Chapter 13

The Diversity of Life

Peter Rabbit is a storybook character that was created by Beatrix Potter, who lived in England from 1866 to 1943. Although best known for her children's book The Tale of Peter Rabbit, Beatrix Potter also spent part of her life studying a life form called lichens. You might have seen flat, textured, light green lichens growing on top of a rock or on a rotting log. Beatrix Potter theorized that a lichen is composed of a special relationship between two different life forms: an algae and a fungus. Decades later, scientists discovered that Potter was exactly right about her theory on lichens. Read this chapter to learn more about lichens and other members of Kingdom Protista and Kingdom Fungi.

Key Questions

1. ***What is a scientific name like Felis domesticus used for, and what does it mean?***
2. ***What living things are included in Kingdom Protista and Kingdom Fungi?***
3. ***What are algae and fungi, and how do they reproduce?***

13.1 Taxonomy and Systematics

In Chapter 2, you learned that all living things are classified into one of six kingdoms. Kingdoms are divided into smaller and smaller levels until you narrow an organism down to the level of species (Figure 13.1). In this section, you will learn how scientists classify organisms according to their characteristics and evolutionary relationships. This process is called *systematics*.

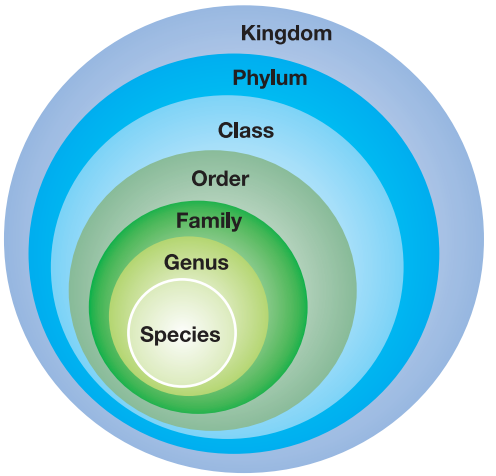
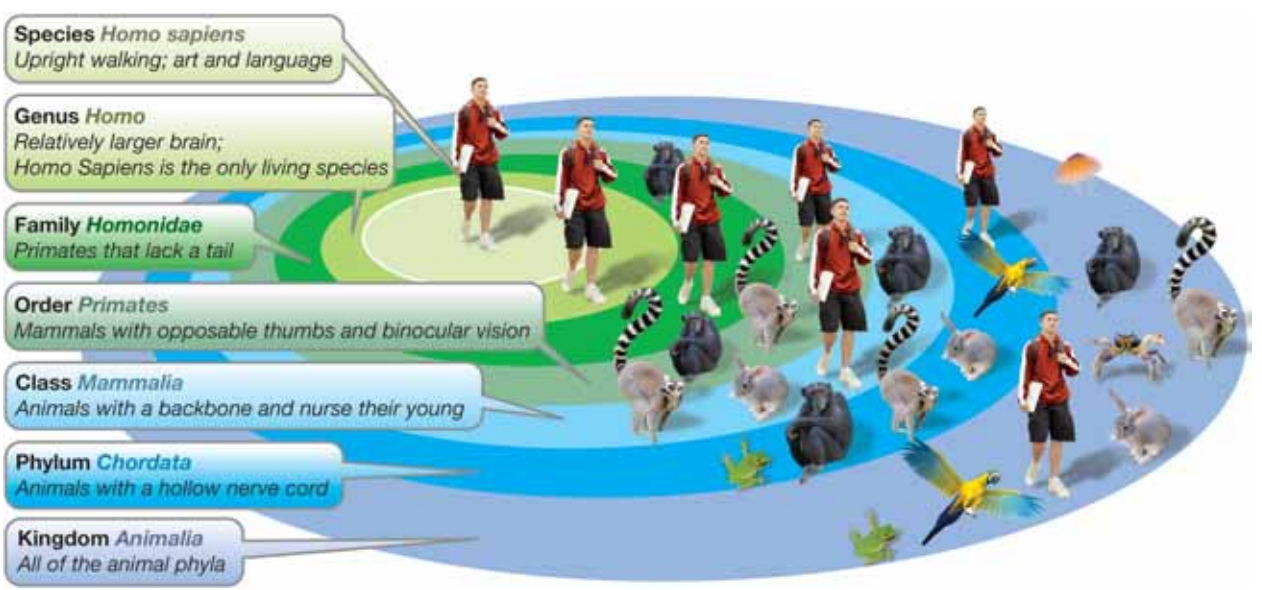


Figure 13.1: *The seven levels of classification of the Kingdom Animalia.*

Taxonomy revisited

Carolus Linnaeus A Swedish scientist and explorer named Carolus Linnaeus (1707–1778) developed a system of classification called *taxonomy* in the 1700s. Linnaeus classified living things according to their shared characteristics. He was able to study and classify over 7,000 species using his system. Recall that there are seven levels of classification. The diagram below shows how taxonomy is used to classify the human species.



