species.
B. A biologist measured their skulls and concluded that in size and structure the red wolf's measurements fell midway between gray wolves and coyotes.
C. Based on these data, the biologist concluded that they are separate species.
D. Geneticists, attempting to determine if the three animal types were separate species, found that the nucleotide sequences from the red wolf's DNA were not distinctively different from those of gray wolves or coyotes.
E. The geneticists concluded that the red wolf is a hybrid of the gray wolf and coyote.

Thinking Critically
1. A species can be defined as a group of animals that can mate with one another to produce fertile offspring but cannot mate successfully with members of a different group. Does statement (A) support or reject this definition? Explain your answer.
2. What type of evidence was the biologist using (B)? The geneticists (D)? Explain your answer.
3. A hybrid is the offspring from two species. Which sentence, beside (D) and (E), supports hybrid evidence? Explain.
4. If you supported the biologist's work, would you use the three different scientific names for coyotes, gray wolves, and red wolves? Explain your answer.
5. If you supported the geneticists' conclusions, would you use the three different scientific names? Explain your answer.
6. How does this example support the idea that the work of scientists results in changing views of species?

BIOLOGY JOURNAL
Organizing Information
Naturalist Provide students with a list of three to five familiar organisms, such as a common fish, amphibian, reptile, bird, and mammal. Have them research how the organisms are classified and use the information to make a table in their journals. L1

GLENCOE TECHNOLOGY
VIDEODISC
The Infinite Voyage
Insects: The Ruling Class The Rothschild Legacy: Study of Fleas and the Bubonic Plague (Ch. 2), 6 min. 30 sec.

Problem-Solving Lab 17-1

Purpose
Students will analyze why taxonomy can change.

Process Skills
analyze information, apply concepts, define operationally, draw a conclusion, think critically

Background
The red wolf is an endangered species. Programs to reintroduce the red wolf into states such as North Carolina have received federal funding. But now that the red wolf is considered a hybrid, some question spending endangered species funds on it.

Teaching Strategies
- Point out that each animal has its own scientific name.
- Use large photos to show the animals' similarities.

Thinking Critically
1. Rejects it. The red wolf mates with two other species.
2. biologist, structural; geneticists, biochemical
3. B; intermediate skull size implies hybridism.
4. Yes; each species must have its own scientific name.
5. No; the red wolf is a hybrid.
6. Since 1995, the red wolf is considered to be a hybrid, not a distinct species.

Assessment
Knowledge The red fox's scientific name is *Vulpes vulpes.* Have students classify the red fox and red wolf. Use the Performance Task Assessssment List for Making and Using a Classification System in **PASC,** p. 49. L2

Careers in Biology

Career Path

Courses in high school: sciences, mathematics, and English

College: bachelor's degree in biology or another science; master's degree usually required

Career Issue

Ask students whether teachers should be required to follow state or national biology teaching guidelines, or be free to develop their own goals and strategies. Have them explain their answers.

For More Information

For more information about teaching biology, write to:

National Association of Biology Teachers
11250 Roger Bacon Drive, #19
Reston, VA 22090.

Visual Learning

Figure 17.5 Ask students how the animals are alike. *whiskers, a short face, short ears, similar camouflaging color, four legs, similar body form, short tail*

Building a Model

Kinesthetic Ask students to design and construct a three-dimensional model of taxonomic hierarchy. L2 ELL

Assessment

Performance Assessment in the Biology Classroom, p. 27, *Designing a Classification System.* Have students do this activity to expand their knowledge of classification. L2

Careers in Biology

Biology Teacher

Are you intrigued by the actions and interactions of plants, animals, and other organisms? Would you like to share this interest with others? Maybe you should become a biology teacher.

Skills for the Job

Biology teachers help students learn about organisms through discussions and activities both inside and outside the classroom. As a biology teacher, you might also teach general science and health. To become a biology teacher, you must earn a bachelor's degree in science, biology, or a closely related field. You sometimes have to spend several months student teaching. Many positions require a master's degree. In addition, you have to pass a national test for teachers in many states. This national test includes a test in biology or in a combination of biology and general science. After all this education, testing, and work, you will be ready to teach others!

interNET CONNECTION To find out more about careers in related fields, be sure to check the Glencoe Science Web Site.
www.glencoe.com/sec/science

In *Figure 17.4*, you can compare the appearance of a lynx, *Lynx rufus*, a bobcat, *Lynx canadensis*, and a mountain lion, *Panthera concolor.* The scientific names of the lynx and bobcat tell you that they belong to the same genus, *Lynx*. All species in the genus *Lynx* share the characteristic of having a jaw that contains 28 teeth. Mountain lions and other lions, which are similar to bobcats and lynxes, are not classified in the *Lynx* genus because their jaws contain 30 teeth.

Bobcats, lynxes, lions, and mountain lions belong to the same family called Felidae. **Family,** the next larger taxon in the biological classification system, consists of a group of similar genera. In addition to domesticated cats, bobcats, lynxes, and lions belong to the family Felidae. All members of the cat family share certain characteristics. They have short faces, small ears, forelimbs with five toes, and hindlimbs with four toes. Most can retract their claws.

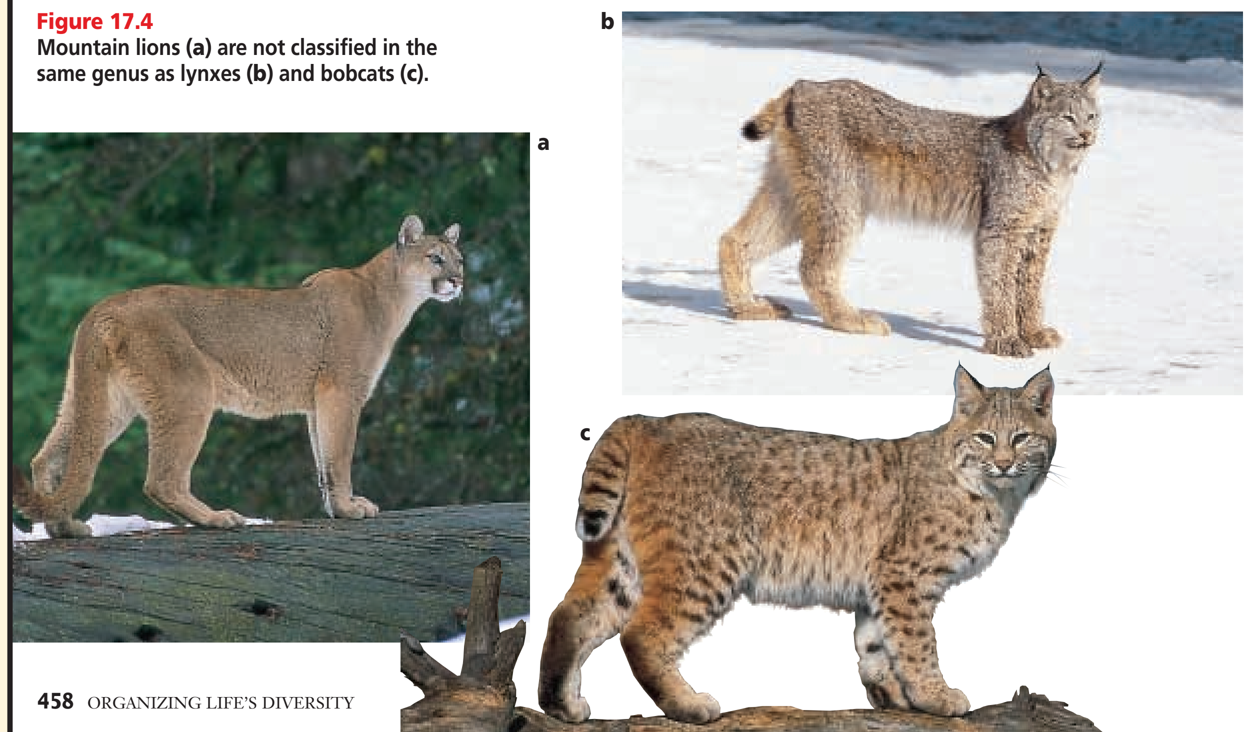


Figure 17.4
Mountain lions (a) are not classified in the same genus as lynxes (b) and bobcats (c).

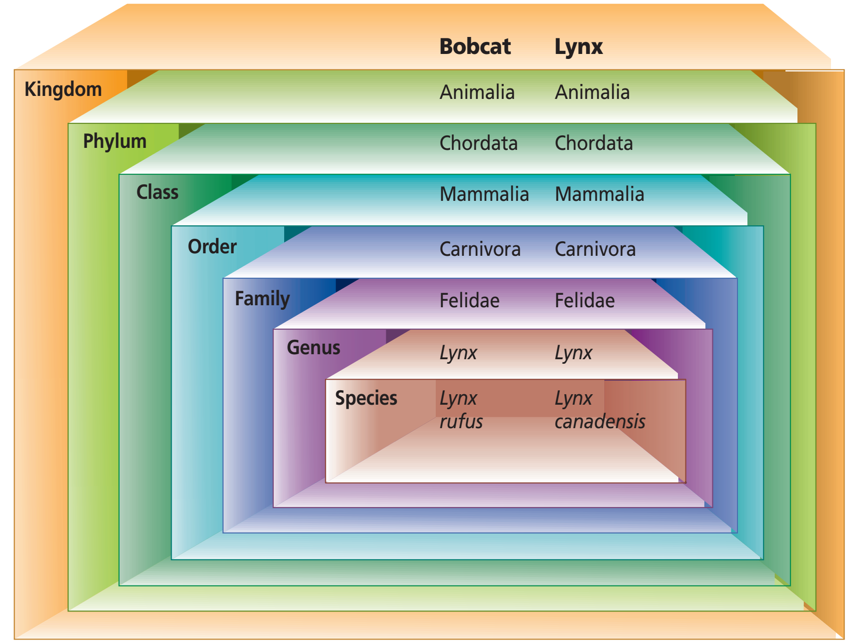


Figure 17.5
A lynx, called *Lynx canadensis*, has both a short tail with black fur circling its tip and highly visible tufts of hair on its ears. A bobcat, *Lynx rufus*, has a short tail with black fur only on the top of its tail's tip and inconspicuous tufts of ear hair. However, these species share many characteristics.

The larger taxa

There are four larger taxa. An **order** is a taxon of similar families. A **class** is a taxon of similar orders. A **phylum** (FI lum) (plural, phyla) is a taxon of similar classes. Plant taxonomists use the taxon **division** instead of phylum. A **kingdom** is a taxon of similar phyla or divisions. The six kingdoms are described in the *Focus on* beginning on the next page.

As shown in *Figure 17.5*, bobcats and lynxes belong to the order, Carnivora. Carnivores have similar arrangements of teeth and belong to the class, Mammalia. Mammals have hair or fur covering their bodies and produce milk for their young. The phylum Chordata, to which mammals belong, includes mostly animals with backbones. Kingdom Animalia includes all phyla of animals.

Section Assessment

Understanding Main Ideas

1. For what reasons are biological classification systems needed?
2. Give two reasons why binomial nomenclature is useful.
3. What did Linnaeus contribute to the field of taxonomy?
4. What are the taxa used in biological classification? Which taxon contains the largest number of species? Which taxon contains the fewest number of species?

Thinking Critically

5. Use categories that parallel the taxa of a biological classification system to organize the items you can borrow from a library.

Skill Review

6. **Classifying** Make a list of all the furniture in either your classroom or your room at home. Classify it into groups based on function. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Reinforcement

Have students use the mnemonic "King Philip came over from Geneva Switzerland" to remember the order of the taxa.

3 Assess

Check for Understanding

Have students compare and contrast the classification systems of species and library books. *Both systems provide a way of organizing information. They differ in the criteria used to create categories and in the number of categories.* L1

Reteach

Naturalist Have students list the taxa biologists use to classify organisms and describe each taxon they list. L1

Extension

Naturalist Have students find the scientific names of the wolf, fox, domestic dog, and coyote and explain how the animals are related. L2

Assessment

Performance Ask students to collect five weeds and use field guides to identify them. L3

4 Close

Activity

Give pairs of students some fruits or vegetables. Ask each team to make up binomials for these "species." L1

Portfolio

Classifying Local Organisms

Visual-Spatial Give students the taxonomic names of a familiar plant and animal. Have them make sketches similar to the blocks in Figure 17.5 and write in the organisms' taxonomic names. Students can place their work in their portfolios. L1 P

Biology Journal

Discovering New Species

Linguistic Ask students to write in their journals the procedures needed to establish that an insect found in a tropical rain forest is a "new" species that has never before been described. L2

Section Assessment

1. With them, it is easier to study organisms and their relationships.
2. Common names do not indicate relationships among organisms. The genus name is the same for closely related species; the species name describes the organism.
3. He developed the binomial system for naming organisms and the basis of today's biological classification system.
4. Kingdom, phylum, class, order, family, genus, species; kingdom taxa contain the largest numbers of species, and species taxa contain the fewest.
5. Answers will vary, but students may use categories like reference books, novels, biographies, audio tapes, etc.
6. Functions may include resting, sleeping, writing, working, eating, and storing.

Resource Manager

Reinforcement and Study Guide, pp. 73-74 L2
Content Mastery, p. 82 L1

Focus On
Kingdoms of Life

Purpose
Students will learn the major differences among organisms in the six kingdoms. They will study the history of classification and different classification systems.

Background
Taxonomists work continually to improve the organizational system of about 1.5 million known species of organisms. Recent attempts at improvement include the division of prokaryotes into Kingdoms Archaebacteria and Eubacteria to better reflect the genetic differences of these two types of prokaryotes. Incorporating a taxon called domain, which is more inclusive than the kingdom taxon, into the modern classification system has been supported by some taxonomists. Such an organizational system would divide all known organisms into three domains that reflect today's knowledge about the evolutionary relationships of living things.

