THEME FOCUS **Stability and Change**
Some protists have a specific organelle that helps maintain homeostasis.

BIG Idea **Protists are a diverse group of unicellular and multicellular organisms that do not necessarily share the same evolutionary history.**

Reading Preview

Essential Questions

- How are protists classified?
- How might some protisits with mitochondria have evolved?
- How might some protists with chloroplasts have evolved?
- Why might the organization of Kingdom Protista change?

Review Vocabulary

heterotroph: organism that cannot make its own food and must get its energy and nutrients from other organisms

New Vocabulary

protozoan
microsporidium

Multilingual eGlossary

BrainPOP

Introduction to Protists

Protists form a diverse group of organisms that are subdivided based on their method of obtaining nutrition.

Real-World Reading Link Hurricanes, such as Katrina in 2005, bring winds and water surges that leave destruction and devastation. Contaminated flood waters, damaged sewage systems, and crowded shelters provide breeding grounds for infectious bacteria, viruses, and microorganisms called protists.

Protists

Protists are classified more easily by what they are not than by what they are. Protists are not animals, plants, or fungi because they do not have all of the characteristics necessary to place them in any of these kingdoms. Kingdom Protista was created to include this diverse group of more than 200,000 organisms.

All protists share one important trait: they are eukaryotes. Recall that eukaryotic cells contain membrane-bound organelles. Like all eukaryotes, the DNA of protists is found within the membrane-bound nucleus. Although protists have a cellular structure similar to other eukaryotes, there are remarkable differences in their reproductive methods. Some reproduce asexually by mitosis, while others exchange genetic material during meiosis.

Classifying protists Because they are such a diverse group of organisms, some scientists classify protists by their method of obtaining nutrition. Protists are divided into three groups using this method: animal-like protists, plantlike protists, and funguslike protists. The **protozoan** (proh tuh ZOH un) (plural, protozoa or protozoans), shown in **Figure 1,** is an example of an animal-like protist because it is a heterotroph–it ingests food. Additional examples of protists and a summary of characteristics are shown in **Table 1.**

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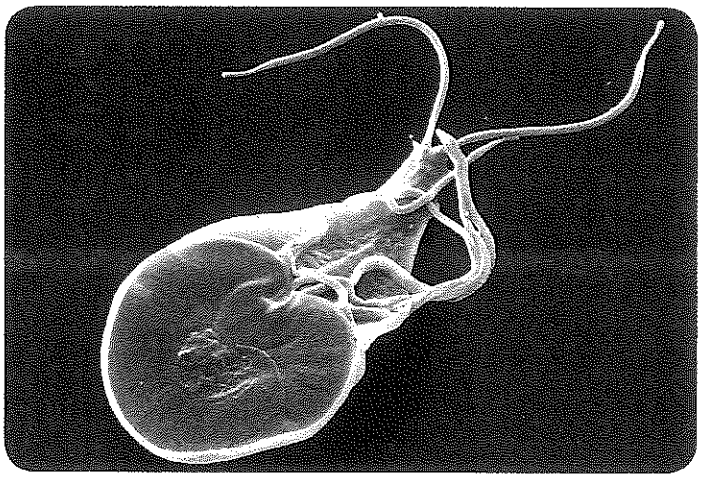


Giardia lamblia

Eye of Science/Photo Researchers

Figure 1 This animal-like protist is a parasite that might be found in the intestinal tract of a person who has consumed contaminated water.
Infer *how this protist obtains its nutrients.*

Animal-like protists An amoeba is an example of a unicellular, animal-like protist or protozoan. Protozoans are heterotrophs and usually ingest bacteria, algae, or other protozoans. The amoeba shown in **Table 1** is in the process of capturing and ingesting another unicellular protozoan–a paramecium.

Plantlike protists A giant kelp, shown in **Table 1**, is an example of a plantlike protist that makes its own food through photosynthesis. Plantlike protists are commonly referred to as algae (AL jee) (singular, alga). Some algae are microscopic. The unicellular algae *Micromonas* are about 10^{-6} m in diameter. Other forms of algae are multicellular and are quite large. Giant kelp, *Macrocystis pyrifera*, can grow up to 65 m long.

Funguslike protists The water mold in **Table 1** is an example of a funguslike protist that is absorbing nutrients from a dead salamander. Funguslike protists are similar to fungi because they absorb their nutrients from other organisms. These organisms are not classified as fungi because funguslike protists contain centrioles–small, cylindrical organelles that are involved in mitosis and usually are not found in the cells of fungi. Fungus and funguslike protists also differ in the composition of their cell walls.

Reading Check **Compare and contrast** the three groups of protists.

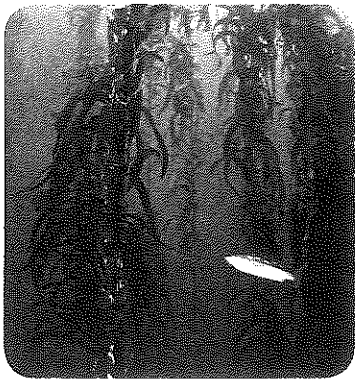
VOCABULARY

Protist
comes from the Greek word *protistos*, meaning *the very first*

FOLDABLES
Incorporate information from this section into your Foldable.

Table 1 The Protists

Interactive Table

	Animal-like protists (Protozoans)	Plantlike protists (Algae)	Funguslike protists
Group	Ciliates, amoebas, apicomplexans, and zooflagellates	Euglenoids, diatoms, dinoflagellates, green algae, red algae, brown algae, yellow-green algae, and golden-brown algae	Slime molds, water molds, and downy mildews
Example	 **Amoeba**	 **Giant kelp**	 **Water mold**
Distinguishing Characteristics	• Considered animal-like because they consume other organisms for food • Some are parasites.	• Considered plantlike because they make their own food through photosynthesis • Some consume other organisms or are parasites when light is unavailable for photosynthesis.	• Considered funguslike because they feed on decaying organic matter and absorb nutrients through their cell walls • Some slime molds consume other organisms and a few slime molds are parasites.

(l)Eric Grave/Photo Researchers; (c)James Forte/Getty Images; (r)Ivan Gomez-Mestre

Figure 2 The protists, green algae, live in the fur of this tree sloth, forming a symbiotic relationship.
Infer *What type of symbiotic relationship do these organisms have?*

Launch Lab

Review **Based on what you've read about protists, how would you now answer the analysis questions?**

Habitats Protists typically are found in damp or aquatic environments such as decaying leaves, damp soil, ponds, streams, and oceans. Protists also live in symbiotic relationships. **Microsporidia** (MI kroh spo rih dee uh) (singular, microsporidium) are microscopic protozoans that cause disease in insects. Some species of microsporidia can be used as insecticides. New technology might allow these microsporidia to be used to control insects that destroy crops.

One beneficial protist lives in the hair of a sloth, shown in **Figure 2.** A sloth is a large, slow-moving mammal that lives in the uppermost branches of trees in tropical rain forests. The sloth spends most of its life hanging upside down. Green algae help the brown sloth blend into the leaves on the tree, providing camouflage for the sloth.

DATA ANALYSIS LAB 1

Based on Real Data*

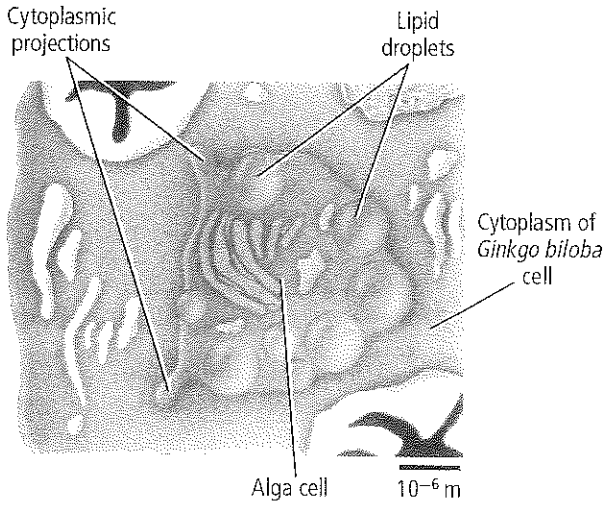
Interpret Scientific Illustrations

What is the relationship between green alga and *Ginkgo biloba* cells? In 2002, scientists in France reported the first confirmed symbiotic relationship between plantlike protists called green algae and a land plant's cells. The figure at the right represents an alga inside a cell from the *Ginkgo biloba* tree.

Think Critically

1. **Examine** the figure and estimate the size of the algal cell.
2. **Explain** why the term endophytic (en duh FIT ihk) is appropriate to describe these algae. The prefix *endo* means "within" and the suffix *-phyte* means "plant."

Data and Observations



*Data obtained from: Tremoullaux-Guiller, et al. 2002. Discovery of an endophytic alga in *Ginkgo biloba*. *American Journal of Botany* 89(5): 727–733.

(t)Francois Gohier/Science Source; (r)buccaneer/Alamy

Origin of Protists

Recall the theory of endosymbiosis, which was proposed by Lynn Margulis. This theory suggests that eukaryotes, including protists, formed when a large prokaryote engulfed a smaller prokaryote. The two organisms lived symbiotically. Eventually, the organisms evolved into a single, more highly developed organism. Some scientists think that the mitochondria and chloroplasts found in some eukaryotes, including protists, were once individual organisms. Protists might have been the first eukaryotes to appear billions of years ago.

Grouping protists by how they obtain nutrition is a convenient method of classifying them. However, this method does not consider an organism's evolutionary history. Scientists are still trying to sort out the evolutionary relationships between protists and the other kingdoms. As scientists learn more information, the organization of Kingdom Protista most likely will change.

The diagram in **Figure 3** shows the current understanding of the evolutionary history of protists based on the theory of endosymbiosis. Notice in the diagram that all of the protists have a common ancestral eukaryotic cell. Examine the diagram and find where mitochondria entered into the evolutionary process. Mitochondria became part of protist cells early in the evolutionary process. Now, locate where chloroplasts entered cells. Follow the path of the arrow and you can see that algae are the only protists with chloroplasts and that undergo photosynthesis.

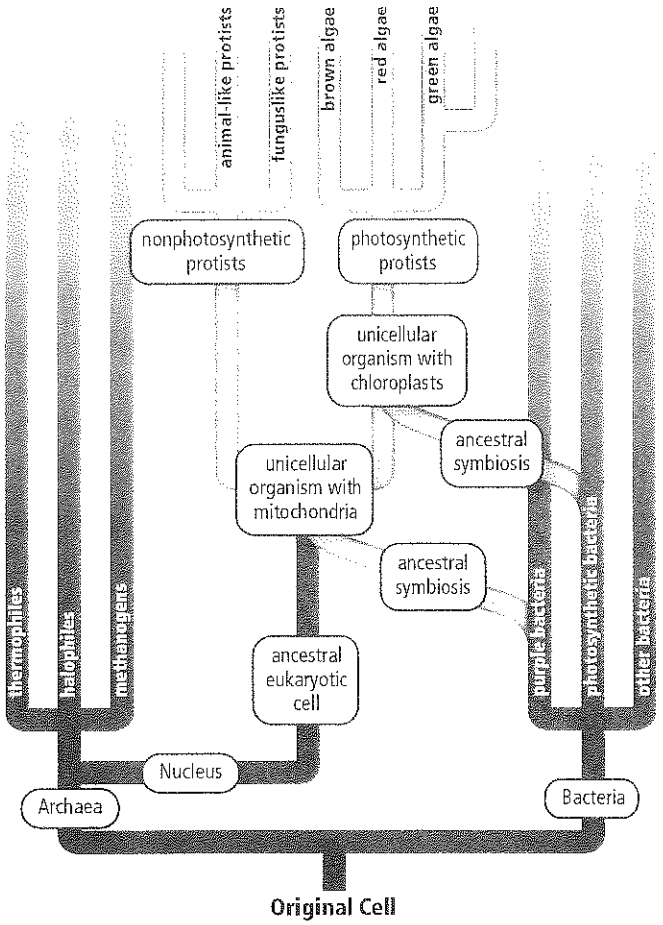


Figure 3 This diagram shows how the theory of endosymbiosis explains the evolution of the protist kingdom.

Section 1 Assessment

Section Summary

- Protists include unicellular and multicellular eukaryotes.
- Protists are classified by their methods of obtaining food.
- The first protists might have formed through endosymbiosis.
- Protists might have been the first eukaryotic cells with chloroplasts and mitochondria, evolving billions of years ago.

Understand Main Ideas

1. MAIN IDEA **Explain** why some scientists use nutrition to classify organisms in Kingdom Protista.
2. **Sketch** a diagram that illustrates how the first protists might have formed from prokaryotes.
3. **Explain** why scientists have classified protists in one kingdom when they are such a diverse group.

Think Critically

4. **Apply Concepts** What if you discovered a new protist? What characteristics would help you decide the group in which it belongs?
5. **Compare and contrast** using nutrition methods and evolutionary relationships to classify protists.

Online Quiz

Reading Preview

Essential Questions

- What are the characteristics of protozoans?
- What are the structures and organelles of protozoans?
- What are the life cycles of protozoans?

Review Vocabulary

hypotonic: the concentration of dissolved substances is lower in the solution outside the cell than the concentration inside the cell

New Vocabulary

pellicle
trichocyst
contractile vacuole
pseudopod
test

Multilingual eGlossary

Protozoans—Animal-like Protists

MAIN Idea **Protozoans are animal-like, heterotrophic protists.**

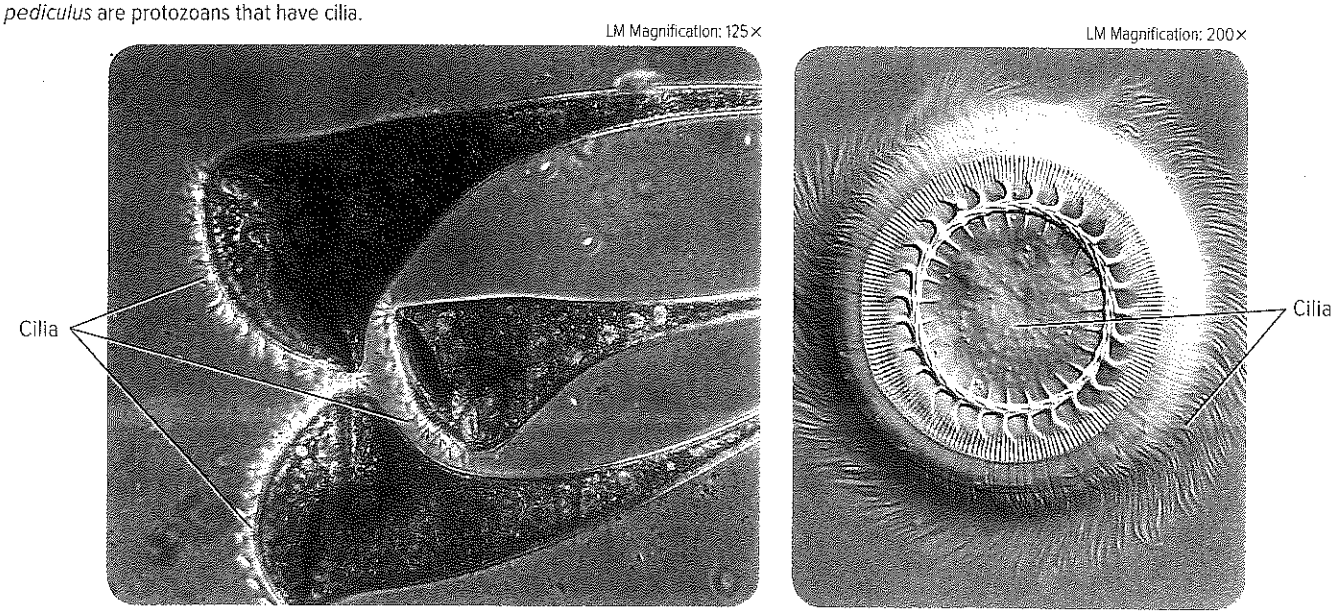
Real-World Reading Link Have you ever looked at pond water under a microscope? If you saw tiny organisms darting around, then you most likely have seen protozoans.