STUDY SKILLS

A mnemonic to help you remember the levels of classification is:

King **P**hilip **C**ame **O**ver **F**rom **G**reater **S**cotland

Invent your own mnemonic for remembering the levels of classification for the Kingdom Animalia.

Scientific names

What is a scientific name?

Have you ever heard of an animal called a *Felis domesticus*? Sure you have, it's a house cat! When organisms are classified, scientists assign them a scientific name. A **scientific name** is the two-part, scientifically recognized name given to an organism, consisting of its genus and species. Scientific names are internationally recognized names given to organisms based on the system developed by Carolus Linnaeus.

Where do scientific names come from?

The first person to describe a new species gives it a scientific name. If the species belongs to an established genus, then the first part of the name is not new. If the organism cannot be placed into an existing genus, a new genus name must be given. Genus names are usually nouns. Species names are usually adjectives. There are many different sources for the species name including appearance, behavior, habitat, location where it was found, or the name of the person who discovered it.

The meaning of scientific names

You may have a difficult time understanding scientific names because they are usually in Latin or Greek. However, scientific names do have meanings. In our cat example (Figure 13.2), *Felis* is Latin for "cat" and *domesticus* is Latin for "domesticated." The scientific name is usually printed in italics, with the genus capitalized. A scientific name is incomplete without both the genus and species names.

The importance of scientific names

There are many different languages in the world. For example, a house cat is called a *gato* in Mexico. Different common names could cause confusion among scientists from around the world. Therefore, all scientists refer to each species by its scientific name. All known living things have a two-part scientific name. Do you know your scientific name? It's *Homo sapiens*!

VOCABULARY

scientific name - the two-part, scientifically recognized name given to an organism, consisting of its genus and species.

Figure 13.2: *The scientific name for the house cat.*

What is systematics?

Defining systematics

Darwin's theory of evolution led to the development of systematics. **Systematics** is the process of classifying living things according to evolutionary relationships. Systematics is based on shared, derived characteristics. *Derived* means that the characteristics evolved from a common ancestor.

Systematics and classification

Systematics is used to classify organisms and to show how they are related by evolution. For example, humans, chimpanzees, baboons, and lemurs are classified together in the order *primates*. Primates have binocular vision and opposable thumbs. *Binocular* refers to vision in which both eyes are used together. *Opposable* means the thumb can touch the tips of all of the other fingers. All four organisms are thought to have evolved from a common ancestor with similar characteristics.

Cladograms

The evolutionary development of primates can be shown on a simple *cladogram* (Figure 13.3). The characteristics listed along the right distinguish the levels above each *node* (the point where two branches meet). The nodes indicate a common ancestor between two groups. As you move up the diagram, organisms are separated into more specific groups. Following the diagram down to the root points to a common ancestor for all of the organisms.

DNA analysis

Today, scientists may use DNA analysis to classify living species. By comparing the DNA base sequences of different species, scientists can tell how closely related the species are. Then they can accurately classify them. For example, skunks were once thought to part of the weasel family which includes weasels, ferrets, and minks. All have a "musky" odor. By comparing their DNA though, scientists have determined that skunks are very different from other members of the weasel family and they have created a new family especially for skunks!

VOCABULARY

systematics - the process of classifying living things according to evolutionary relationships.