NATIONAL GEOGRAPHIC

FOCUS ON Kingdoms of Life


PUFFIN

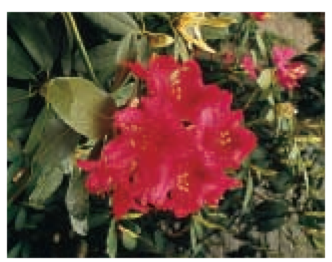

DROMEDARY

The great diversity of life on Earth—estimated at 3 to 10 million species and counting—can be overwhelming. To make sense of this bewildering array of living things, biologists use classification systems to group organisms in ways that highlight their similarities, differences, and relationships. The systematic grouping of living things originated in the 4th century B.C. But biological classification has changed a great deal over the years, as new tools and technologies have made it possible to examine organisms in increasing detail and trace their complex evolutionary pathways through time.


MOTH COLLECTION

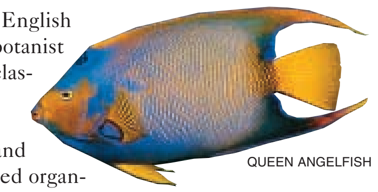
ARISTOTLE RECOGNIZES PLANTS AND ANIMALS
Taxonomy, as the science of biological classification is called, began with the Greek philosopher Aristotle (384–322 B.C.). A keen observer of nature, Aristotle separated all living things into two major groups: plants and animals. He grouped plants into herbs, shrubs, and trees, and classified animals on the basis of size, where they lived—on the land or in the water, and how they moved. Although Aristotle's system of classification did little to reveal natural relationships among living things, it was widely accepted and used, with few modifications, into the Middle Ages.


CONEFLOWER


RHODODENDRON


OAK TREE

LINNAEUS IDENTIFIES TWO KINGDOMS
Modern classification began with the work of John Ray (1627–1705), an English naturalist who outlined the idea of species. In the mid-1700s, Swedish botanist Carolus Linnaeus (1707–1778) picked up on this idea and developed a classification scheme that formed the basis of the system we use today. Linnaeus divided all living things between two kingdoms—plants and animals. But he subdivided these kingdoms into a hierarchy of smaller and more specific groups: classes, orders, genera, and species. Linnaeus placed organisms in these groups primarily on the basis of their physical similarities and differences.

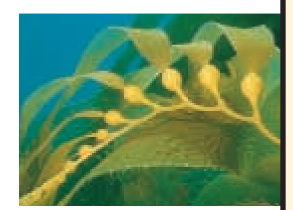

QUEEN ANGELFISH

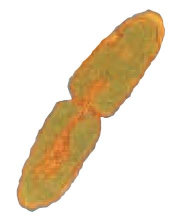

BARREL SPONGE WITH CRINOIDS

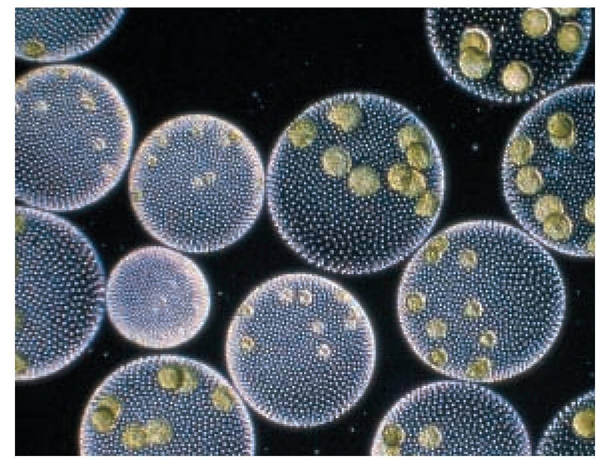
PROTISTS: THE THIRD KINGDOM
Linnaeus' classification system revolutionized taxonomy, but from the start there were problems. Organisms such as mushrooms and sponges resemble plants but do not make their own food. To which kingdom did they belong? As light microscopes improved, the situation became much more complex as biologists discovered a vast assortment of minute, primarily one-celled organisms. In 1866, German zoologist Ernst Haeckel (1834–1919) proposed giving these unicellular organisms—named protists—a kingdom of their own.


FLY AGARIC MUSHROOMS

PROKARYOTES AND FOUR KINGDOMS
The three-kingdom classification system persisted, however, until the middle of the 20th century when the electron microscope and advances in biochemistry made it possible to study living things at the subcellular level. These new tools revealed that there are two fundamentally different kinds of cells in the living world—prokaryotes and eukaryotes. Prokaryotes, such as the bacterium *Salmonella* (below left), lack the membrane-bound nuclei and most of the organelles characteristic of eukaryotic cells. All prokaryotes were then recognized as a separate kingdom that contained all the bacteria.


KELP (EUKARYOTE)


SALMONELLA (PROKARYOTE) Magnification: 34 300 X


VOLVOX (EUKARYOTE) Magnification: 15 x

NATIONAL GEOGRAPHIC

Teaching Strategies
- As you review the kingdoms with your students, ask them to explain the meaning of the word *diversity* in order to identify any preconceptions.
- Ask students to identify both the similarities and differences among the organisms in the photos on these pages.
- Have students locate some books, journals, magazines, and newspaper articles that estimate the numbers of species in each kingdom. Ask them to research the numbers and discuss how the numbers were derived.

Quick Demo
Place the parts of different organisms, such as a leaf, a mushroom, moss, a feather, seeds, a poultry wishbone, seaweed, and a piece of sponge, in a box. As you remove each item and display it, ask students to identify the organism that produced the item and classify it in one of the six kingdoms.

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Biodiversity
Preserving Diversity
Unit 2, Side 1, 12 min. 10 sec.
Preserving Diversity
(in its entirety)

Destroying Diversity
(in its entirety)
Unit 1, Side 1, 12 min. 15 sec.

Biology Journal
Looking at Classification from an Historical Perspective
Have students research the work of Aristotle, Linnaeus, Haeckel, Whittaker, and Woese and then write an essay that compares their work. L3

PROJECT
How Many Are There?
Have students work in groups to research the issue of diminishing diversity. Students should make a display of illustrations or photos that visually explore this issue. L2 COOP LEARN

Using Science Terms

On the chalkboard, write the names of the six kingdoms and the two words *eukaryote* and *prokaryote*. Have students use dictionaries to find the meanings of the Latin or Greek prefixes and suffixes in each word. Then ask them to explain how each name describes its group. L1 ELL

Display

Make a bulletin board display from photos and illustrations of organisms from each kingdom. Group the visuals according to kingdom. Invite students to add photographs they find in magazines and newspapers.

Activity

Have students use a microscope to observe a variety of prokaryotic and eukaryotic cells. Ask students to explain differences they observe. L2 ELL

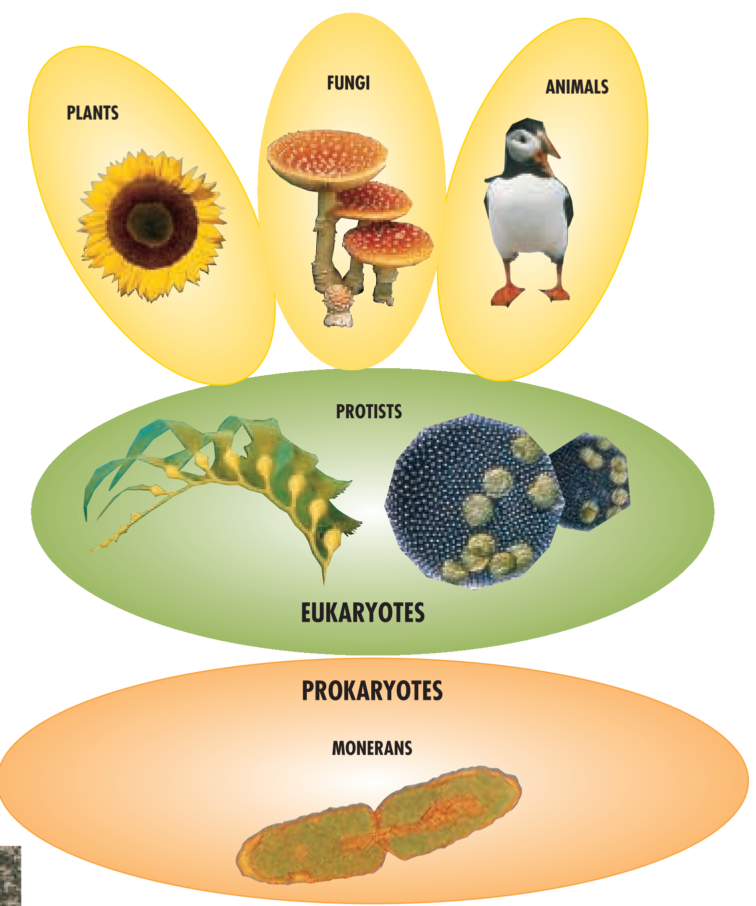
GLENCOE TECHNOLOGY

CD-ROM
BioQuest: *Biodiversity Park*
Disc 3, 4

THE FIVE-KINGDOM SYSTEM

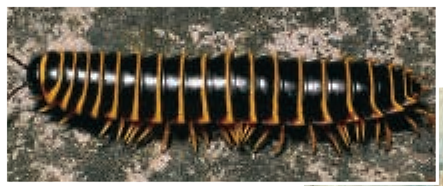
A flurry of ideas for new classification systems followed close on the heels of the discovery of prokaryotes. In 1959, American biologist R.H. Whittaker (1924–1980) proposed a five-kingdom system (right) that soon became universally accepted. The five kingdoms were Monera (bacteria), Protista (algae and other protists), Fungi (mushrooms, molds, and lichens), Plantae (mosses, ferns, and cone-bearing and flowering plants), and Animalia (invertebrate and vertebrate animals). The kingdom Monera included all the prokaryotes; the other four kingdoms consisted of eukaryotes. Fungi, plants, and animals were easily distinguished by their modes of nutrition. But the kingdom Protista was a grab bag, a diverse assortment of living things—some plantlike, some animal-like, some funguslike—that did not fit clearly into any of the other eukaryotic kingdoms.

WHITTAKER'S SYSTEM



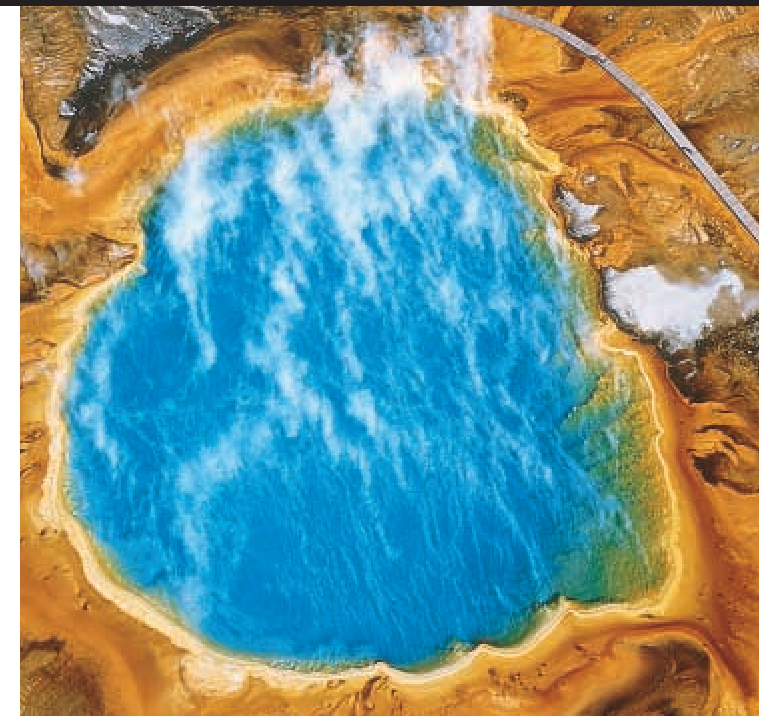
EVOLUTIONARY RELATIONSHIPS

With the five-kingdom system in place, many taxonomists focused their research on reclassifying living things in terms of their evolutionary relationships rather than on their structural similarities. Present-day organisms, such as the millipede (below), were compared with extinct forms preserved in the fossil record, such as the trilobite (below right). New biochemical techniques made it possible to compare nucleotide sequences in genes and amino-acid sequences in proteins from different organisms to determine how closely those organisms were related.



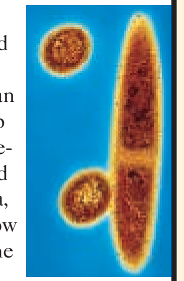
MILLIPEDE

TRILOBITE



GRAND PRISMATIC SPRING, YELLOWSTONE NATIONAL PARK

THE SIXTH KINGDOM



ARCHAEA
Magnification: 29 000×

In the 1970s, genetic tests showed that members of the kingdom Monera were far more diverse than anyone had suspected. One group of bacteria, originally called archaebacteria (ancient bacteria), seemed especially unusual. Archaebacteria, or archaeans, as most biologists now refer to them, often live in extreme environments—very hot or salty places—such as the Grand Prismatic Spring (left) in Yellowstone National Park. In 1996, researchers sequenced the archaean genome and discovered that these tiny cells are as different from bacteria as you are. A sixth kingdom was formed.

