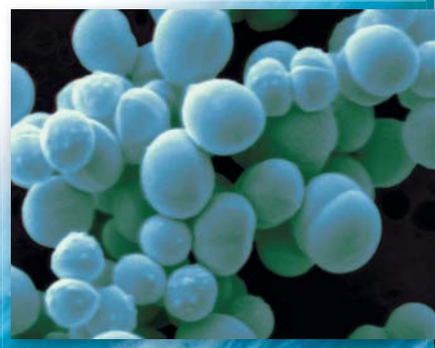
UNIT 6 Microbes

Giant kelp



Staphylococcus xylosus

UNIT 6

Fossilized diatoms

DISCOVERIES IN SCIENCE

Microbiology

1300

The bubonic plague kills 25 million people in Europe. The bacterium that causes the disease is carried by rats and transmitted to humans by fleas.

Rat, a carrier of the bubonic plague

1862

Louis Pasteur and Claude Bernard use heat to eliminate bacteria in liquid for the first time. The process of heating a liquid to kill bacteria is soon called pasteurization and helps prevent milk from spreading bacterial diseases.

1876

A botanical journal publishes Robert Koch's experiments and observations on anthrax bacilli. Koch demonstrates that the bacteria can still cause disease after growing for several generations in pure culture, without animal contact.

1901

Beatrix Potter, an amateur mycologist, finishes a portfolio of about 270 watercolor illustrations of fungi. Potter is best known as an author and illustrator of children's books, such as *The Tale of Peter Rabbit.*

Beatrix Potter with one of her dogs

1928

Alexander Fleming accidentally discovers antibiotics in his laboratory. He observes that *Penicillium notatum,* a mold that was contaminating culture plates, prevents the growth of a bacterium, *Staphylococcus aureus.*

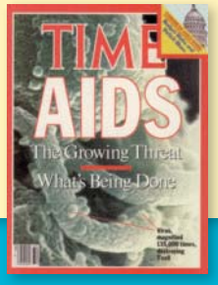
1955

The United States Government permits the widespread use of the polio vaccine developed by Dr. Jonas Salk.

Jonas Salk

1983

Luc Montagnier of the Pasteur Institute in France identifies HIV as the virus that causes AIDS. This discovery made it possible to test blood for HIV.



***Time* magazine cover on AIDS**

2003

In Northeast Oregon, an enormous fungus, *Armillaria ostoyae,* is discovered. The fungus covers 10 km^2, an area the size of 1,600 football fields. This fungus is believed to be the largest single organism on Earth.

Fungi on a moss-covered log

BIOLOGY CAREER

Epidemiologist

Linda Gaul

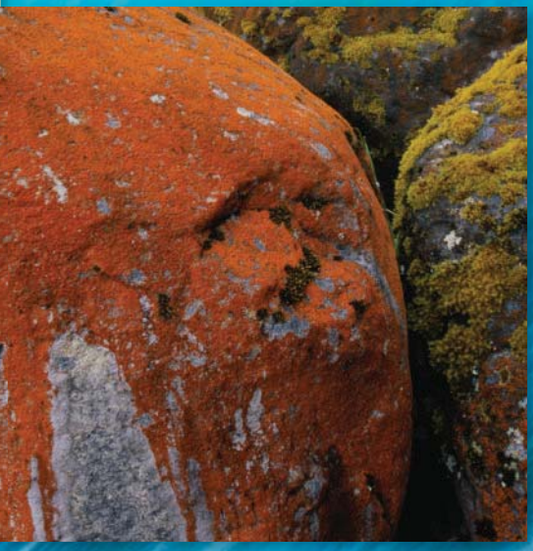
Linda Gaul is an epidemiologist at the Texas Department of State Health Services. She conducts surveillance and epidemiological investigations related to infectious diseases. She has also taught biology and epidemiology at the college level.

Gaul enjoys the process of scientific learning. She especially enjoys discovering connections between seemingly very different organisms that have adapted to a similar environmental constraint.

Gaul also loves teaching and helping others understand and appreciate the living world.

Gaul's father, who is a scientist, and Gaul's mother encouraged Gaul to be inquisitive about the world around her. Gaul credits their encouragement and several enthusiastic college professors for helping her decide to become a scientist.

Gaul also enjoys traveling with her family, gardening, and quilting.



Lichen on rocks

Chapter Planner 21

Protists

		Standards	Teach Key Ideas
CHAPTER OPENER, pp. 494–495	15 min.	*National Science Education Standards*	
SECTION 1 Characteristics of Protists, pp. 497–500 › What Are Protists? › Reproduction › Classifying Protists	90 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSGene 1, LSEvol 1, LSEvol 4, LSEvol 5, UCP1, UCP4	**Bellringer Transparency** **Transparencies** F14 Reproduction of Chlamydomonas • F17 Reproduction of Ulva **Visual Concepts** Characteristics of Protists • Origin of Eukaryotic Cells • Endosymbiosis • Comparing Organisms That Are Unicellular and Multicellular • Sexual Reproduction • Sexual Reproduction in Unicellular Protists • Reproduction in Ulva • Conjugation
SECTION 2 Groups Protists, pp. 501–506 › Grouping Protists › Animal – like Protists › Plantlike Protists › Funguslike Protistslassifying Protists	45 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSGene 1, LSEvol 1, LSEvol 4, LSEvol 5, LSMat 2, LSMat 4, UCP4, UCP5, SI1, SI2, HNS3	**Bellringer Transparency** **Transparencies** F18 Structure of Euglena • F16 Paramecium • F29 Life Cycle of Plasmodium **Visual Concepts** Types of Animal – like Protists • Parts of an Amoeba • Movement of a Amoeba • Parts of a Flagellate • Eyespot • Movement of a Flagellate • Feeding Habits of a Flagellate • Structure of Cilia and Flagella • Parts of a Paramecium • Movement of a Ciliate • Feeding Habits of a Ciliate • Sexual Reproduction in Paramecium
SECTION 3 Protists and Humans, pp. 507–511 › Protists and Disease › Protists and the Environment › Protists and Industry	45 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSGene 1, LSEvol 5, LSInter 3, LSInter 5, SPSP1, SPSP3, SPSP4, SPSP5, SPSP6, HNS1	**Bellringer Transparency** **Transparencies** F19 Diseases Caused by Protists **Visual Concepts** Malaria • Malaria Life Cycle
			See also PowerPoint® Resources

Chapter Review and Assessment Resources

- SE Super Summary, p. 514
- SE Chapter Review, p. 515
- SE Standardized Test Prep, 517
- Review Resources
- Chapter Tests A and B
- go.hrw.com Holt Online Assessment

CHAPTER FastTrack

To shorten instruction due to time limitations, cover Sections 2 and 3 in one class period. Eliminate the Quick Labs in these sections.

Basic Learners

- TE Alternation of Generations, p. 498
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Advanced Learners

- TE Silica, p. 504
- TE Space Algae, p. 505
- Critical Thinking Worksheets*
- Concept Mapping Worksheets*
- Science Skills Worksheets*
- Lab Datasheets, Level C*

Key

SE Student Edition
TE Teacher's Edition
Chapter Resource File
Workbook
Transparency
CD or CD-ROM
* Datasheet or blackline master available
■ Also available in Spanish

All resources listed below are also available on the Teacher's One-Stop Planner.

Why It Matters	Hands-On	Skills Development	Assessment
Build student motivation with resources about high-interest applications.	SE **Inquiry Lab** Pond-Water World, p. 495* ■	TE **Reading Toolbox** Assessing Prior Knowledge, p. 494 SE **Reading Toolbox,** p. 496	
TE **Pond Scum,** p. 498 TE **Anton Van Leeuwenhoek,** p. 498 SE **Protist Plague,** p. 509	SE **Inquiry Lab** Protistan Responses to Light, p. 512* ■ **Exploration Lab** Protists: A Comparison*	TE **Math Skills** Binary Fission, p. 498 SE **Reading Toolbox** Word Origins, p. 499 TE **Reading Toolbox** Word Origins, p. 499	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*** ■ **Section Quiz** ■
TE **Demonstration** Comparing Algae, p. 501 TE **Animal Cells,** p. 502 TE **Diatoms and Dynamit,** p. 504	SE **Quick Lab** Diatom Observation, p. 505* ■ **Inquiry Lab** Slowing the Movement of Protists*	SE **Reading Toolbox** General Statements, p. 504 TE **Reading Toolbox** General Statements, p. 504	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*** ■ **Section Quiz** ■
SE **Protist Plague,** p. 509 TE **Importance of Coral Reefs,** p. 510	SE **Quick Lab** Everyday Algae, p. 511* ■	SE **Reading Toolbox** Word Origins, p. 508 TE **Reading Toolbox** Word Origins, p. 508 TE **Reading Toolbox** Visual Literacy, p. 509	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*** ■ **Section Quiz** ■
	See also Lab Generator		**See also Holt Online Assessment Resources**

Resources for Differentiated Instruction

English Learners

TE Protist Groups, p. 502
TE Organizing Information, p. 508
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide* ■
Note-taking Workbook*
Multilingual Glossary

Struggling Readers

TE Asexual and Sexual Reproduction, p. 498
TE Finding Main Ideas, p. 504
TE Organizing Information, p. 508
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Special Education Students

TE Making a Model, p. 503
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide* ■
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Alternative Assessment

TE Reproduction in Multicellular Protists, p. 499
Science Skills Worksheets*
Section Quizzes* ■
Chapter Tests A, B, and C* ■

Chapter 21

Overview

The purpose of this chapter is to learn about the amazingly diverse members of the Kingdom Protista. Many of the characteristics and reproductive strategies of these organisms are not seen in other kingdoms. The various phyla of protists are discussed and compared. Beneficial and pathogenic protists are introduced.

READING TOOLBOX

Assessing Prior Knowledge Students should understand the following concepts:
- eukaryotic and prokaryotic cells
- how organisms are classified
- sexual and asexual reproduction

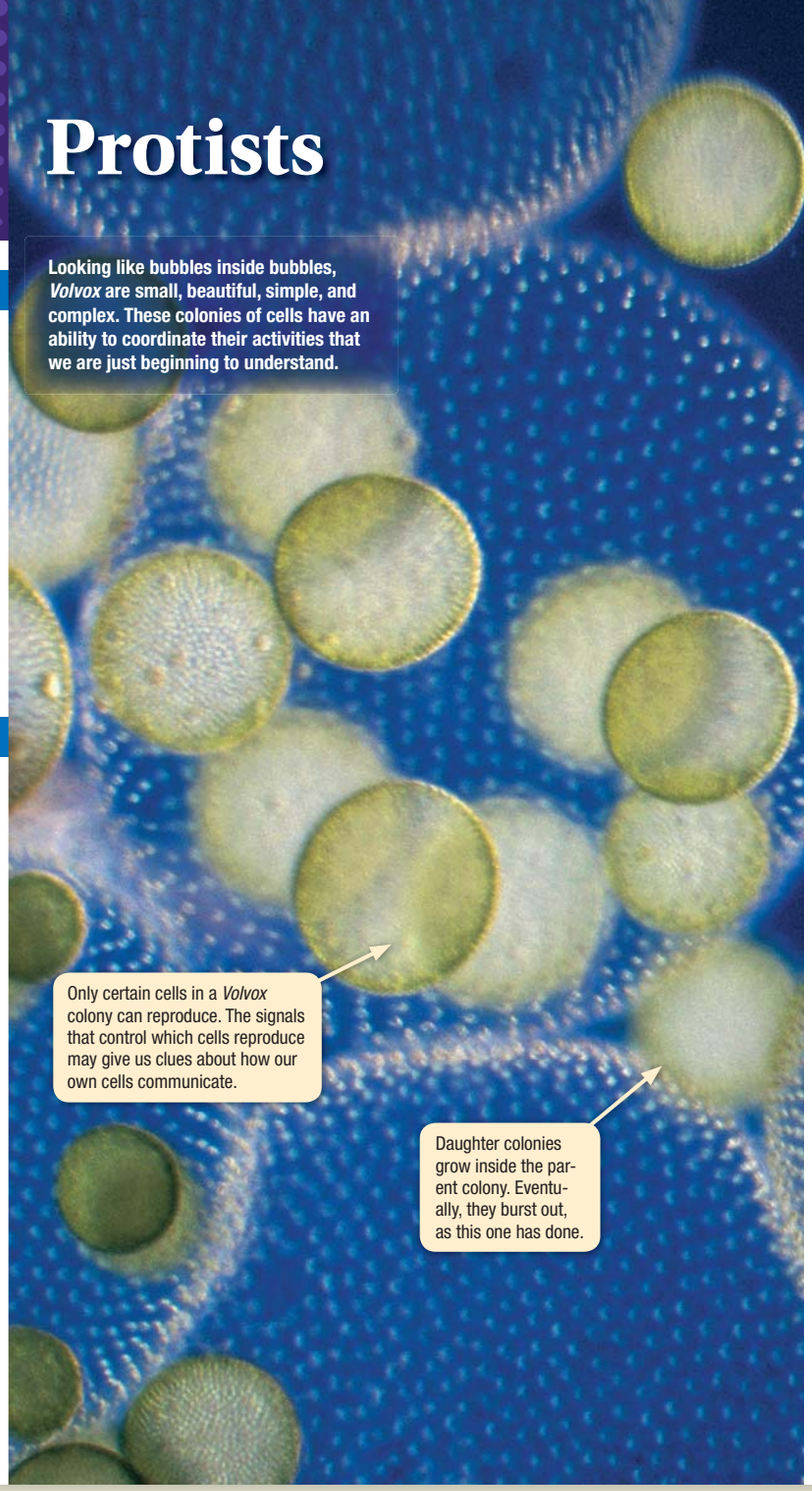
Visual Literacy Ask students how *Volvox* colonies are similar to multicellular organisms, such as plants and animals. (They are made up of groups of cells that work together.) How are *Volvox* colonies different from multicellular organisms? (The cells that make them up are all the same; they do not have different, specialized cells.)
LS Visual/Logical

Chapter 21 Protists

Preview

Why It Matters

Protists give us oxygen, gelatin, sparkly paint, and deadly diseases. Although most are microscopic, these organisms play a big part in our world.