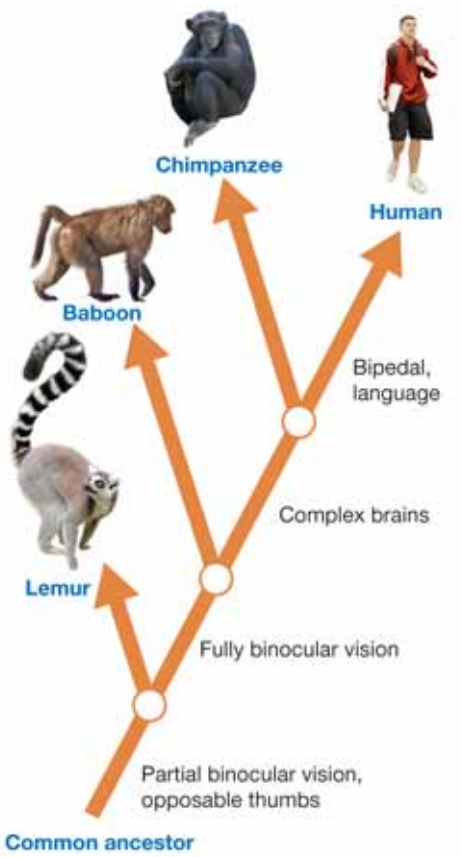
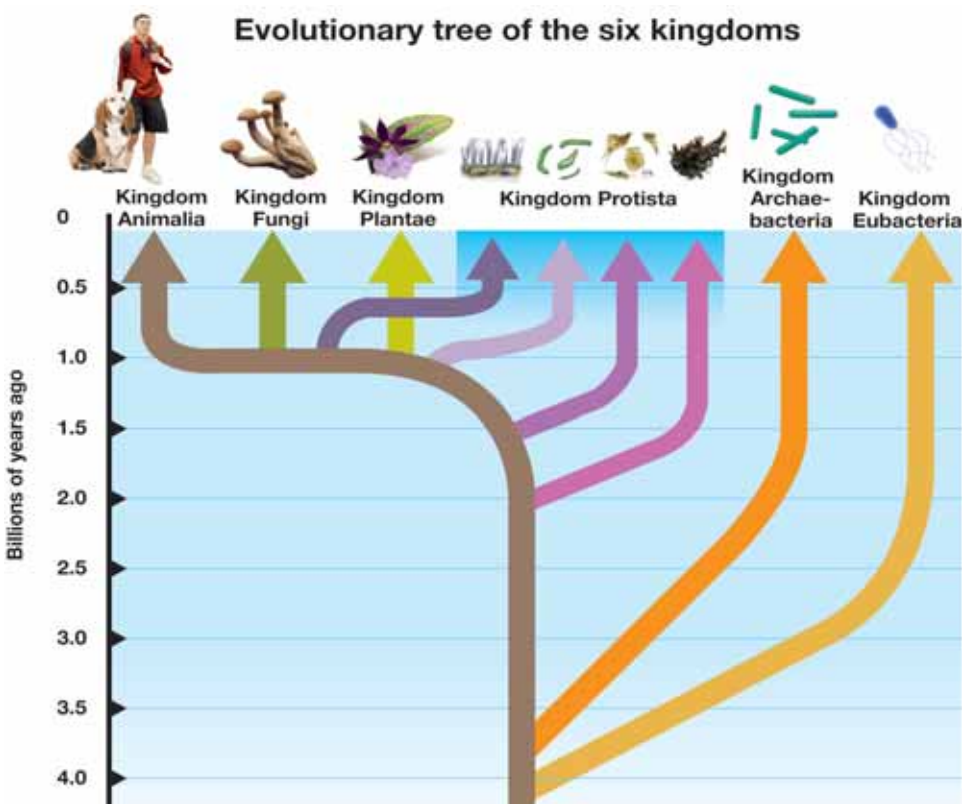


Figure 13.3: *A cladogram shows evolutionary relationships among different organisms.*

Evolution and the six kingdoms

An **evolutionary tree** is a diagram with many branches that shows evolutionary relationships among organisms, both living and extinct. The root of the diagram represents a common ancestor of all organisms. The point between each branch represents a common ancestor between branching groups. The diagram below is an evolutionary tree that shows the relationships among the six kingdoms. In a complete evolutionary tree, the levels of classification (phylum, class, order, etc.) would branch off from each kingdom all the way down to the species level.



VOCABULARY

evolutionary tree - a diagram with many branches that shows evolutionary relationships among organisms, both living and extinct.

STUDY SKILLS

In this unit, you will study the kingdoms that consist of multicellular organisms. The kingdoms and chapters where they will be studied are:

Kingdom Fungi - Chapter 13

Kingdom Plantae - Chapter 14

Kingdom Animalia - Chapter 15

Recall that you studied single-celled organisms in Chapter 7. These include the kingdoms of bacteria (Archaebacteria and Eubacteria) and protozoans—single-celled members of the Kingdom Protista).

Make a set of Kingdom Flashcards to aid in your studies. Place the kingdom on the front of the card. List the characteristics of the kingdom and some examples on the other side.

13.1 Section Review

1. Who was Carolus Linnaeus and what contribution did he make to the study of living things?
2. List the following terms in order of least-specific level to most-specific level.:

genus	order
kingdom	family
class	phylum
species	

3. Which of the following resembles a correctly written scientific name?
   a. *felis Domesticus*
   b. Felis
   c. Felis domesticus
   d. *Felis domesticus*
4. How are systematics and taxonomy similar? How are they different?
5. Use the cladogram in Figure 13.4 to answer the following questions.
   a. Which organisms have fur and nurse their young?
   b. Which organisms are air-breathing and live on land?
   c. Which organism is the most closely related to the mouse?
6. Study the diagram on page 265, then answer the questions below.
   a. Which evolved first, plants or fungi?
   b. Which group of organisms evolved just after bacteria?
   c. CHALLENGE! Why does Kingdom Protista have four branches?