DOMAINS AND SUPERKINGDOMS

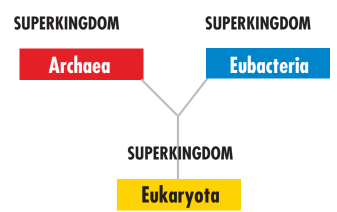
The discovery of the nature of Archaea led C. R. Woese and his colleagues at the University of Illinois to propose a new classification scheme (left) made up of three domains. The domain Bacteria has one kingdom, Eubacteria (true bacteria). The domain Archaea contains two kingdoms. The domain Eukarya consists of the kingdoms Fungi, Plantae, and Animalia. Woese recognized that there were unresolved questions regarding where to place protists in Eukarya.

Recent efforts to establish the most natural groupings of organisms that show evolutionary relationships use molecular genetics. Genbank is a federal agency that gathers genetic data for all of Earth's organisms. Genbank's system (below left) recognizes three superkingdoms: Archaea, Eubacteria, and Eukaryota. The eukaryotes are not grouped into kingdoms because the six kingdoms we are now familiar with show many different origins.

WOESE'S SYSTEM

DOMAIN Bacteria	DOMAIN Archaea	DOMAIN Eukarya
KINGDOMS Eubacteria	KINGDOMS Euryarchaeota (Methanogens)	KINGDOMS Animalia
	Crenarchaeota (Thermophiles)	Plantae
		Fungi
		Protista?

GENBANK'S SYSTEM



EXPANDING Your View

1 **THINKING CRITICALLY** How have technological advances, such as improved microscopes and new biochemical tests, changed biological classification?

2 **JOURNAL WRITING** The kingdom Protista contains very diverse organisms—from unicellular "animallike" amebas to multicellular "plantlike" giant kelp. In your journal, predict what might happen to the protist kingdom in the next few years as biologists study its members in more detail at biochemical and genetic levels.

Enrichment

Have students identify which species of archaebacteria was sequenced. Current information suggests that archaebacteria may live in subsurface pores of rocks, as well as in other less severe environments. Ask how such data might affect the view of archaebacteria as "extremophiles."

Answers to Expanding Your View

1. Improved microscopes allow scientists to differentiate between prokaryotic and eukaryotic cells and among the cell organelles. Biochemical tests determine the presence of specific molecules in cells.
2. Answers will vary. Possible ideas are that organisms currently classified in Kingdom Protista may be reclassified into other kingdoms or that the subgroupings in Kingdom Protista may become additional kingdoms.

Going Further

Have students choose a kingdom to research. They should explore the kingdom's diversity by determining its number of phyla and listing representative organisms. Urge the students to include other information they discover. L2

Resource Manager

Critical Thinking/Problem Solving, p. 17 L3

MEETING INDIVIDUAL NEEDS

Visually Impaired

Kinesthetic When discussing eukaryotic cells and prokaryotic cells, provide visually impaired students with cell models. Provide them with a scale that compares the size difference between prokaryotic and eukaryotic cells.

MEETING INDIVIDUAL NEEDS

English Language Learners

Have the students complete a time line about the historical evolution of biological classification. Provide students with a baseline of major events to include and a word bank of names and key terms. L1 ELL

Section 17.2

Prepare

Key Concepts

Students will learn how to interpret phylogenetic classification models. They will compare the characteristics of organisms in the six kingdoms.

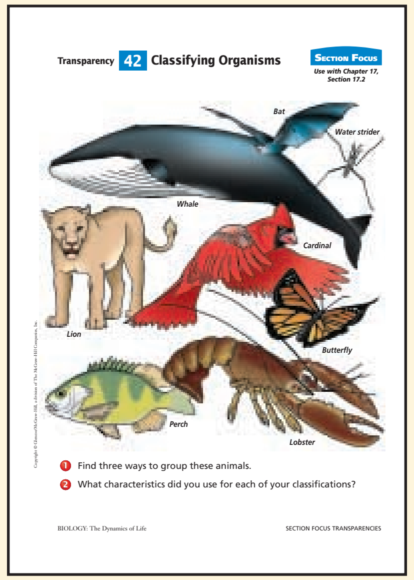
Planning

- Obtain pictures of seven dinosaurs for MiniLab 17-2.
- Collect laboratory glassware for the Alternative Lab.
- Gather some protractors for Problem-Solving Lab 17-2.
- Obtain metric rulers and guidebooks with dichotomous keys of insects for the Biolab.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 42** on the overhead projector and have students answer the accompanying questions. L1 ELL



SECTION PREVIEW

Objectives

Describe how evolutionary relationships are determined.

Explain how cladistics reveals phylogenetic relationships.

Compare the six kingdoms of organisms.

Vocabulary

phylogeny
cladistics
cladogram
eubacteria
protist
fungus

Section 17.2 The Six Kingdoms

Suppose you entered a room full of strangers and were asked to identify two related people. What clues would you look for? You might listen for similar-sounding voices. You might look for similar hair, eye, and skin coloration. You might watch for shared behaviors and mannerisms among individuals. When taxonomists want to identify evolutionary relationships among species, they examine certain characteristics of species.


Western sword fern *(Polystichum munitum)* (above) and Northern holly fern *(Polystichum lonchitis)* (inset)

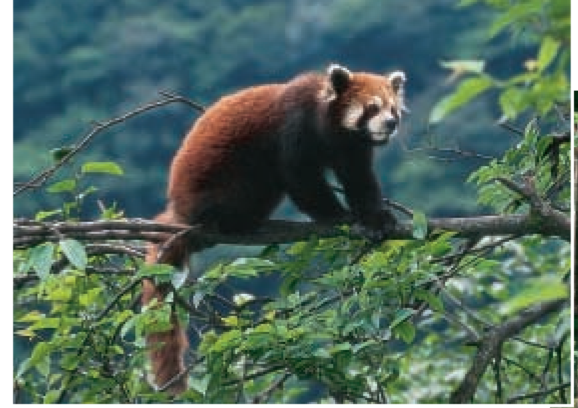
How Are Evolutionary Relationships Determined?

Evolutionary relationships are determined on the basis of similarities in structure, breeding behavior, geographical distribution, chromosomes, and biochemistry. Because these characteristics provide the clues about how species evolved, they also reveal the probable evolutionary relationships of species.

Structural similarities

Structural similarities among species reveal relationships. For example, the presence of many shared physical structures implies that species are closely related and may have evolved from a common ancestor. For example, because lynxes and bobcats have structures more similar to each other than to members of any other groups, taxonomists suggest that they share a common ancestor. Likewise, plant taxonomists use structural evidence to classify dandelions and sunflowers in the same family, Asteraceae, because they have similar flower and fruit structures.

If you observe an unidentified animal that can retract its claws, you can infer that it belongs to the cat family. You can then assume that the animal has other characteristics in common with cats. Taxonomists observe and compare features among members of different taxa and use this information to infer their evolutionary history.



a

b

Figure 17.6
DNA sequences in red pandas (a) and giant pandas (b) suggest that red pandas are related to raccoons and giant pandas are related to bears.

Breeding behavior

Sometimes, breeding behavior provides important clues to relationships among species. For example, two species of frogs, *Hyla versicolor* and *H. chrysoscelis*, live in the same area and look similar. During the breeding season, however, there is an obvious difference in their mating behavior. The males of each species make different sounds to attract females, and therefore attract and mate only with members of their own group. Scientists concluded that the frogs were two separate species.

Geographical distribution

The location of species on Earth helps biologists determine their relationships with other species. For example, many different species of finches live on the Galapagos Islands off the coast of South America. Biologists propose that in the past some members of a finchlike bird species that lived in South America reached the Galapagos Islands, where they became isolated. These finches probably spread into different niches on the volcanic islands and evolved over time into many distinct species. The fact that they share a common ancestry is supported by their geographical distribution in addition to their genetic similarities.

Chromosome comparisons

Both the number and structure of chromosomes, as seen during mitosis and meiosis, provide evidence about relationships among species. For example, cauliflower, cabbage, kale, and broccoli look different but have chromosomes that are almost identical in structure. Therefore, biologists propose that these plants are related. Likewise, the similar appearance of chromosomes among chimpanzees, gorillas, and humans suggest a common ancestry.

Biochemistry

Powerful evidence about relationships among species comes from biochemical analyses of organisms. Closely related species have similar DNA sequences and, therefore, similar proteins. In general, the more inherited nucleotide sequences that two species share, the more closely related they are. For example, the DNA sequences in giant pandas and red pandas differ. They differ so much that many scientists suggest that giant pandas are more closely related to bears than to red pandas such as the one shown in ***Figure 17.6.*** Read the *BioTechnology* feature at the end of this chapter to learn more about how chemical similarities can reveal evolutionary relationships.

2 Teach

Activity

Interpersonal Make a set of cards containing the features biologists use to classify organisms. Have a student select a card, describe the feature, and explain why the feature is useful in classification. Return the card to the set and continue until each student has chosen a card. L2

Visual Learning

Figure 17.6 Ask students in what ways the giant panda and red panda are similar and different. *They have similar names and body shape and features, but have different DNA sequences.*

Internet Address Book

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

Resource Manager

Section Focus Transparency 42 and Master L1 ELL

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Museum Collections*
Disc 3

VIDEODISC
Biology: The Dynamics of Life
Museum Collections (Ch. 8)
Disc 1, Side 2, 20 sec.

MEETING INDIVIDUAL NEEDS

Gifted

Visual-Spatial Have students report on the use of cytochrome c to determine the relatedness of organisms. Ask them to use at least two visual aids, such as transparencies or large charts, to present their findings. L3

Visual Learning

Use Figure 17.7 to explain how cladistics reflects an organism's phylogeny. Provide students with other examples of derived traits, such as tetrapod limbs and mammalian and avian endothermy, that might be used in cladistic analysis.

Assessment

Knowledge Ask students to define in their own words the meaning of derived trait. *It is an inherited characteristic that is unique in an organism's phylogeny.* L2

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Using Cladistics

Vertebrate Cladogram

Phylogenetic Classification: Models

Word Origin

phylogeny
From the Greek words *phylon*, meaning "related group," and *geny*, meaning "origin." Organisms are classified based on their phylogeny.

cladistics
From the Greek word *klados*, meaning "sprout" or "branch." Cladistics is based on phylogeny.

Species that share a common ancestor also share an evolutionary history. The evolutionary history of a species is called its **phylogeny** (fy LOH juh nee). A classification system that shows the evolutionary history of species is a phylogenetic classification and reveals the evolutionary relationships of species.

Early classification systems did not reflect the phylogenetic relationships among organisms. As scientists learned more about geologic time, they modified the early classification schemes to reflect the phylogeny of species.

Cladistics

One biological system of classification that is based on phylogeny is **cladistics** (kla DIHS tiks). Scientists who use cladistics assume that as groups of organisms diverge and evolve from a common ancestral group, they retain some unique inherited characteristics that taxonomists call derived traits. Biologists identify a group's derived traits and use them to make a branching diagram called a **cladogram** (KLAD eh gram). A cladogram is a model of the phylogeny of a species, and models are important tools for understanding scientific concepts.

Cladograms are similar to the pedigrees, or family trees, you studied in an earlier chapter. Branches on both pedigrees and cladograms show proposed ancestry. In a cladogram, two groups on diverging branches probably share a more recent ancestor than those groups farther away. If two organisms are near each other on a pedigree's branch, they also share an ancestor. However, an important difference between cladograms and pedigrees is that, whereas pedigrees show the direct ancestry of an organism from two parents, cladograms show a probable phylogeny of a group of organisms from ancestral groups.

In *Figure 17.7*, you see the cladogram for modern birds, such as robins. How was the cladogram developed? First, taxonomists identified the derived traits of modern birds—flight feathers, light bones, a wishbone, down feathers, and feathers with shafts. Next, they identified ancestral species that have at least some of these traits. Most biologists agree that the ancestors of birds are a group of dinosaurs called theropods. Some of these theropods are *Allosaurus*, *Archaeopteryx*, *Velociraptor*, *Sinornis*, and *Protoarchaeopteryx*. Each of these ancestors has a different number of derived traits. Some groups share more derived traits than others.

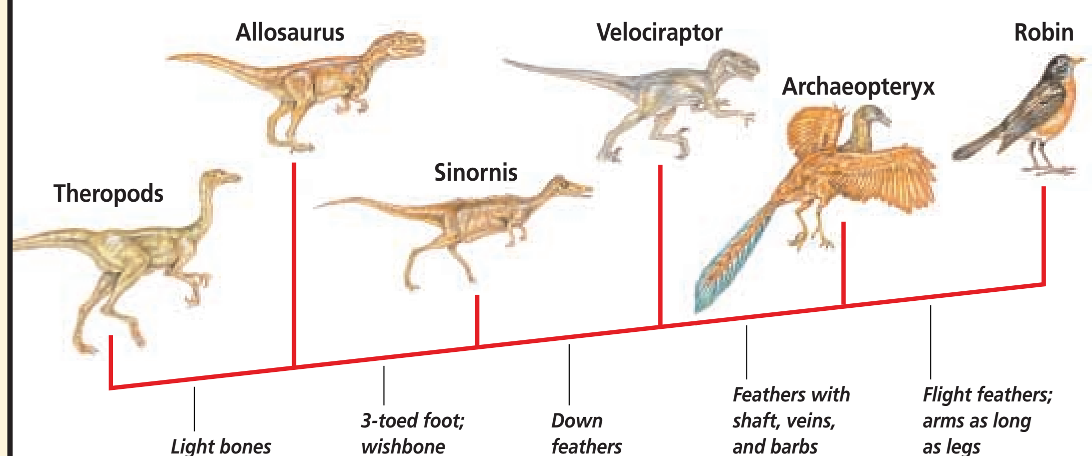
Finally, taxonomists constructed the robin's cladogram from this information. They assume that if groups share many derived traits, they share common ancestry. Thus, *Archaeopteryx* and the robin, which share four derived traits, are on adjacent branches, indicating a recent common ancestor. Use the *MiniLab* on this page to construct a cladogram for another species.