Chapter Correlations

National Science Education Standards

LSCell 1 Cells have particular structures that underlie their functions.

LSCell 2 Most cell functions involve chemical reaction.

LSCell 3 Cells store and use information to guide their functions.

LSCell 4 Cell functions are regulated.

LSGene 1 In all organisms, the instructions for specifying the characteristics of the organisms are carried in DNA.

LSEvol 1 Species evolve over time.

LSEvol 4 The millions of difference species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

LSEvol 5 Biological classifications are based on how organisms are related.

LSInter 3 Organisms both cooperate and compete in ecosystems.

LSInter 5 Human beings live within the world's ecosystems.

LSMat 2 The energy for life primarily derives from the sun.

LSMat 4 The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

UCP1 Systems, order, and organization

UCP4 Evolution and equilibrium

UCP5 Form and function

SI1 Abilities necessary to do scientific inquiry

SI2 Understandings about scientific inquiry

SPSP1 Personal and community health

InquiryLab

15 min

Pond-Water World

Protists are everywhere. Even a single drop of water can hold an entire community of protists.

Procedure

1. Place a drop of **pond water** in the center of a clean **slide.**
2. Place a **coverslip** on the slide.
3. Use a **compound light microscope** to observe the wet mount under both low power and high power.
4. Place a drop of **slowing agent** at the very edge of the coverslip.
5. Observe the wet mount under low power and high power again.
6. Draw the organisms that you see.

Analysis

1. **State** how many types of organisms you could see before you added the slowing agent.
2. **Describe** the various types of organisms that you observed after you added the slowing agent.
3. **Propose** whether the organisms that you observed were prokaryotes or eukaryotes.

Each *Volvox* cell has two cilia that beat in unison like oars on a ship. No one knows how these movements are synchronized.

A Volvox colony has a front and a back. Cells at the front have one red eyespot and a light receptor. These cells can "see" where the colony is going.

SPSP3 Natural resources
SPSP4 Environmental quality
SPSP5 Natural and human-induced hazards
SPSP6 Science and technology in local, national, and global challenges
HNS1 Science as a human endeavor
HNS3 Historical perspectives

InquiryLab

Teacher's Notes Specimens should be ordered or collected in advance. Methyl cellulose or Detain™ can be used to slow the organisms so they are easier to view.

Materials
- pond water
- microscope slides
- coverslips
- microscope
- slowing agent

Safety Caution Make sure students wear long pants, long-sleeved shirts, closed-toe shoes, disposable gloves, and appropriate protection from insect and the sun when collecting specimens. Use only unbreakable specimen jars. Make sure students wear goggles and gloves in the lab when handling specimens or slides.

Treat all microbes as potential pathogens. Warn students not to taste the protist solution or touch their faces. Remind students to handle slides and coverslips with care. Have students clean up all spills and place any broken slides and coverslips in an appropriate sharps container. Students should wash their hands thoroughly before leaving the lab.

Answers to Analysis

1. Answers will vary. Students should note that identifying organisms is difficult because many move very quickly.
2. Answers will vary. Students should be able to observe more organisms after using the slowing agent.
3. eukaryotes; the organisms have internal compartments and a nucleus.

READING TOOLBOX

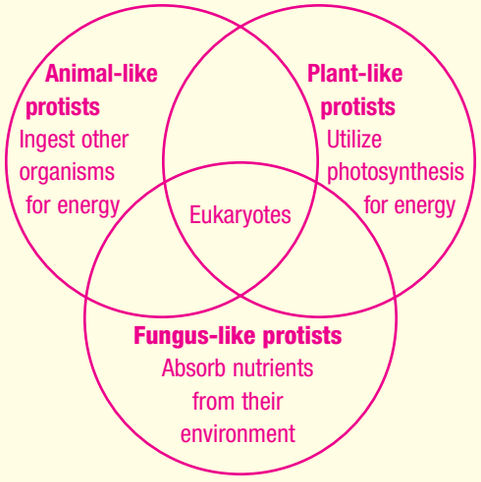
Using Words

1. something that is hidden
2. Answers will vary. Sample answer: A pseudonym is a false name; writers might use a pseudonym to protect their identity.
3. Answers will vary. Sample answer: A pseudopod is a false foot. A pseudopod might be an appendage that looks or acts like a foot, so it might help an organism move.

Using Language

1. Accept any reasonable answers. Students should state comparisons, such as that all are round or used in sports.
2. Answers will vary. Students should be able to think of several exceptions to the statement.

Using Graphic Organizers



READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

Using Words

Word Origins Many of the words we use today come from Greek or Latin words. Knowing the meaning of Greek and Latin roots can help you figure out and remember the meaning of modern English words.

Your Turn Use the table to answer the following questions.

1. What do you think the word *cryptic* means?
2. Why might a writer use a pseudonym?
3. What do you think a pseudopod helps an organism do?

Word Origins

Word part	Origin	Meaning
pseudo-	Greek	false, fake
-nym	Greek	name
-pod	Greek	foot
crypto-	Greek	hidden

Using Language

General Statements A general statement summarizes the features of a group or describes an average feature of members of the group. Some individuals in the group may not share all of the features. So, general statements may be true most of the time, but not always.

Your Turn Use what you know about general statements to answer the following questions.

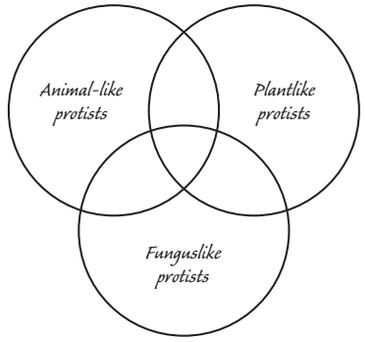
1. Write a general statement that summarizes the features of baseballs, basketballs, tennis balls, soccer balls, and footballs.
2. Brainstorm exceptions to the general statement "In general, dogs have four legs, fur, and a tail and can bark."

Using Graphic Organizers

Venn Diagram A Venn diagram is useful for comparing topics in science. A Venn diagram shows which characteristics the topics share and which characteristics are unique to each topic.

Your Turn Make a Venn diagram to compare animal-like, plantlike, and funguslike protists.

1. Draw three circles, as shown here. Make sure that each circle partially overlaps the other circles.
2. Label one circle "Animal-like protists," another circle "Plantlike protists," and the third circle "Funguslike protists."
3. In the areas where the circles overlap, write the characteristics that the groups of protists share.
4. In the areas where the circles do not overlap, write the characteristics that are unique to each group of protists.



Section 1

Characteristics of Protists

Key Ideas	Key Terms	Why It Matters
❯ What types of organisms are classified as protists? ❯ What methods of reproduction do protists use? ❯ Why is the classification of protists likely to change in the future?	gamete zygote zygospore alternation of generations	Protists offer clues about the evolution of fungi, plants, and animals.

From tiny glass stars that float in the ocean to slimy green fuzz that carpets rocks on the shore, a wide variety of organisms make up the group we call *protists*.

What Are Protists?

The kingdom Protista is made up of organisms that do not belong in any of the other kingdoms. As a result, the members of this kingdom are quite diverse, as **Figure 1** shows. But all protists have one thing in common: they are eukaryotic. ❯ **Protists are eukaryotic organisms that cannot be classified as fungi, plants, or animals.**

Several important characteristics evolved in protists. These characteristics include membrane-bound organelles, complex cilia and flagella, sexual reproduction with gametes, and multicellularity. Organelles, including mitochondria and chloroplasts, allow single cells to perform a wide variety of functions. Complex cilia and flagella like those found in protists are also found in many other types of cells. For example, the cells that keep particles out of our lungs use the same type of cilia as is found in protists. Sexual reproduction allows for greater genetic diversity than reproduction by binary fission does. Multicellularity allows cells to specialize, which in turn allows for the development of tissues, organs, and organ systems.

❯ **Reading Check** *What important characteristics arose among protists during their evolution? (See the Appendix for answers to Reading Checks.)*

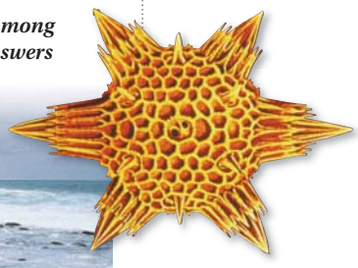


Figure 1 The radiolarian shown above is an example of a unicellular protist that captures and engulfs food. Algae, such as the kind growing on these rocks, contain chloroplasts and use photosynthesis to produce energy.

Key Resources

Transparencies
F14 Reproduction of *Chlamydomonas*
F17 Reproduction of *Ulva*

Visual Concepts
Characteristics of Protists
Origin of Eukaryotic Cells
Endosymbiosis
Comparing Organisms That Are Unicellular and Multicellular
Sexual Reproduction
Sexual Reproduction in Unicellular Protists
Reproduction in *Ulva*
Conjugation

Section 1

❯ Focus

This section introduces students to protists and how they are classified. The distinguishing characteristics of protists and their methods of reproduction are discussed.

Bellringer
Use the Bellringer transparency to prepare students for this section.

❯ Teach

Teaching Key Ideas

How Do Protists Evolve? Ask students what characteristics of an organism can help ensure the survival of its genes in the next generation. (Suggestions might include improved ways of storing and protecting genetic information or alternative forms of reproduction under different environmental conditions.) Explain that environmental pressures have led to the diversity of reproductive strategies in protists.
LS Verbal

Why It Matters

Pond Scum Pollution of fresh water can lead to a proliferation of green algae known as pond scum. When a small body of water is polluted with nitrates and phosphates from sewage, detergents, or runoff from fertilizers, green algae reproduce rapidly. When the algae die, bacteria decompose them, depleting the oxygen in the water. Ask students what is the overall effect of explosive algae growth on other organisms living in the pond? (As the algae decompose, oxygen-dependent organisms, such as fish, may die.) LS Logical

Math Skills

Binary Fission Tell students that binary fission allows organisms to reproduce quickly and results in large numbers of offspring because reproduction occurs exponentially. You can illustrate the concept on the board. Ask students how many protists will result if the organism reproduces five times. (The answer is 2^5 or 32.) LS Logical

Why It Matters

Anton van Leeuwenhoek The first person to describe microorganisms was a Dutch cloth merchant named Anton van Leeuwenhoek. An amateur scientist, he is credited with the first descriptions of microorganisms such as bacteria and protists. Van Leeuwenhoek ground his own lenses and developed some of the first powerful microscopes (270×) to inspect cloth. He called the tiny organisms "animalcules" because he assumed they were tiny animals.

gamete (GAM eet) a haploid reproductive cell that unites with another gamete to form a zygote

zygote (ZIE GOHT) the cell that results from the fusion of gametes

zygospore (ZIE goh SPAWR) a thick-walled protective structure that contains a zygote

alternation of generations within the life cycle of an organism, the occurrence of two or more distinct forms that differ from each other in method of reproduction

Reproduction

Asexual reproduction results in offspring that are genetically identical to the parent. Sexual reproduction results in offspring that are genetically different from either parent. Sexual reproduction involves the union of reproductive cells, usually called **gametes.** Gametes are haploid cells that join to form a diploid **zygote.** **Protists can reproduce asexually by binary fission, budding, and fragmentation. Protists can also reproduce sexually by fusion of gametes.**

Asexual Reproduction

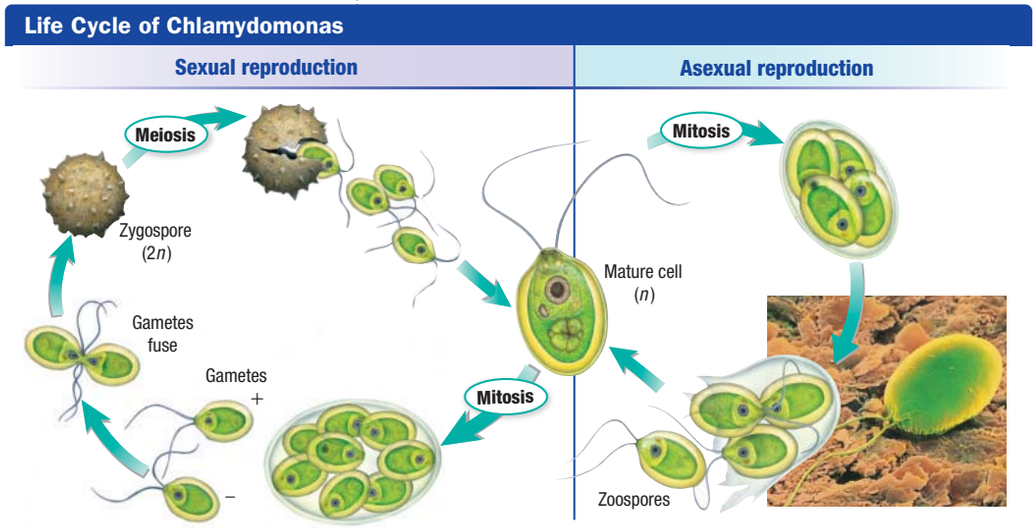
Asexual reproduction in protists occurs through binary fission, budding, or fragmentation.