Ciliophora

One of the characteristics that biologists use to further classify protozoans into different phyla is their method of movement. Members of the phylum Ciliophora (sih lee AH fuh ruh), also known as ciliates (SIH lee ayts), are animal-like protists that have numerous short, hairlike projections. Recall that some unicellular organisms use cilia (singular, cilium) to propel themselves through water and to move food particles into the cell. Some ciliates have cilia covering their entire plasma membrane, while others have groups of cilia covering parts of their membrane, as shown in **Figure 4.** Note that the *Stentor's* cilia are located on the anterior end; they help propel food into the cell. The ciliate *Trichodina pediculus* has two visible sets of cilia. The outer ring is used for movement, and the inner ring is used for feeding.

There are more than 7000 species of ciliates. They are abundant in most aquatic environments—ocean waters, lakes, and rivers. They also are found in mud, and it is estimated that as many as 20 million ciliates can inhabit one square meter in some mud flats.

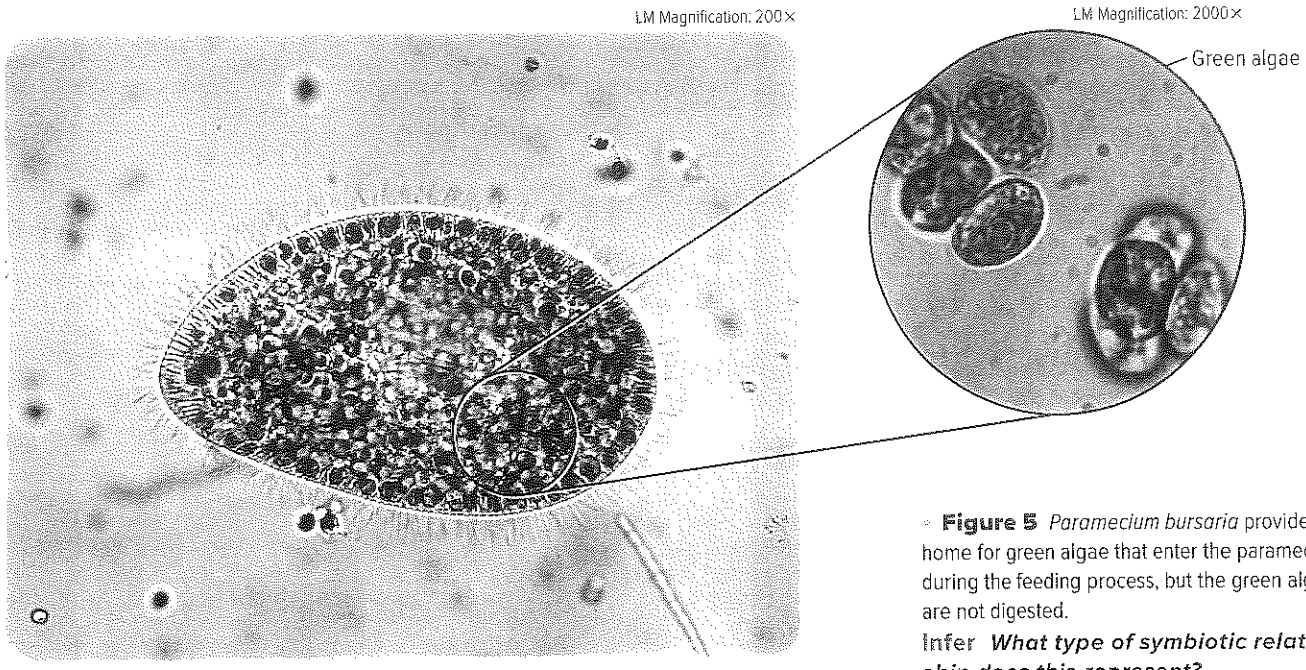
Figure 4 *Stentor* and *Trichodina pediculus* are protozoans that have cilia.



***Stentor*—use cilia for feeding**

***Trichodina pediculus*—use cilia for feeding and movement**

(l)Eric V. Grave/Photo Researchers; (r)Gerd Guenther/Photo Researchers



Paramecium bursaria

Figure 5 *Paramecium bursaria* provides a home for green algae that enter the paramecium during the feeding process, but the green algae are not digested.
Infer ***What type of symbiotic relationship does this represent?***

Paramecia Some of the most commonly studied ciliates are found in the genus *Paramecium* (per uh MEE see um) (plural, paramecia). The paramecium in **Figure 5** lives symbiotically with green algae. The green algae undergo photosynthesis, providing nutrients to the paramecium.

A paramecium is a unicellular protozoan. It is enclosed by a layer of membrane called a **pellicle.** Directly beneath the pellicle is a layer of cytoplasm called ectoplasm. Embedded in the ectoplasm are the **trichocysts** (TRIH kuh sihsts), which are elongated, cylindrical bodies that can discharge a spinelike structure. The function of trichocysts is not completely understood, but they might be used for defense, as a reaction to injury, as an anchoring device, or to capture prey.

Cilia The cilia on the paramecium in **Figure 5** are used for movement and feeding. Cilia completely cover the organism–including the oral groove. Locate the oral groove on the paramecium in **Figure 6.** The cilia covering the wall of the oral groove are used to guide food, primarily bacteria, into the gullet. Once the food reaches the end of the gullet, it is enclosed in a food vacuole. Enzymes within the food vacuole break down the food into nutrients that can diffuse into the cytoplasm of the paramecium. Waste products from the paramecium are excreted through the anal pore.

Contractile vacuoles Because freshwater paramecia live in a hypotonic environment, water constantly enters the cell by osmosis. Recall that a hypotonic solution is one in which the concentration of dissolved substances is lower in the solution outside the cell than the concentration inside the cell. The **contractile vacuoles,** shown in **Figure 6,** collect the excess water from the cytoplasm and expel it from the cell. The expelled water might contain waste products, which is another way that paramecia can excrete waste. Paramecia often have two or three contractile vacuoles that help to maintain homeostasis in the cell.

Reading Check **Explain** why the contractile vacuoles are necessary in hypotonic environments to maintain homeostasis.

CAREERS IN BIOLOGY

Microbiologist A microbiologist studies organisms that usually are seen only with a microscope. One area of study in which a microbiologist can specialize is the study of protists. Microbiologists can work as researchers, teachers, and in other fields.

VOCABULARY

SCIENCE USAGE V. COMMON USAGE

Expel

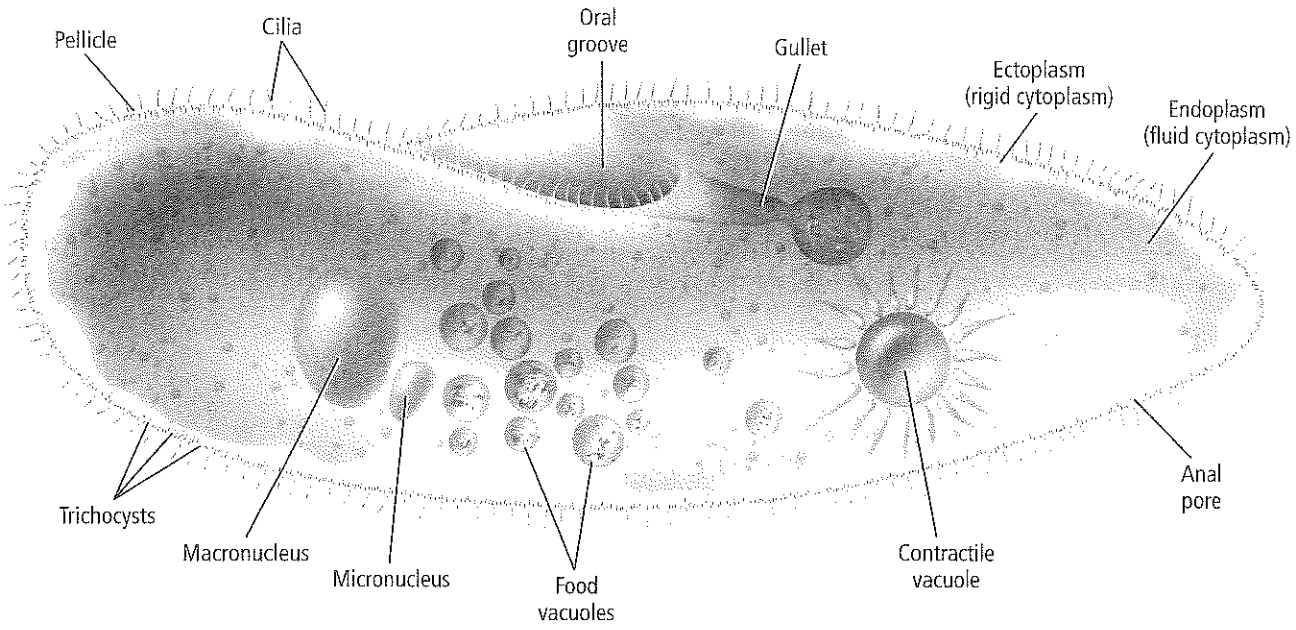
Science usage: to force out
Contractile vacuoles expel water from cells.

Common usage: to force to leave
The principal will expel students for breaking school rules.

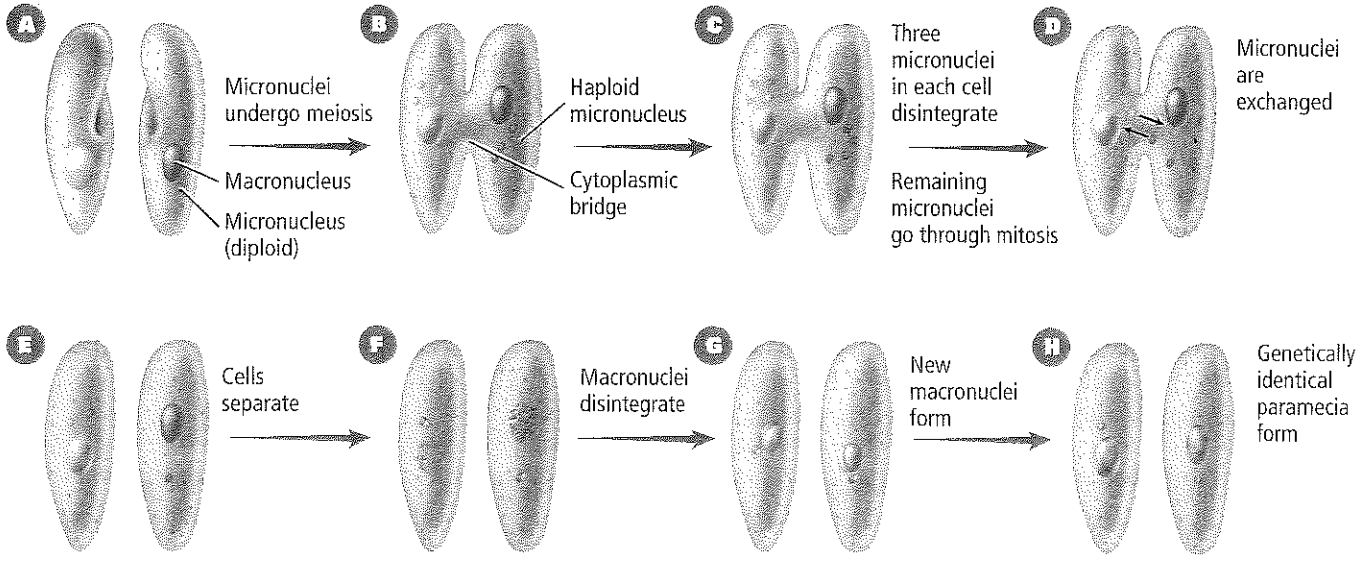
Visualizing Paramecia

Figure 6

Paramecia are unicellular organisms with membrane-bound organelles. They undergo a process called conjugation in which a pair of paramecia will exchange genetic information, as shown in the diagram at the bottom of the page. This is not considered sexual reproduction because new individuals are not formed.



Conjugation



Animation

Reproduction in ciliates All known ciliates have two kinds of nuclei: the macronucleus and a smaller micronucleus. A cell might contain more than one of each of these nuclei. Both nuclei contain the genetic information for the cell. The macronuclei contain multiple copies of the cell's genome, which controls the everyday functions of the cell, such as feeding, waste elimination, and maintaining water balance within the cell. The micronucleus is used for reproduction.

Ciliates reproduce asexually by binary fission. During this process, the macronucleus elongates and splits rather than undergoing mitotic division. Most ciliates maintain genetic variation by undergoing conjugation—a sexual process in which genetic information is exchanged. Conjugation is considered a sexual process, but it is not considered sexual reproduction because new organisms are not formed.

The process of conjugation for *Paramecium caudatum* is typical of most ciliates and is illustrated in **Figure 6.** During conjugation, two paramecia form a cytoplasmic bridge and their diploid micronuclei undergo meiosis. After three of the newly formed haploid micronuclei dissolve, the remaining micronucleus undergoes mitosis. One micronucleus from each connected cell is exchanged, and the two paramecia separate. The macronucleus disintegrates in each paramecium, and the micronuclei combine and form a new, diploid macronucleus. Each cell now contains a macronucleus, micronuclei, and a new combination of genetic information.

Reading Check **Explain** the purpose of the cytoplasmic bridge, shown in **Figure 6,** during conjugation.

VOCABULARY

Conjugation

Science usage: an exchange of genetic information without reproduction
Genetic variation is increased in paramecia through a process called conjugation.

Common usage: in grammar, an arrangement of the correct form of a verb
Victoria is practicing the conjugation of Spanish verbs.