Another type of model

In this book, you will see cladograms and other types of models that provide information about the phylogenetic relationships among species. One type of model resembles a fan. Unlike a cladogram, a fanlike model may communicate the time organisms became extinct or the relative number of species in a group. A fanlike diagram incorporates fossil information and the knowledge gained from anatomical, embryological, genetic, and cladistic studies.

In *Figure 17.8* on the next page, you can see a fanlike model of the six-kingdom classification system. For easy reference, the same diagram is located inside the back cover of this textbook. This model includes both Earth's geologic time and the probable evolution of organisms during that timespan. In addition, this fanlike diagram helps you to find relationships between modern and extinct species.

Figure 17.7
This cladogram uses the derived traits of a modern bird, such as the robin, to model its phylogeny. Groups that are closer together on the cladogram probably share a more recent common ancestor.



MiniLab 17-2 Classifying

Using a Cladogram to Show Relationships Cladograms were developed by Willie Hennig. They use derived characteristics to illustrate evolutionary relationships.

Procedure

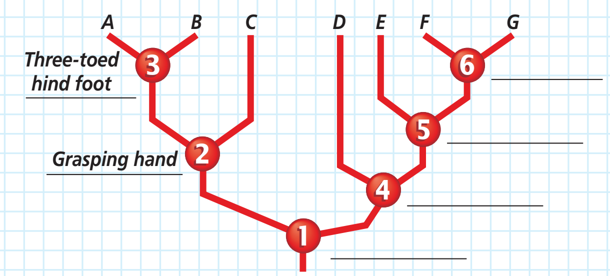
1. The following table shows the presence or absence of six derived traits in the seven dinosaurs that are labeled A-G.
2. Use the information listed in *Table 17.1* to answer the questions below.

Table 17.1 Derived traits of dinosaurs

Dinosaur trait	A	B	C	D	E	F	G
Hole in hip socket	yes	yes	yes	yes	yes	yes	yes
Extension of pubis bone	no	no	no	yes	yes	yes	yes
Unequal enamel on teeth	no	no	no	no	yes	yes	yes
Skull has "shelf" in back	no	no	no	no	no	yes	yes
Grasping hand	yes	yes	yes	no	no	no	no
Three-toed hind foot	yes	yes	no	no	no	no	no

Analysis

1. Copy the partially completed cladogram. Complete the missing information on the right side.



2. How many traits does dinosaur F share with dinosaur C, with dinosaur D, and with dinosaur E?
3. Dinosaurs A and B form a grouping called a clade. The dinosaurs A, B, and C form another clade. What derived trait is shared only by the A and B clade? By the A, B, and C clade? By the D, E, F, and G clade?
4. Traits that evolved very early, such as the hole in the hip socket, are called primitive traits. The traits that evolved later, such as a grasping hand, are called derived traits. Are primitive traits typical of broader or smaller clades? Are derived traits typical of broader or smaller clades? Give an example in each case.

MiniLab 17-2

Purpose
Students will make a cladogram.

Process Skills
acquire information, analyze information, apply concepts, classify, compare and contrast, interpret data

Teaching Strategies
■ Check student answers to question 1 before they complete the remaining analysis questions.
■ Show students pictures of dinosaurs A-G.

Archaeopteryx *Allosaurus*
Plateosaurus *Stegosaurus*
Parasaurolophus *Triceratops*
Pachycephalosaurus

Expected Results
Students will complete the cladogram as follows: node 1 = hole in hip socket, node 4 = extension of pubis bone, node 5 = unequal enamel, node 6 = skull shelf.

Analysis
1. See "Expected Results."
2. 1 trait with C, 2 traits with D, and 3 traits with E.
3. three-toed hind foot; grasping hand; extension of pubis bone
4. broader—hole in hip socket extends to all 7 animals; smaller—three-toed hind foot extends to only 1 clad

Assessment

Performance Ask students to classify the seven dinosaurs according to their external similarities and record their scheme on the chalkboard. Then, show them how a cladogram classifies these dinosaurs. Use the Performance Task Assessment List for Making and Using a Classification System in **PASC**, p. 49. L2

BIOLOGY JOURNAL

Vertebrate Phylogeny

Naturalist Provide students with the following list of vertebrate classes: birds, reptiles, mammals, amphibians, and fish. In addition, give them a listing of derived traits, such as legs, feathers, and hair. Have them construct a vertebrate cladogram from the lists. L3

MEETING INDIVIDUAL NEEDS

Visually Impaired

Kinesthetic Fold paper into a fan shape. Open the fan and allow visually impaired students to feel its shape. Explain that in the fanlike phylogenetic model, prokaryotes are located where the fan forms a point (its base). Just above this point are eukaryotes, which evolved from prokaryotes. L1

Resource Manager

BioLab and MiniLab Worksheets, p. 82 L1

Quick Demo

Show students actual examples of organisms in each kingdom. Briefly describe the characteristics of the organisms. You may have to use photos or drawings of different archaebacteria and eubacteria

Visual Learning

Figure 17.8 Ask the students to explain how time is indicated on the model. *Earth's earliest organisms are near the center of the model, and those that appeared later are near the rim.*

Resource Manager

Concept Mapping, p. 17 L3 ELL

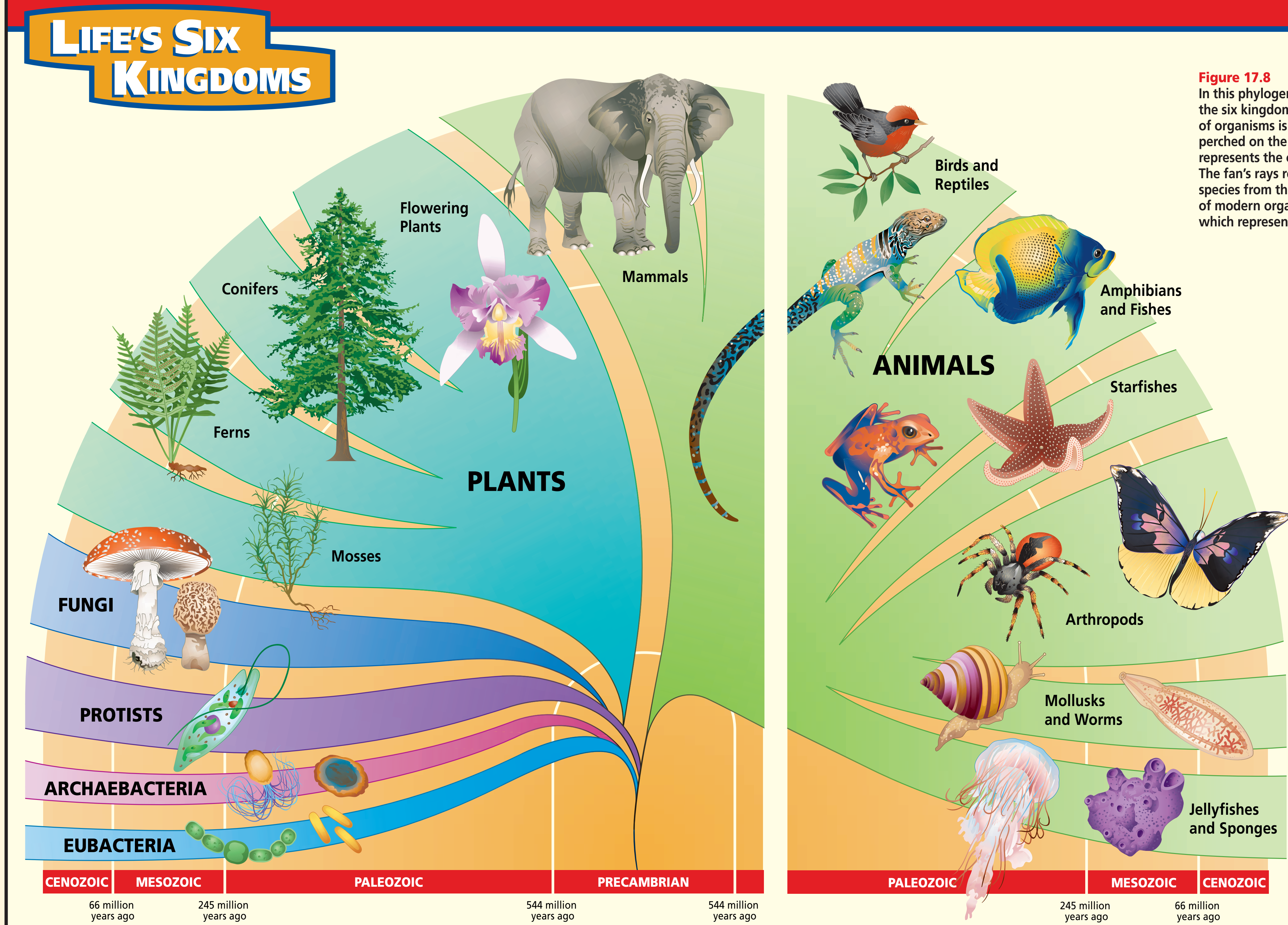


Figure 17.8
In this phylogenetic diagram, six colors represent the six kingdoms of living things. The phylogeny of organisms is represented by a fanlike structure perched on the Geologic Time Scale. The fan's base represents the origin of life during the Precambrian. The fan's rays represent the probable evolution of species from the common origin. The major groups of modern organisms occupy the fan's outer edge, which represents present time.

Brainstorming

Have students use Figure 17.8 to identify other organisms that belong in each group. Ask them to explain their choices.

Time Line

Visual-Spatial Have students make a time line of the evolutionary history of life on Earth using the information in Figure 17.8. Remind students that their time lines represent millions of years. L1

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Domains/Six Kingdoms

CD-ROM
Biology: The Dynamics of Life
Explorations: *The Five Kingdoms*
Disc 3

Resource Manager

Reteaching Skills Transparency 26 and Master L1 ELL

Alternative Lab

Classification of Glassware

Purpose
Students will classify laboratory glassware.

Materials
laboratory glassware such as flasks, test tubes, beakers, stirring rods, thermometers, bottle stoppers, pipets, droppers, funnels, petri dishes, graduated cylinders, and jars

Procedure
Give students the following directions.

1. Obtain a set of glassware to classify according to its structure and function. CAUTION: *Handle glassware carefully because it can break easily. Dispose of broken glass as your teacher directs.*
2. Classify the glassware into two groups. Then subdivide the groups. Note each group's characteristics and the names of its glassware.
3. Place the glassware groups in a phylogenetic model such as in Figure 17.8. Consider how the glassware may have "evolved," and why some groups may be more closely "related" than others. Closely related groups should be closer together on your model.
4. Make a large diagram of your phylogenetic model.

Analysis

1. What glassware features were most useful in your model? *Responses are likely to indicate functional traits.*
2. How did your phylogenetic model differ from the model in Figure 17.8? *The glassware model lacks dates, which would be purely speculative.*

Assessment

Portfolio Have students write an essay about the "evolution" of their glassware. They should use the glassware's features to support their statements. Use the Performance Task Assessment List for Writing in Science in **PASC**, p. 87. L2 P

Problem-Solving Lab 17-2

Purpose

Students will determine the approximate number of species in each kingdom.

Process Skills

classify, make and use graphs, use numbers, think critically

Teaching Strategies

- Have a supply of protractors.
- Review how to use a protractor and calculate percent.

Background

The number of named species is around 1.4 million, but estimates of as many as 30 million living species have been proposed. Of the species named, about 75% are animals. This value probably does not reflect their relative abundance, but rather their size and accessibility for study.

Thinking Critically

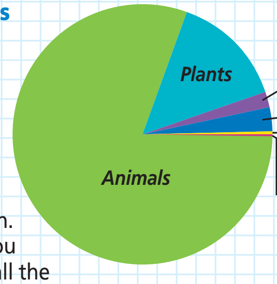
1. Answers should be close to the following. Archaebacteria = 500, Eubacteria = 10 000, Protista = 70 000, Fungi = 110 000, Plants = 510 000, Animals = 2 900 000.
2. 3 580 500
3. Archaebacteria = 0.028%, Eubacteria = 0.3%, Protista = 2.8%, Fungi = 5.6%, Plants = 15%, Animals = 76%.
4. Answers may vary—the number of species may vary due to the extinction and discovery of species.

Assessment

Skill Have students find the approximate number of species that become extinct each day, week, month, and year and summarize their findings in a data table. Then ask them to list the factors that contribute to the loss of species. Use the Performance Task Assessment List for Data Table in **PASC,** p. 37. L3

Problem-Solving Lab 17-2 Using Graphs

How many species are there in each kingdom? You may not realize it, but you probably already have seen more than 1000 different species since you were born. How close might you be to having seen all the different species that exist?



Analysis

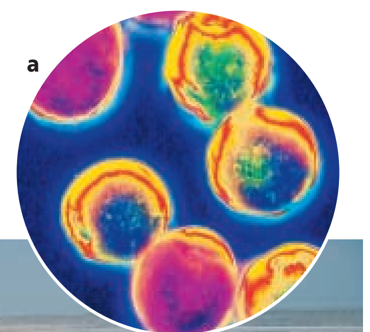
The circle graph above shows Earth's six kingdoms.