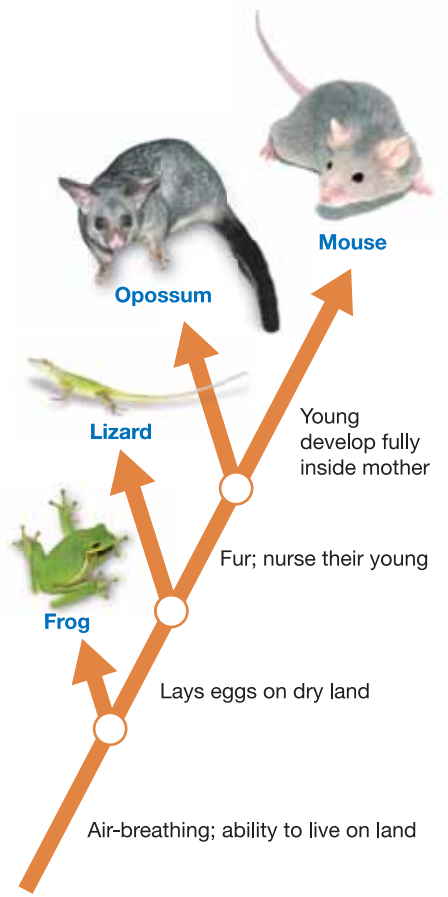


Figure 13.4: *Use this diagram to answer question 5.*

13.2 Algae and Fungi

In Chapter 7, you studied microscopic, single-celled organisms. These are the simplest organisms on Earth. In this unit, you will study the structure and function of *multicellular* organisms which are made of more than one cell. Plant-like algae are simple multicellular organisms. Algae can produce their own food and belong to the Kingdom Protista. The Kingdom Fungi consists of simple multicellular organisms that cannot produce their own food. In this section, you will learn about the structure and function of algae and fungi.

The evolution of sexual reproduction

An increase in the variety of life

Recall that the first prokaryotic cells appeared about 3 billion years ago. About 1 billion years ago, the first eukaryotic cells appeared. Then, rapid evolution produced the diverse life forms of protists, fungi, plants, and animals. What caused the rapid evolution that led to the diversity of life as we know it? The answer is that eukaryotic cells evolved the ability to reproduce sexually.

The importance of sexual reproduction

Prokaryotic cells reproduce asexually by splitting in two. Asexual reproduction does not allow for genetic variation unless a mutation occurs. Organisms that reproduce sexually produce more genetic variation among their offspring. You may recall that chromosomes become separated during meiosis and end up in different sex cells. During fertilization, the sex cells from each parent unite (Figure 13.5). These processes increase genetic variation. Genetic variation must be present for natural selection to occur. For that reason, once sexual reproduction evolved, new species began to evolve. This gave rise to multicellular organisms and eventually, the astounding diversity of life.

Sexual reproduction increases genetic variation and leads to new species.

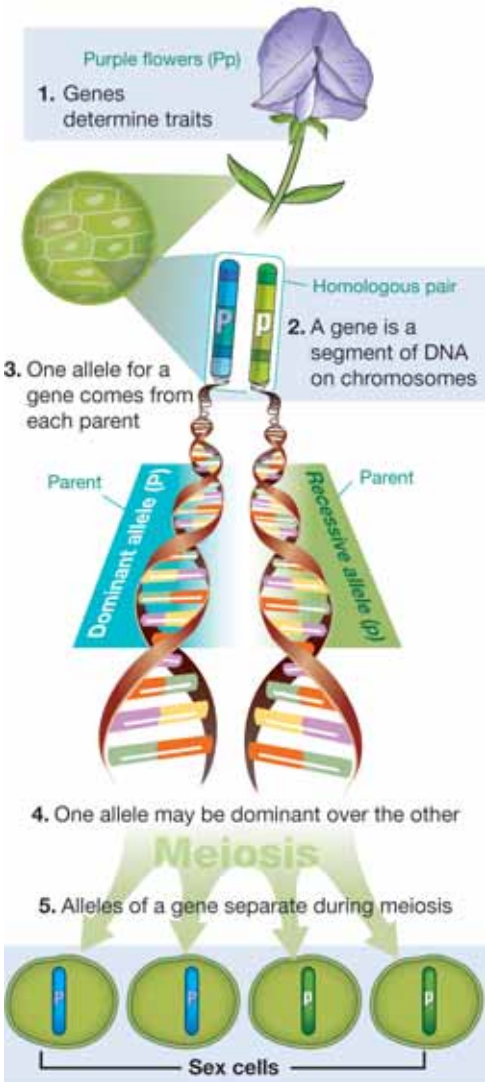


Figure 13.5: *The process of sexual reproduction increases genetic variation and leads to more new species.*

Algae

What are algae?

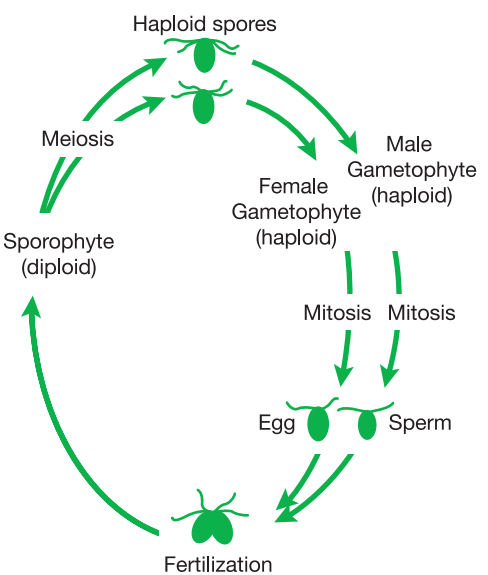
The Kingdom Protista, often called *protists*, contains many groups that evolved separately. For that reason, many scientists think that protists should be classified into several smaller kingdoms. **Algae** are photosynthetic protists that are plant-like in many ways. Scientists have classified about 30,000 species of algae in ocean and freshwater environments. These include single-celled species like diatoms and multicellular species like sea lettuce (*Ulva*) shown in Figure 13.6 and red algae.