DATA ANALYSIS LAB 2

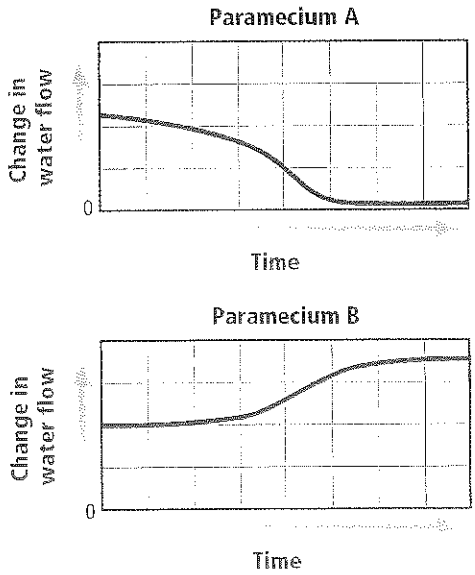
Based on Real Data*

Recognize Cause and Effect

How does solution concentration affect the contractile vacuole? The contractile vacuole moves water from inside a paramecium back into its freshwater environment. Researchers have studied the effects of solution concentrations on paramecia.

Data and Observations

Paramecia were allowed to adapt to various solutions for 12 h. Then, they were placed into hypertonic and hypotonic solutions. The graphs show the change in rate of water flow out of the contractile vacuole over time.



Think Critically

1. **Analyze** What do the downward and upward slopes in the graphs indicate about the contractile vacuole?
2. **Infer** which paramecium was placed into a hypertonic solution. Explain.

*Data obtained from: Stock, et al. 2001. How external osmolarity affects the activity of the contractile vacuole complex, the cytosolic osmolarity and the water permeability of the plasma membrane in *Paramecium Multimicronucleatum*. *The Journal of Experimental Biology* 204: 291–304.

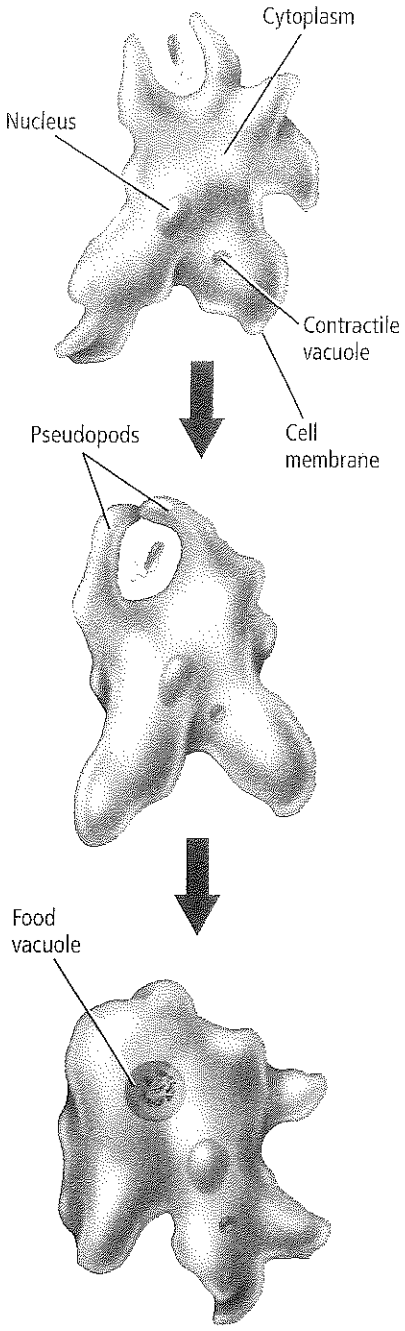


Figure 7 Chemical stimuli from smaller organisms can cause the amoeba to form pseudopods from their cell membrane.

Sarcodina

Members of the phylum Sarcodina (sar kuh DI nuh), also called sarcodines (SAR kuh dinez), are animal-like protists that use pseudopods for feeding and locomotion. A **pseudopod** (SEW duh pahd) is a temporary extension of cytoplasm and is shown in **Figure 7.** These extensions surround and envelop a smaller organism, forming a food vacuole. Digestive enzymes are secreted and break down the captured organism.

Some of the most commonly studied sarcodines are found in the genus *Amoeba*. Most amoebas are found in saltwater, although some freshwater species live in streams, in the muddy bottoms of ponds, and in damp patches of moss and leaves. Some amoebas are parasites that live inside an animal host.

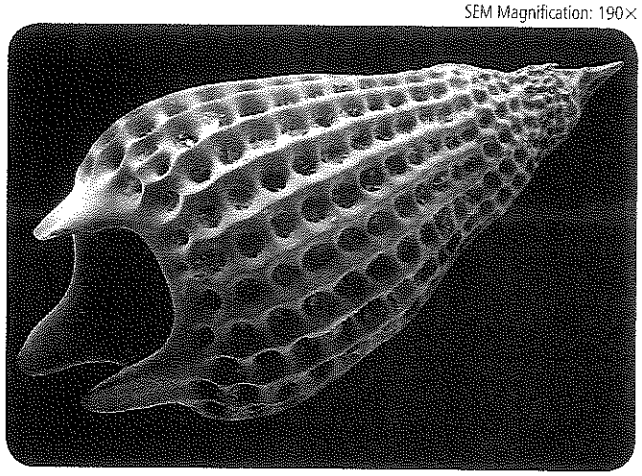
Amoeba structure The structure of an amoeba is simple, as shown in **Figure 7.** Amoebas are enveloped in an outer cell membrane and an inner thickened cytoplasm called ectoplasm. Inside the ectoplasm, the cytoplasm contains a nucleus, food vacuoles, and occasionally a contractile vacuole. Notice that an amoeba does not have an anal pore like the paramecium. Waste products and undigested food particles are excreted by diffusion through the cell membrane into the surrounding water. The oxygen needed for cellular processes also diffuses into the cell from the surrounding water.

Foraminiferans (fuh rah muh NIH fur unz) and radiolarians (ray dee oh LER ee unz) are types of amoebas that have tests. A **test** is a hard, porous covering similar to a shell, which surrounds the cell membrane. Most of these amoebas live in marine environments, although there are some freshwater species.

Connections to Earth Science Foraminiferans have tests made of calcium carbonate ($CaCO_3$), grains of sand, and other particles cemented together. Geologists use the fossilized remains of foraminiferans to determine the age of some rocks and sediments, and to identify possible sites for oil drilling. Radiolarians, another type of amoeba with tests, shown in **Figure 8,** have tests made mostly of silica (SiO_2).

Amoeba reproduction Amoebas reproduce by asexual reproduction during which a parent cell divides into two identical offspring. During harsh environmental conditions, some amoebas become cysts that help them survive until environmental conditions improve and survival is more likely.

SEM Magnification: 190×



Andrew Syred/Photo Researchers

Figure 8 Radiolarians have tests made of silica. Foraminiferans and radiolarians extend their pseudopods through openings in their tests.

Apicomplexa

Animal-like protists that belong to the phylum Apicomplexa (ay puh KOM pleks uh) are also known as sporozoans (spo ruh ZOH unz). They are called sporozoans because they produce spores at some point in their life cycle. Spores are reproductive cells that form without fertilization. Sporozoans lack contractile vacuoles and methods for locomotion. Respiration and excretion occur by diffusion through the plasma membrane.

All sporozoans are parasitic. Recall that parasites get their nutritional requirements from a host organism. Sporozoans infect vertebrates and invertebrates by living as internal parasites. Organelles at one end of the organism are specialized for penetrating host cells and tissues, allowing them to get their nutrients from their host.

The life cycle of sporozoans has both sexual and asexual stages. Often two or more hosts are required for an organism to complete a life cycle. The life cycle of *Plasmodium*, which causes malaria, is shown in **Figure 9.**

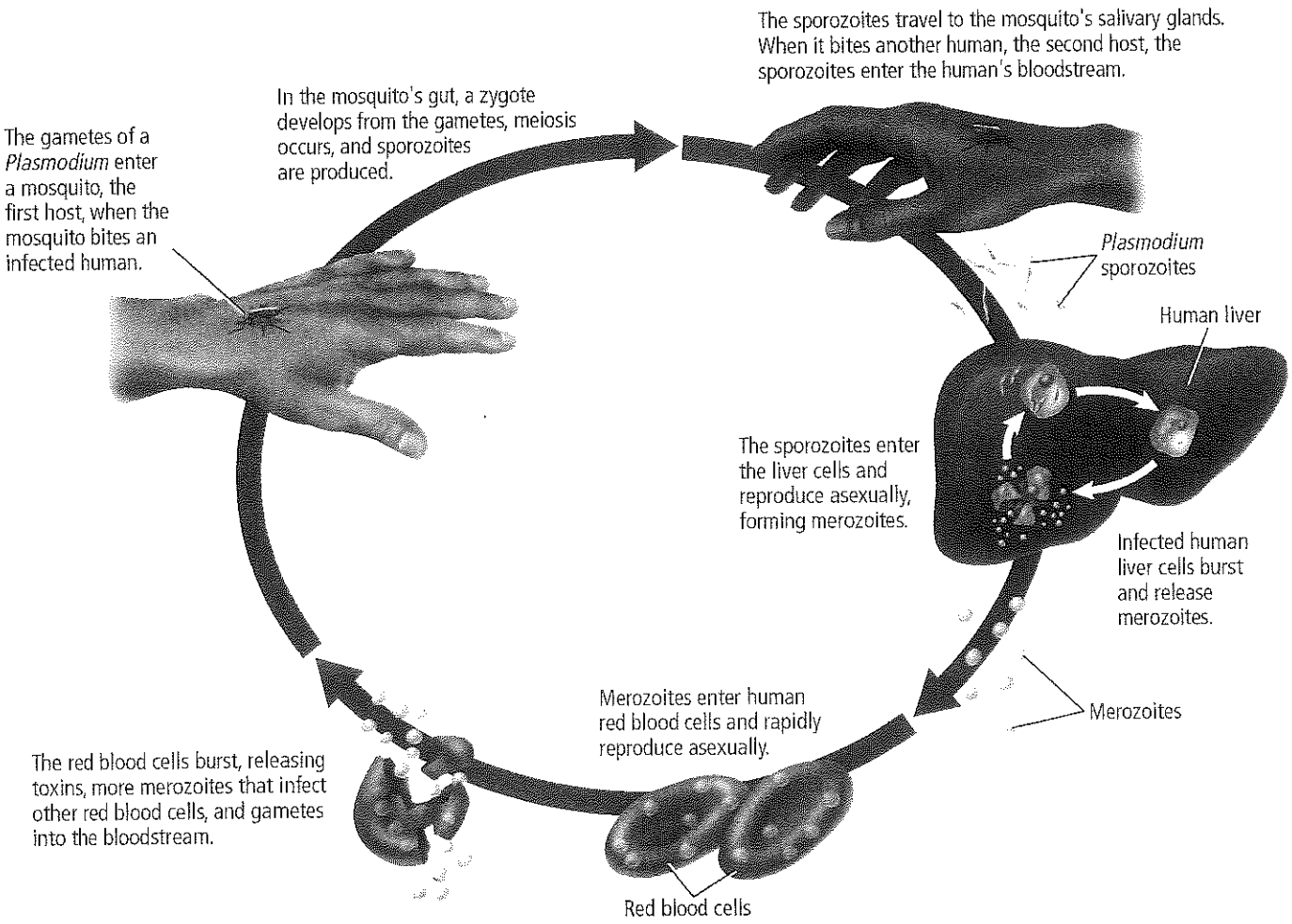
Sporozoans cause a variety of illnesses in humans, some of which are fatal. The sporozoans responsible for the greatest number of human deaths are found in the genus *Plasmodium*. These parasites cause malaria in humans and are transmitted to humans by female *Anopheles* mosquitoes. Malaria causes fever, chills, and other flulike symptoms. Its greatest impact is in tropical and subtropical regions where factors such as high temperature, humidity, and rainfall favor the growth of mosquitoes and sporozoans, and preventative measures are too costly.

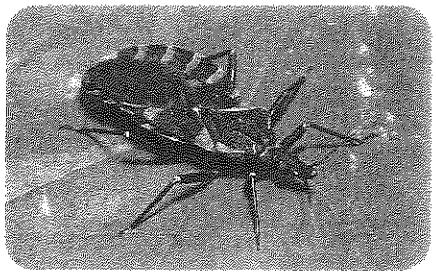
VOCABULARY

WORD ORIGIN

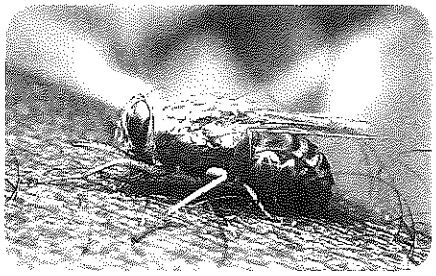
Apicomplexa
apicalis from Latin; meaning *uppermost point or tip*
complexus from Latin; meaning *comprised of multiple objects*

Figure 9 Malaria is caused by the sporozoan *Plasmodium*, which is transmitted by mosquitoes.
Describe *the asexual state of this sporozoan.*





Reduviid bug



Tsetse fly

Figure 10 The insects that carry protozoans from person to person are controlled by insecticides.

Zoomastigina

Protozoans in the phylum Zoomastigina (zoh oh mast tuh JI nuh) are called zooflagellates. Zooflagellates (zoh oh FLA juh layts) are animal-like protozoans that use flagella for movement. Flagella are long whip-like projections that protrude from the cell and are used for movement. Some zooflagellates are free living, but many are parasites.

At least three species of zooflagellates from the genus *Trypanosoma* (TRY pan uh zohm uh) cause infectious diseases in humans that often are fatal because of limited treatment options. One species found in Central and South America causes Chagas' disease, sometimes called American sleeping sickness. The second species causes East African sleeping sickness. The third species causes West African sleeping sickness.

American sleeping sickness The zooflagellates that cause Chagas' disease are similar to the sporozoans that cause malaria in that they have two hosts in their life cycles and insects spread the diseases through the human population. The reduviid bug (rih DEW vee id) bug, shown in **Figure 10,** serves as one host for the protist in Central and South America. The parasitic zooflagellates reproduce in the gut of this insect. The reduviid bug gets its nutrients by sucking blood from a human host. During the feeding process, the zooflagellates pass out of the reduviid body through its feces. The zooflagellates enter the human body through the wound site or mucus membranes. Once the zooflagellate enters the body, it multiplies in the bloodstream and can damage the heart, liver, and spleen.

African sleeping sickness The life cycles of the zooflagellates that cause both African sleeping sicknesses are similar to the one that causes American sleeping sickness. The insect host is the tsetse (SEET see) fly, shown in **Figure 10.** The blood-sucking tsetse fly becomes infected when it feeds on an infected human or other mammal. The zooflagellate reproduces in the gut of the fly and then migrates to its salivary glands. When the fly bites the human, the zooflagellate is transferred to the human host. The zooflagellates reproduce in the human host and cause fever, inflammation of the lymph nodes, and damage to the nervous system.

Section 2 Assessment

Section Summary

- Protozoans are unicellular protists that feed on other organisms to obtain nutrients.
- Protozoans live in a variety of aquatic environments.
- Protozoans reproduce in a variety of ways, including sexually and asexually.
- Protozoans have specialized methods for movement, feeding, and maintaining homeostasis.

Understand Main Ideas

1. **READING Check** Compare the methods of feeding, locomotion, and reproduction of three groups of protozoa.
2. **Explain** the function of three organelles found in protozoans.
3. **Diagram** and explain the life cycle of a member of the genus *Plasmodium*.
4. **Explain** why paramecium conjugation is not considered sexual reproduction.