Binary Fission *Binary fission* occurs when a unicellular organism reproduces by splitting in half after replicating its DNA. Binary fission is sometimes called mitosis. Mitosis is technically only the division of the nucleus. After the nucleus divides by mitosis, the cell generally divides in a process called cytokinesis. Prokaryotes lack nuclei and can undergo binary fission, but not mitosis. The cells of a multicellular organism reproduce by mitosis with cytokinesis, often simply called mitosis. Multicellular organisms do not undergo binary fission.

Budding Budding is a form of asexual reproduction in which a part of the parent organism pinches off and forms a new organism. This can occur in unicellular and multicellular organisms. Budding differs from binary fission in that the offspring is smaller than the parent.

Fragmentation In fragmentation, part of a multicellular organism breaks off and starts a new organism. Fragmentation differs from budding in that budding is an action that is performed by the organism itself. Fragmentation is the result of an action that is done to an organism. An accident can result in fragmentation, but not budding.

Figure 2 Chlamydomonas reproduces both sexually and asexually. Sexual reproduction is triggered by environmental stress, such as drought.



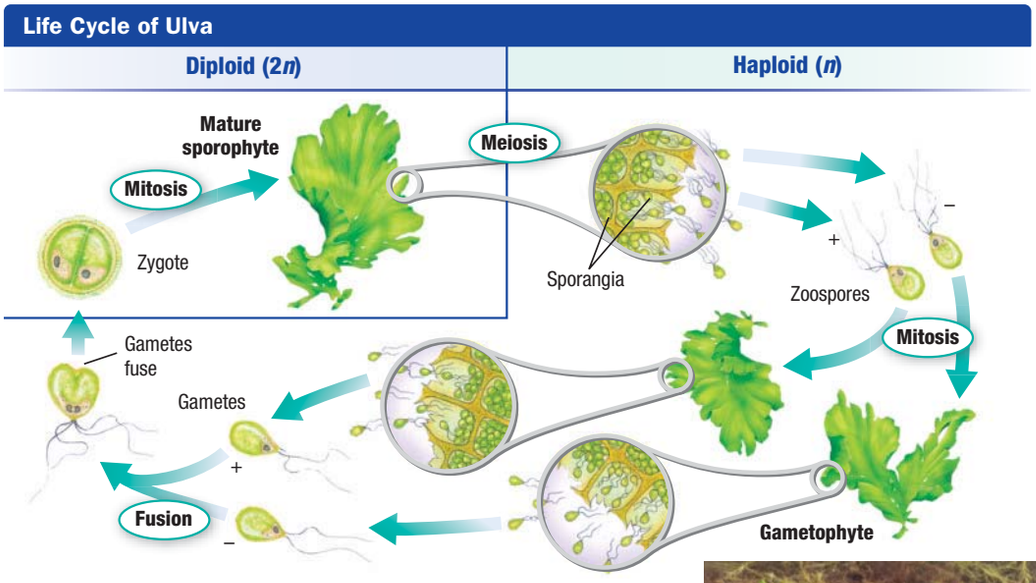
Differentiated Instruction

Struggling Readers

Asexual and Sexual Reproduction Use **Figure 2** to trace sexual and asexual reproduction in *Chlamydomonas.* Ask students to identify the parts of the text that describe the diagrams. Then ask the following questions: Which form of asexual reproduction is being shown? (binary fission) Which form of reproduction is used most frequently? (asexual reproduction) Which is used under environmental stress? (sexual reproduction) LS Visual

Basic Learners

Alternation of Generations Have students describe the structures shown in the *Ulva* life cycle diagram in terms of ploidy. Ask them to pick out the haploid structures (gametophytes, gametes, zoospores) and diploid structures (zygote, sporophyte), and then to explain how many sets of genetic material are present in each structure. LS Logical



Sexual Reproduction In many protists, sexual reproduction occurs as a response to environmental stress. In some protists, the zygote secretes a tough outer coating and becomes a **zygospore.** Zygospores can survive freezing, drying, and UV radiation.

Sexual Reproduction in Unicellular Protists In most unicellular protists, such as the chlamydomonas shown in **Figure 2,** a mature organism is haploid. A haploid cell divides by binary fission to produce haploid gametes. Two gametes fuse to form a diploid zygote, which becomes a zygospore. When environmental conditions improve, meiosis occurs within the zygospore. Haploid cells break out of the zygospore and grow into mature cells.

Sexual Reproduction in Multicellular Protists Many multicellular protists can reproduce both sexually and asexually. This process, called **alternation of generations,** consists of two distinct forms that differ in method of reproduction. Ulva, shown in **Figure 3,** displays this kind of reproduction. The diploid, spore-producing phase is called the *sporophyte generation.* The adult sporophyte has sporangia, reproductive cells that produce haploid spores by meiosis. The spores grow into multicellular haploid organisms that produce gametes. The haploid, gamete-producing phase is called the *gametophyte generation.* The mature gametophyte produces haploid gametes by mitosis. Two gametes fuse and form a diploid zygote. The zygote divides to form a multicellular diploid organism. This step begins the first stage of a new sporophyte generation.

Reading Check ***How does alternation of generations differ from sexual reproduction in unicellular protists?***

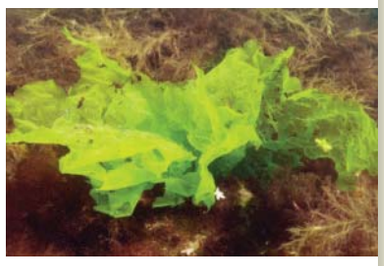


Figure 3 Ulva, or sea lettuce, has a life cycle in which haploid and diploid individuals alternate.

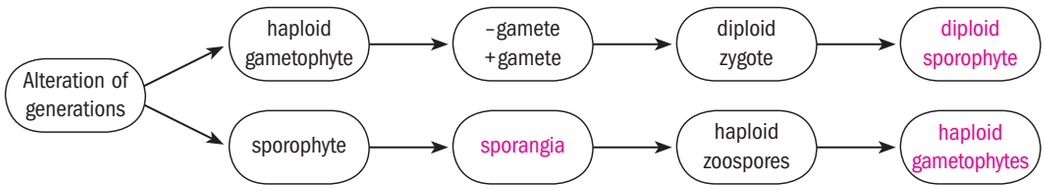
READING TOOLBOX

Word Origins The Greek word root *phyte* means "plant." Using this information, propose your own definitions for *sporophyte* and *gametophyte*.

Differentiated Instruction

Alternative Assessment

Reproduction in Multicellular Protists Have students complete the graphic organizer shown to summarize alternation of generations in multicellular green algae. LS Logical



Teach, *continued*

Teaching Key Ideas

Demonstration Fill several containers with water from a fish tank or a nearby pond and set them in the sun for two weeks. Add small amounts of a nitrogen- and/or phosphorus-based fertilizer to some of the containers. Dilute fertilizers 100:1 with water. Use tap water as a control. Have students compare the resulting algal growth. Ask how this experiment simulates real-life conditions. (The containers represent bodies of water. The fertilizer represents agricultural runoff, lawn care products, and detergent-loaded wastewater.) Note that some of the observed "algal" growth may be photosynthetic prokaryotes. LS Visual

READING TOOLBOX

Word Origins ***sporophyte*** plant with spore-producing stage; ***gametophyte*** plant with a gamete-producing stage

Teach, *continued*

Teaching Key Ideas

Based on Appearance Divide students into groups based on hair color. Tell students that classifying protists based on appearance would be similar to assuming that all the students in a group with the same hair color are related.

Close

Formative Assessment

Organisms are classified with protists because they

A. look like protists (Incorrect. Protists are highly diverse and are not classified based on appearance.)

B. do not fit with any other kingdom (Correct. The only unifying features among protists is that they are all eukaryotic and that they do not belong with any other kingdom.)

C. are genetically similar (Incorrect. The organisms classified as protists are highly diverse. Many are more closely related to plants, animals, or fungi than they are to each other.)

D. are unicellular (Incorrect. Some protists are unicellular, but many are multicellular.)

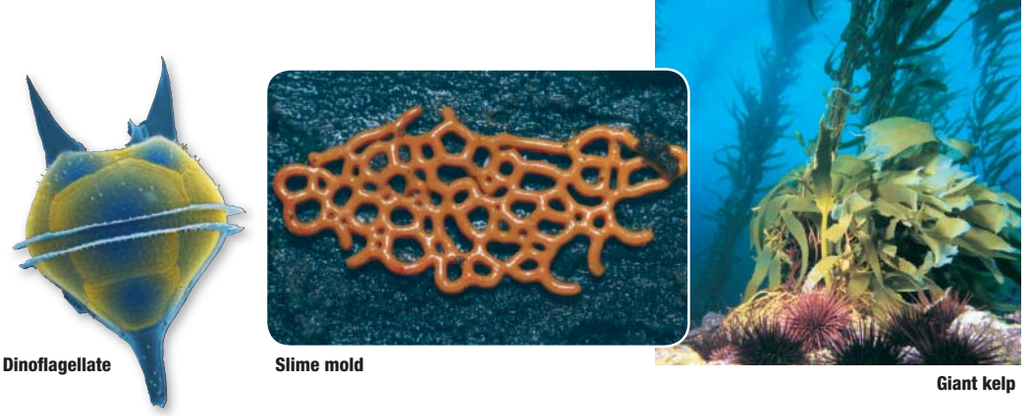


Figure 4 Dinoflagellates, slime molds, and giant kelp are classified as protists. It is not yet clear how these and other protists are related to each other and to organisms in other kingdoms.

SCILINKS
www.scilinks.org
Topic: Protists
Code: HX81245

Classifying Protists

Understanding the relationships between protists and developing a classification system that reflects these relationships are ongoing challenges. **The classification of organisms currently grouped in the kingdom Protista is likely to change as scientists learn more about how these organisms are related to each other and to members of other kingdoms.**

When living things are classified, relationships between groups are inferred from specific shared characteristics. Some protists share characteristics of plants or animals, while others are more like fungi, as **Figure 4** shows. The sequencing of DNA, RNA, and proteins has allowed scientists to infer relationships among groups of protists and between protists and other kingdoms. Molecular studies suggest that protists could be classified into up to 20 kingdoms!

The characteristics that protists share with plants, animals, and fungi provide information about the evolution of these organisms. For example, molecular evidence shows that green algae are more closely related to plants than to other algae. Studying green algae can offer clues about how plants evolved. Other protists that resemble cells found in sponges may help us understand the evolution of multicellular animals. The relationships between modern protists are still being discovered, and the classification of protists is uncertain. A new classification system for protists is currently being developed.

Section 1 Review

KEY IDEAS

1. **Explain** which organisms are classified as protists.
2. **Compare** reproduction by binary fission, mitosis, budding, and fragmentation.
3. **Describe** sexual reproduction in unicellular and multicellular protists.
4. **Explain** how research may affect the classification of protists.

CRITICAL THINKING

5. **Evaluating Statements** A classmate tells you that he saw a unicellular organism through a microscope and concluded that it was a protist. Is his conclusion valid? What other information might be needed?

METHODS OF SCIENCE

6. **Classification** Using several sources, research the classification of protists. Note any differences in the ways in which the sources classify protists. Draw a phylogenetic tree that reflects the information that you find in your research.

Answers to Section Review

1. eukaryotic organisms that cannot be classified as fungi, plants, or animals
2. In binary fission an organism divides in half. Mitosis is the division of the nucleus. In budding a part of an organism pinches off to form a new organism. Fragmentation occurs when part of an organism breaks off and forms a new organism.
3. A unicellular protist is haploid. Haploid cells produce haploid gametes that fuse to produce a diploid zygote, which undergoes meiosis, and produces haploid adults. Sexual reproduction for multicellular protists starts with a diploid organism (sporophyte) that produces haploid spores by meiosis. The spores grow into haploid adults that produce haploid gametes by mitosis. The gametes fuse to form a diploid sporophyte.
4. As more is learned about evolutionary relationships between protists and other organisms, protists may be reclassified.
5. No; they would also need to know whether the organism had a nucleus and was a mature organism or the gamete of a multicellular organism.
6. Answers will vary based on the current classification of protists.

Section 2

Groups of Protists

Key Ideas	Key Terms	Why It Matters
❯ Why is it useful to group protists based on their methods of obtaining nutrition? ❯ What characteristic do animal-like protists share? ❯ What key characteristic do plantlike protists share? ❯ What characteristic makes funguslike protists similar to fungi?	**pseudopodium** **plasmodium**	The kingdom Protista includes an enormous diversity of life. You might be amazed to find out how many of the organisms you are familiar with are protists.

The group we call protists include snail-like creatures, giant kelp, yellow slime molds, and many other organisms. Its members have little in common. So, how do we discuss them in an organized way?

Grouping Protists

One common way to group protists is by their source of nutrition. ❯ **Grouping protists by the way they obtain nutrients helps us understand their ecological roles.** Using this method, we can divide protists into three groups, as shown in **Figure 5.** One group includes protists that, like plants, get energy by photosynthesis. Another group includes protists that, like animals, capture and eat other organisms. The third group includes protists that, like fungi, absorb nutrients from their environment. Keep in mind that discussing protists as plant-like, animal-like, and funguslike does not indicate anything about their relationship to each other or to plants, animals, and fungi. Also remember that for every generalization that is made about protists, there will be exceptions.