Thinking Critically

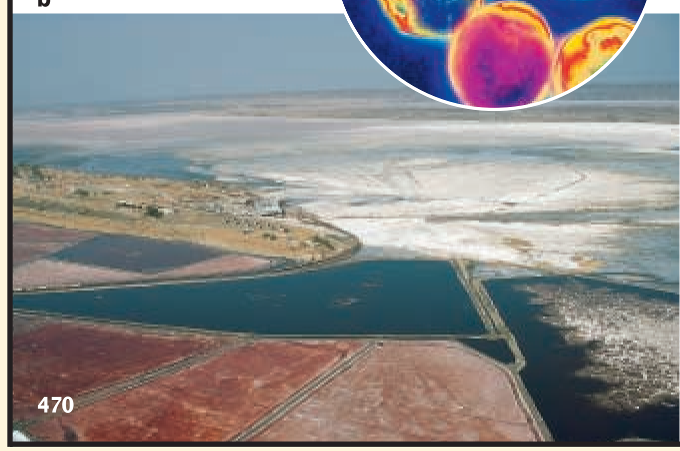
1. List the approximate number of species for each of the six kingdoms. Each degree of the circle graph is equal to 10 000 species. Archaebacteria represent 1/20 of a degree, and Eubacteria represent 1 degree.
2. What is the approximate total number of species for all life forms on Earth?
3. What approximate percent of the total life forms on Earth are in each kingdom?
4. Why do all questions refer to the number of species as "approximate?"

Figure 17.9
Most archaebacteria, such as these salt-loving *Halococcus* (a) live in extreme environments, such as seawater evaporating ponds (b).

a



b



Groups of organisms that are closer in the same colored ray share more inherited characteristics and are probably more closely related than groups that are farther apart. For example, find the jellyfishes, the fishes, and the reptiles on the model. Notice that fishes and reptiles are closer to each other than they are to the jellyfishes, indicating that they are more closely related to each other than they are to jellyfishes.

The Six Kingdoms of Organisms

As you saw in *Figure 17.8,* the six kingdoms of organisms are archaebacteria, eubacteria, protists, fungi, plants, and animals. In general, differences in cellular structures and methods of obtaining energy are the two main characteristics that distinguish among the members of the six kingdoms. The six kingdoms reflect evolutionary history. Learn more about the number of species in each kingdom in the *Problem-Solving Lab* on this page.

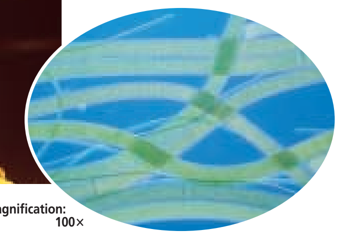
Prokaryotes

The prokaryotes, organisms with cells that lack distinct nuclei bounded by a membrane, are microscopic and unicellular. Some are heterotrophs and some are autotrophs. In turn, some prokaryotic autotrophs are chemosynthetic, whereas others are photosynthetic. Prokaryotes are classified in two kingdoms: Archaebacteria and Eubacteria. The oldest prokaryotic fossils are about 3.5 billion years old.

There are a few hundred species of archaebacteria and most of them live in extreme environments such as swamps, deep-ocean hydrothermal vents, and seawater evaporating ponds, *Figure 17.9.* Most of these environments are oxygen-free. The

Figure 17.10
Eubacteria are a diverse kingdom of prokaryotes. Both their cellular structure and the way they obtain food vary widely.

A The bacteria that cause strep throat are heterotrophs called *Streptococcus.*



B Cyanobacteria, such as *Oscillatoria,* live in freshwater and are photosynthetic.

lipids in the cell membranes of archaebacteria, the composition of their cell walls, and the sequence of nucleic acids in their ribosomal RNA differ considerably from those of other prokaryotes. However, their genes have a similar structure to those in eukaryotes.

All of the other prokaryotes, more than 10 000 species of bacteria, are classified in Kingdom Eubacteria. **Eubacteria,** such as the ones you see in *Figure 17.10,* have very strong cell walls and a less complex genetic makeup than found in archaebacteria or eukaryotes. They live in most habitats except the extreme ones where the archaebacteria live. Although some eubacteria cause diseases, such as strep throat and pneumonia, most bacteria are harmless and many are actually helpful.

Protists: A diverse group

Kingdom Protista contains diverse species as you can see in *Figure 17.11,* but protists do share some characteristics. A **protist** is a eukaryote that

Word Origin

eubacteria
From the Greek words *eu,* meaning "true," and *bakterion,* meaning "small rod." Eubacteria are prokaryotes.

protist
From the Greek word *protistos,* meaning "very first" or "superlative." The first eukaryote cells were protists.

Figure 17.11
Although these three protists look different, they are all eukaryotes and live in moist environments.

A Funguslike slime molds often creep through damp forests, feeding on microorganisms.

B The paramecium is an animal-like protist that moves through water.

C These kelps are multicellular plantlike protists. Although they look like plants, they do not have organs or organ systems.

Quick Demo

Display pictures or actual organisms from each kingdom. Have students observe the organisms and identify common traits of each kingdom's organisms.

Visual Learning

Use the organisms in Figures 17.10 and 17.11 to point out the differences between bacteria and protists. Be certain that students understand that, unlike protists, bacteria lack a nucleus and organelles bound by membranes.

Resource Manager

Basic Concepts Transparency 24 and Master L2 ELL
Laboratory Manual, pp. 121-124 L2

Internet Address Book

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

Portfolio

Gathering Protists

Kinesthetic Have students obtain water samples from local ponds. Tell them to scrape the underneath surfaces of rocks into their collecting jars. Have them use microscopes to observe their samples and sketch any protists they see, explaining why each is a protist. L1 ELL P

PROJECT

Classifying Organisms

Visual-Spatial Ask students to make a photo essay of the six kingdoms. They should label each organism with its scientific and common name and explain the essay to their group members. L1 ELL

Visual Learning

Use Figures 17.12 and 17.13 to compare the features of fungi and plants. Have students explain why fungi used to be classified in the plant kingdom. *The fungi are plantlike and have cell walls, but, unlike plants, the fungi are not autotrophic.*

Activity

Naturalist Have students collect fungi from their local environment. Caution them not to ingest any of the fungi as some are poisonous and to wash their hands after collecting. Ask them to describe the similarities and differences among the fungi. *The differences include the shapes and colors of fruiting bodies, the gills, and other features. Similarities include cell walls made of chitin and heterotrophy.* L3

Brainstorming

Ask students to brainstorm a list of familiar plants. Be sure they include trees, shrubs, and grasses, as well as annual and perennial garden plants.

Visual Learning

Figure 17.14 Ask students what senses the cheetah uses while running. *sight, touch, and smell*

3 Assess

Check for Understanding

Visual-Spatial Show students pictures of organisms. Ask them to identify the kingdom to which each belongs. L1

Figure 17.12
Morels are edible fungi that grow for only a few days in only a few places.

lacks complex organ systems and lives in moist environments. Fossils of plantlike protists show that protists existed on Earth up to two billion years ago. Although some protists are unicellular, others are multicellular. Some are plantlike autotrophs, some are animal-like heterotrophs, and others are funguslike heterotrophs that produce reproductive structures like those of fungi.

Fungi: Earth's decomposers

Organisms in Kingdom Fungi are heterotrophs that do not move from place to place. A **fungus** is either a unicellular or multicellular eukaryote that absorbs nutrients from organic materials in the environment. Fungi first appeared in the fossil record about 400 million years ago. There are more than 100 000 known species of fungi, including the one you see in *Figure 17.12.*

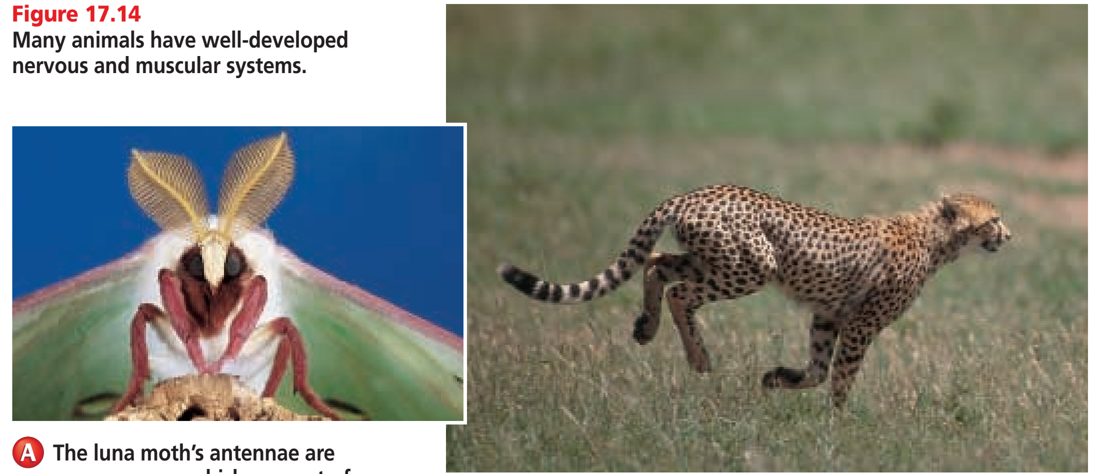
Plants: Multicellular oxygen producers

All of the organisms in Kingdom Plantae are multicellular, photosynthetic eukaryotes. None moves from place to place. A plant's cells usually contain chloroplasts and have cell walls composed of cellulose. Plant cells are organized into tissues that, in turn, are organized into organs and organ systems. You can see two of the many diverse types of plants in *Figure 17.13.*

The oldest plant fossils are a little more than 400 million years old.

Figure 17.13
A *Hibiscus* is just one kind of flowering plant (a). Tropical tree ferns do not produce flowers (b).

Figure 17.14
Many animals have well-developed nervous and muscular systems.



A The luna moth's antennae are sense organs, which are part of its nervous system. The moth's antennae detect tiny quantities of chemicals in the air.

B The cheetah uses many of its organ systems, especially its nervous and muscular systems, to speed through the grasslands, perhaps chasing prey.

However, some scientists propose that plants existed on Earth's land masses much earlier than these fossils indicate. Plants do not fossilize as often as organisms that contain hard structures, such as bones, which more readily fossilize than soft tissues.

There are more than 500 000 known species of plants. Although you may be most familiar with flowering plants, there are many other types of plants, including mosses, ferns, and evergreens.

Animals: Multicellular consumers

Animals are multicellular heterotrophs. Nearly all are able to move from place to place. Animal cells do not have cell walls. Their cells are organized into tissues that, in turn, are organized into organs and complex organ systems. Some organ systems in animals are the nervous, circulatory, and muscular systems, *Figure 17.14.* Animals first appeared in the fossil record 600 million years ago.

Section Assessment

Understanding Main Ideas

1. How do members of the different kingdoms obtain nutrients?
2. Make a list of the characteristics that archaebacteria and eubacteria share. Then make a list of their differences.
3. For what reasons is a fanlike diagram a useful model for phylogenetic classification? Explain each of your reasons.
4. How do cladograms and fanlike diagrams differ?

Thinking Critically

5. Why is phylogenetic classification more natural than a system based on characteristics such as medical usefulness, or the shapes, sizes, and colors of body structures?

SKILL REVIEW

6. **Making and Using Tables** Make a table that compares the characteristics of members of each of the six kingdoms. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Reteach

Intrapersonal Have students make flash cards with a photo of an organism on one side and, on the reverse, the name, kingdom, and distinguishing features of the organism. Have them use their cards in groups. L1 ELL COOP LEARN

Extension

Ask students to research the classification of show dogs or cats and explain the additional classification levels that are used. L2

Assessment

Performance Set up 15 stations, with numbered specimens. Use microscopes for bacteria and protists and pictures for the larger organisms. Ask students to move among the stations and identify each organism's kingdom. L1 ELL

4 Close

Activity

Visual-Spatial Give groups of students a large piece of paper and markers. Ask them to sketch a phylogenetic model similar to the one in Figure 17.8. L2 ELL COOP LEARN

Resource Manager

Reinforcement and Study Guide, pp. 75-76 L2
Content Mastery, pp. 81, 83-84 L1

Cultural Diversity

Classifying Lion Tamarins

Introduce students to the work of Adelmar Coimbra-Filho, Brazil's leading primatologist. Since the 1960s, Coimbra-Filho has published many articles on the systematics of the lion tamarin, *Leontopithecus*, a newly discovered primate species. Coimbra-Filho directs Rio de Janeiro's Primate Center. He has coordinated efforts with the World Wildlife Fund to save lion tamarins from extinction. Elicit from students the importance of the work done by taxonomists and systematicists in discovering new species.

Section Assessment

1. Prokaryotes and protists use photosynthesis or chemosynthesis. Fungi absorb nutrients. The plants photosynthesize. Animals eat other organisms.
2. They are unicellular prokaryotes with cell walls. They differ in their RNA and cell wall composition.
3. The location of species shows their relationships and when they evolved.
4. Cladograms show phylogeny; fanlike diagrams show evolutionary history in geologic time.
5. Phylogenetic classification relies on inherited features and can provide more reliable information than other systems that do not.
6. Information for tables can be found on pages 470-473.

INVESTIGATE BioLab

Time Allotment
One class period

Process Skills
classify, observe and infer, compare and contrast, interpret data, sequence

PREPARATION

Alternative Materials

- Students can make a key from Styrofoam packing pieces or kitchen utensils with a variety of sizes, shapes, and colors.

ANALYZE AND CONCLUDE

1. The keys may or may not have been alike. The groups may have first divided the beetles into groups based on different features, such as size rather than color.
2. Useful: size, color, and shape of various body parts, number of body sections, and antennae features; not useful: number of legs, number of antennae, habitat.
3. Having only two choices makes it easy to analyze organisms. In many keys, the choice is that the organism either has or does not have a particular characteristic.