Think Critically

WRITING in Biology

5. Create an informational brochure about zooflagellates for people living in South America.

MATH in Biology

6. There are approximately 50,000 species of protozoa, of which about 7000 are ciliates. What percentage of protozoans are ciliates?

Online Quiz

Reading Preview

Essential Questions

- What are the characteristics of the different phyla of algae?
- What is the role of secondary photosynthetic pigments that are characteristic of some algae?
- How do diatoms differ from most other types of algae?

Review Vocabulary

chloroplasts: chlorophyll-containing organelles found in the cells of green plants and some protists that capture light energy and convert it to chemical energy

New Vocabulary

bioluminescent
colony
alternation of generations

Multilingual eGlossary

Algae—Plantlike Protists

Algae are plantlike, autotrophic protists that are the producers for aquatic ecosystems.

Real-World Reading Link Have you ever looked at a group of people and wondered what they had in common? You might discover that they like the same type of music or they like the same type of sports. Most plantlike protists have something in common—they make their own food.

Characteristics of Algae

The group of protists called algae (singular, alga) is considered plantlike because the members contain photosynthetic pigments. Recall that photosynthetic pigments enable organisms to produce their own food using energy from the Sun in a process called photosynthesis. Algae differ from plants because they do not have roots, leaves, or other structures typical of plants.

The light-absorbing pigments of algae are found in chloroplasts. In many algae, the primary pigment is chlorophyll, which is the same pigment that gives plants their characteristic green color. Many algae also have secondary pigments that allow them to absorb light energy in deep water. As water depth increases, much of the sunlight's energy is absorbed by the water. These secondary pigments allow algae to absorb light energy from wavelengths that are not absorbed by water. Because these secondary pigments reflect light at different wavelengths, algae are found in a variety of colors, as shown in **Figure 11.**

Reading Check **Explain** the function of chloroplasts and photosynthetic pigments in algae.

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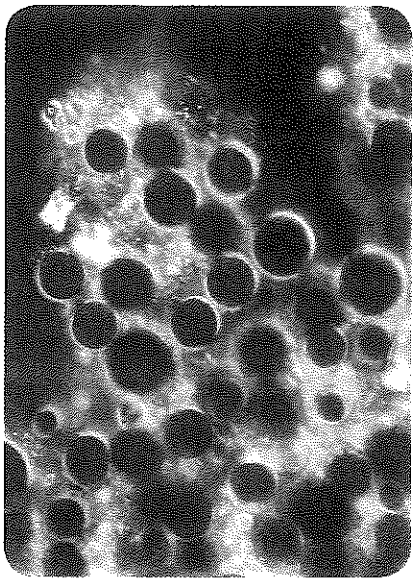


Red algae

LM Magnification: 250×

Green algae

Figure 11 Algae vary in color because they contain different pigments.

LM Magnification: 30×

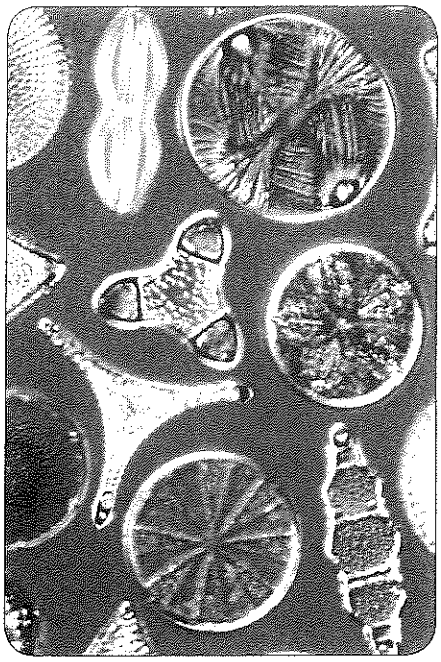


Figure 12 The various species of diatoms have different shapes and sizes.

Diversity of Algae

Algae have more differences than only their colors. For example, many algae exist as single cells, whereas others are huge multicellular organisms reaching 65 m in length. Some unicellular algae are referred to as phytoplankton—meaning "plant plankton." Phytoplankton are vital in aquatic ecosystems because they provide the base of the food web in these environments. As a by-product of photosynthesis, they also produce much of the oxygen found in Earth's atmosphere.

The great diversity of algae makes them a challenge to classify. Algologists usually use three criteria to classify algae: the type of chlorophyll and secondary pigments, the method of food storage, and the composition of the cell wall.

Diatoms The unicellular algae shown in **Figure 12** are members of the phylum Bacillariophyta (BAH sih LAYR ee oh FI tuh). These intricately shaped organisms are called diatoms. Look at **Figure 13** and notice that the diatom consists of two unequal halves—one fits neatly inside the other, forming a small box with a lid.

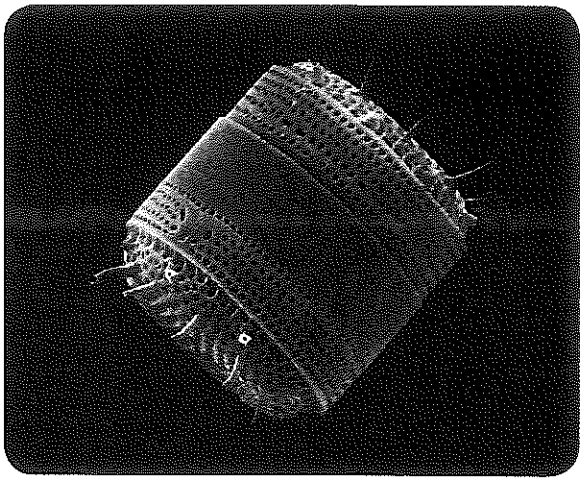
Connection to Physics Diatoms are photosynthetic autotrophs. They produce food by photosynthesis using chlorophyll and secondary pigments called carotenoids, which give diatoms their golden-yellow color. Diatoms store their food as oil instead of as carbohydrates. The oil not only makes diatoms a nutritious food source for many marine animals, but it also provides buoyancy. Oil is less dense than water, so diatoms float closer to the surface of the water, where they can absorb energy from the Sun for photosynthesis.

Diatoms reproduce both sexually and asexually, as illustrated in **Figure 14.** Asexual reproduction occurs when the two separated halves each create a new half that can fit inside the old one. This process produces increasingly smaller diatoms. When a diatom is about one-quarter of its original size, sexual reproduction is triggered and gametes are produced. The gametes fuse to form a zygote that develops into a full-sized diatom. The reproduction cycle then repeats.

The hard silica walls of the diatom last long after the diatom has died. The silica walls accumulate on the ocean floor to form sediment known as diatomaceous earth. This sediment is collected and used as an abrasive and a filtering agent. The gritty texture of many tooth polishes and metal polishes is due to the presence of diatom shells.

CAREERS IN BIOLOGY

Algologist A biologist who specializes in the study of algae is an algologist. Algologists might work at fish hatcheries or conduct marine research.



Color-Enhanced SEM Magnification: 13000×

Figure 13 Diatoms are found in both marine and freshwater environments. A unique feature of the diatom is its cell wall made of silica.

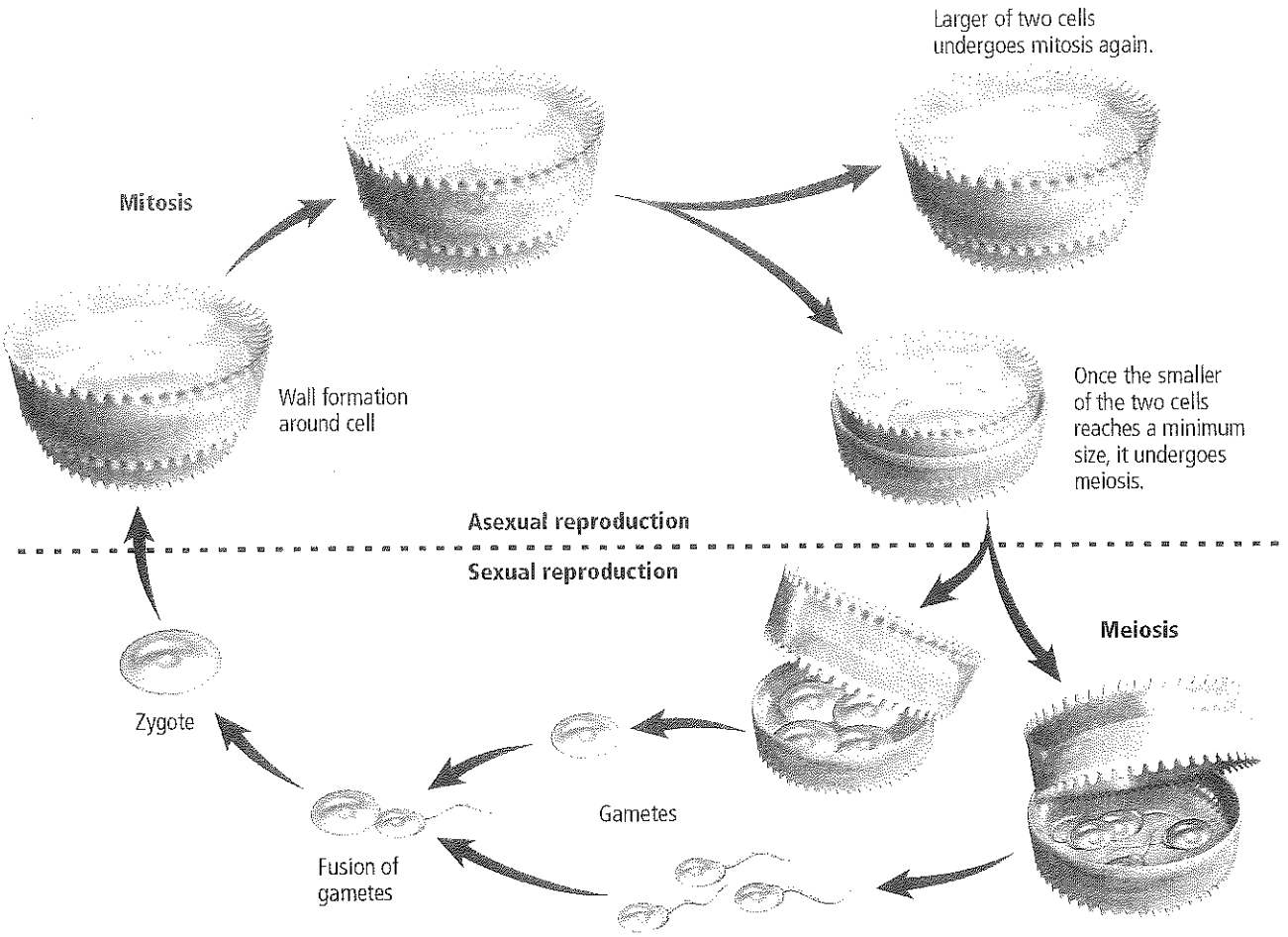


Figure 14 Diatoms reproduce asexually for several generations before undergoing sexual reproduction.

Dinoflagellates Plantlike protists that are members of the phylum Pyrrophyta (puh RAH fuh tuh) are called dinoflagellates (di nuh FLA juh layts). Most members of the phylum are unicellular and have two flagella at right angles to one another. As these flagella beat, a spinning motion is created, so dinoflagellates spin as they move through the water. Some members in this group have cell walls made of thick cellulose plates that resemble helmets or suits of armor. Other members of this group are **bioluminescent,** which means that they emit light. Although there are a few freshwater dinoflagellates, most are found in saltwater. Like diatoms, photosynthetic dinoflagellates are a major component of phytoplankton.

Dinoflagellates vary in how they get their nutritional requirements. Some dinoflagellates are photosynthetic autotrophs, and other species are heterotrophs. The heterotrophic dinoflagellates can be carnivorous, parasitic, or mutualistic. Mutualistic dinoflagellates have relationships with organisms such as jellyfishes, mollusks, and corals.

Algal blooms When food is plentiful and environmental conditions are favorable, dinoflagellates reproduce in great numbers. These population explosions are called algal blooms. Algal blooms can be harmful when they deplete the nutrients in the water. When the food supply diminishes, the dinoflagellates die in large numbers. As the dead algae decompose, the oxygen supply in the water is depleted, suffocating fish and other marine organisms. Additional fish suffocate when their gills become clogged with the dinoflagellates.

VOCABULARY

WORD ORIGIN

Pyrrophyta

pyro- prefix; from Greek; meaning *fire*

-phyton from Greek word *phyton,* meaning *plant*

Figure 15 The microscopic organism *Gymnodinium catenatum* is one species of dinoflagellate that causes red tides. During red tides, many marine organisms die and shellfish can be too toxic for humans to eat.

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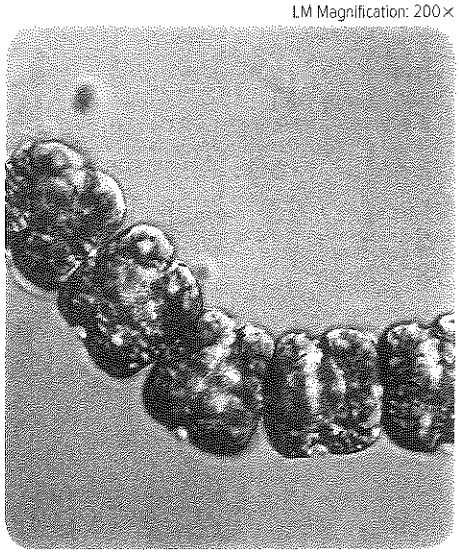
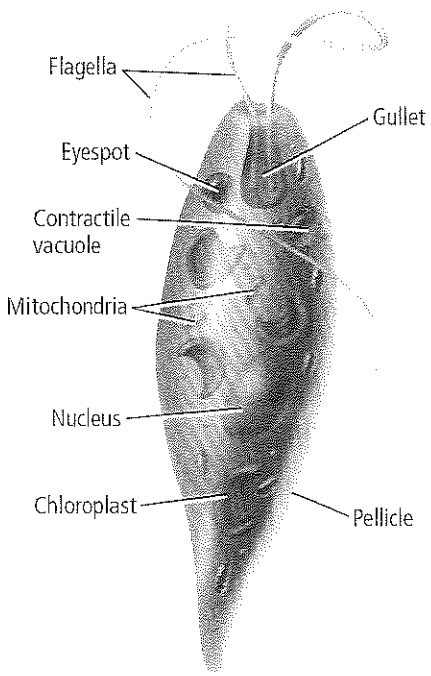


Gymnodinium catenatum

Red tide

Video Lab

Figure 16 *Euglena gracilis* are unicellular, plantlike algae that have characteristics of both plants and animals.