❯ **Reading Check** *What method can be used to group protists?*

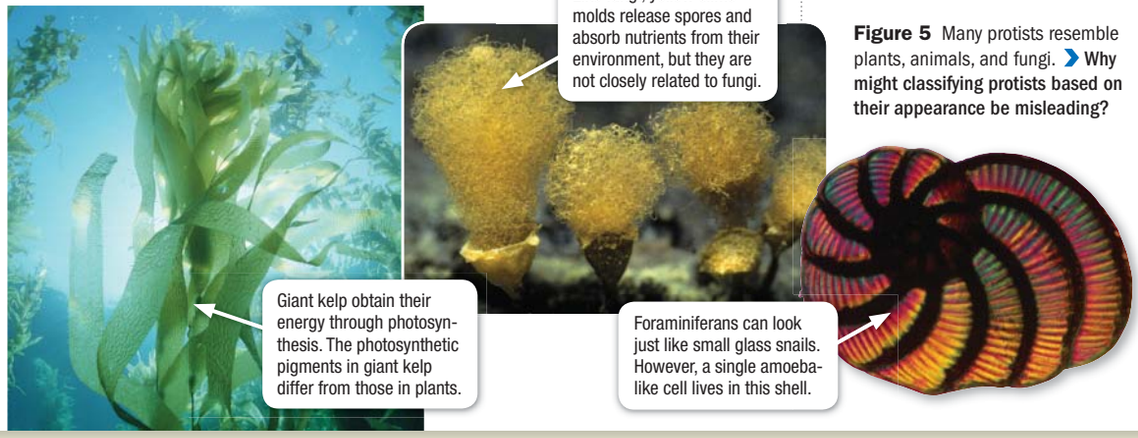


Figure 5 Many protists resemble plants, animals, and fungi. ❯ **Why might classifying protists based on their appearance be misleading?**

Key Resources

Transparencies
F18 Structure of *Euglena*
F16 *Paramecium*

Visual Concepts
Types of Animal-like Protists
Parts of an Amoeba
Movement of an Amoeba
Parts of a Flagellate
Eyespot
Movement of a Flagellate
Feeding Habits of a Flagellate
Structure of Cilia and Flagella
Parts of a Paramecium
Movement of a Ciliate
Feeding Habits of a Ciliate
Sexual Reproduction in Paramecium

Section 2

❯Focus

This section introduces students to the characteristics of the various groups of protists. Movement, structure, reproduction, and mode of nutrition are discussed for each phylum.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯Teach

Demonstration

Comparing Algae Collect live specimens of algae or obtain preserved specimens from a biological supply house. Have students examine the algae and compare their characteristics.
LS Visual

Answers to Caption Questions

Figure 5: Although protists may look like plants, animals, or fungi, they may not be closely related to these groups. Classifying protists based on appearance might imply a relationship that is not correct.

Teach, *continued*

Why It Matters

Animal Cells Review the characteristics of animal cells with students, and compare the structure and contents of an animal cell with a bacterial cell and a protozoan cell. Students should see that animal-like protist cells are very similar to animal cells and contain many of the same organelles. LS Visual

Teaching Key Ideas

Amoebas Obtain a culture of live amoebas. Using a microprojector or videomicroscope, project an image of an amoeba for students to view. Discuss the general characteristics of the amoeba, pointing out the nucleus and means of locomotion (pseudopodia). If time permits, repeat with *Paramecium* and *Euglena*. If live cultures are not available use transparencies F16 *Paramecium* and F18 Structure of *Euglena*. LS Visual

ACADEMIC VOCABULARY

variety a collection of things that are very different from each other; diversity

pseudopodium (soo doh POH dee uhm) a cytoplasmic extension that functions in food ingestion and movement

Animal-like Protists

Animal-like protists are often called *protozoa,* which means "first animals." **Animal-like protists ingest other organisms to obtain energy.** Like animals, these protists are heterotrophic. All animal-like protists are unicellular, most can move, and most reproduce asexually by binary fission.

Amoeboid Protists Amoeboid protists include a wide variety of organisms that move by using extensions of their cells called **pseudopodia** (singular, *pseudopodium*). Pseudopodia are also used to surround and engulf food particles. Amoebas, such as the one in **Figure 6,** live in fresh water, in salt water, and in soil. Most amoebas are free-living, but some are parasites. Some amoeboid protists form outer shells called *tests.* These shells can be made of protein, calcium carbonate, silica, or mineral particles. Pseudopodia extend through holes in the tests to help amoebas move and catch prey.

Ciliates The ciliates include some of the most complex single-celled organisms. Most or all of the body of a ciliate is covered by a tough yet flexible outer covering and short, hairlike structures called *cilia.* Ciliates move and hunt for food by beating their cilia. Most ciliates are free-living and can be found in fresh water and salt water. Ciliates reproduce sexually by conjugation, in which two cells join temporarily and exchange one of their small nuclei with each other.

Flagellates Flagellates are protists that have whip-like structures called *flagella.* Some have one flagellum, while others have many. Some flagellates also have cilia or form pseudopodia. Many flagellates are free-living. Others, such as members of the genus *Leishmania,* shown in **Figure 6,** are parasites that cause disease.

Sporozoans Animal-like protists that form sporelike cells when they reproduce are called sporozoans. They lack flagella, cilia, and pseudopodia and thus do not move. All sporozoans are parasitic and cause disease. Sporozoans reproduce both asexually and sexually.

Reading Check ***Which group of protists is all parasitic?***

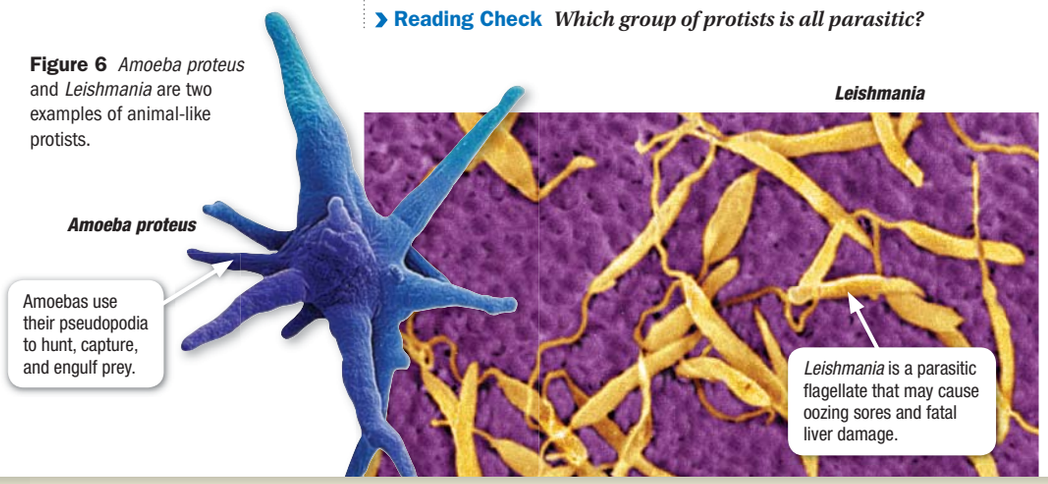


Figure 6 *Amoeba proteus* and *Leishmania* are two examples of animal-like protists.

MISCONCEPTION ALERT

Animal-like Protists Students may assume that protists such as those pictured are animals simply because they do not appear to be plants or fungi. The protists that may be visible in a drop of pond water, for example, show similarities to animals in that they are able to swim through water, have cilia and flagella, and may appear to have distinct body parts. Remind students that the protists are in fact not animals.

Differentiated Instruction

English Learners

Protist Groups Have students make index cards to help them remember the different types of protists described in this section. Tell them to write the names of the different protists on one side of each card. Have them include the characteristics and examples of each protist group with a drawing on the other side.
LS Verbal/Intrapersonal

Up Close Protists

Paramecium caudatum is a ciliate protist. It is well known for its ability to avoid harm. If a paramecium encounters a negative stimulus, it will maneuver itself to escape. It may also fire a trichocyst, a sac that can eject a stinging filament to ward off predators or capture prey.

Paramecium

Scientific name: *Paramecium caudatum*
Size: microscopic; up to 1 mm long
Habitat: freshwater streams and ponds
Diet: bacteria, small protists, and organic debris

Contractile Vacuole Like other freshwater protists, *P. caudatum* constantly absorbs water by osmosis. Excess water is removed by contractile vacuoles. These organelles fill with water. When they contract, they squeeze the water out of the cell.

Nuclei Paramecia have two kinds of nuclei. The macronucleus controls routine cellular functions. The micronucleus functions in a sexual process called *conjugation*.

Cilia *P. caudatum* is covered with thousands of hairlike cilia that are arranged in rows along the cell. The cilia beat in waves that cause the protist to spin through the water.

Micronucleus

Food vacuo

Oral Groove Cilia line the oral groove and create a "whirlpool" that draws in bacteria and other food. Food moves down the funnel-shaped groove and is engulfed in a food vacuole. Enzymes in the vacuole digest the food. *P. caudatum* can consume up to 5,000 bacteria per day!

Genetic Variation *P. caudatum* generally reproduces asexually by binary fission. During conjugation, the micronuclei of two paramecia fuse, and their genes are recombined.

Differentiated Instruction

Special Education Students

Making a Model Have developmentally-delayed students make a model of a paramecium using common materials, such as gelatin, grapes, beans, and spaghetti. Ask them to write each name of a structure on a separate index card and explain its function in their own words. LS Kinesthetic/Verbal

Up Close

Teacher's Notes Most students will not realize that the illustration shows a cross-section of the actual organism. *Paramecia* are not flat, though they may appear so under the microscope. The cilia shown along the perimeter of the organism actually cover the entire organism.

Discussion

1. Ask students to draw a flowchart to trace the movement of food through a paramecium. (Food enters via the oral groove, then is engulfed at the mouth by a food vacuole containing digestive enzymes. Undigested food is excreted by exocytosis.)
2. Ask students to compare the methods of capturing food by amoebas and paramecia. (Amoebas use pseudopodia to surround and engulf food by endocytosis. Paramecia use cilia to create a whirlpool to pull food into the oral groove.) LS Visual
3. How would paramecia differ in a polluted vs. a clean environment? (Paramecia in polluted water may be less efficient at maintaining water balance, acquiring nutrients, and moving due to the pollutants and damage to cilia.)
4. Ask students to describe an ideal environment for a paramecium. (Answers will vary but should include a food source and a freshwater environment that allows maintenance of homeostasis.)

Teach, *continued*

READING TOOLBOX

General Statements Sample general statement: Plantlike protists obtain energy through photosynthesis, so they are green. Sample exceptions: Some euglenoids lack chloroplasts and are heterotrophs. Photosynthetic protists vary in the types of pigments that they use for photosynthesis, so some are red or brown rather than green.

Teaching Key Ideas

Euglenoids Have students examine the picture of the *Euglena* in **Figure 7.** Make sure the students understand that the pellicle is inside the cell membrane. Ask students to explain exceptions to the generalization that euglenoids are plantlike. (Some are photosynthetic, some are heterotrophic, and some are both.) LS Visual/Logical

Why It Matters

Diatoms and Dynamite When nitroglycerin is absorbed by diatomaceous earth, it is stable, safe to handle, and can be transported. This compound is more commonly known as dynamite. In the absence of diatomaceous earth, the nitroglycerin is highly unstable and explodes with great force when jolted or heated.

SCILINKS
www.scilinks.org
Topic: Algae
Code: HX80042

READING TOOLBOX

General Statements Write a general statement that describes plantlike protists. Then, find two exceptions to this generalization in the text.

Plantlike Protists

Plantlike protists include the organisms commonly called *phytoplankton* and *algae.* **Plantlike protists obtain energy through photosynthesis.** They vary widely in the types of pigments that they use for photosynthesis and the types of molecules that they use to store energy. Some are very similar to plants and others are not.

Diatoms Diatoms are photosynthetic, unicellular protists with unique double shells. These shells are made of silica or calcium carbonate and have distinct patterns, as **Figure 7** shows. Diatom shells are like small boxes with lids. Individuals are diploid and usually reproduce asexually. The two halves of a "box" separate. Each half regenerates a new base that fits inside the lid. As a result, diatoms tend to get smaller with each generation. When they reach a certain minimum size, they shed their shells and begin a sexual reproductive cycle that produces full-sized offspring that have new shells.

Euglenoids Euglenoids are freshwater protists that have one or two flagella. Many euglenoids are photosynthetic. Some are both photosynthetic and heterotrophic. Others lack chloroplasts and ingest their food. Some, such as *Euglena,* for which the group is named, have an eyespot, a light-sensitive organ that helps them move toward light. A euglena is shown in **Figure 7.**

Dinoflagellates Dinoflagellates are unicellular protists that typically have two flagella. Most dinoflagellates are photosynthetic, but some are heterotrophic. Most dinoflagellates have protective cellulose coats that may become encrusted with silica. The silica coats give dinoflagellates unusual shapes, as **Figure 7** shows. A dinoflagellate's flagella beat in two grooves. One groove encircles the body like a belt; the other is perpendicular. As its flagella beat, a dinoflagellate spins through the water like a top.