Kelp structure and function

Kelp is a good example of multicellular algae. Figure 13.7 shows how kelp is adapted to life in regions where the tide washes in and out. The *holdfast* anchors it to the rock. The *air bladders* allow it to float. The *stipe* and *fronds* are flexible allowing it to bend with the waves. The presence of the brown pigment *fucoxanthin* allows the absorption of wavelengths of light that penetrate the water.

Sexual reproduction in algae

Some multicellular algae, such as *Ulva*, follow a pattern of reproduction called *alternation of generations*. Two forms of the algae alternate between diploid and haploid individuals. The haploid form, called a *gametophyte*, produces haploid sex cells. Sex cells unite to form a zygote. The zygote develops into the diploid form called a *sporophyte*. The sporophyte undergoes meiosis to form haploid spores that, in turn, form gametophytes.



VOCABULARY

algae - photosynthetic protists that are plant-like in many ways.

Figure 13.6: *Sea lettuce.*

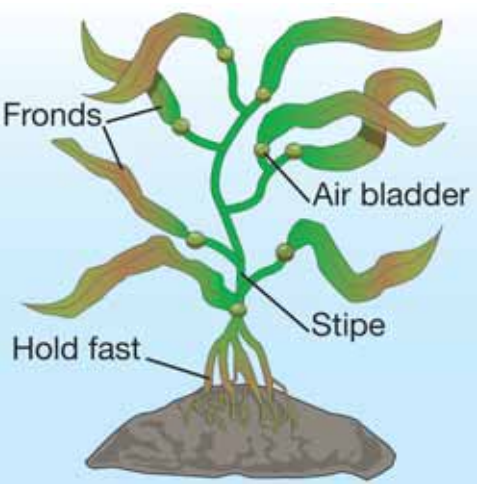


Figure 13.7: *The structures of kelp are adaptations to living in tidal areas.*

What are fungi?

Characteristics of fungi

Mushrooms, molds, and yeasts are examples of organisms in the Kingdom Fungi. Originally classified as plants, **fungi** (singular, *fungus*) do not make their own food. Nor do they have many animal-like characteristics. All fungi are made of eukaryotic cells that have cell walls made of *chitin*, a complex carbohydrate found in insects. Fungi range in form from a single-celled yeast to the multicellular honey mushroom that may reach the size of many football fields! Some types of fungi are shown in Figure 13.8.

How fungi get their food

Fungi do not eat their food as animals do. Instead, they release digestive enzymes into their surroundings. The enzymes break down organic material and the fungi absorb the nutrients directly into their cells. Some fungi get their food by digesting the dead remains of other organisms. Others are parasites that live on plants or animals, causing them harm. Athlete's foot, for example, is caused by a fungus.

Lichens

Some fungi live in symbiotic relationships with algae, bacteria, or plants. In those relationships, both the fungi and the other organism benefit. A good example is lichens. You may be familiar with lichens if you like to walk in the woods. Lichens are made of two organisms—a fungus, and a green algae or cyanobacteria. The algae carry out photosynthesis and provide the fungus with food. The fungus provides the algae with water and minerals it absorbs from the surface on which it lives.

VOCABULARY

fungi - organisms that make up the Kingdom Fungi, including yeasts, molds, and mushrooms, consisting of eukaryotic cells with cell walls made of chitin.

Figure 13.8: *Representatives of the Kingdom Fungi.*

Fungi structure and reproduction

Fungi structures

Figure 13.9 shows the structure of a typical fungus. All fungi are made up of thread-like filaments called **hyphae**. The cells that make up the hyphae sometimes contain two, three, or even more nuclei. In the fungi you are familiar with, the hyphae grow into whatever the fungus is feeding on—like a rotting log. The hyphae form a cottony mass of threads called a *mycelium*. The mycelium grows throughout the food source and releases digestive enzymes. The enzymes break down larger compounds into smaller molecules that can be absorbed into the cells of the fungus. Under the right conditions, part of the mycelium organizes and forms the fruiting body. The *fruiting body* is the part of a fungus that you would call a mushroom.

Asexual reproduction in fungi

Fungi can reproduce both sexually and asexually. Asexual reproduction occurs by the production of spores. A **spore** is a small, usually single-celled reproductive body that is capable of growing into a new organism. In a mushroom, spores are produced by the fruiting body within the gills (Figure 13.9). The spores are very light and are carried by the wind. If they land in suitable places, they grow into hyphae again. In another form of asexual reproduction, fragments of the hyphae can also grow into a new organism.