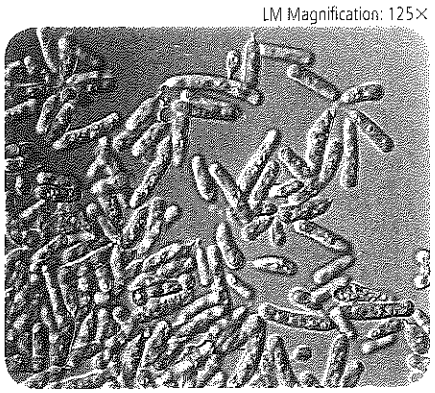


Red tides Some dinoflagellates have red photosynthetic pigments, and when they bloom, the ocean is tinged red, as shown in **Figure 15.** These blooms are called red tides. Red tides can be a serious threat to humans because some species of dinoflagellates produce a potentially lethal nerve toxin. The toxins affect people primarily when people eat shellfish. Shellfish that feed by filtering particles ingest the toxic dinoflagellates from the water. The toxins become concentrated in tissues of the shellfish. People and other organisms can become seriously ill or die from consuming these toxic shellfish.

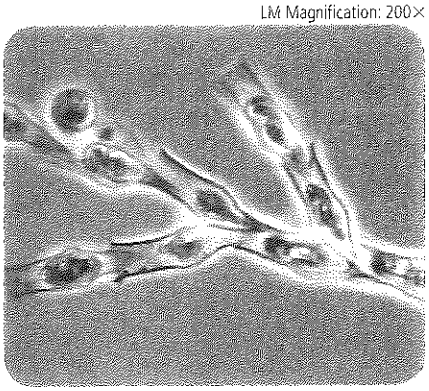
Red tides must be closely monitored. One method scientists use to track red tides is reviewing satellite images. However, floating robots are being developed that can constantly measure the concentration of red tide algae. If the concentration becomes too high, scientists can issue a warning to stop shellfish harvesting.

Euglenoids Members of the phylum Euglenophyta are unicellular, plantlike protists called euglenoids (yoo GLEE noydz). Most euglenoids are found in shallow freshwater, although some live in saltwater. Euglenoids are challenging to classify because they have characteristics of both plants and animals. Most euglenoids contain chloroplasts and photosynthesize, which is characteristic of plants, yet they lack a cell wall. Euglenoids also can be heterotrophs. When light is not available for photosynthesis, some can absorb dissolved nutrients from their environments. Others can ingest other organisms such as smaller euglenoids, which is a characteristic of animals. There even are a few species of euglenoids that are animal parasites.

The structure of a typical euglenoid is shown in **Figure 16.** Notice that instead of a cell wall, a flexible, tough outer membrane, called a pellicle, surrounds the cell membrane, which is similar to a paramecium's structure. The pellicle allows euglenoids to crawl through mud when the water level is too low to swim. Note the flagella that are used to propel the euglenoid toward food or light. The eyespot is a light-sensitive receptor that helps orient the euglenoid toward light for photosynthesis. The contractile vacuole serves the same purpose in the euglenoid as it does in a paramecium. It expels excess water from the cell to maintain homeostasis inside the cell.



Yellow-green algae



Golden-brown algae

Figure 17 Chrysophytes, like yellow-green and golden-brown algae, have carotenoids—secondary pigments used in photosynthesis.

Chrysophytes Yellow-green algae and golden-brown algae are in phylum Chrysophyta (KRIS oh fyt uh) and are called chrysophytes (KRIS oh fytz). Like diatoms, these algae have yellow and brown carotenoids that give them their golden brown color. The algae in **Figure 17** are two examples of organisms from this phylum. Most members of this phylum are unicellular, but some species form colonies. A **colony** is a group of cells that join together to form a close association. The cells of chrysophytes usually contain two flagella attached at one end of the cell. All chrysophytes are photosynthetic, but some species also can absorb dissolved organic compounds through their cell walls or ingest food particles and prokaryotes. They reproduce both asexually and sexually, although sexual reproduction is rare. Chrysophytes are components of both freshwater and marine plankton.

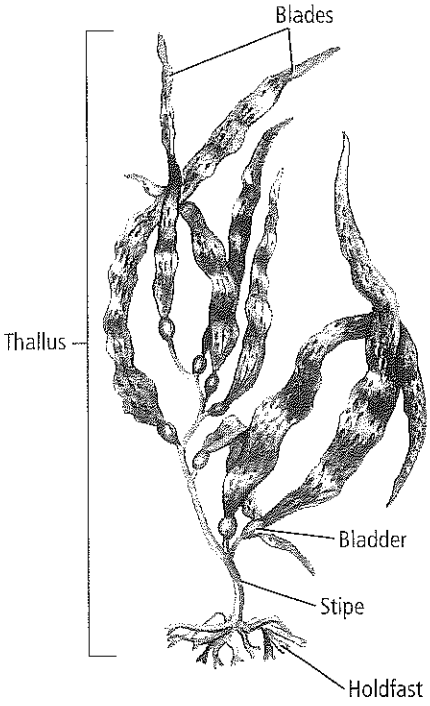
Reading Check **Identify** the substance that gives chrysophytes their golden-brown color.

Study Tip

Shared Reading Read two paragraphs aloud to a classmate. Have your partner summarize the key ideas. Then switch roles.

Brown algae Brown algae are members of phylum Phaeophyta (FAY oh FI tuh) and are some of the largest multicellular plantlike algae. These algae get their brown color from a secondary carotenoid pigment called fucoxanthin (fyew ko ZAN thun). Most of the 1500 species of brown algae live along rocky coasts in cool areas of the world. Look back at **Table 1** to see kelp, an example of a brown alga. The body of a kelp is called the thallus, as shown in **Figure 18.** The blades are the flattened portions, the stipe is the stalklike part, the holdfast is the rootlike structure, and the bladder is the bulging portion of the alga. The bladder is filled with air and keeps the alga floating near the surface of the water where light is available for photosynthesis.

Figure 18 Underwater kelp forests provide a habitat for many marine organisms, as well as provide algin, which is an additive used in many products.
Explain ***What is the function of the bladder in kelp?***



Green algae The diverse group of algae from phylum Chlorophyta (kloh RAH fy tuh) contains more than 7000 species. Green algae have several characteristics in common with plants. Green algae and plants both contain chlorophyll as a primary photosynthetic pigment, which gives both groups a green color. Both green algae and plant cells have cell walls, and both groups store their food as carbohydrates. These shared characteristics lead some scientists to think that there is an evolutionary link between these two kingdoms.

Most species of green algae are found in freshwater, but about ten percent are marine species. Green algae also are found on damp ground, tree trunks, and in snow. Green algae even are found in the fur of some animals, such as the sloth shown in **Figure 2.**

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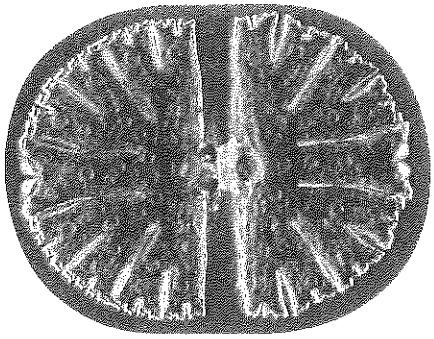

Desmids

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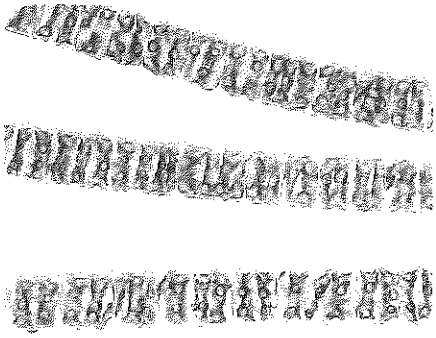

Spirogyra

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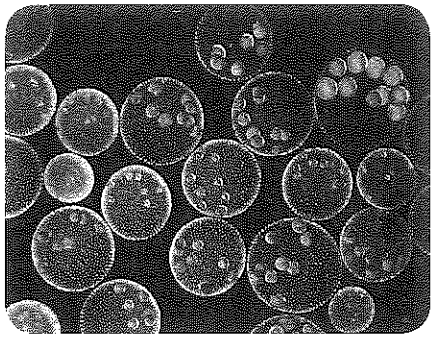


Volvox

Figure 19 *Desmids* are unicellular green algae that have elaborate cell walls. The green alga *Spirogyra* is named for its spiraling chloroplasts. Many cells that make up the *Volvox* colony have daughter colonies within the larger colony.

There are a variety of growth patterns exhibited by green algae. The unicellular algae *Desmids*, shown in **Figure 19**, are characterized by their symmetrically divided cells. Notice how the cells have two identical sides that are connected by a bridge. Another growth pattern is found in *Spirogyra*, shown in **Figure 19**. *Spirogyra* is a multicellular green alga characterized by its long, thin filaments. The name *Spirogyra* comes from the spiral pattern of the chloroplasts. *Volvox*, shown in **Figure 19**, is an example of an alga that has a colonial growth pattern.

The single cells of the *Volvox* colony are held together by a gelatinlike secretion called cytoplasmic strands. Each cell has flagella that beat in unison to move the colony. *Volvox* colonies might include hundreds or even thousands of cells that form a hollow ball. Smaller colonies, called daughter colonies, form balls inside the larger colony. When the daughter cells have matured, they digest the parental cell and become free-swimming.

Reading Check **Identify** three growth patterns of green algae.

Mini Lab 1

Investigate Photosynthesis in Algae

MiniLab

How much sunlight do green algae need to undergo photosynthesis? Algae contain photosynthetic pigments that allow them to produce food by using energy from the Sun. Observe green algae to determine whether the amount of light affects photosynthesis.

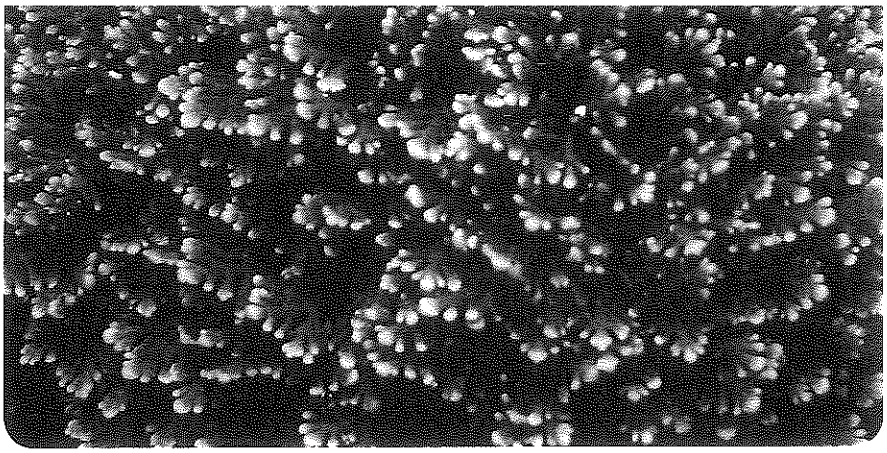
Procedure:

1. Read and complete the lab safety form.
2. Obtain samples of **green algae** from your teacher. Place the sample of each type of algae in different locations in the classroom. Be sure that one location is completely dark.
3. Hypothesize what will happen to the algae in each location.
4. Check each specimen every other day for a week. Record your observations.

Analysis

1. **Describe** the evidence that you used to determine whether photosynthesis was occurring.
2. **Conclude** whether your hypothesis was supported. Explain.
3. **Identify** which organelles you would expect to see if you looked at each type of alga under a microscope.

(l, r)M.I. Walker/Photo Researchers; (c)Andrew Syred/Photo Researchers



Coralline

Figure 20 The red photosynthetic pigments allow the red algae to live in deep water and still use sunlight to photosynthesize. Explain *how the red photosynthetic pigments make this possible.*

Red Algae Most red algae in phylum Rhodophyta (roh dah FI duh) are multicellular. Look at **Figure 20** to see how red algae got their name. These organisms contain red photosynthetic pigments called phycobilins that give them a red color. These pigments enable the red algae to absorb green, violet, and blue light that can penetrate water to a depth of 100 m or more. This allows red algae to live and photosynthesize in deeper water than other algae.

Some red algae also contribute to the formation of coral reefs. The cell walls of the red alga *Coralline* contain calcium carbonate. The calcium carbonate binds together the bodies of other organisms called stony coral to form coral reefs.

VOCABULARY

ACADEMIC VOCABULARY

Supplement
something that completes or makes an addition
Vitamins are taken to supplement one's diet.

Uses for Algae

Algae are used as a source of food for animals and people worldwide. In coastal areas of North America and Europe, algae are fed to farm animals as a food supplement. Algae are found in many dishes and processed foods, as described in **Table 2.** Algae are nutritious because of their high protein content and because they contain minerals, trace elements, and vitamins. Some of the substances found in algae also are used to stabilize or improve the texture of processed foods, without adding fat to those products.

Table 2 Some Uses for Algae — Interactive Table

Type of Algae	Uses
Red algae	A species of red alga, *Porphyra,* is called nori, which is dried, pressed into sheets, and used in soups, sauces, sushi, and condiments. Some species of red algae provide agar and carrageenan, which are used in the preparation of scientific gels and cultures. Agar also is used in pie fillings and to preserve canned meat and fish. Carrageenan is used to thicken and stabilize puddings, syrups, and shampoos.
Brown algae	Brown algae are used to stabilize products, such as syrups, ice creams, and paints. The genus *Laminaria* is harvested and eaten with meat or fish and in soups.
Green algae	Species from the genera *Monostroma* and *Ulva,* also called sea lettuce, are eaten in salads, soups, relishes, and in meat or fish dishes.
Diatoms	Diatoms are used as a filtering material for processes such as the production of beverages, chemicals, industrial oils, cooking oils, sugars, water supplies, and the separation of wastes. They are also used as abrasives.

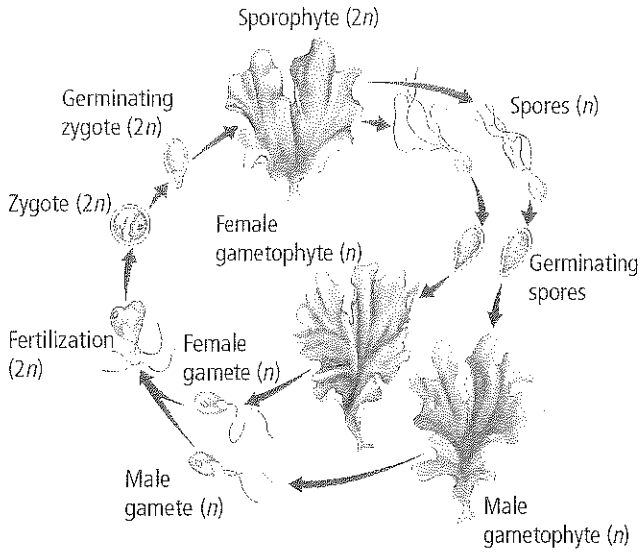


Figure 21 The life cycle of many algae, including the sea lettuce *Ulva* shown here, includes an alternation between a diploid and haploid generation. Alternation of generations is also found in members of both the plant and fungi kingdoms.

Personal Tutor

Life Cycles of Algae

Algae can alternate between spore-producing forms and gamete-producing forms. They can reproduce sexually as well as asexually. Green algae also reproduce asexually through fragmentation, a process in which a multicellular individual breaks into separate pieces and each grows into an individual organism.