Resource Manager

BioLab and MiniLab Worksheets, pp. 83-84 L2

INVESTIGATE BioLab

Making a Dichotomous Key

Do you remember the first time you saw a beetle? You may have asked someone nearby, "What is it?" You may still be naturally curious and want to know the names of insects you find. To help identify organisms, taxonomists have developed dichotomous keys. A dichotomous key is a set of paired statements that can be used to identify organisms. When you use a dichotomous key, you choose one statement from each pair that best describes the organism. At the end of each statement you chose, you are directed to the next set of statements to use. Finally, you will read a statement that contains at the end the name of the organism or the group to which it belongs.


Scarab beetle


Longhorned woodboring beetle

PREPARATION

Problem
How is a dichotomous key made?

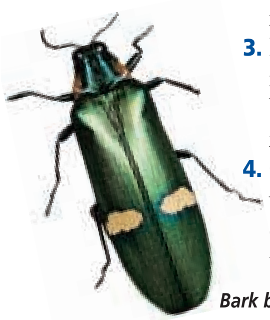
Objectives
In this BioLab, you will:

- **Classify** organisms on the basis of structural characteristics.
- **Develop** a dichotomous key.

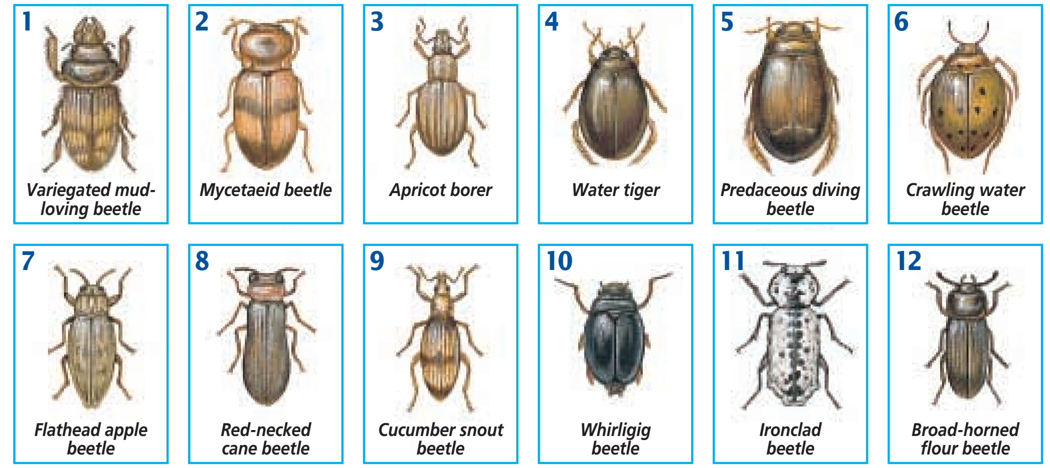
Materials
sample keys from guidebooks
metric ruler

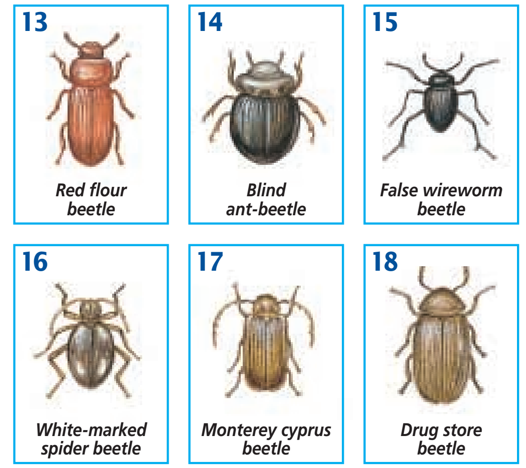
Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

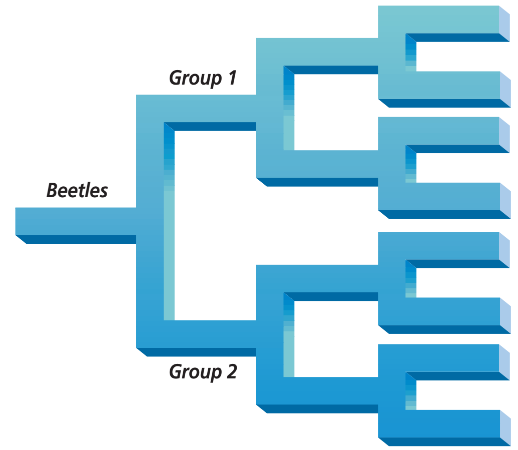
PROCEDURE


Bark beetle

1. Study the drawings of beetles.
2. Choose one characteristic of the beetles and classify the beetles into two groups based on that characteristic. Take measurements if you wish.
3. Record the chosen characteristic in a diagram like the one shown. Write the numbers of the beetles in each group on your diagram.
4. Continue to form subgroups within your two groups based on different characteristics. Record the characteristics and numbers of the beetles in your diagram until you have only one beetle in each group.
5. Using the diagram you have just made, make a dichotomous key for the beetles. Remember that each numbered step should contain two choices for classification. Begin with 1A and 1B. For help, examine sample keys provided by your teacher.
6. Exchange dichotomous keys with another team. Use their key to identify the beetles.







ANALYZE AND CONCLUDE

1. **Comparing and Contrasting** Was the dichotomous key you constructed exactly like those of other students? Explain your answer.
2. **Analyzing Data** What characteristics were most useful for making a classification key for beetles? What characteristics were not useful?
3. **Thinking Critically** Why do keys typically offer only two choices and not more?

Going Further

Application Using the same procedure that you just used to make a beetle key, make a dichotomous key to identify the students in your class.

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

INVESTIGATE BioLab

Assessment

Performance Give each group a bag of mixed beans. Ask them to make a dichotomous key for the beans. Have the groups exchange their keys to see if they work. Students can place the keys in their portfolios. Use the Performance Task Assessment List for Making and Using a Classification system in **PASC**, p. 49. L2 P

Going Further

Naturalist Have students use 10-20 features of their classmates, such as hair color or some personal belongings, such as notebooks, shoes, and backpacks, to classify them. You may want to select neutral features in advance to avoid sensitive issues. L1

Internet Address Book

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

PROCEDURE

Teaching Strategies

- Have the students examine samples of dichotomous keys.
- Explain that a well-designed key has contrasting traits from which to chose.
- Point out that after a beetle is identified, its characteristics are not used to develop additional choices.
- Have groups make transparencies of their keys and explain them. Ask students to list the keys' strengths and weaknesses.

Data and Observations

Have students exchange their keys. If another group can use them, their accuracy is confirmed.

BIO Technology

Purpose
Students learn how molecular characteristics can reveal the relative timing of evolutionary events.

Background
In DNA-DNA hybridization, the temperature at which hybrid strands separate indicates the species' DNA similarity. The higher the separation temperature, the stronger the bond, and the more similar are the DNAs. Estimates of the time when types of organisms began evolving assume that mutations occur at a fairly constant, unknown rate. Therefore, DNA sequencing only estimates when major evolutionary events occurred.

Teaching Strategies
- Remind students that molecular analysis adds to traditional morphological information.
- In contrast to distantly related species, closely related species, such as humans and chimpanzees, diverged from a common ancestor fairly recently.

Investigating the Technology
Students may infer that their order of evolution and relationship was fishes, reptiles, dogs, and lastly humans.

Going Further
Fossil DNA, such as that from mummies or bones, helps scientists determine relationships among living and fossil species. Ask students to research how such work is conducted and what it has revealed.

BIO Technology: Molecular Clocks

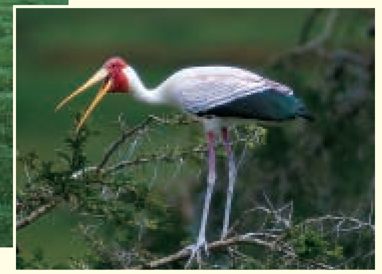
How long ago did animals first appear on Earth? Did the giant panda evolve along the same family line as bears or raccoons? To help answer questions like these, biologists have learned how to use DNA, proteins, and other biological molecules as "clocks" that reveal details about evolutionary relationships.

Accumulated molecular differences in the DNA of two species can indicate how long they have been separate species. Comparing both the DNA base sequences and the amino acid sequence of a specific protein of two species can indicate the closeness of their relationship.

Comparing DNA One way to compare DNA is to measure how strongly the single strands of DNA from two species will bond. This method is known as DNA-DNA hybridization. Double-stranded DNA from each species is heated to separate the complementary strands. Then the single strands of DNA from each species are mixed and allowed to cool. As the DNA cools, the single strands from the two species bond, or hybridize. If the species are closely related, more of their DNA base pairs will match, and their DNA strands will bond strongly.

Another method of comparing the DNA of species is called DNA sequencing. Biologists select a gene that species have in common and compare the genes' bases. Counting how many base pairs differ can indicate approximately how long ago each species became distinct. Estimates obtained by DNA sequencing show that many of the animal phyla began to appear on Earth about 1.2 billion years ago.

Protein Clocks A specific protein is assumed to evolve at about the same rate in all species that contain the protein. Comparing the amino acid sequences of the protein in several species can show about how long ago the species diverged. For example, cytochrome *c* is a protein in the cells of aerobic organisms. Both human and chimpanzee cytochrome *c* has the same amino acid sequence. The cytochrome *c* of other primates has a different amino acid sequence.

Flamingoes and storks are closely related.

Application for the Future
DNA-DNA hybridization has shown that flamingoes are more closely related to storks than they are to geese. Protein clock data suggest that humans and chimpanzees became distinct species recently in the history of Earth. These biotechnological methods are useful in determining phylogenetic relationships.

Investigating the Technology
Analyzing Information The cytochrome *c* found in humans and chimpanzees differs from that found in dogs by 13 amino acids, in tuna by 31 amino acids, and in rattlesnakes by 20 amino acids. What assumptions can you make based on this information?

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

Summary

Section 17.1 Classification

Main Ideas
- Although Aristotle developed the first classification system, Linnaeus laid the foundation for modern classification systems by using structural similarities to organize species and by developing a binomial naming system for species.
- Scientists use a two-word system called binomial nomenclature to give species scientific names.
- Classification provides an orderly framework in which to study the relationships among living and extinct species.
- Organisms are classified in a hierarchy of taxa: kingdom, phylum or division, class, order, family, genus, and species.

Vocabulary
binomial nomenclature (p. 454)
class (p. 459)
classification (p. 453)
division (p. 459)
family (p. 458)
genus (p. 454)
kingdom (p. 459)
order (p. 459)
phylum (p. 459)
taxonomy (p. 453)

Section 17.2 The Six Kingdoms

Main Ideas
- Biologists use similarities in body structures, breeding behavior, geographic distribution, chromosomes, and biochemistry to determine evolutionary relationships.
- Modern classification systems are based on phylogeny. Both cladograms and the fanlike models include information about phylogeny.
- Taxonomists organize organisms into six kingdoms. Kingdoms Archaebacteria and Eubacteria contain only unicellular prokaryotes that differ chemically from each other. Kingdom Protista contains eukaryotes that lack complex organ systems. Kingdom Fungi includes heterotrophic eukaryotes that absorb their nutrients. Kingdom Plantae includes multicellular eukaryotes that are photosynthetic. Kingdom Animalia includes multicellular, eukaryotic heterotrophs with cells that lack cell walls.

Vocabulary
cladistics (p. 466)
cladogram (p. 466)
eubacteria (p. 471)
fungus (p. 472)
phylogeny (p. 466)
protist (p. 471)

Understanding Main Ideas

1. Which of the following is a scientific name of a species?
   a. *bison bison*
   b. Mimus Polyglottis
   c. *homo Sapiens*
   d. *Quercus alba*
2. Which of the following would be a useful characteristic to use in cladistics?
   a. derived characteristic
   b. similar habitat
   c. mutations
   d. random differences

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. d
2. a

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage: *The Geometry of Life, Evolution, Molecular Genetics, and DNA Sequencing* (Ch. 5)
8 min.

The Dawn of Humankind, DNA Studies Create Controversy (Ch. 7)
3 min. 30 sec.

Bridging of Fossils and Genetic Research (Ch. 9)
2 min. 30 sec.

GLENCOE TECHNOLOGY

VIDEOTAPE
MindJogger Videoquizzes
Chapter 17: *Organizing Life's Diversity*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

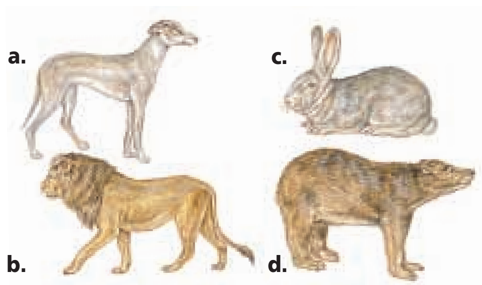
Chapter Assessment, pp. 97-102
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 17 quiz

3. d
4. b
5. d
6. c
7. a
8. b
9. b
10. c
11. phylogeny; taxonomy
12. protist
13. division; phylum
14. genus
15. order
16. phylogeny
17. Fungi
18. binomial nomenclature
19. classification
20. family

Applying Main Ideas

21. Aristotle based his system on a small number of organisms and used criteria, such as habitat, that do not reveal phylogenetic relationships. Linnaeus classified large numbers of organisms based on similarities in physical characteristics that often reflect relationships.
22. It belongs in Kingdom Fungi because it is eukaryotic, multicellular, not autotrophic, and has cell walls.

3. Which taxon contains the others?
   a. family c. order
   b. species d. phylum
4. Unlike a pedigree, a cladogram _______.
   a. shows ancestry
   b. shows hypothesized phylogeny
   c. indicates ancestry from two parents
   d. explains relationships
5. Which of the following pairs of terms are most closely related?
   a. Linnaeus—DNA analysis
   b. Aristotle—binomial nomenclature
   c. protist—prokaryote
   d. taxonomy—classification
6. Linnaeus based most of his classification system on _______.
   a. cell organelles
   b. biochemical comparisons
   c. structural comparisons
   d. embryology
7. A group of prokaryotes that often live in extreme environments is the _______.
   a. archaebacteria c. eubacteria
   b. protists d. fungi
8. Based on the structures of the organisms you see, which of the following is most closely related to a domestic cat?