Sexual reproduction in fungi

To introduce genetic variation into the population, most fungi have a form of sexual reproduction. It involves two "mating types" of the organism. When the hyphae of opposite mating types meet, they fuse together. The nuclei of the mating types then fuse and immediately undergo meiosis. As a result, tiny haploid spores are formed.

VOCABULARY

hyphae - the thread-like filaments that make up a fungus.

spore - a small, usually single-celled reproductive body that is capable of growing into a new organism.

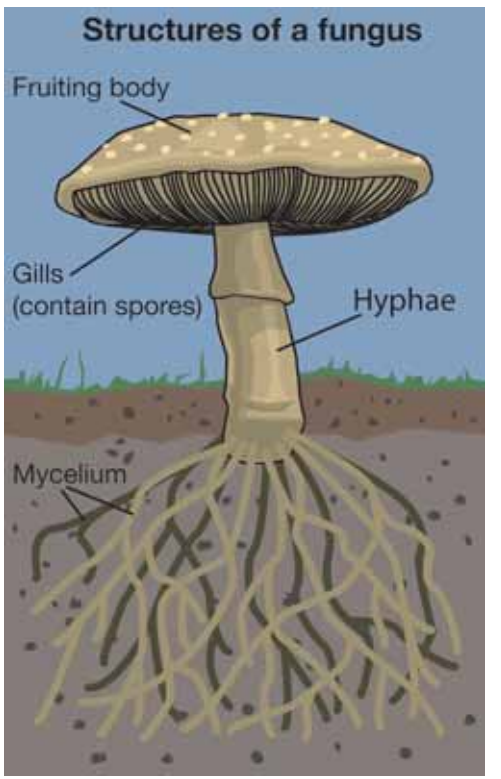


Figure 13.9: *The structures of a typical fungus.*

13.2 Section Review

1. Explain why the evolution of sexual reproduction led to the diversity of life on Earth.
2. Why do some scientists think the Kingdom Protista should be divided into several smaller kingdoms?
3. All of the following are characteristics of algae except:
   a. Algae have eukaryotic cells.
   b. Algae use the process of photosynthesis.
   c. Algae are single-celled and animal-like.
   d. Algae are multicellular and some are single-celled.
4. Describe how *Fucus* is adapted to living in tidal areas of the ocean.
5. Explain, using the terms *diploid* and *haploid*, what is meant by the term alternation of generations.
6. All of the following are characteristics of fungi except:
   a. Fungi are multicellular.
   b. Fungi have eukaryotic cells that contain chlorophyll.
   c. Fungi have cell walls made of chitin.
   d. Fungi are made up of filaments called hyphae.
7. Explain the function of each structure of a fungus:
   a. hyphae
   b. mycelium
   c. fruiting body
8. What is a spore? How do fungi reproduce using spores?

Many vocabulary terms from previous chapters were used in this chapter. In your journal, make a three-column table. In the first column write the words below. In the second column, write down the definition for each word from the chapter it was introduced. In the third column, write down how the term applies in this chapter.

Previous vocabulary terms:

asexual reproduction

sexual reproduction

meiosis

sex cells

genetic variation

haploid

diploid

symbiosis

parasite

ECOLOGY CONNECTION

Restoring Natural Ecosystems Is Not Easy

What if your bike got so damaged that you could no longer ride it? You would at least try to restore it to working condition. You might hope to do the same if you got a terrible haircut, or burned your fingers badly - you would try to restore them. People are trying to accomplish that with wetlands. These ecosystems have been damaged or destroyed and now we are trying to restore them.

Wetland ecosystems are always wet and near a water source. Water floods into the area and there is little or no drainage; water always remains. Freshwater wetlands are found at the edges of lakes and rivers. Saltwater wetlands are found in coastal areas on the oceans.

Wetlands usually have slow-moving or standing water. They also have soil. Wetlands are not true bodies of water, but are not considered dry land. For example, swamps and marshes are wetlands. In their natural state, wetlands serve crucial purposes, including:

- Reducing erosion.
- Protecting against floods.
- Improving water quality.
- Providing habitat for wildlife.

Wetlands reduce erosion by slowing water flow. When flowing water enters a wetland area, it meets resistance. This slows the flow. Slower water has less force and picks up and carries away less soil. Slower water also means a smaller volume of water at any one time. This means less flooding. Wetlands can act as a buffer between a water source and dry land.

Wetlands absorb sediments. In slow-moving water, sediments sink. So wetlands act as a filter, thereby improving the quality of the water.

Finally, wetlands provide homes and food for wildlife. Many species of plants, birds, amphibians, fish, and insects depend on wetland areas.

California's wetlands are almost gone

In California, more than 90 percent of the natural wetlands are gone from the coast. Inland wetlands also have been destroyed, with only patches remaining.

Those inland wetlands have been drained, some for farming, some to create landfills, some for mining. All of that has meant big changes for wetland ecosystems.