Reading Check ***In which group of protists do the individuals get smaller every time they reproduce asexually?***

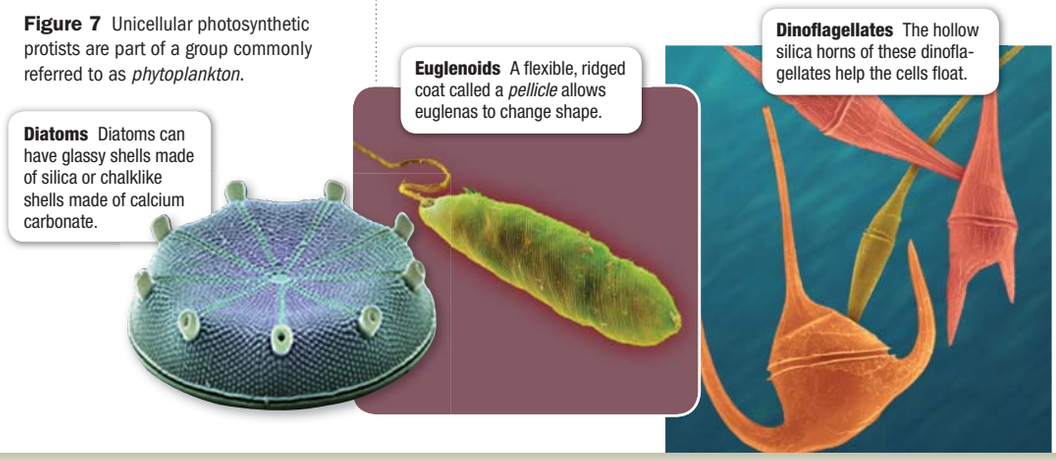


Figure 7 Unicellular photosynthetic protists are part of a group commonly referred to as *phytoplankton.*

Differentiated Instruction

Struggling Readers

Finding Main Ideas The text for these two pages contains a number of multisyllabic words that can challenge students' ability to comprehend the material. Help them breakdown the text by asking them to find three or more meaningful phrases that distinguish each group of *Plantlike Protists.* For example, the key phrases for *Diatoms* would be the following: shells made of silica or calcium carbonate; regeneration results in smaller and smaller diatoms with each generation; and sexual reproduction produces full-size offspring. LS Verbal

Advanced Learners

Silica Have students find the chemical formula for silica and classify it as a mixture, element, or a compound. (compound) Ask students to research the composition and uses of diatomaceous earth. Is it a mixture, element, or compound? (mixture) Have them defend their answers. LS Logical

Red Algae Most red algae are multicellular. These protists are usually found in warm ocean waters. The pigments in red algae can absorb the blue light that penetrates deep into water. As a result, red algae are able to grow at greater depths than other algae are. Some red algae, such as the one in **Figure 8**, have calcium carbonate in their cell walls. These coralline algae play an important role in the formation of coral reefs.

Brown Algae Brown algae are multicellular protists that are found in cool ocean environments. The largest brown algae are kelp that can reach 60 m (197 ft) in length. The body of a kelp has a rootlike structure called a *holdfast,* a stemlike structure called a *stipe,* and leaflike structures called *blades.* The blades often have air-filled sacs that help the algae float close to the surface of the ocean. Brown algae are the only algae that form more than one tissue type.

Green Algae Green algae are a very diverse group of protists. They form a major part of marine plankton. Some, such as algae of the genus *Acetabularia,* inhabit damp soil and resemble plants. Some are symbiotic within the cells of other organisms. Green algae are similar to plants in several ways. They use the same photosynthetic pigments that plants do, they use starch to store energy, and their cell walls contain cellulose. Green algae are thought to have given rise to the first true plants. Because they lack complex tissue layers, green algae are usually classified as protists. In the future, they may be classified as plants.

Hands-On

QuickLab

10 min

Diatom Observation

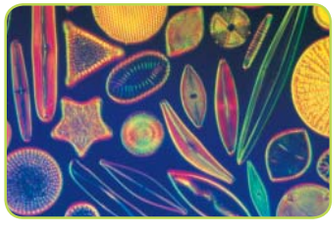
If you look at diatomaceous earth, you can see why it is used to make fine abrasives, filters, and reflective paint.

Procedure

1. Mix a small amount of **diatomaceous earth** with a drop of **water** on a **slide.** Add a **coverslip.**
2. Using a **compound microscope,** observe your wet mount under low power and high power.
3. Turn off your microscope's light, and use a **flashlight** held at a 45° angle to light your slide.

Analysis

1. **Draw** each type of diatom that you observed.
2. **Describe** what you observed when the flashlight was shone on the slide.



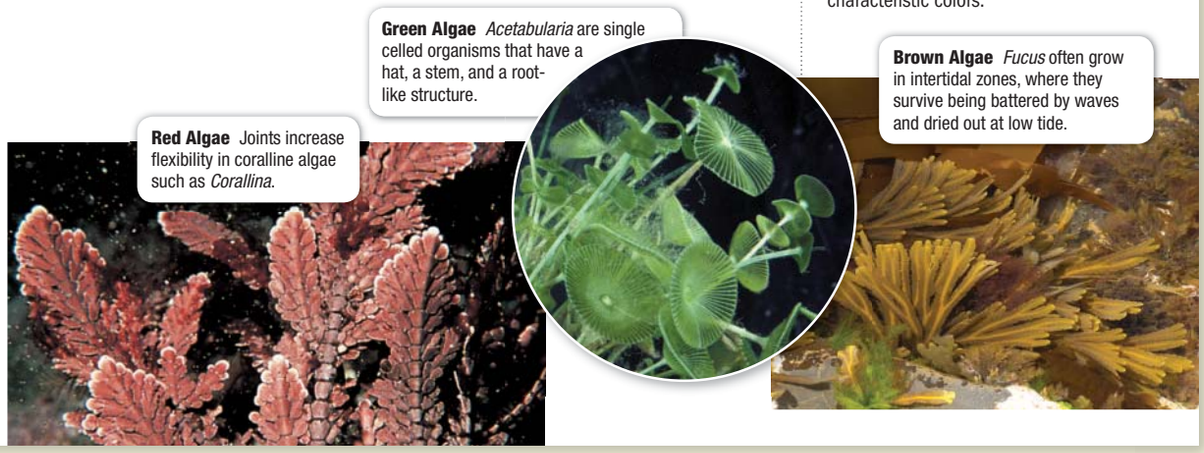


Figure 8 Red, green, and brown algae use different pigments for photosynthesis. These pigments give the algae their characteristic colors.

Differentiated Instruction

Advanced Learners

Space Algae Have student groups research and give a class presentation on how algae might be useful in space. Green algae have been tested in the space program as a means of eliminating some of the cargo needed for long missions. The algae would feed shrimp, a food source for the astronauts, and would also recycle carbon dioxide and release oxygen. Because they regenerate continuously, the algae would add less weight and volume to the spacecraft than more traditional food and air sources. LS **Interpersonal**

MISCONCEPTION ALERT

Hidden Green Pigments Both brown and red algae contain chlorophyll in addition to the pigments that make them look brown and red. A common misconception is that they lack chlorophyll; however, the green pigment is simply hidden by the other colors.

Teach, *continued*

QuickLab

Teacher's Notes Review with students that in radial symmetry, a plane can pass through the center of the diatom in more than one direction to divide the organism into two identical halves. In bilateral symmetry only one plane divides the diatom into two equal halves. Have students experiment with different light angles.

Materials
- compound microscope
- coverslip
- diatomaceous earth
- flashlight
- microscope slide
- water

Answers to Analysis

1. Students' drawings will vary.
2. Changing the light angle changes the observed reflectance and alters the appearance of surface features of the diatoms.

Teaching Key Ideas

Algae Products Have students keep a tally of algae-derived products they eat or use in one week. Encourage them to read food labels. Key terms that identify algae extracts are *lecithin, algin, emulsifier,* and *thickening agent.* Products that contain algae include pudding, ice cream, processed cheese, and salad dressing. LS **Intrapersonal**

Teach, *continued*

Teaching Key Ideas

Summary Table Have students make a table that summarizes the fungus-like protists discussed in this section. Allow students to choose their own headings so they can organize the information in their own terms. (Sample headings include: *Habitat, Appearance,* and *Type of Mold.*)

LS Logical

Close

Formative Assessment

The type of protist that obtains energy through photosynthesis is a(n) _____.

A. amoeba (Incorrect. An amoeba obtains energy by consuming other organisms.)

B. slime mold (Incorrect. Slime molds absorb nutrients from decaying material.)

C. sporozoan (Incorrect. Sporozoans are parasites.)

D. diatom (Correct! Diatoms are photosynthetic organisms.)

Physarum

Saprolegna

Figure 9 Slime molds, such as *Physarum*, are often brightly colored. Some even glow in the dark. Water molds, like *Saprolegna*, can kill aquarium fish.

plasmodium the multinucleate cytoplasm of a slime mold that is surrounded by a membrane and that moves as a mass

Funguslike Protists

Funguslike protists absorb nutrients from their environment and reproduce by releasing spores. Funguslike protists were once classified as fungi. However, according to molecular analyses, they are not closely related to fungi.

Slime Molds Slime molds are funguslike organisms that form spores and absorb nutrients from soil, decaying wood, or animal dung. Under normal conditions, cellular slime molds exist as single-celled amoebas. When food or water runs out, the cells release a chemical signal that causes them to form colonies and to release spores. A plasmodial slime mold, such as the one shown in **Figure 9,** is a **plasmodium,** a mass of cytoplasm that has many nuclei. If the plasmodium begins to dry out or starve, it divides into many small mounds and produces spores. Slime molds help researchers understand how cells interact and how cytoplasm moves within cells.

Water Molds and Downy Mildews Water molds and downy mildews typically form multicellular filaments that resemble fungi. Many of these protists decompose dead organisms. Others, such as the one shown in **Figure 9,** are common parasites of aquarium fish. In 1846, one type of water mold destroyed almost the entire potato crop in Ireland, which led to the Great Famine. In 1879, a downy mildew of grapes almost wiped out the French wine industry.

Section 2 Review

KEY IDEAS

1. **Explain** why protists are grouped based on their source of nutrition.
2. **Identify** the characteristic that animal-like protists share.
3. **Name** the characteristics shared by plantlike protists.
4. **Describe** the characteristics of funguslike protists.

CRITICAL THINKING

5. **Recognizing Relationships** What characteristics of brown algae might cause people to think that brown algae should be classified as plants? Do you think that brown algae should be classified as plants? Explain why or why not.
6. **Analyzing Methods** What might be the major drawback of grouping protists based on their source of nutrition?

ALTERNATIVE ASSESSMENT

7. **Cookbook** Many types of algae are edible. Some are very important food sources in various parts of the world. Research edible algae, and construct a cookbook in which every recipe includes algae. Your cookbook should include an appetizer, a soup, a salad, a main course, and a dessert.

Answers to Section Review

1. Grouping protists based on nutrition is useful for understanding their ecological roles.
2. Animal-like protists ingest other animals to obtain energy.
3. Plant-like protists obtain energy by photosynthesis.
4. Like fungi, fungus-like protists absorb nutrients from their environment and reproduce using spores.
5. Sample answer: Brown algae photosynthesize and are large, multicellular organisms that look very similar to plants. They should probably not be classified with plants because they use different pigments for photosynthesis.
6. Sample answer: Many of the protists grouped with animal-like, plant-like, and fungus-like protists are not very closely related, so classifying them based on nutrition would be misleading.
7. Sample menu: Appetizer: Mekong algae chips; Soup: seaweed soup; Salad: salad with sea lettuce *(Ulva)* or any salad with thick salad dressing; Main course: sushi; Dessert: ice cream

Section 3

Protists and Humans

Key Ideas	Key Terms	Why It Matters
What are seven diseases that protists cause? How do protists have a significant effect on the environment? What are five examples of ways that humans use protists in industry?	algal bloom	Some protists cause disease, but most have vital roles in ecosystems, and many provide useful products for humans.

Protists have significant effects on humans and other organisms. They can cause disease and alter ecosystems, and they are useful in industry and research.

Protists and Disease

Protists cause a number of human diseases, including giardiasis, amebiasis, toxoplasmosis, trichomoniasis, cryptosporidiosis, Chagas disease, and malaria. Parasitic protists are a significant cause of illness and death, especially in the developing world.

Giardiasis Giardiasis is a disease caused by an intestinal parasite of the genus *Giardia,* shown in **Figure 10.** The parasite enters the body as a cyst. The cyst releases two flagellated protists that reproduce by binary fission. As the protists move through the intestine, they cause severe diarrhea and intestinal cramps that may last for two to six weeks. The disease is rarely fatal. When the cells reach the colon, they form cysts. A tough outer covering enables the cysts to survive for several months outside a host. Animals and humans can contaminate water with feces that contain cysts. Campers, hikers, and people who drink untreated water are at highest risk for infection. Infection can be prevented by boiling or filtering water.

Amebic Dysentery The parasite *Entamoeba histolytica* causes two forms of diarrheal illness. One form, amebiasis, is mild and can last a couple of weeks. Amebic dysentery is a severe form of amebiasis. Symptoms of amebic dysentery include pain, bloody diarrhea, and fever. In rare cases, amoebas travel to the liver, lungs, or brain and can be fatal. *E. histolytica* forms cysts that are transmitted in contaminated water, most commonly in countries that have poor sanitation. *E. histolytica* can also be transmitted on fruits, vegetables, and other foods that have been washed with contaminated water and eaten raw.