Alternation of generations The life cycles of many algae exhibit a pattern called alternation of generations, illustrated in **Figure 21** for the sea lettuce *Ulva*. **Alternation of generations** is a life cycle of algae that takes two generations to complete a life cycle, one that reproduces sexually and one that reproduces asexually. Organisms alternate between a diploid *(2n)* form and a haploid *(n)* form, each of which is considered a generation.

Haploid and diploid generations The haploid form of the organism is called the gametophyte generation because it produces gametes. This generation begins with spores and ends with male and female gametes. Gametes from two different organisms combine to form a zygote with two complete sets of chromosomes. The diploid form begins with fertilization and ends when the sporophyte creates spores. The zygote develops into the sporophyte *(2n)*. In the sporophyte, some cells divide by meiosis and become haploid spores *(n)*. Spores are reproductive cells that develop into gametophytes. The new gametophytes continue the cycle, as shown in **Figure 21.**

Section 3 Assessment

Section Summary

- Algae are autotrophic protists.
- Algae are important producers of oxygen and food for aquatic ecosystems.
- Euglenoids, diatoms, and dinoflagellates are unicellular algae.
- Red, brown, and green algae have multicellular forms.
- The life cycles of algae include an alternation of generations.

Understand Main Ideas

1. **Explain** why algae are considered the primary producers for aquatic and marine ecosystems.
2. **Describe** the major characteristics of three phyla of algae.
3. **Explain** why you would expect to find more evidence of diatoms than green algae in a sample of ocean floor sediment.
4. **Apply** what you know about photosynthesis to explain why most algae live at or near the surface of the water.

Think Critically

5. **Design an experiment** to determine the optimum color of light to grow green algae.
6. **Summarize** the role of secondary photosynthetic pigments in algae.

WRITING in Biology

7. Write a brief public service announcement explaining the dangers of eating shellfish during a red tide.

Online Quiz

Section 4

Funguslike Protists

Reading Preview

Essential Questions

- What are the characteristics of cellular and acellular slime molds?
- How are the life cycles of cellular and acellular slime molds similar?
- How do water molds obtain their nutrition?

Review Vocabulary

cellulose: a glucose polymer that forms the cell walls of plants and some funguslike protists

New Vocabulary

plasmodium
acrasin

Multilingual eGlossary

Main Idea **Funguslike protists obtain their nutrition by absorbing nutrients from dead or decaying organisms.**

Real-World Reading Link Have you ever heard the saying, "Don't judge a book by its cover"? The same could be said of funguslike protists. At first glance, they look like fungi. But when they are examined more closely, many traits are revealed that are not true of fungi.

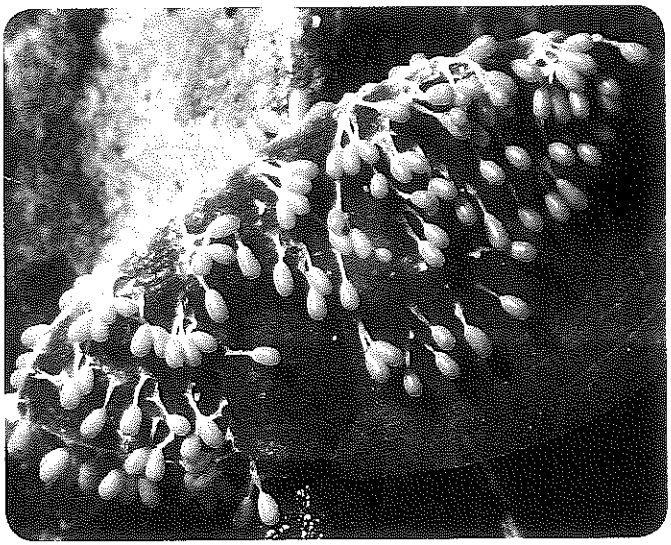
Slime Molds

As you can imagine, funguslike protists are protists that have some characteristics of fungi. Fungi and slime molds use spores to reproduce. Like fungi, slime molds feed on decaying organic matter and absorb nutrients through their cell walls. However, fungi and slime mold dif-fer in the composition of their cell walls. Fungi cell walls are composed of a substance called chitin (KI tun). Chitin is a complex carbohydrate that is found in the cell walls of fungi, and in the external skeletons of insects, crabs, and centipedes. The cell walls of funguslike protists do not contain chitin, as a true fungus does. The cell walls of these protists contain cellulose or celluloselike compounds.

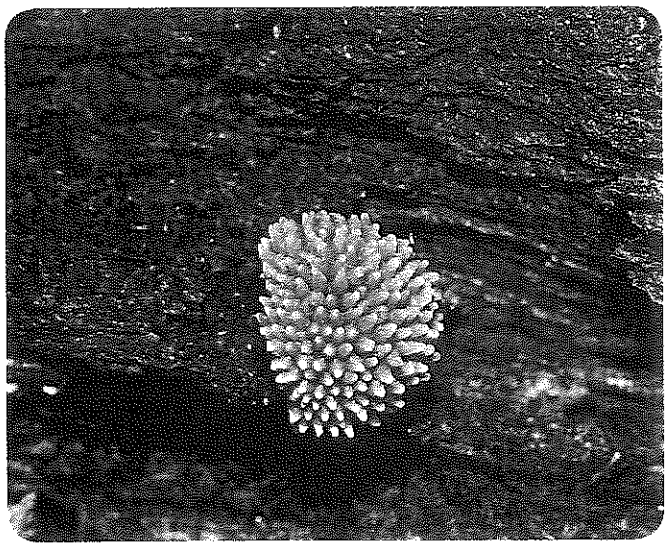
Slime molds are found in a variety of colors, ranging from yellows and oranges to blue, black, and red, as shown in **Figure 22.** They usually are found in damp, shady places where decaying organic matter is located, such as on a pile of decaying leaves or on rotting logs. Slime molds are divided into two groups: acellular slime molds and cellular slime molds.

Reading Check **Compare and contrast** fungi and slime molds.

Figure 22 Slime molds have a variety of colors and shapes, but they all have funguslike characteristics.
Infer ***Where might these slime molds be obtaining their nutrition?***



Myxamoebae slime mold



Red raspberry slime mold

(l)Biology Media/Photo Researchers; (r)Matt Meadows/Peter Arnold/Getty Images

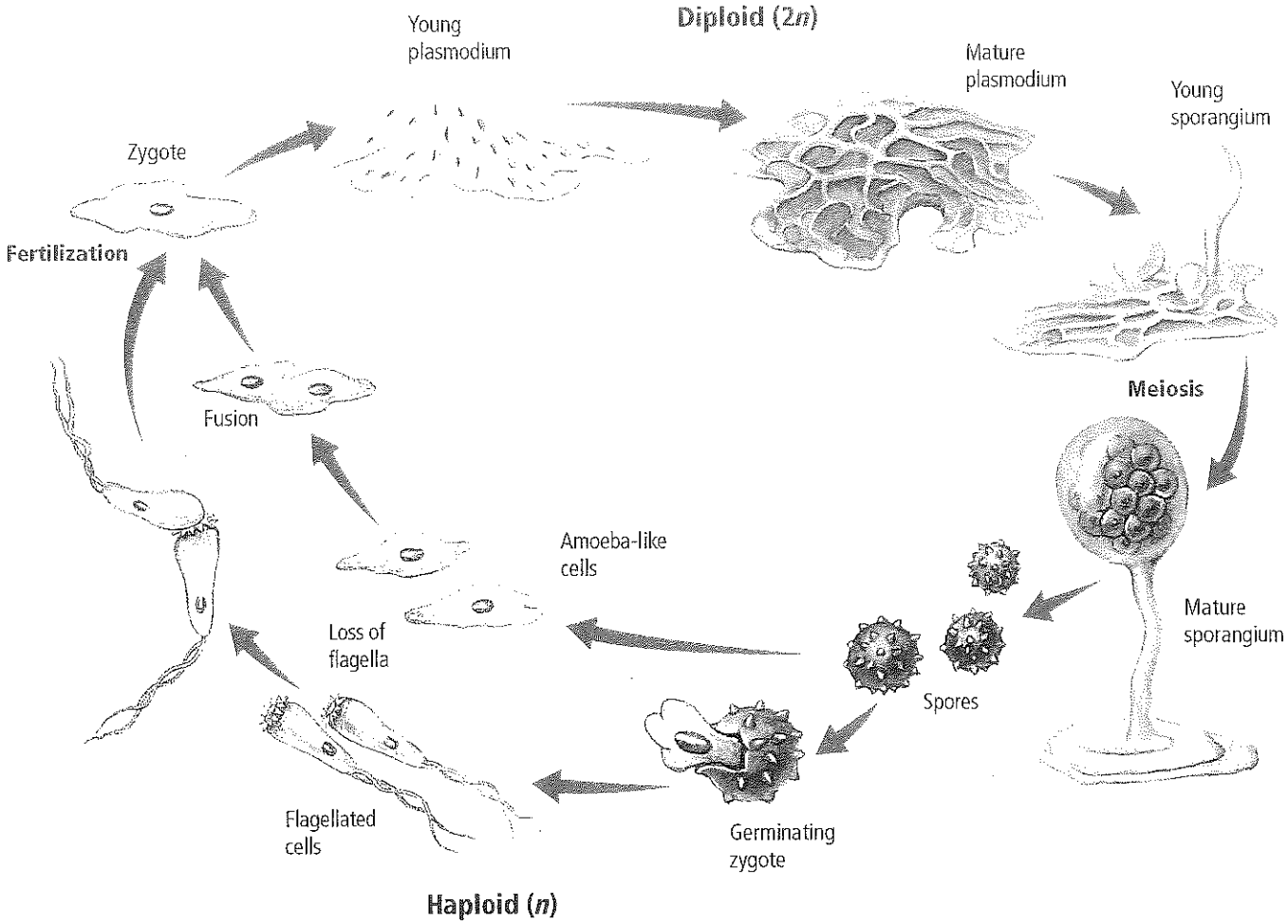


Figure 23 Acellular slime mold goes through haploid and diploid phases during its life cycle.

Acellular slime molds Funguslike protists called acellular slime molds are found in the phylum Myxomycota (mihk soh mi COH tuh). They are acellular because they go through a phase in their life cycle in which the nucleus divides but no internal cell walls form, resulting in a mass of cytoplasm with multiple nuclei.

Follow the life cycle of a typical acellular slime mold, shown in **Figure 23.** Acellular slime molds begin life as spores, usually when conditions are harsh–such as during a drought. In the presence of water, the spore produces a small mass of cytoplasm, or an amoeboid cell, or a cell with a flagella. The cell is propelled by the flagella until it comes in contact with a favorable surface. Then, the flagella permanently retract and the cell produces pseudopods that allow it to move like an amoeba. Both the flagellated cell and the amoeba-like cell are gametes and are haploid *(n)*.

When two gametes unite, the next phase of the life cycle begins. The fertilized cells undergo repeated divisions of the nuclei, forming a plasmodium. A **plasmodium** (plaz MOH dee um) is a mobile mass of cytoplasm that contains many diploid nuclei but no separate cells. This is the feeding stage of the organism. It creeps over the surface of decaying leaves or wood like an amoeba and can grow as large as 30 cm in diameter. When food or moisture becomes limited, the slime mold develops spore-producing structures. Spores are produced through meiosis and dispersed by the wind. Once the spores are in the presence of water, the cycle repeats.

VOCABULARY

ACADEMIC VOCABULARY

Phase
a particular state in a regular cycle of changes
The phases of the Moon are based on the positions of Earth, the Sun, and the Moon.

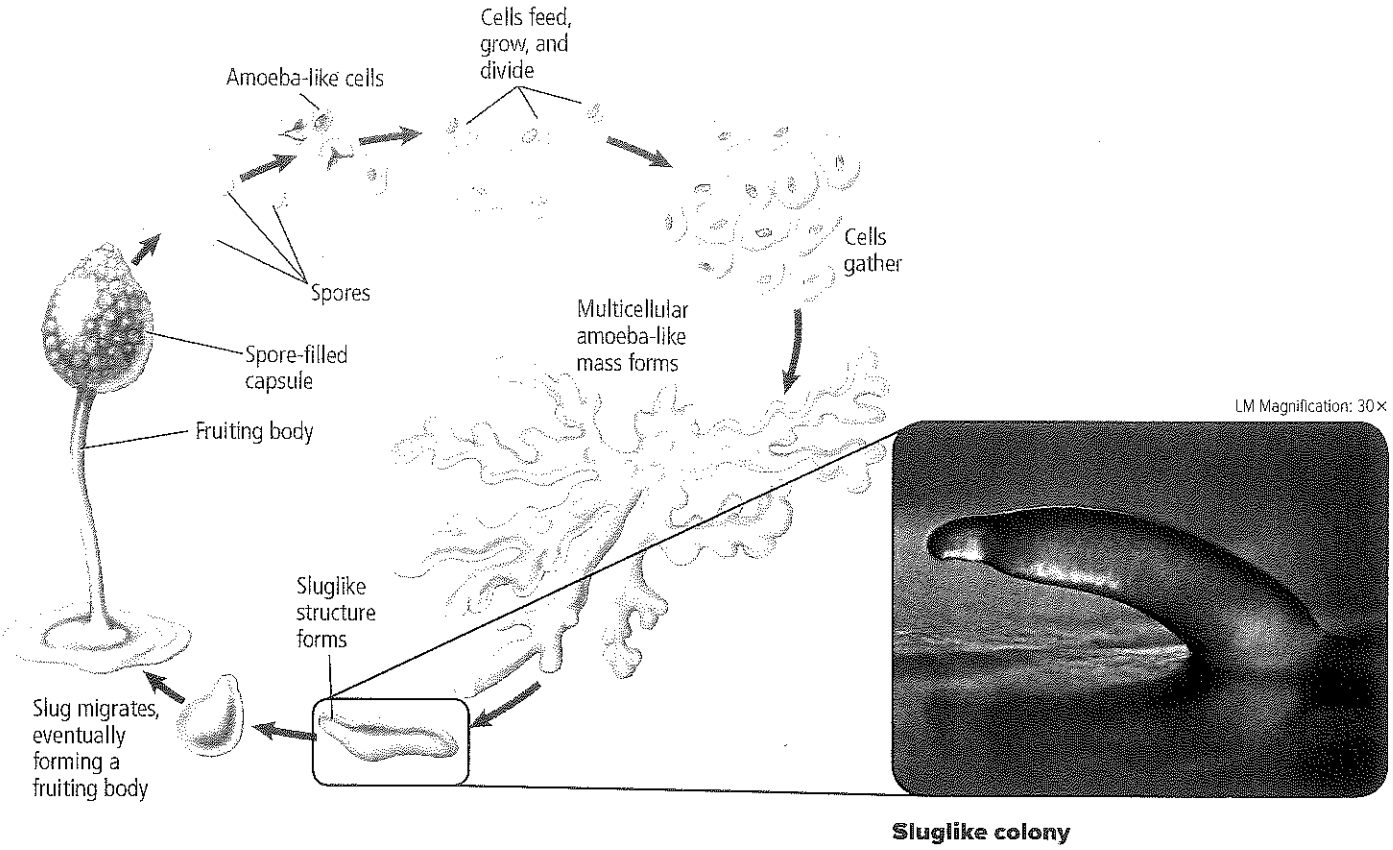


Figure 24 Cellular slime molds reproduce both sexually and asexually. Amoeba-like cells congregate during asexual reproduction, shown above, to form a sluglike colony, which functions like a single organism.
Explain ***why the sluglike stage is considered a colony.***

Cellular slime molds Cellular slime molds are found in the phylum Acrasiomycota (uh kray see oh my COH tuh). These funguslike protists creep over rich, moist soil and engulf bacteria. Unlike acellular slime molds, they spend most of their life cycle as single amoeba-like cells and have no flagella.