The San Francisco area once had many tidal wetlands, one of them on the southern part of San Francisco Bay. The water there is naturally salty, and since the 1860s, these wetlands were used to produce salt. The process involved making levees to block the tides. Ponds were formed and then were partially drained. This process was repeated over and over until finally the salt was concentrated and could be removed.

This salt-mining process had a big impact on local ecosystems.

We know now that even a small change in an environment can cause great harm. When the South Bay wetlands were turned into salt mines, the natural balance was upset. Animals that depended on the wetlands were threatened. Benefits to humans were lost, too, because the wetlands had helped to protect water quality and prevent flooding.

Restoration will take time

People became aware of these problems in the 1960s. Some people thought the salt mining should be stopped and the wetlands restored to their natural state. Others were against the idea. Finally, in 2002, the state announced a coastal restoration project for the San Francisco Bay Area.

But restoring an ecosystem is complicated business. The planning alone was expected to take five years, and the restoration between 10 and 30 years. At the end of the project, it is expected that water quality will be improved, endangered animals will find safe habitats, and commercial fishing will reap benefits, too.

A cautious approach

Just the same, some scientists advise caution. Levees will be removed when the wetlands are restored, which will allow tides to flow naturally. That will change the salt ponds that formed when the tides were blocked. The ponds will adjust to support a new ecological balance. The resulting ecosystem may not be purely "natural," but it supports many migrating birds.

Restoring natural ecosystems is complicated and difficult. Many things have to be considered. California's current plan is to restore some of the natural wetlands and preserve some of the salt ponds as they are.

When people try to reshape or control or repress natural forces, problems usually occur - some of them completely unexpected. For example, consider what has resulted from our putting out forest fires. Fires are a natural part of a forest's life cycle and, years ago, most of the fires were small. A portion of a forest would burn, but it would grow back over time. Often, fire would sweep through a forest, and many trees would survive.

Then people began to control the fires. With what unexpected result? There are more fires now and the fires are bigger. Uncontrolled fires used to clean out dry and dead plant material. Now, when people put fires out, that material does not get cleared away. It provides fuel for much hotter fires - which, in turn, can kill all the trees in a forest.

Like the restoration of wetlands, the problem of forest fire management will be solved only over a long time.

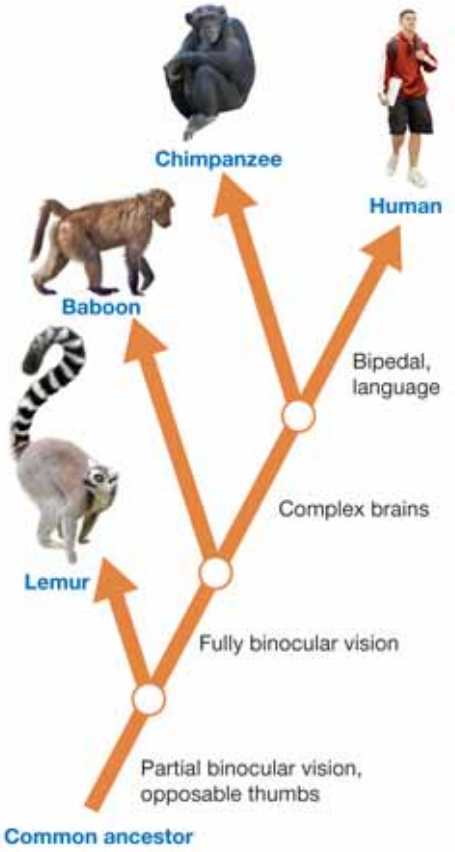
Questions:

1. What are some of the functions of natural wetlands?
2. Why have much of California's natural wetlands been lost?
3. What is one of the possible problems with restoring the San Francisco Bay Area wetlands?
4. What has resulted from decades of preventing natural forest fires?

CHAPTER ACTIVITY

How to Make a Simple Cladogram

A cladogram shows evolutionary relationships among groups of organisms. Shared characteristics are listed below each node (the point where two branches meet). Each node indicates a common ancestor from which different organisms branched. As you move up the diagram, organisms share fewer and fewer characteristics.



In this activity, you will use fruit to learn how to make a simple cladogram. Your cladogram will not show evolutionary relationships among the fruit. Instead, it will simply compare the observable characteristics of the fruit. For this activity, you will need a nectarine, kiwi, grapefruit, apple, lime or pictures of the fruit.

What you will do

1. Make tables like the ones shown to the right in your notebook.
2. Examine the fruit. Next to each characteristic in Table 1, list the fruit or fruits to which it applies.

Table 1: Fruit characteristics

Characteristic	Fruits to which it applies
has a skin	
smooth skin - not fuzzy	
segments inside	
green skin	
multiple or no seeds inside	

3. Now fill in Table 2 below:

Table 2: Fruit data

Fruit	Number of times it appears in Table 1
kiwi	
nectarine	
grapefruit	
lime	
apple	

4. Use the characteristics in Table 1 and the values in Table 2 to help you draw a cladogram for the fruit. Each fruit can only be used once in your cladogram.