Reading Check ***In what form are*** **Giardia** ***and*** **Entamoeba** ***parasites transmitted?***

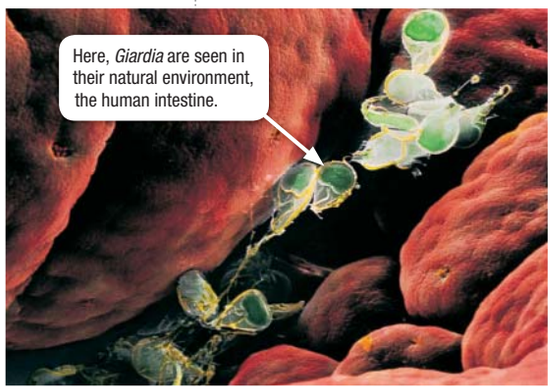


Figure 10 *Giardia* attaches to the wall of the small intestine using a sucking disk. There they absorb nutrients from food passing through the small intestine.

Key Resources

Transparencies
F19 Diseases Caused by Protists

Visual Concepts
Malaria
Malaria Life Cycle

Section 3

Focus

This section discusses how protists affect humans in beneficial and harmful ways.

Bellringer
Use the Bellringer transparency to prepare students for this section.

Teach

Teaching Key Ideas

Protection from Protists Before teaching this section, ask students to write a short paragraph about how they would protect themselves from diseases caused by protists. After students have read the section, have them edit their paragraphs as needed. (Precautions might include getting appropriate vaccinations or medications, avoiding infested areas, watching for possible food or water contamination, and protecting themselves from the insects or other animals that can carry pathogens.)
LS Verbal

Teach, *continued*

READING TOOLBOX

Word Origins Sample answer: *Cryptosporidium* probably means "hidden spore." The spores survive outside the host for long periods of time. Because of this, people may not know that the spores are present on food or in water and may ingest the spores accidentally. For this reason, *Cryptosporidium* is a good name for this organism.

Teaching Key Ideas

Disease Outbreaks Typically, diseases caused by protists occur because of unsafe food or other sanitary conditions. Have students form small groups and research to find examples of recent disease outbreaks. Have them prepare a short report on what they find.

LS **Interpersonal**

ACADEMIC VOCABULARY

rarely not very often

READING TOOLBOX

Word Origins The word part *crypto-* means hidden. *Cryptosporidium* forms spores that can survive for long periods of time outside a host. Why might the name *crypto be* appropriate?

Toxoplasmosis Toxoplasmosis (TAHKS oh plaz MOH sis), caused by the protist *Toxoplasma gondii,* is spread by cats and by eating undercooked meat that contains cysts. Infected cats release spores in their feces for up to two weeks after infection. Adult humans who have a healthy immune system are usually not affected. A small number of people develop flulike symptoms. Rarely, infection causes nerve, brain, or eye damage. If a pregnant woman is infected, her fetus can suffer eye or brain damage. To avoid toxoplasmosis, cook meat fully and wash hands thoroughly after gardening or changing a cat's litter box. Pregnant women should avoid changing cat litter.

Trichomoniasis Trichomoniasis (TRIK oh moh NIE uh sis) is one of the most common sexually transmitted infections in the United States. It is caused by *Trichomonas vaginalis*, shown in **Figure 11.** Men often have no symptoms, but can still spread the infection. Women who are infected typically experience discolored discharge, genital itching, and the urge to urinate. If a pregnant women is infected, her infant may be born prematurely or with low birth weight. Trichomoniasis is easily treated with medication.

Cryptosporidiosis Cryptosporidiosis (KRIP toh spuh RID ee OH sis), commonly called *crypto,* is caused by protists of the genus *Cryptosporidium.* It can be spread by contaminated water or objects and in uncooked food. In 1993, water contaminated with crypto infected more than 400,000 people in Wisconsin. The most common symptoms of crypto are severe cramps and diarrhea that may last up to two weeks. Individuals who have weakened immune systems may suffer severe, prolonged cases of cryptosporidiosis.

Chagas Disease Chagas disease, or American trypanosomiasis (TRIP uh NOH soh MIE uh sis), is caused by the protist *Trypanosoma cruzi.* This disease occurs in South and Central America. It is spread by kissing bugs, shown in **Figure 11.** The early stage of infection has few or no symptoms. The chronic stage can result in heart disease, abnormal heartbeat, heart failure, heart attack, and enlargement of the esophagus and the large intestine.

Figure 11 Trichomoniasis and Chagas disease are two common diseases caused by protists.

Differentiated Instruction

Struggling Readers/English Learners

Organizing Information Have students create a table to organize key information about the four diseases described on this page. The column heads for the table should be as follows: *Name of disease, Cause, Symptom(s), Treatment*. Review all symptoms of the diseases with students to be sure they understand the following terms: symptom, diarrhea, genital, cysts, discolored, discharge, and chronic.

LS **Verbal**

Why It Matters

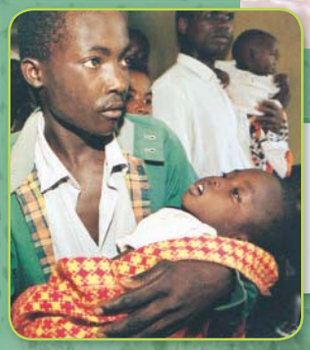
Protist Plague

Malaria was eradicated from the United States in the 1950s. Yet today it is the third most deadly disease in the world. Up to 500 million people are infected. Up to 3 million die every year. A child dies from malaria every 30 seconds.

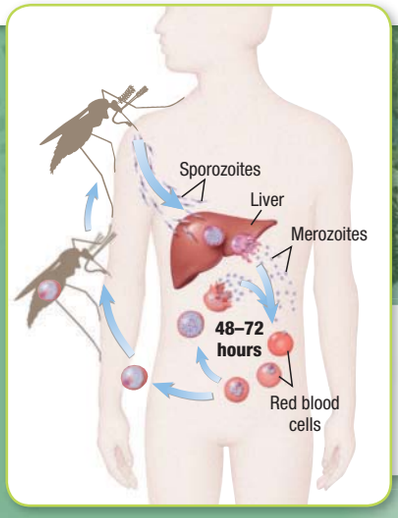
WEIRD SCIENCE

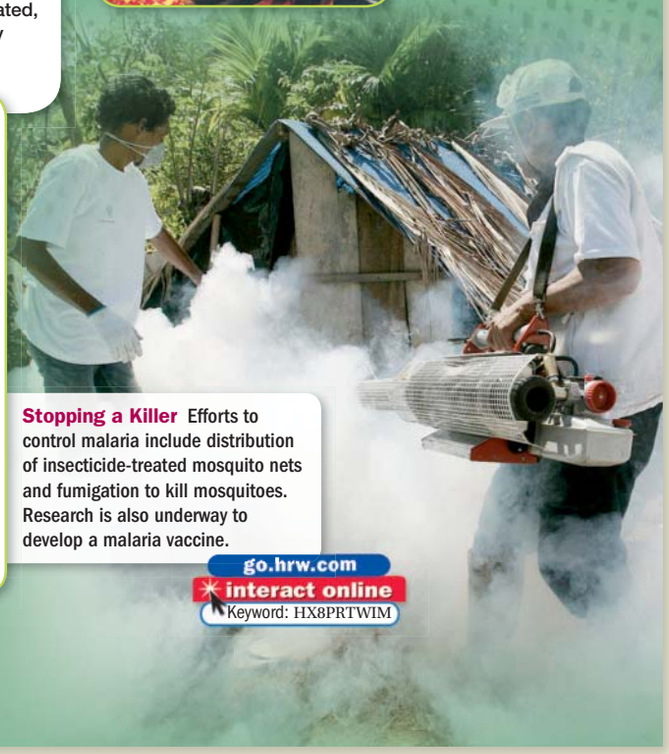
Malaria

Malaria is caused by several types of sporozoans of the genus *Plasmodium.* It is spread by the bite of the *Anopheles* mosquito. When an infected mosquito bites a human, it injects saliva containing the parasite. The first stage of the malaria parasite, called a *sporozoite,* infects the liver. It invades liver cells, produces millions of parasites, and destroys the liver cells in the process. The second stage, called a *merozoite,* infects red blood cells. Inside a red blood cell, the parasite divides. It produces 8 to 24 merozoites that burst from the cell and destroy the red blood cell. The new merozoites invade and destroy more red blood cells in a cycle that repeats every 48 to 72 hours. As red blood cells die, malaria causes anemia and cycles of fever. If left untreated, malaria can cause rupture of the spleen, kidney failure, coma, brain damage, and death.



The Price of Life The cost of potentially life-saving treatment is as low as 13 cents per dose. However, medicines are not always available.





Stopping a Killer Efforts to control malaria include distribution of insecticide-treated mosquito nets and fumigation to kill mosquitoes. Research is also underway to develop a malaria vaccine.

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interact online
Keyword: HX8PRTWIM

Research Use library and Internet sources to find out more about the efforts to eradicate malaria worldwide.

Why It Matters

Teacher's Notes Explain that forty-one percent of the world's population live in areas where malaria is transmitted. These areas include Africa, Asia, the Middle East, Central and South America. Several species of *Anopheles* mosquitoes carry and spread the pathogen to humans while feeding on their blood. In tropical Africa, one person can receive more than 300 bites by infected mosquitoes per year. International researchers hope to introduce a pathogen-inhibiting gene into the genomes of these mosquitoes. Releasing transgenic mosquitoes to spread the new gene throughout the *Plasmodium*-carrying mosquito populations could help to combat malaria.

Answer to Research

Students will find that several strategies are being applied to combat malaria. The development of a malaria vaccine is underway, with several potential candidates. Efforts to prevent malaria by controlling mosquitoes include insecticide treated mosquito nets, indoor spraying of mosquito poison, insecticide to kill mosquito larvae, wearing protective clothing to avoid mosquito bites, and area-wide fogging with insecticide.

go.hrw.com
interact online

Students can interact with the life cycle of *Plasmodium* by going to go.hrw.com and typing in the keyword HX8PRTWIM.

Teach, *continued*

Teaching Key Ideas

Red Tides The toxic substance produced by the dinoflagellate responsible for "red tides" can kill fish and invertebrates that consume the algae. Red tides can also be a human health risk. Ask students how red tides might result in human poisoning. (People who ingest mussels that feed on the toxic dinoflagellates can become ill and may even die.) LS **Logical**

Why It Matters

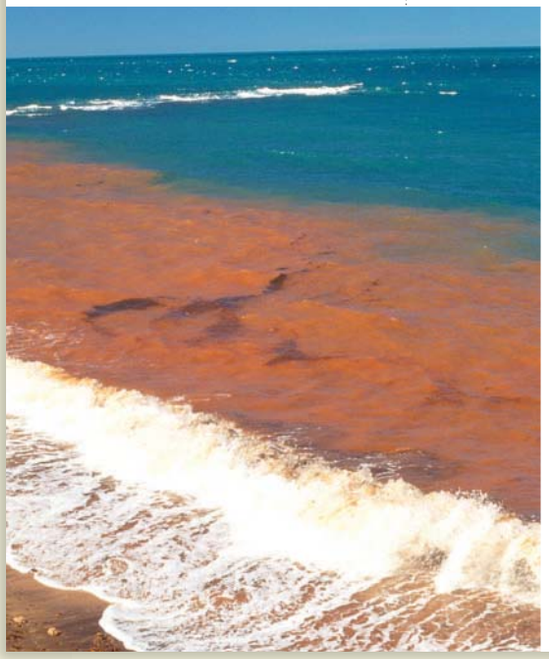
Importance of Coral Reefs Because they provide an environment for algae to flourish and grow, coral reefs are an important part of the food chain. Tell students that coral reefs are in danger due to human activity. Have students do research on the challenges that coral reefs face. Have them present their findings on a poster. LS **Verbal/Visual**

Answers to Caption Questions

Figure 12: Fish and shellfish feed on plankton, such as dinoflagellates. The toxins may build up in the bodies of the fish and shellfish that eat the dinoflagellates.

algal bloom a rapid increase in the population of algae in an aquatic ecosystem

Figure 12 Ciguatera is a combination of digestive, nerve, and cardiovascular disorders caused by eating fish that are contaminated with dinoflagellate toxins.
Why might toxins become concentrated in fish and shellfish?



Protists and the Environment

Protists produce oxygen, take up carbon dioxide, are important producers in aquatic food webs, can produce deadly blooms, serve as nutrient recyclers, and have symbiotic relationships with many animals and plants.

Oxygen Production and Nutrient Cycling Plantlike protists, along with photosynthetic cyanobacteria, produce at least half of Earth's oxygen. During photosynthesis, these protists also consume carbon dioxide, a greenhouse gas. By taking up carbon dioxide, protists may play an important role in reducing global warming. Other protists are important decomposers. They contribute to the recycling of nutrients, such as carbon, nitrogen, and other minerals.

Food Webs Photosynthetic protists, with cyanobacteria, and tiny arthropods form the base of almost all aquatic food chains. For example, protists make up a large percentage of the plankton in the oceans. Plankton are eaten by organisms such as anchovies. The anchovies are eaten by sea lions, and the sea lions become food for orcas. Many organisms depend solely on plankton for food. In fact, baleen whales, the largest animals on Earth, which can grow to up to 100 ft long, feed exclusively on tiny plankton in the ocean.

Algal Blooms During warm seasons, when nutrients in ocean water are abundant, algae populations can rise dramatically. An **algal bloom** is a rapid increase in the population of algae in an aquatic ecosystem. During a bloom, there may be as many as 20 million protists per liter of sea water. A *red tide,* such as the one in **Figure 12,** is caused by a bloom of dinoflagellates. Dinoflagellates produce powerful toxins. Humans can become ill if they eat fish or shellfish during a red tide. One genus of dinoflagellates, *Pfiesteria,* produces a powerful toxin that can become airborne. This toxin can cause memory and concentration problems as well as skin rashes. When an algal bloom dies, the bacteria that consume and decompose the algae deplete the oxygen levels in the water. As a result, large numbers of fish and other marine animals may die.