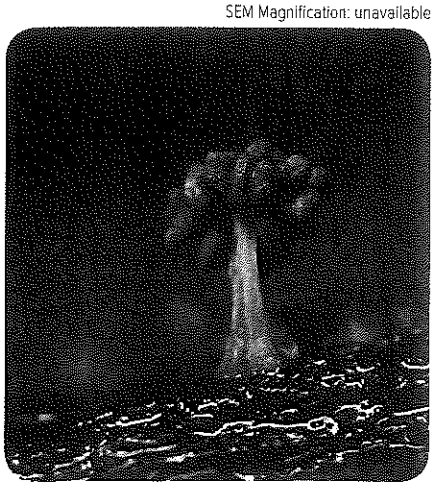
The life cycle of cellular slime molds is shown in **Figure 24.** When food is plentiful, the single amoeba-like cells reproduce rapidly by sexual reproduction. During sexual reproduction, two haploid amoebas unite and form a zygote. The zygote develops into a giant cell and undergoes meiosis followed by several divisions by mitosis. Eventually, the giant cell ruptures, releasing new haploid amoebas.

When food is scarce, the single amoeba-like cells reproduce asexually. The starving amoeba-like cells give off a chemical called **acrasin** (uh KRA sun). The amoeba-like cells begin to congregate in response to the chemical signal, forming a sluglike colony that begins to function like a single organism. The colony migrates for a while, eventually forming a fruiting body, like the one shown in **Figure 25.** The fruiting body produces spores. Once the spores are fully developed, they are released. The spores germinate, forming amoeba-like cells, and the cycle repeats.

Reading Check **Infer** why the stages in the life cycle of cellular slime molds contribute to their long-term survival.

Figure 25 Cellular slime molds produce fruiting bodies that contain spores during part of their life cycle.

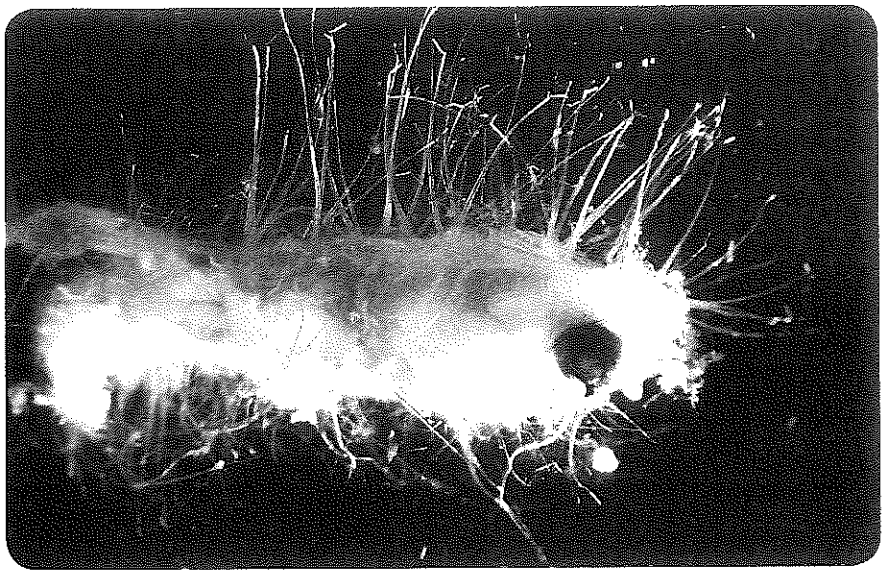
SEM Magnification: unavailable



(t)Carolina Biological Supply Company/Phototake; (b)Eye of Science/Science Source

Figure 26 This water mold is absorbing nutrients found in this dead goldfish. Explain *the funguslike characteristics of water molds.*

LM Magnification: 10×



Water mold

Water Molds and Downy Mildew

There are more than 500 species of water molds and downy mildews in the phylum Oomycota (oo oh my COH tuh). Most members of this group of funguslike protists live in water or damp places. Some absorb their nutrients from the surrounding water or soil, while others obtain their nutrients from other organisms, as shown in **Figure 26.**

Originally, water molds were considered fungi because of their method of obtaining nutrients. Like fungi, water molds envelop their food sources with a mass of threads; they break down the tissue and absorb the nutrients through their cell walls. Although this is characteristic of fungi, water molds differ from fungi in the composition of their cell walls and their production of flagellated reproductive cells. Recall that the cell walls of funguslike protists are composed of cellulose and celluloselike compounds.

Reading Check **Compare and contrast** water molds and fungi.

MiniLab 2

Investigate Slime Molds

MiniLab

What is a slime mold? In a kingdom of interesting creatures, slime molds perhaps are the most interesting. Observe different types of slime molds and observe the unusual nature of their bodies.

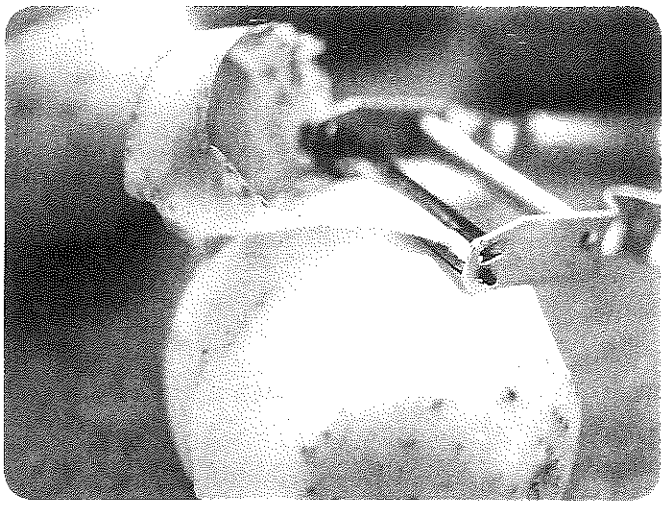
Procedure

1. Read and complete the lab safety form.
2. Obtain **slides of different specimens of slime molds.** Examine the slides under a **microscope.**
3. Create a data table to record your information. Sketch and describe each specimen.

Analysis

1. **Compare and contrast** the specimens.
2. **Identify** specimens that have similar characteristics. Explain why the specimens are similar.
3. **Think Critically** How would you classify each specimen that you examined? Explain.

Infected potato



Healthy potato

Figure 27 Compare the infected potato on the left with the normal one on the right. *Phytophthora infestans* will destroy the harvested potato in a matter of weeks.

Connection to History One member of phylum Oomycota has had a far-reaching impact. The downy mildew *Phytophthora infestans* (FI toh fah thor uh • in FEST unz) infects potato plants and destroys potatoes, as shown in **Figure 27.** This organism devastated the potato crop of Ireland in the 19th century. Because the potato was the country's primary food source, about one million people died of starvation or famine-related diseases in Ireland. Ironically, during this time, many other agricultural products were produced in Ireland. The Irish farmers could not afford to purchase the agricultural products, so the products were exported to Britain. The British government did provide some assistance to the farmers, but it was too little to prevent the widespread famine. During this time, a large number of people emigrated from Ireland to the United States to escape the terrible famine.

Section 4 Assessment

Section Summary

- The cell walls of funguslike protists do not contain chitin.
- Slime molds, water molds, and downy mildew grow in aquatic or damp places.
- Acellular slime molds form a plasmodium that contains many nuclei but no separate cells.
- Cellular slime molds form colonies of cells to reproduce.
- Water molds envelop their food source with a mass of threads.

Understand Main Ideas

1. **Explain** how funguslike protists obtain their nutrition.
2. **Compare** characteristics of cellular and acellular slime molds.
3. **Describe** how amoeba-like cells move.
4. **Outline** the life cycles of cellular and acellular slime molds.
5. **Classify** an organism that has cell walls made of cellulose and absorbs its nutrients from dead organisms.

Think Critically

6. **Design an experiment** to determine the moisture requirements of an acellular slime mold.
7. **Recommend** a procedure that a garden-shop owner should follow to prevent slime molds from growing on his or her wooden benches.

Writing in Biology

8. Write a short newspaper article about the Irish Potato Famine.

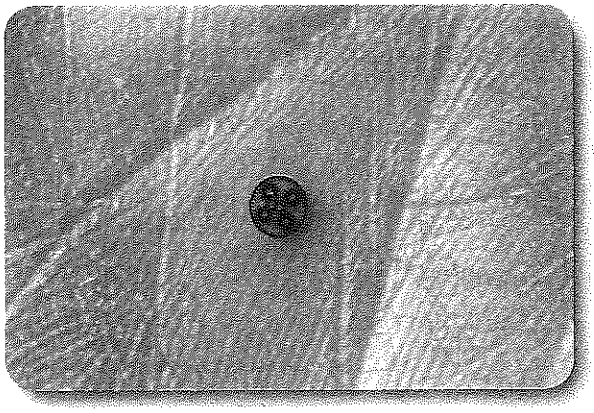
In the Field

Career: Nanotechnologist

Diatoms: Living Silicon Chips

Diatoms have recently gained the attention of nanotechnologists—scientists who engineer devices on the atomic level. Diatoms build intricate shells with incredible precision and regularity. Nanotechnologists think these organisms could be used to build useful structures from silicon on the atomic level.

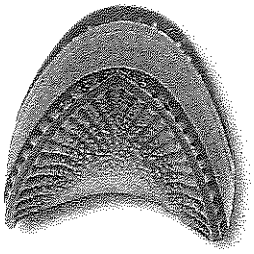
Nature's nanotechnologists Humans still have a lot to learn from diatoms about constructing materials on the nanoscale. Currently, nanotechnologists etch features onto silicon and other materials to produce components. The process is costly, time-consuming, and generates chemical waste.



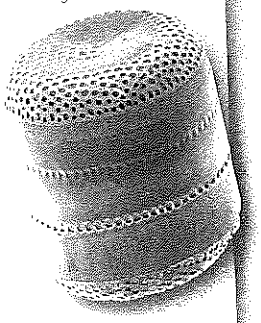
Silicon dioxide shell in a hand

Living silicon chips Diatoms have been described as living silicon chips because they construct their shells atom by atom. Silicon derived from seawater is processed into intricate microstructures to form a rigid silica shell, such as the one shown in the photo. Each diatom species forms a unique and potentially useful shell structure.

Color-Enhanced SEM
Magnification: 390×



Color-Enhanced SEM
Magnification: 390×



Diatoms

To create nanomaterials from diatoms, scientists prepare feeding solutions containing silicon and other elements that they wish to test. The diatoms take these elements in and use them to build shells. When diatoms replace silicon atoms in their shell with elements like magnesium or titanium, a structurally intact unit with a desired shape and chemical makeup is produced. Scientists are working to use diatom shell patterns, many of which cannot currently be duplicated by nanotechnologists, as templates to build components with desired specifications.

Future applications Diatoms might prove to be an important tool in the evolving science of nanotechnology with potential applications in biomedicine, telecommunications, and energy storage and production.

WRITING in Biology

Newspaper Article The worldwide need for nanotechnology workers could reach two million by the year 2015. Write a want ad for a specific career in nanotechnology.

WebQuest

BIOLAB

Design Your Own

INVESTIGATE: HOW DO PROTOZOANS BEHAVE?

Background: **Animals respond and react to the world around them. One such type of reaction is known as *taxis*, in which an animal orients itself toward (positive) or away (negative) from a stimulus. Some of the things to which animals respond are light (phototaxis), temperature (thermotaxis), chemicals (chemotaxis), and gravity (gravitaxis).**

Question: *How do simple, unicellular, animal-like protozoans respond to stimuli?*

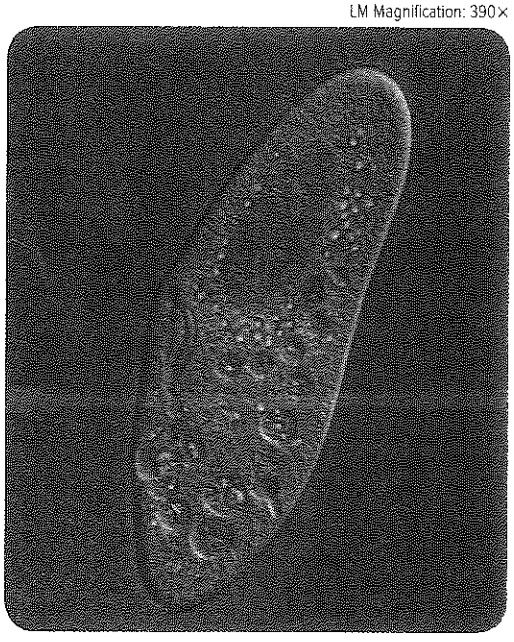
Materials

cultures of live protozoans
compound microscope
glass slides and coverslips
materials needed to produce stimuli

Safety Precautions

WARNING: ***Use care when handling slides. Dispose of any broken glass in a container provided by your teacher.***

LM Magnification: 390×



Plan and Perform the Experiment

1. Read and complete the lab safety form.
2. Design an experiment to answer the question to the left. Reword the original question to include the taxis you plan to investigate.
3. Make sure your teacher approves your plan before you proceed.
4. Collect the materials and supplies needed and begin conducting your experiment.
5. Dispose of your protozoan cultures as instructed by your teacher.

Analyze and Conclude

1. **Observe and Infer** Some protozoans often are described as animal-like. What animal-like characteristics did you observe?
2. **State the Problem** What stimuli were you trying to test with your experimental design?
3. **Hypothesize** What was your hypothesis for the question to be solved?
4. **Summarize** What data did you collect during the experiment?
5. **Analyze and Conclude** Did your data support your hypothesis? What is your conclusion?
6. **Error Analysis** Compare your data and conclusions with those of other students in your class. Explain the differences in the data.

WRITING in Biology

Report In this lab, you tested the response of an organism to a stimuli. Write a short report critiquing your methods. Include ways in which you can improve your techniques.

Chapter 19 Study Guide

THEME FOCUS Systems and System Models Scientists are still deciphering the evolutionary relationships between protists and other kingdoms.

BIG Idea Protists are a diverse group of unicellular and multicellular organisms that do not necessarily share the same evolutionary history.

Section 1 Introduction to Protists

protozoan (p. 542)
microsporidium (p. 544)

KEY Idea Protists form a diverse group of organisms that are subdivided based on their method of obtaining nutrition.

- Protists include unicellular and multicellular eukaryotes.
- Protists are classified by their methods of obtaining food.
- The first protists might have formed through endosymbiosis.
- Protists might have been the first eukaryotic cells with chloroplasts and mitochondria, evolving billions of years ago.