Applying your knowledge

a. Which fruit has all of the characteristics? Which fruit has only one characteristic?

b. Give examples of three other characteristics that could have been used for your cladogram. Would your cladogram look different if other characteristics were chosen?

c. Draw a cladogram using the following organisms: *paramecium*, *algae*, *mushroom*, *redwood tree*, and *cat*. You may need to review previous chapters of this text for more information.

Chapter 13 Assessment

Vocabulary

Select the correct term to complete the sentences.

algae	spore	fungi
scientific name	systematics	hyphae
evolutionary tree		

Section 13.1

1. _____ is used to classify organisms and to show how they are related by evolution.
2. Carolus Linnaeus developed the system of using an organism's _____, or Genus species, to avoid confusion in communication.
3. A diagram that shows evolutionary relationships among living and extinct organisms is called (an) _____.

Section 13.2

4. Asexual reproduction in fungus occurs by the production of _____.
5. _____ are photosynthetic protists that share many characteristics with plants.
6. Mushrooms, molds, and yeast are all examples of _____.
7. _____ are threadlike filaments that absorb nutrients from whatever the fungus is feeding on.

Concepts

Section 13.1

1. If two organisms belong to the same family, what other taxonomic levels must those two organisms also share?
2. Which two of these organisms are most closely related?
   a. Buteo jamaicanensis
   b. Lagopus lagopus
   c. Buteo lagopus
   d. Laterallus jamaicensis
3. Sometimes scientific names are given for the scientist that discovered the organism. Name four other sources for scientific names.
4. List three reasons that you can tell that *Ursus maritimus* is a scientific name.
5. Explain how DNA analysis has changed the classification of skunks.
6. What is found at the root of an evolutionary tree?

Section 13.2

7. Which type of reproduction leads to greater genetic diversity: sexual reproduction or asexual reproduction? Why?
8. Describe how algae are similar to plants.
9. True or false: The pattern of reproduction called alteration of generations includes both sexual and asexual reproductive stages.
10. How would you classify a single celled, eukaryotic organism that performs photosynthesis and does not move?
11. The algae and the fungus that comprise lichen are an example of which of the three types of symbiosis?
    a. parasitism
    b. commensalism
    c. mutualism
12. Infer why gills (where the spores are produced) are located on the underside of the mushroom cap. Why do you think that fungi produce millions of spores?

Math and Writing Skills

Section 13.1

1. Use the greater than (>) or less than (<) symbol to complete these comparisons about taxonomic levels.
   a. genus _____ phylum
   b. class _____ family
   c. # of kingdoms _____ # of species
   d. # of orders _____ # of classes
   e. # of organisms in a phylum _____ # of organisms in a family
2. There are approximately 270 members of the order Carnivora, which includes a variety of organisms like bats, seals, cats, and bears. There are only 4 species of bears in the genus Ursus. What percent of the order Carnivora does the genus Ursus represent?
3. Common names often give misinformation about an organism like the names "koala bear", "jellyfish", and "horseshoe crab". Using these examples as well as your own examples and reasons, write a persuasive paragraph about the importance of using scientific names.

Section 13.2

4. Choose one type of algae. Describe a day in the life of the algae that you have chosen.
5. A family buys two loaves of bread at the grocery store on the same day. One loaf is served with dinner that night, while the other loaf stays in the refrigerator unopened. The remaining slices of the loaf served at dinner are put back in the refrigerator. A week later, one of the loaves of bread has mold growing on it. Which loaf is moldy - the dinner loaf or the unopened loaf? Explain your prediction.
6. A fairy toadstool ring is a type of underground fungus that produces mushrooms in a circle at the outer edge. This fungus got it's name because it appeared to many people that magical fairies made a ring of mushrooms overnight. A particular fairy toadstool ring grows in diameter by 3 meters each year. How many years old is this fairy toadstool ring if it has a diameter of 180 meters?
7. One giant puffball mushroom produces 7,000,000,000 spores, but for various reasons, only 25% survive. How many giant puffball spores will grow into new mushrooms at this survival rate?

Chapter Project

Studying yeast

Yeast is a member of Kingdom Fungi. *Saccharomyces cerevisiae*, called baker's yeast, is a fungi often used by cooks and bakers to make breads and other foods "rise". For this project, you will experiment with some baker's yeast and find out why it is such an important ingredient in bread recipes. You will need: 1 packet of active dry yeast; 1 cup very warm water; 2 tablespoons sugar; balloon; an empty water bottle. Follow the procedures:

1. Stretch out your balloon - blow it up several times and then put it aside.
2. Put the yeast, water, and sugar into the water bottle and swirl it around to dissolve the sugar and yeast.
3. Attach the balloon to the mouth of the bottle and set it aside.
4. Observe the balloon and find the answers to the questions.
5. Sketch the bottle/balloon to show what happened in your experiment
6. Do some research to find out what happened to the yeast, and write the explanation in your own words.
7. Explain why yeast is an important ingredient in a bread recipe. List at least two sources.