Protist Symbioses Symbiotic protists, including the ones that cause disease, make up about 15% of all of the species on Earth. Some photosynthetic protists live with corals. The protists supply the coral with nutrients and give the coral its color. The coral provides the protists with a stable environment, nitrogen, and minerals. Many protists live in the digestive tracts of humans and other animals. Cattle could not digest hay and grass without their protist symbionts. Termites could not digest wood without the aid of protists. Photosynthetic single-celled algae form an association with fungi that we call lichen.

Reading Check ***What are three ways in which protists affect ocean ecosystems?***

Hands-On

QuickLab

10 min

Everyday Algae

You may be surprised to learn how many products in your kitchen contain algae.

Procedure

1. Look at a group of **food products** that your teacher has placed on display.
2. Guess which products contain algae and which do not. Write down the names of the products that you think contain algae.
3. As your teacher reveals which products contain algae, note how many you got right.

Analysis

1. **State** how many of your guesses were correct.
2. **Identify** some common characteristics of the products that contain algae.
3. CRITICAL THINKING **Recognizing Relationships** Based on the similarities between products containing algae, what role do you think algae play in these products?

Protists and Industry

Protists are important in many foods, in industrial and consumer products, and in scientific research. Many types of algae are eaten as vegetables. Algae produce substances that are used to thicken many food products. Carrageenan, agar, and alginate are used in foods such as ice cream, salad dressings, and gelatin desserts.

Agar is also used to grow bacteria in laboratories and to make gelatin capsules for medications. Carrageenan is used in paints, fire-fighting foam, and cosmetics. The empty shells of diatoms are used as abrasives in cleaning agents, such as toothpaste. They also add the reflective quality to roadway paint. Diatomaceous earth (DE) is sold as a natural product to control insect pests. DE absorbs oils from an insect's body, causing water loss, dehydration, and death.

Protists are important in biological research. They are used to study ribosomes, cell aging, and cell cycle control. Slime molds are studied as models of cell movement and cell signaling. They also help scientists understand how white blood cells fight disease.

Section 3

Review

KEY IDEAS

1. **Name** seven diseases that are caused by protists.
2. **Explain** why a cycle of fever occurs when one has malaria.
3. **Describe** the roles that protists play in the environment.
4. **Identify** three ways that protists are used in industry.

CRITICAL THINKING

5. **Making Connections** Disease-causing protists often form cysts or spores before they leave a host. Does this fact indicate that these protists are closely related to each other? Why or why not?
6. **Forming Reasoned Opinions** The mosquitoes that transmit malaria live in warm climates. How might global warming affect the incidence of malaria?

WRITING FOR SCIENCE

7. **Persuasive Speaking** Imagine that you are speaking to Congress to request funding for malaria treatment. Write a persuasive speech stating why you should receive funding. Be sure to include data that support your position.

Answers to Section Review

1. giardiasis, amebic dysentery, toxoplasmosis, trichomoniasis, cryptosporidiosis, Chagas disease, malaria
2. Every 48–72 hours red blood cells burst, releasing malaria parasites. The bursting of the blood cells and release of the parasite cause fever.
3. Protists produce oxygen, take up carbon dioxide, are producers in aquatic food webs, recycle nutrients, and have important symbiotic relationships with many animals and plants.
4. foods, industrial and consumer products, and scientific research
5. Sample answer: This does not indicate that they are closely related. Forming spores or cysts would convey an advantage to disease-causing protists, allowing them to survive outside a host for long periods of time. As a result, species that formed cysts or spores would survive better, reproduce more, and become the majority in the population.
6. Sample answer: Global warming could cause the incidence of malaria to increase as suitable habitats increase for host mosquitoes.
7. Answers will vary. Accept any well-written speech that includes evidence and data.

Teach, *continued*

QuickLab

Teacher's Notes Examples of products that contain algae should be purchased in advance. Examples include toothpaste, salad dressings, mayonnaise, coffee creamer, chocolate milk, and many cosmetics.

Safety Caution Remind students not to eat in the laboratory.

Answers to Analysis

1. Answers will vary.
2. Almost all the products with algae are thick and creamy.
3. as a thickening agent

Close

Formative Assessment

A person has an abnormal heartbeat 30 years after visiting a foreign country. The protist that might have caused this is _____.

A. *Trypanosoma cruzi* (Correct! This protist can cause Chagas disease. The chronic stage of Chagas disease can cause irregular heartbeat.)
B. *Cryptosporidium* species (Incorrect. These protists cause intestinal diseases in humans.)
C. *Trichomonas vaginalis* (Incorrect. This protist causes sexually-transmitted diseases.)
D. *Toxoplasma gondii* (Incorrect. This protist causes flu-like symptoms in adults and brain or eye damage in infants.)

Lab

Inquiry

Chapter 21 Lab

Time Required

45 minutes

Ratings

EASY — HARD

Teacher Prep	
Student Setup	
Concept Level	
Cleanup	

Safety Cautions

Treat all microbes as potential pathogens. Remind students to avoid touching their faces when working with microbes. Use sterile technique, and sterilize all lab equipment after exposure to microbes. Remind students to wash their hands thoroughly after handling microbes. Microbes must be disposed of in a safe manner as outlined by local and school safety protocols. Often this involves sterilization of the used glassware in an autoclave. Use heat resistant gloves with a long gauntlet when operating an autoclave.

Tips and Tricks

This investigation may take more than one class period. To save time, you may wish to make the "sun shades" in advance.

Answer to Form a Hypothesis

Sample answer: Producers will be more attracted to light than consumers or decomposers.

Objectives

- Identify several types of protists.
- Compare the structures, methods of locomotion, and behaviors of several kinds of protists.
- Relate a protist's response to light to the protist's method of feeding.

Materials

- protist slowing agent
- plastic pipets with bulbs
- mixed culture of protists
- compound microscope
- microscope slides
- coverslips
- toothpicks
- construction paper, black
- paper, white
- paper punch
- scissors
- forceps
- sunlit windowsill or lamp

Safety

Protistan Responses to Light

Photosynthetic protists depend on light to make food. Consumers and decomposers do not require light. In this lab, you will observe live protists and test their responses to light. To do this, you will make a shade that you can place over a wet mount of protists to find out whether they move toward or away from light.

Preparation

1. SCIENTIFIC METHODS **State the Problem** How do protists respond to various amounts of light?
2. SCIENTIFIC METHODS **Form a Hypothesis** Form a testable hypothesis about how different protists will respond to various levels of light.

Procedure

Make a Wet Mount of Protists

1. Put on safety goggles, gloves, and a lab apron.
2. **CAUTION: Do not touch your face while handling microorganisms.** Place a drop of protist slowing agent on a microscope slide. Add a drop of liquid from the bottom of a mixed culture of protists. Add a coverslip.
3. View the slide under low power and high power of a microscope.
4. Make a drawing of each type of protist. Note whether the protist moves, and try to determine how it moves.
5. Repeat step 1, but do not use the slowing agent. Note differences in the movement of the protists that you see.

Light micrograph of protist mixture

Answers to Procedure

10. Sample procedure: Prepare a wet mount of protists without any protist slowing agent. View under the low power of a compound microscope, and record the observations. Place the wet mount on top of a piece of white paper on a sunlit window sill or under a table lamp. Position the "sun shade" so that the hole is in the center of the coverslip for each slide. After 10 minutes, place each slide on the stage of a compound microscope and view the slide using the low-power objective. Record your observations. Have one person remove the "sun shade" on each slide (using forceps) while another person continues to view the protists. Record your observations.

45 min

Test Protistan Responses to Light

6. Place a wet mount of protists on a piece of white paper. Then, place the paper and the slide on a sunlit windowsill or under a table lamp.
7. Punch a hole in a piece of black construction paper that has a slight curl, as shown in the photo. Position the black paper on top of the slide so that the hole is in the center of the coverslip.
8. To examine the slide, first view the area in the center of the hole under low power. (Note: Do not disturb the black paper, and do not switch to high power. Switching to high power will move the paper.) Then, have a partner carefully remove the black paper with forceps while you observe the slide. Note any movement of the protists in response to the change in light.

Design an Experiment

9. Design an experiment that tests your hypothesis and that uses the materials listed for this lab. Predict what will happen during your experiment if your hypothesis is supported.
10. Write a procedure for your experiment. Identify the variables that you will control, the experimental variables, and the responding variables. Construct any tables you will need to record your data. Make a list of all the safety precautions you will take. Have your teacher approve your procedure before you begin.
11. Set up and carry out your experiment.
12. Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.

Analyze and Conclude

1. **Summarizing Results** Describe the various types of locomotion that you observed in protists, and give examples of each type.
2. SCIENTIFIC METHODS **Analyzing Results** Identify which protists were affected by light, and describe how they were affected.
3. SCIENTIFIC METHODS **Drawing Conclusions** How are a protist's response to light and the protist's method of feeding related?

Extensions

4. **Research** Investigate livestock diseases that are caused by parasitic protists. Which of these diseases are most common in the United States?
5. **Research** Find out how backpackers can avoid getting diseases that are caused by protists and transmitted in water.

Sample Data Table

Protist	Color	Method of Locomotion	Method of Feeding	Other Observations
Amoeba	Whitish	Pseudopodia	Consumer	Changes shape
Blepharisma	Pinkish	Cilia	Consumer	
P. caudatum	Clear	Cilia	Consumer	
Euglena	Green	Flagellum	Producer	Has "eye-spot"
Stentor	Bluish	Cilia	Consumer	Trumpet-shaped
Volvox	Green	Flagellum	Producer	Colonial

Answers to Analyze and Conclude

1. *Amoeba* moves by flowing cytoplasm into a pseudopodium, *Paramecium* uses cilia beating in waves to propel the cell, *Euglena* uses a whiplike flagellum, and *Volvox* uses many flagella.
2. *Euglena* congregated within the area exposed to light. Once the shade was removed, they scattered.
3. Protists that depend on light for food were attracted to the light.

Answers to Extensions

4. Answers will vary. Diseases might include blackhead, coccidiosis, and giardia.
5. Sample answer: develop a water-filtering system

Chapter 21

SUPER SUMMARY

Have students connect the major concepts in this chapter through an interactive Super Summary. Visit **go.hrw.com** and type in the keyword **HX8PRTS** to access the Super Summary for this chapter.

Reteaching Key Ideas

Concept Map Have students work individually or in small groups to make a concept map of the following terms: zoospores, haploid, diploid, unicellular, multicellular, zygospore, conjugation, gametes, alternation of generations, *Chlamydomonas, Spirogyra, Ulva,* zygote, and sporangia. LS **Visual**

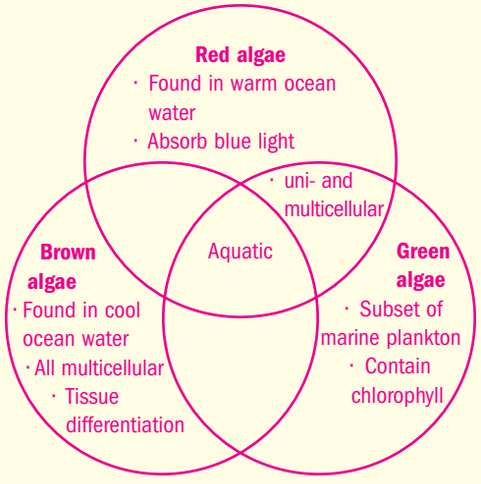
Making a Table Have students work in pairs to make a table that compares and contrasts the characteristics of the three groups of protists. LS **Visual/Interpersonal**

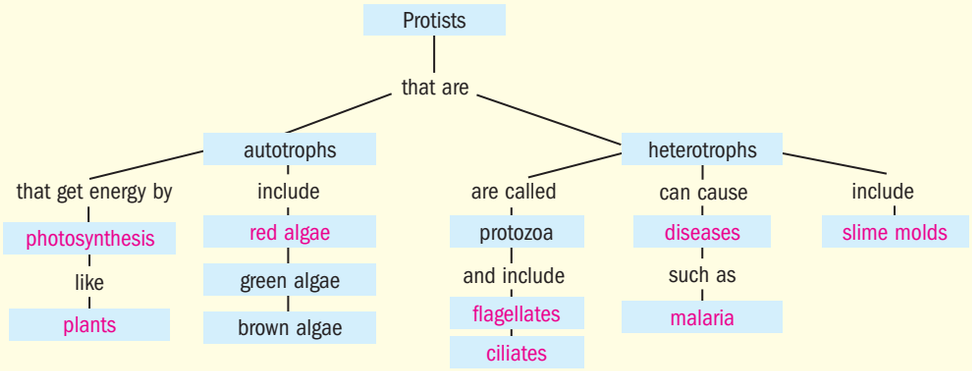
Comparisons Have students list disease-causing protists and the diseases they cause. Then beside the list have them list protists that are beneficial and why. Ask students to summarize these comparisons in a few paragraphs. LS **Verbal**

Answers to Concept Map

The following is one possible answer to Chapter Review question 2.