The Princeton Review Test-Taking Tip

You Are Smarter Than You Think
Nothing on these tests is rocket science. You can learn to master any of it. When you admit that, you're 90 percent of the way home. Just keep practicing.

9. A flaw in Aristotle's classification system was that _______.
   a. it included too many organisms
   b. it did not show natural relationships
   c. large organisms were not included
   d. it was based on Greek instead of Latin
10. Which of the following describes the organism shown to the right?
   a. unicellular consumer
   b. unicellular producer
   c. multicellular consumer
   d. multicellular producer

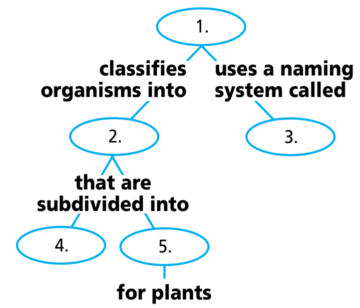
11. The evolutionary history of a species is its _______, but _______ is the science that groups and names species.
12. A diverse group of eukaryotes that lack complex organ systems and live in moist places is the _______.
13. A group of related classes in the plant kingdom is a _______, but in the animal kingdom it is called a _______.
14. From their scientific names, *Quercus alba* and *Quercus rubrum*, you know that these species of oak trees are in the same _______.
15. _______ is the name given to the taxon that contains all the families of carnivores, such as bears and cats.
16. Modern classification systems are based on _______.
17. A multicellular heterotrophic eukaryote that absorbs nutrients would be classified in Kingdom _______.
18. Linnaeus devised a two-word naming system for organisms that is called _______.
19. The process of grouping similar objects or information is called _______.
20. All genera of dogs are classified in the taxon called a _______.

Applying Main Ideas

21. Explain why Linnaeus's system of classification is more useful than Aristotle's.
22. You find an unusual organism growing on the bark of a dying tree. Under a microscope, you observe that its cells are eukaryotic, have cell walls, and do not contain chloroplasts. Into what kingdom would you classify this organism? Explain your decision.

Thinking Critically

23. **Observing and Inferring** In what way does the work of Linnaeus illustrate the nature of science?
24. **Classifying** Make a list of a minimum of five physical features you could use to classify trees.
25. **Comparing and Contrasting** Compare the classification system of your school library with that of organisms.
26. **Concept Mapping** Complete the concept map by using the following vocabulary terms: divisions, taxonomy, kingdoms, binomial nomenclature, phyla.



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

Identify the organisms in these photographs.

Key
1A Front and hind wings similar in size and shape, and folded parallel to the body when at rest..damselflies
1B Hind wings wider than front wings near base, and extended on either side of the body when at rest..................................dragonflies

Classifying Study the dichotomous key and answer the following questions.

1. **Interpreting Data** The insect in the photo on the right is a damselfly because it has _______.
   a. wings that are opaque
   b. wings folded at rest
   c. smaller eyes
   d. wings not similar in size
2. The insect in the photo on the left is a dragonfly because it has _______.
   a. wings that are opaque
   b. wings folded at rest
   c. larger eyes
   d. wings not similar in size
3. **Classifying** From the key and the photographs above, identify traits that indicate dragonflies and damselflies may have evolved from a common ancestor.

Thinking Critically

23. Linnaeus developed his classification system based on observation and experimentation.
24. The features might include bark types, buds, leaves, root systems, branch patterns, and the average height and girth of each species.
25. Librarians group books by type and content similarities, but not by their chronology. Classification of organisms is based on both similarities and evolutionary history, a factor that implies chronology.
26. 1. Taxonomy; 2. Kingdoms; 3. Binomial nomenclature; 4. Phyla; 5. Divisions

Assessing Knowledge & Skills

1. b
2. d
3. two pairs of wings located on same body segment; wings transparent with clearly defined veins; long, thin body. Accept any reasonable answers.

BioDigest

National Science Education Standards: UCP.1, UCP.2, UCP.3, UCP.4, UCP.5, A.2, C.3, C.4, C.6, D.3, E.2, G.1, G.2, G.3

Prepare

Purpose

This BioDigest can be used as an overview of the concepts of evolution and classification. If time is limited, you may wish to use this unit summary to teach these concepts in place of the chapters in the Change Through Time unit.

Key Concepts

Students are introduced to the formation of Earth and the origins of life. They learn about the theory of evolution by natural selection and the classification of diverse organisms.

1 Focus

Bellringer

Before beginning the lesson, pass around iron, nickel, silica sand, and charcoal samples. Ask students to infer why Earth's core contains iron and nickel, and the crust contains silicon and carbon. *Dense elements fell into Earth's*

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Discovering Dinosaurs*
Disc 2

BioDigest

For a **preview** of the change through time unit, study this BioDigest before you read the chapters. After you have studied the change through time chapters, you can use the BioDigest to **review** the unit.

Change Through Time

Scientists propose that about five billion years ago Earth was extremely hot. As Earth slowly cooled, water vapor in its atmosphere fell as rain, forming today's oceans. Life had appeared in these oceans by 3.6 billion years ago. Since then, millions of species have evolved and then become extinct.

Geologic Time Scale

The four eras of the Geologic Time Scale span about 4.6 billion years of Earth's history.

The Precambrian Era

The Precambrian era encompasses approximately the first four billion years of the scale. Prokaryotic cells appear in rocks dated 3.6 billion years old. By the end of the Precambrian, the first eukaryotic cells had evolved.

The Geologic Time Scale illustrates major events that have occurred during Earth's 4.6-billion-year history. Each era is subdivided into smaller time spans called periods.

The Paleozoic Era

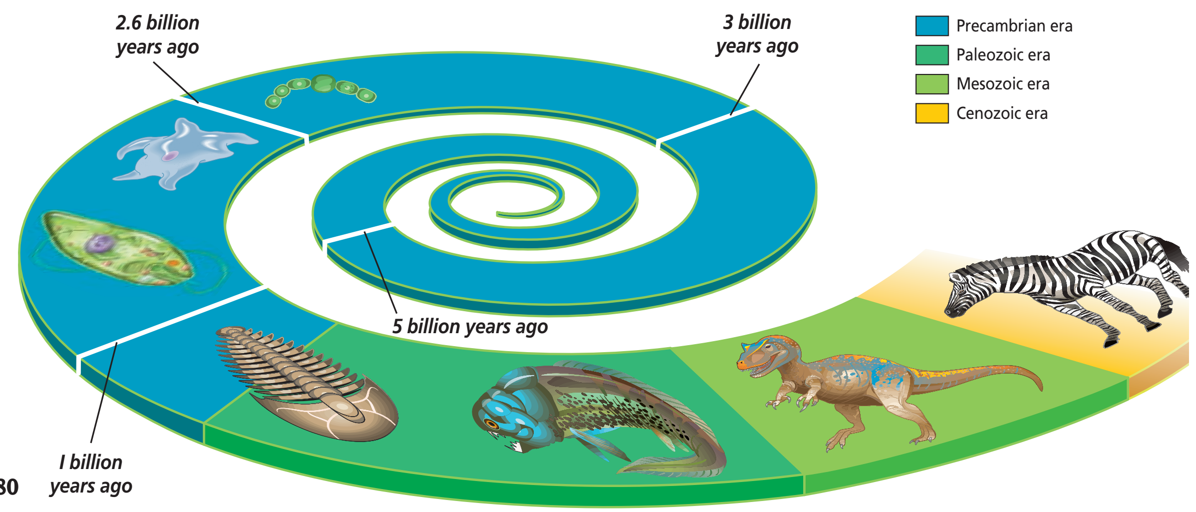
The following 300 million years make up the Paleozoic era. Many plant groups such as ferns and conifers appeared. Animal groups such as worms, insects, fishes, and reptiles evolved.

The Mesozoic Era

From 245 million years ago to 66 million years ago, the Mesozoic era, reptiles diversified, and mammals and flowering plants evolved. The Mesozoic, the Age of Dinosaurs, ended with a rapid extinction of the dinosaurs.

The Cenozoic Era

The current Cenozoic era, which has encompassed the previous 66 million years, is often referred to as the Age of Mammals. Primates, including humans, evolved during this era.



Origin of Life Theories

People once thought that life was able to arise spontaneously from nonliving material. Two scientists, Francesco Redi and Louis Pasteur, designed controlled experiments to try to disprove spontaneous generation. Their experiments convinced scientists to accept the theory of biogenesis—that life comes only from preexisting life.

Modern Ideas About the Origin of Life

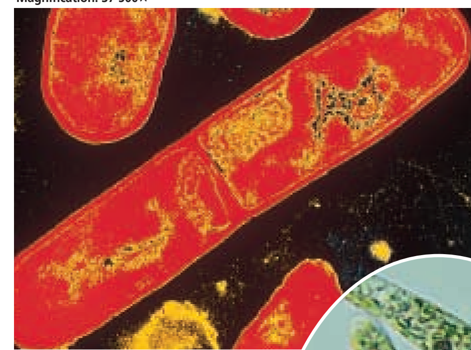
Most scientists agree that small organic molecules formed from substances present in Earth's early atmosphere and oceans. At some point, nucleic acids must have formed. Then, clusters of organic molecules might have formed protocells that may have evolved into the first true cells.

Louis Pasteur disproved the idea of spontaneous generation by conducting experiments using broth in swan-necked flasks like this one.

Heterotrophic, anaerobic prokaryotes were probably the earliest organisms to live on Earth. Chemosynthetic prokaryotes evolved over time, followed by oxygen-producing photosynthetic prokaryotes. As the amount of oxygen in the atmosphere increased, aerobically respiring eukaryotes probably evolved.

Magnification: 37 500×

A heterotrophic prokaryote



Magnification: 2250×

Eukaryotic cells, like this *Euglena*, contain organelles, such as mitochondria and chloroplasts, that probably evolved over time from a symbiotic association of prokaryotes.

Focus on History

Pioneers

Lynn Margulis

Two scientists, Stanley Miller and Harold Urey, pioneered work about the origin of Earth's life. Their experiments showed that small molecules can form complex organic materials under conditions that may have existed on early Earth. Other scientists demonstrated how these complex chemicals could form protocells, which are large, organized structures that carry out some activities associated with life, such as growth and division.

The American biologist Lynn Margulis proposed the endosymbiont theory. This theory suggests that cell organelles, such as mitochondria and chloroplasts, may have evolved when small prokaryotes entered larger prokaryotes and began to live symbiotically inside these larger cells.

BioDigest

2 Teach

Quick Demo

Kinesthetic Set up microscopes with slides of *Euglena* showing chloroplasts. Then, use the slides and photos on this page to explain Lynn Margulis's endosymbiont theory.

Field Trip

Arrange a class trip to a local natural history museum where the students can see much of the material discussed in this unit. Ask students to describe how the fossils they observe relate to today's species L1

Assessment

Skill Direct the students' attention to the Geologic Time Scale at the bottom of page 480. Ask them to order the eras from longest to shortest. L1

GLENCOE TECHNOLOGY

VIDEOTAPE
The Secret of Life
Gone Before You Know It: The Biodiversity Crisis
What's in Stetter's Pond: The Basics of Life
It's in the Genes: Evolution

Multiple Learning Styles

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

Kinesthetic Quick Demo, p. 481

Visual-Spatial Activity, pp. 482, 483; Biology Journal, p.482; Reteach, p. 484

Intrapersonal Project, p. 483; Biology Journal, p. 483; Meeting Individual Needs, p. 484

Linguistic Meeting Individual Needs, p. 482; Extension, p. 484

Logical-Mathematical Visual Learning, p. 482

Naturalist Activity, p. 485

Assessment Planner

Portfolio Assessment
Assessment, TWE, p. 482

Performance Assessment
Assessment, TWE, p. 484

Knowledge Assessment
BioDigest Assessment, SE, p. 485

Skill Assessment
Assessment, TWE, p. 481

Visual Learning

Logical-Mathematical Point out the photos and the Vital Statistics on this page. Ask students which isotopes they would use to date the shells that are several thousand years old and the dinosaur that lived more than a million years ago. *carbon-14 for the shells, and uranium-235 for the dinosaur* L2

Activity

Visual-Spatial Have students look at slides of diatomaceous earth. Point out that the shells they observe are fossils of protists that lived thousands of years ago. L1 ELL

Assessment

Portfolio Have students write an essay in which they distinguish between the two types of fossil dating methods and explain the value of each method. L2 P

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Exploration: *The Record of Life,* Disc 2

Evidence of Evolution

Charles Darwin and Alfred Wallace proposed the idea of natural selection as a mechanism of evolution. Natural selection occurs because all organisms, which produce many more young than can survive, compete for mates, food, space, and other resources. Such competition favors the survival of individuals with variations that help them compete successfully in a specific environment. Individuals that survive to reproduce can pass their traits to the next generation.

Fossils

The fossil record contains evidence for evolution and provides a record of life on Earth. Fossils come in many forms, such as imprints, the burrow of a worm, or an actual bone. By studying fossils, scientists learn how organisms changed over time.

Scientists use relative and radiometric dating methods to determine the age of fossils. Relative dating assumes that in undisturbed layers of rock, the deepest rock layers contain the oldest fossils. Radiometric dating analysis compares the known half-lives of radioactive isotopes to a ratio of the amount of radioactive isotope originally in a rock or fossil with the amount of isotope in the rock or fossil today.