Section 2 Protozoans—Animal-like Protists

pellicle (p. 547)
trichocyst (p. 547)
contractile vacuole (p. 547)
pseudopod (p. 550)
test (p. 550)

KEY Idea Protozoans are animal-like, heterotrophic protists.

- Protozoans are unicellular protists that feed on other organisms to obtain nutrients.
- Protozoans live in a variety of aquatic environments.
- Protozoans reproduce in a variety of ways, including sexually and asexually.
- Protozoans have specialized methods for movement, feeding, and maintaining homeostasis.

Section 3 Algae—Plantlike Protists

bioluminescent (p. 555)
colony (p. 557)
alternation of generations (p. 560)

KEY Idea Algae are plantlike, autotrophic protists that are the producers for aquatic ecosystems.

- Algae are autotrophic protists.
- Algae are important producers of oxygen and food for aquatic ecosystems.
- Euglenoids, diatoms, and dinoflagellates are unicellular algae.
- Red, brown, and green algae have multicellular forms.
- The life cycles of algae include an alternation of generations.

Section 4 Funguslike Protists

plasmodium (p. 562)
acrasin (p. 563)

KEY Idea Funguslike protists obtain their nutrition by absorbing nutrients from dead or decaying organisms.

- The cell walls of funguslike protists do not contain chitin.
- Slime molds, water molds, and downy mildew grow in aquatic or damp places.
- Acellular slime molds form a plasmodium that contains many nuclei but no separate cells.
- Cellular slime molds form colonies of cells to reproduce.
- Water molds envelop their food source with a mass of threads.

Vocabulary eGames

Chapter 19 Assessment

Section 1

Vocabulary Review

Answer the following questions with complete sentences.

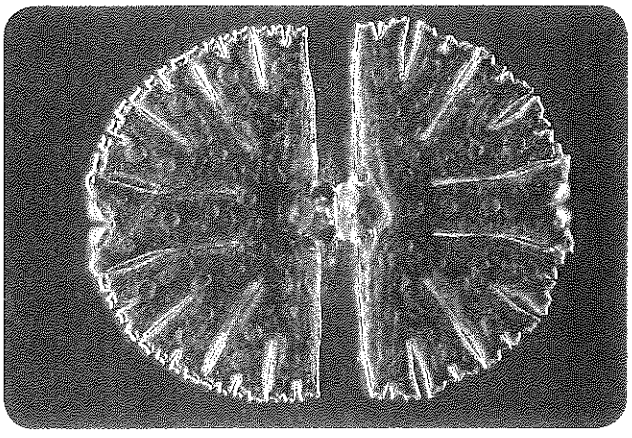
1. What is another name for animal-like protists?
2. What are microscopic protozoans that are found in the guts of insects?

Understand Main Ideas

3. Which process is most likely the way in which the first protists formed?
   A. aerobic respiration C. endosymbiosis
   B. decomposition D. photosynthesis
4. MAIN IDEA Which method below is used to divide protists into three groups?
   A. method of getting food
   B. method of movement
   C. type of reproduction
   D. type of respiration
5. Which is least likely to be a suitable environment for protists?
   A. decaying leaves C. damp soil
   B. the ocean D. dry sand

Use the photo below to answer questions 6 and 7.

LM Magnification: 125×



6. To which group does the protist belong?
   A. algae C. funguslike
   B. animal-like D. protozoans
7. Which term best describes this protist?
   A. acellular C. multicellular
   B. eukaryotic D. prokaryotic

Constructed Response

8. **Open Ended** Describe three locations near your home or school where you could find protists.
9. **Short Answer** Explain the differences between animal-like protists, plantlike protists, and funguslike protists.

Think Critically

10. **Predict** changes in protist populations if an area had an above-average amount of rainfall.

Section 2

Vocabulary Review

Define each structure. Provide an example of an organism where each structure could be found.

11. pseudopod
12. contractile vacuole
13. test

Understand Main Ideas

Use the diagram below to answer question 14.

14. Which structure does this organism use for movement?
   A. cilia
   B. contractile vacuole
   C. flagella
   D. pseudopodia
15. THEME FOCUS Stability and Change What does the paramecium's contractile vacuole help regulate inside the cell?
   A. amount of food C. movement
   B. amount of water D. reproduction
16. Which are most likely to form fossils?
   A. apicomplexans C. foraminifera
   B. flagellates D. paramecia

Chapter 19 Assessment

Constructed Response

17. Explain why termites might die if their symbiotic flagellates died.

18. **Short Answer** Describe the process of conjugation in paramecia.

Think Critically

19. **Apply Concepts** Recommend several options that villagers might consider to slow down the spread of malaria.

20. **Research Information** Research other diseases that are caused by protozoans. Use a map and plot locations where the diseases occur.

Section 3

Vocabulary Review

Match each definition below with the correct vocabulary term from the Study Guide page.

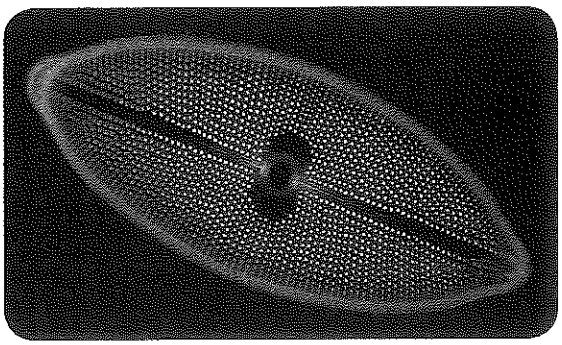
21. a life cycle of algae that requires two generations

22. a group of cells living together in close association

23. gives off light

Understand Main Ideas

Use the photo below to answer question 24.

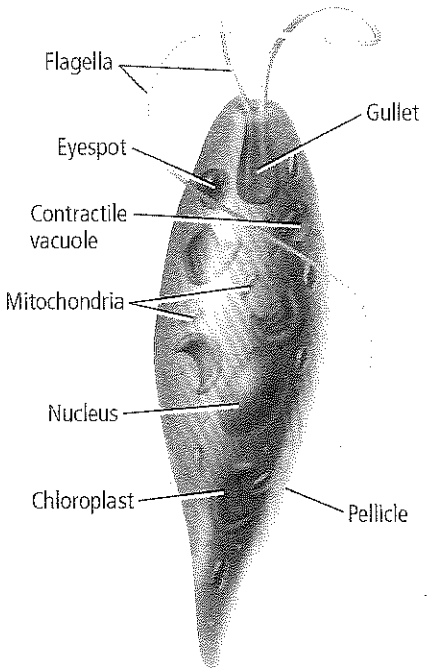


24. Where does this organism store its excess food?
    A. cellulose C. protein
    B. oil D. carbohydrate

25. Which are used in the human food supply?
    A. dinoflagellates C. protozoans
    B. euglenoids D. red algae

26. Which organism has silica walls?
    A. brown alga C. dinoflagellate
    B. diatom D. euglenoid

Use the illustration below to answer questions 27 and 28.



27. Which structures are used by the organism above for movement?
    A. cilia C. flagella
    B. contractile vacuoles D. pseudopods

28. Which structure is used to sense light?
    A. chloroplast C. nucleus
    B. eyespot D. pellicle

Constructed Response

29. **Open Ended** Why are there more fossils of diatoms, foraminiferans, and radiolarians than of other algae?

30. **Short Answer** Explain why diatoms must sometimes reproduce sexually.

31. **Short Answer** Explain the relationship between the sporophyte and gametophyte in alternation of generations.

Think Critically

32. **Analyze** the difference between freshwater algae and marine algae.

John Burbidge/Photo Researchers

Online Test Practice

33. BIG Idea Explain the effects of a marine parasite that kills all phytoplankton.

Section 4

Vocabulary Review

Replace the underlined words with the correct vocabulary term from the Study Guide page.

34. A motile organism that consists of many diploid nuclei but no separate cells is a protoplasm.

35. Starving amoeboid cells give off a chemical called arsenic.

Understand Main Ideas

36. Acellular slime molds have many nuclei, but which structure do they lack?
   A. chromosomes
   B. spores
   C. separate cells
   D. cilia

37. Which is present in the life cycle of water molds in a flagellated form?
   A. nuclei
   B. plasmodia
   C. pseudopods
   D. reproductive cells

Constructed Response

38. BIG Idea Compare and contrast a water mold and a cellular slime mold.

39. **Open Ended** Describe some environmental conditions that might lead to the production of spores by an acellular slime mold.

Think Critically

40. **Analyze and Conclude** During the multinucleated plasmodial stage, could acellular slime molds be classified as multicellular organisms? Explain your reasoning.

Summative Assessment

41. BIG Idea If you were a taxonomist given the task of organizing protists into groups, would you use the same method described in this book? Explain your answer.

42. Choose one protist and imagine a new organelle or structure that is going to develop. How will this new condition affect the protist? Will this change increase or decrease the chance of survival?

43. Is it possible to describe the typical protist? Hypothesize why the organisms in Kingdom Protista are more diverse than the organisms in any of the other kingdoms.

44. WRITING in Biology Write a descriptive essay describing the types of environments where you would expect to find protists. Be sure to include details about biotic and abiotic factors in the environments.

DB Document-Based Questions

The text below describes a new detection method for finding microscopic organisms in water sources.

The protozoans *Giardia lamblia* and *Cryptosporidium parvom* are major causes of waterborne intestinal diseases throughout the world. A very sensitive detection method was developed using the DNA amplification procedure–polymerase chain reaction. This procedure can detect the presence of incredibly small amounts of these pathogens–as little as a single cell in two liters of water.

Data obtained from: Guy, et al. 2003. Real-time PCR for quantification of *Giarida* and *Cryptosporidium* in environmental water samples and sewage. *Applications of Environmental Biology* 2003 69(9): 5178-5185.

45. Explain how this detection method might be used by municipal water departments.

46. Analyze the significance of this research for global human health concerns, especially in remote regions of the world.

47. Predict how this detection method might be used to monitor the level of organisms that cause red tides.

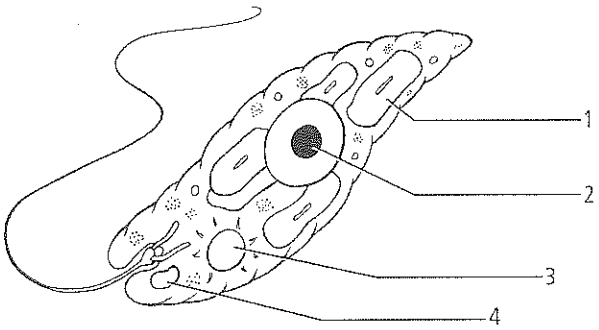
Standardized Test Practice

Cumulative

Multiple Choice

1. Which environment would likely have chemosynthetic autotrophic eubacteria?
   A. coral reef
   B. deep-ocean volcanic vent
   C. lake in the mountains
   D. soil near a spring

Use the diagram below to answer questions 2 and 3.



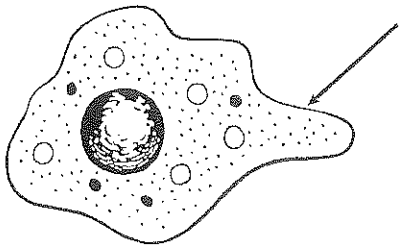
2. Which number represents the eyespot of the *Euglena*?
   A. 1
   B. 2
   C. 3
   D. 4

3. Which number represents an organelle that captures energy for the cell from sunlight?
   A. 1
   B. 2
   C. 3
   D. 4

4. Which do the two bats *Craseonycteris thonglongyai* and *Noctilio leporinus* have in common?
   A. division
   B. genus
   C. phylum
   D. species

5. Suppose you are investigating bone characteristics of two birds to determine how closely they are related in terms of phylogeny. Which type of evidence are you using?
   A. biochemical characters
   B. cellular characters
   C. chromosomal characters
   D. morphological characters

Use the diagram below to answer question 6.



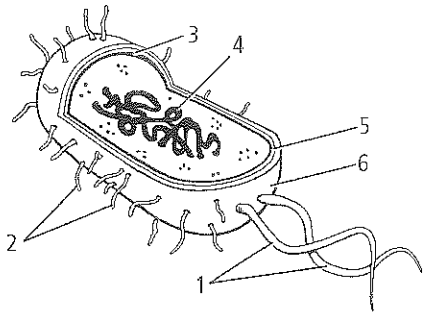
6. Members of the phylum Sarcodina use this structure for locomotion and which other activity?
   A. conjugation
   B. feeding
   C. protection
   D. reproduction

7. How do prions harm their host?
   A. by activating synthesis of viral RNA
   B. by causing normal proteins to mutate
   C. by deactivating part of the host's DNA
   D. by disrupting the way cells reproduce

8. Which could be a derived, rather than ancestral, character in one group of vertebrates?
   A. nervous system
   B. organized systems of tissues
   C. role of ATP in mitochondria
   D. wings used for flight

Short Answer

Use the diagram below to answer questions 9 and 10.



9. Name the parts of this bacterium and classify each part according to its function.

10. From the diagram, deduce how the structure of a typical bacterium enables it to survive in a harsh environment that frequently changes.

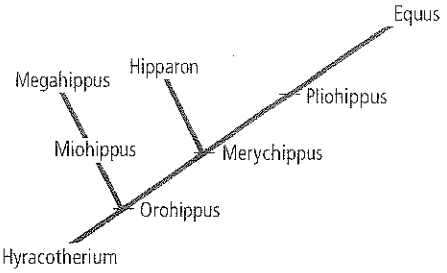
11. Imagine that you have been asked to do an experiment in which you boil different leaves and flower petals in different solutions to extract the pigments. State what safety equipment would be appropriate for your experiments and give reasoning for your choices.

12. Organisms in Kingdom Fungi and Kingdom Plantae used to be classified in the same kingdom. State a reason why they are now classified in different kingdoms.

13. Write a hypothesis about how the life cycle of a retrovirus, such as HIV, might be disrupted to slow or stop the reproduction of the virus.

Extended Response

Use the illustration below to answer question 14.



14. The figure above shows the evolution of horses, including the modern-day horse, *Equus*. Does this diagram support the idea of gradualism or of punctuated equilibrium? Explain your answer.

Essay Question

One challenge that people face is the presence of antibiotic-resistant bacteria. Antibiotics are used to treat many diseases. Generally, they improve the quality of life of people. However, the widespread use and misuse of antibiotics has created antibiotic-resistant bacteria. This means that some diseases caused by bacteria no longer can be cured with the same antibiotics. Doctors must use new and stronger antibiotics to cure the diseases. This gives bacteria an opportunity to develop a resistance to the new antibiotics. Unfortunately, antibiotic resistance in bacteria is spreading faster than new antibiotics are being developed.

Using the information in the paragraph above, answer the following question in essay format.

15. Evaluate how the characteristics of bacteria contribute to the rapid development of antibiotic-resistant bacteria.

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Review Section . . .	18.1	19.3	19.3	17.1	17.2	19.2	18.2	17.2	18.1	18.1	1.3	17.3	18.2	15.3	18.1