Answers to Reading Toolbox





Chapter 21 Summary

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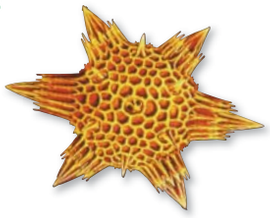
SUPER SUMMARY
Keyword: HX8PRTS

Key Ideas	Key Terms
1 Characteristics of Protists	**gamete** (498) **zygote** (498) **zygospore** (499) **alternation of generations** (499)
2 Groups of Protists	**pseudopodium** (502) **plasmodium** (506)
3 Protists and Humans	**algal bloom** (510)

1 Characteristics of Protists



- Protists are eukaryotic organisms that cannot be classified as fungi, plants, or animals.
- Protists can reproduce asexually by binary fission, budding, and fragmentation. Protists can also reproduce sexually by fusion of gametes.
- The classification of organisms currently grouped in the kingdom Protista is likely to change as scientists learn more about how these organisms are related to each other and to members of other kingdoms.

2 Groups of Protists

- Grouping protists by the way they obtain nutrients helps us understand their ecological roles.
- Animal-like protists ingest other organisms to obtain energy.
- Plantlike protists obtain energy through photosynthesis.
- Funguslike protists absorb nutrients from their environment and reproduce by releasing spores.

3 Protists and Humans

- Protists cause a number of human diseases, including giardiasis, amebic dysentery, toxoplasmosis, trichomoniasis, cryptosporidiosis, Chagas disease, and malaria.
- Protists produce oxygen, take up carbon dioxide, are important producers in aquatic food webs, can produce deadly blooms, serve as nutrient recyclers, and have symbiotic relationships with many animals and plants.
- Protists are important in many foods, in industrial and consumer products, and in scientific research.

Chapter 21 Review

READING TOOLBOX

1. **Venn Diagram** Make a Venn diagram to summarize the similarities and differences between red algae, brown algae, and green algae.
2. **Concept Map** Make a concept map that describes protists. Try to include the following terms in your map: *red algae, malaria, slime mold, photosynthesis, plants, diseases, flagellates,* and *ciliates.* You may include additional terms.

Using Key Terms

Use each of the following terms in a separate sentence.

3. *alternation of generations*
4. *algal bloom*
5. *gamete*

For each pair of terms, explain how the meanings of the terms differ.

6. *zygote* and *zygospore*
7. *pseudopodium* and *plasmodium*

Understanding Key Ideas

8. The organisms in the kingdom Protista are grouped together because
   a. all of them are eukaryotic.
   b. all of them are closely related.
   c. all of them are microscopic and unicellular.
   d. they do not belong in the plant, fungi, or animal kingdoms.
9. Which process would *not* occur during asexual reproduction in protists?
   a. budding
   b. fragmentation
   c. binary fission
   d. fusion of gametes
10. Grouping protists by nutrition reflects their
    a. ancestry.
    b. ecological roles.
    c. importance to humans.
    d. evolutionary relationships.
11. Photosynthetic protists that have boxlike double shells are called
    a. kelp. **c.** euglenoids.
    b. diatoms. **d.** dinoflagellates.
12. Slime molds reproduce by forming
    a. slugs. **c.** plasmodia.
    b. spores. **d.** pseudopodia.
13. Which organism is responsible for transmitting Chagas disease?
    a. tsetse fly
    b. house cat
    c. kissing bug
    d. *Anopheles* mosquito
14. Photosynthetic protists affect the ecosystem in all but which of the following ways?
    a. They produce oxygen.
    b. They take up carbon dioxide.
    c. They consume harmful bacteria.
    d. They form the base of many aquatic food chains.
15. Which protists are used in cleaning agents, toothpaste, and reflective paint?
    a. kelp **c.** red algae
    b. diatoms **d.** dinoflagellates
16. To which group of protists does the organism shown belong?
    a. ciliates **c.** sporozoans
    b. flagellates **d.** amoeboid protists

Explaining Key Ideas

17. **Differentiate** between the classification of protists and the relationships between protists.
18. **Name** two traits that evolved among protists.
19. **Sequence** the steps in the life cycle of *Ulva*. Begin with the zygote stage.

Assignment Guide

Section	Questions
1	2, 3, 5, 6, 8, 9, 17, 18, 19, 24
2	1, 2, 7, 10, 11, 12, 16, 17, 22, 24, 29, 30
3	2, 4, 13, 14, 15, 20, 21, 22, 23, 25, 26, 27, 28

Review

Reading Toolbox

1. See previous page for answer to Venn diagram.
2. See previous page for answer to concept map.

Using Key Terms

3. *Alternation of generations* involves both a haploid and diploid multicellular phase.
4. An *algal bloom* is a rapid increase in the population of algae in an aquatic ecosystem.
5. *Gametes* are haploid cells that join to form a diploid zygote.
6. A *zygote* is a diploid cell that results from the fusion of gametes. A *zygospore* is a structure that contains the zygote.
7. A *pseudopodium* is a cytoplasmic extension of a cell, used for movement and engulfing food. A plasmodium is a mass of cytoplasm that has many nuclei.

Understanding Key Ideas

8. d 9. d 10. b 11. b
12. b 13. c 14. c 15. b
16. a

Explaining Key Ideas

17. Though protists are classified in the same kingdom, they are not closely related to each other.
18. Answers may include multicellularity, membrane-bound organelles, complex cilia and flagella, and sexual reproduction involving gametes.
19. The zygote develops into a diploid sporophyte. It produces haploid spores by meiosis. The spores develop into haploid gametophytes. The gametophyte produces gametes by mitosis. The gametes fuse to form a zygote.

Critical Thinking

20. Predicting Outcomes The protist that causes malaria is rapidly developing resistance to drugs used to treat malaria. Would it be possible for drug-resistant malaria to become an epidemic in the United States? Explain your reasoning.

21. Making Connections How might agricultural fertilizer cause large numbers of fish to die?

22. Relating Form and Function Recall that sporozoans are animal-like protists that have no means of locomotion and are all parasitic. How does the lack of locomotion relate to a parasitic lifestyle?

23. Recognizing Relationships How could polluting the ocean affect global warming?

24. Forming Reasoned Opinions A classmate says that giant kelp should be classified as plants. Do you agree with your classmate? Why or why not?

Using Science Graphics

The table shows the number of new cases of amebiasis and malaria in the United States from 1986 to 1994. Use the table to answer the following questions.

Cases of Protist-Caused Diseases in the United States, 1986–1994

Year	Amebiasis cases	Malaria cases
1986	3,532	1,123
1988	2,860	1,099
1990	3,328	1,292
1992	2,942	1,087
1994	2,983	1,229

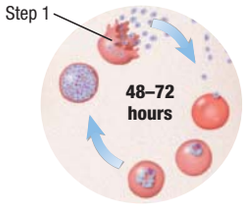
25. How many more cases of malaria were reported in 1990 than were reported in 1986?

a. 100 **c.** 130
b. 106 **d.** 169

26. What is the difference between the average number of cases of amebiasis and the average number of cases of malaria between 1986 and 1994?

a. 1,166 **c.** 2,166
b. 1,963 **d.** 3,192

This diagram shows part of the life cycle of malaria. Use the diagram to answer the following question.



27. What event is taking place in step 1?

a. mitosis **c.** release of spores
b. meiosis **d.** release of merozoites

Why It Matters

28. Proposing Solutions Health agencies around the world are working to provide medicine to treat malaria as well as insecticide-treated mosquito nets, fumigation to kill mosquitoes, and a vaccine to prevent malaria. Can you think of other efforts that might be effective in the battle against malaria?

Methods of Science

29. Designing an Experiment Design an experiment to test whether protists respond to chemical signals such as food. Write a question, a hypothesis, and a procedure for your experiment. Include all safety precautions that you will take.

Math Skills

30. Calculating Speed Some protists move very quickly for their size. For example, if a protist of the genus *Strobilidium* were the same size as a cheetah, it would travel faster than a cheetah! Speed is calculated by dividing the distance an object travels by the time the object takes to travel that distance.

$$speed = distance/time$$

Suppose that a microscopic protist travels 3 cm in 1 s. You could express the speed of this protist as 3 cm/s.

If this protist keeps traveling at 3 cm/s, how far will it travel in 5 h? Express your answer in meters. (Hint: There are 100 cm in 1 m.)

Critical Thinking

20. Sample answer: Yes, it would be possible. If a person infected with drug-resistant malaria were to travel to the United States and be bitten by a mosquito, drug resistant malaria could spread and become an epidemic.

21. Fertilizer could increase the amount of nutrients in water, leading to an algal bloom, which could release toxins.

22. Sample answer: Parasitic protists obtain nutrients from other organism, so they do not require a means of locomotion to obtain food.

23. Photosynthetic protists in the ocean absorb carbon dioxide from the air. If ocean pollution killed the protists, carbon dioxide levels would rise and global warming would increase.

24. Sample answer: Though giant kelp look like plants, they are not closely related to them. They have different photosynthetic pigments than plants do.

Using Science Graphics

25. d **26.** b **27.** d

Why It Matters

28. Sample answer: Combating mosquitoes by bringing in natural predators of either the mosquito or the larvae might reduce transmission of malaria.

Methods of Science

29. Answers will vary. Accept any reasonable answer that includes a question, a testable hypothesis, a procedure, and safety precautions.

Math Skills

30. $5\text{ h} \times \frac{60\text{ min}}{\text{h}} \times \frac{60\text{ s}}{\text{min}} \times \frac{3\text{ cm}}{\text{s}} = 54{,}000\text{ cm} = 540\text{ m}$

Chapter 21 Standardized Test Prep

TEST TIP If time permits, take short mental breaks during a test to improve your concentration.

Science Concepts

1. Which of the following features do protists, fungi, plants, and animals share but bacteria lack?

A DNA
B a nucleus
C reproduction
D a cell membrane

2. In which group of animal-like protists do organisms that have tests belong?

F ciliates
G amoebas
H flagellates
J sporozoans

3. How is amoebic dysentery spread?

A by the bite of a mosquito
B by eating overcooked meat
C by the bite of a kissing bug
D by drinking contaminated water

4. Which of the following items is produced without the use of protists?

F soap
G ice cream
H roadway paint
J fire-fighting foam

5. Which of the following processes can be found in both bacteria and protists?

A mitosis
B meiosis
C binary fission
D fusion of gametes

6. Which of the following is a sexually transmitted infection caused by a protist?

F toxoplasmosis
G trichomoniasis
H Chagas disease
J cryptosporidiosis

7. Which of the following protists are likely to be classified as plants in the future?

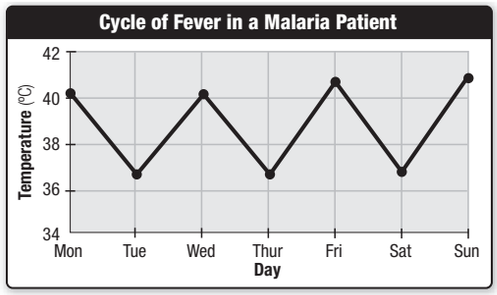
A red algae
B green algae
C brown algae
D dinoflagellates

Writing Skills

8. Short Response Describe the life cycle of *Plasmodium*, the protist that causes malaria.

Using Science Graphics

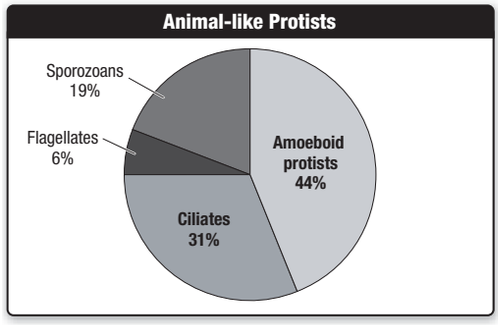
Use the diagram of the cycle of fever in a person who has malaria to answer the following question(s).



9. If the fever pattern continues, what will be the approximate temperature of the patient on the following Monday?

F 37 °C
G 39 °C
H 41 °C
J 45 °C

The diagram shows the percentage of animal-like protists belonging to each major group. Use the diagram to answer the following question(s).



10. What percentage of animal-like protists are not able to move on their own?

A 6%
B 19%
C 31%
D 44%

11. What percentage of animal-like protists move by pseudopodia?

F 6%
G 19%
H 31%
J 44%

State Resources

For specific resources for your state, visit go.hrw.com and type in the keyword **HSHSTR**.

Test Practice with Guided Reading Development

Answers

1. B **2.** G **3.** D
4. F **5.** C **6.** G
7. B
8. *Plasmodium* is carried by a mosquito. The mosquito bites a human, releasing parasites into the blood. *Plasmodium* infects the liver, produces millions of second stage parasites, and destroys liver cells. The second stage of *Plasmodium* infects red blood cells, divides, and bursts from the cells. A mosquito bites an infected person, picks up the second stage parasite, and carries the disease to another person.
9. F **10.** B **11.** J

TEST DOCTOR

Question 1 This item tests students' recognition of the distinguishing characteristic of prokaryotes vs. eukaryotes, namely the nucleus. **A** is incorrect, because all of the organisms named have DNA. **B** is correct. Bacteria are prokaryotes with no nucleus. **C** is incorrect, because all of the organisms listed reproduce, even though the processes may differ. **D** is incorrect, because all of the organisms listed have a cell membrane.

Question 2 Students must recognize that tests are a characteristic of amoeboid protists. **G** is correct, some amoebas have tests. **F, H,** and **J** are incorrect because these organisms do not have tests.

Question 9 From the temperature pattern shown, students should recognize that temperature will drop on Monday. **F** is correct because the trend shows temperature drops in the 36–38 degree range. Choices **G, H,** and **J** are incorrect because those values fall outside of the pattern for temperature drops.