Fossils of dinosaurs similar to this *Tyrannosaurus rex* have been found in North and South America, and also in China.

The members of related species have variations such as those you see in the shells of these snails.

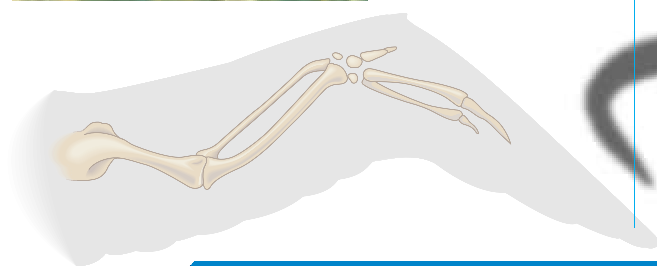
Vital Statistics

Half-Lives of Radioactive Isotopes
Radium226—1620 years
Carbon14—5710 (± 30) years
Potassium40—1.3 billion years
Rubidium87—4.7 billion years
Uranium235—710 million years
Uranium238—4.5 billion years

Additional Evidence

Similar anatomical structures, called homologous structures, in different organisms might indicate possible shared ancestry. For example, both vertebrate limbs and developmental stages show how vertebrates might be related. In addition, similarities among the nucleic acid sequences of species provide evidence for evolution. Direct evidence for evolution has been observed in the laboratory among species of bacteria that have developed resistance to antibiotics.

The bones that make up a penguin's wings are homologous to those that form the wings of an albatross. The forelimb bones of four-legged vertebrates are also homologous.



Mechanics of Evolution

Evolution occurs when a population's genetic equilibrium changes. Mutations, genetic drift, and migration may slightly disrupt the genetic equilibrium of large populations, but they will greatly alter that of small populations. Natural selection affects the genetic equilibrium of all populations.

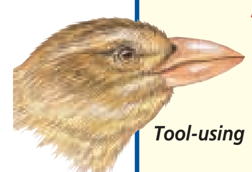
Three Patterns of Evolution

Three patterns of natural selection lead to speciation. Stabilizing selection favors the survival of a population's average individuals for a feature. Directional selection naturally selects for an extreme feature. Disruptive selection, which usually occurs when a physical barrier divides one population into two, eventually produces two populations, each with one of a feature's extreme characteristics.

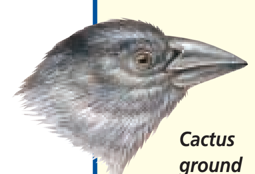
In California, there are seven subspecies of reproductively isolated salamanders, *Ensatina eschscholtzi.*

Focus on Adaptations

Adaptive Radiation in Galapagos Finches



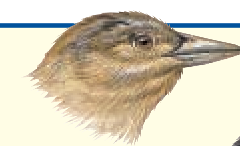
Tool-using



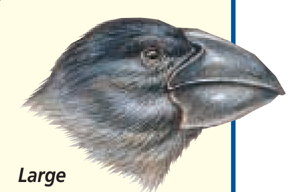
Cactus ground

The finches in the Galapagos Islands are an example of the rapid development of a species. It has been proposed that the 13 species of Galapagos finches evolved from just a few ancestral species of finches that arrived from South America and colonized the newly formed habitats of these volcanic islands.

The adaptive radiation of finch species occurred as the original finch population adapted to the different niches found in the islands. The pressures of natural selection produced different species, each with their own feeding and habitat adaptations.



Warbler



Large ground

Vegetarian

Insectivorous

Biology Journal

The Endosymbiont Theory

Visual-Spatial Have students read more about the endosymbiont theory and make a labeled drawing in their journals that illustrates Margulis's ideas about how mitochondria, chloroplasts, and flagella evolved. L3

Meeting Individual Needs

English Language Learners

Linguistic To enhance students' understanding of the information in this BioDigest, have them write a summary in their native language and in English. L2 ELL

Project

Collecting Fossils

Intrapersonal Have students make a collection of fossils from the local area. Ask them to identify each type of fossil and the organism that was fossilized and research additional information. L2

Biology Journal

Patterns of Evolution

Intrapersonal Have the students describe the three patterns of evolution using examples other than those presented in the text. L2

Activity

Visual-Spatial Have students make a bulletin board collage of organisms from magazine photos. Ask each student to point out an adaptation that helps one of the organisms survive. L1

Visual Learning

Ask students how albatross, penguin, and other vertebrate forelimbs are homologous. *They all possess bones from the same embryonic structures that have evolved for different purposes.*

Quick Demo

Display a small, caged mammal, such as a hamster or a mouse. Have students describe the animal's variations and its adaptations for survival in its natural environment.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life, Exploration: *Selection Pressure,* Disc 2
Animation: *Geographic Isolation and Speciation,* Disc 2

VIDEODISC
Biology: The Dynamics of Life
Geographic Isolation (Ch.6)
Disc 1, Side 2, 17 sec.

BioDigest

3 Assess

Check for Understanding

Have students explain adaptations that are advantageous for a primate in its environment. L1

Reteach

Visual-Spatial Have students make a time line of the Geologic Time eras and their life forms. L1

Extension

Linguistic Have students read a chapter from one of Darwin's books and then discuss what they learned. L3

Assessment

Performance Give students examples of classification levels and have them identify the examples' taxonomic levels. For example, *Homo sapiens* is the species, cats is the family, and mollusks is the phylum. L2

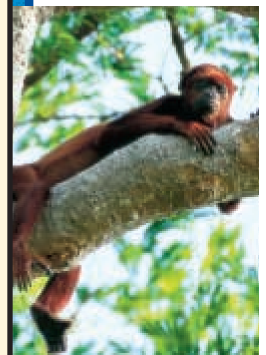
Meeting Individual Needs

Gifted

Intrapersonal Have students research the Galapagos finches and tortoises and compare these two examples of divergent evolution. L3

Primate Evolution

Primates are a grouping of mammals with adaptations such as binocular vision, opposable thumbs, and mobile skeletal joints. These adaptations help arboreal animals survive in forest trees, where all primates may have originally lived and where most primates still live.



Unlike most Old World monkeys, New World monkeys, such as this howler monkey, have prehensile tails that are used as a fifth limb.

There are two categories of primates: the prosimians, including lemurs and tarsiers, and the anthropoids, including humans, apes, and monkeys. Monkeys are subdivided further into two groups that are called Old World monkeys and New World monkeys.

Primates first appear in the fossil record in the Cenozoic era. Fossils indicate that increasing brain size and bipedal locomotion are the two major trends in primate evolution.

Human Ancestry

Fossils of the possible human ancestors, called *Australopithecines,* were discovered in Africa and date from 5 to 8 million years ago. They show that these ancestors were bipedal and climbed trees.

After examining more recently discovered hominid fossils, paleoanthropologists suggest that the increasing efficiency of bipedal locomotion and the decreasing size of jaws and teeth were two directions of human evolution.

The appearance of both the genus *Homo* and stone tools coincides in the fossil record about 2 million years ago. The use of fire, tools, language, and ceremonies developed in later species of *Homo.*

Organizing Life's Diversity

Biologists use a classification system to study and communicate about both the three to ten million species living on Earth today and the many extinct species represented by fossils. Although Aristotle produced the first system of classification, Linnaeus developed the basic structure of the modern-day classification system. Linnaeus also developed a naming system, termed binomial nomenclature, that is still used today.

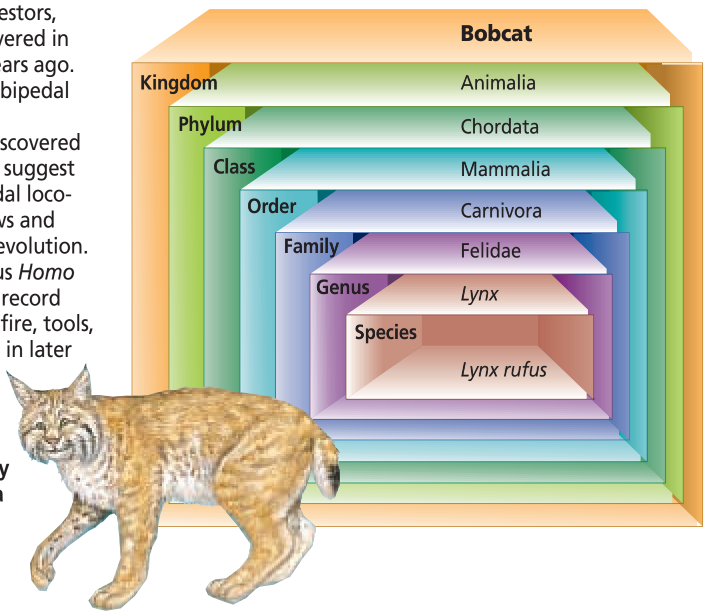
Today's phylogenetic classification uses a hierarchy of taxa to classify organisms. From largest to smallest, this hierarchy is kingdom, phylum or division, class, order, family, genus, and species. The most useful systems of classification show evolutionary relationships among species.

Vital Statistics

Hominids

Cranial Capacity of Hominids

Australopithecus—range of 375–550 cc
Homo habilis—range of 500–800 cc
Homo erectus—range of 750–1225 cc
Homo sapiens (archaic)—average of 1200 cc
Homo neanderthalensis—average of 1450 cc
Homo sapiens (modern)—average of 1350 cc



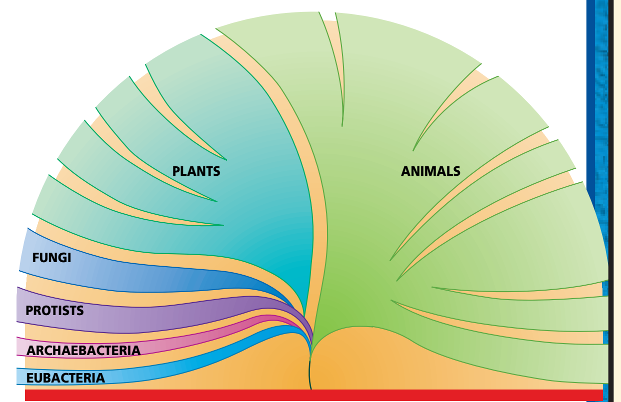
Taxonomists classify the bobcat within a hierarchy of taxa.

Six Kingdoms of Classification

Species are classified into one of six kingdoms. Prokaryotes belong to Kingdom Archaebacteria or Kingdom Eubacteria depending on their RNA sequences. Kingdom Protista contains the eukaryotes that lack complex organ systems and live in moist environments. The kingdom Fungi includes heterotrophic eukaryotes that absorb nutrients. Multicellular autotrophs with complex organ systems are placed in Kingdom Plantae. Kingdom Animalia includes multicellular heterotrophs.

Criteria for Classification

Biologists use criteria such as body structure, breeding behavior, and geographic distribution to classify organisms. Biochemistry and chromosome analysis are also important for explaining the relationships among organisms.



The phylogenetic relationship of the six kingdoms can be represented by a fanlike diagram.

BioDigest Assessment

Understanding Main Ideas

1. The Geologic Time Scale's longest era was the ________.
   a. Precambrian c. Mesozoic
   b. Paleozoic d. Cenozoic
2. When did humans and primates evolve?
   a. the Precambrian c. the Mesozoic
   b. the Paleozoic d. the Cenozoic
3. Who disproved spontaneous generation?
   a. Louis Pasteur c. Charles Darwin
   b. Lynn Margulis d. Miller and Urey
4. Which scientist proposed the endosymbiont theory?
   a. Francesco Redi c. Harold Urey
   b. Lynn Margulis d. Stanley Miller
5. Direct evidence of evolution includes ________.
   a. fossils
   b. anatomical similarities
   c. bacterial antibiotic resistance
   d. embryo
6. Which dating method relies on the position of rock layers?
   a. radiometric c. absolute
   b. relative d. morphology
7. Which of the following was proposed by Charles Darwin?
   a. endosymbiont hypothesis
   b. biogenesis
   c. natural selection
   d. experimentation
8. ________ is one of the two major groups of primates.
   a. Old World monkey c. apes
   b. New World monkey d. prosimians
9. Binomial nomenclature is a biological system of ________.
   a. naming species c. evolution
   b. phylogeny d. bipedalism
10. Multicellular heterotrophs are placed in Kingdom ________.
    a. Protista c. Plantae
    b. Fungi d. Animalia

Thinking Critically

1. Describe the types of organisms that existed in the Mesozoic. In the Cenozoic.
2. Explain how natural selection might be a mechanism of evolution.
3. Why do biologists classify organisms?

BioDigest

4 Close

Activity

Naturalist Provide photos and specimens of organisms and have students classify each organism in a kingdom. Or, have students bring in photos of members of each kingdom. L1

BioDigest Assessment

Understanding Main Ideas

1. a
2. d
3. a
4. b
5. c
6. b
7. c
8. d
9. a
10. d

Thinking Critically

1. Reptiles, mammals, and flowering plants flourished in the Mesozoic. Primates evolved in the Cenozoic and mammals and flowering plants have diversified.
2. When natural selection occurs, organisms pass environmentally beneficial traits to offspring. After a long time, a population consists of very different organisms.
3. to study and communicate about species.

GLENCOE TECHNOLOGY

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

CD-ROM
Biology: The Dynamics of Life
Exploration: *The Five Kingdoms*
Disc 3
Video: *Primate Characteristics*
Disc 2

GLENCOE TECHNOLOGY

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

VIDEODISC
Biology: The Dynamics of Life
Museum Collections (Ch. 8)
Disc 1, Side 2
20 sec.

Resource Manager

Reinforcement and Study Guide, pp. 77-78 L2
Content Mastery, pp. 85-88 L1