1 FOCUS

Objectives

20.3.1 ***Describe*** the function of chlorophyll and accessory pigments in algae.
20.3.2 ***Describe*** the major phyla of unicellular algae.
20.3.3 ***Summarize*** the ecological roles of unicellular algae.

Guide for Reading

Vocabulary Preview

Have students preview the Vocabulary terms by skimming the section for the highlighted, boldface terms and writing down their definitions.

Reading Strategy

Point out that in several of the sections, the phrases or sentences students should write after each heading would be the Key Concepts, which are in boldface type.

2 INSTRUCT

Chlorophyll and Accessory Pigments

Demonstration

Before class, under a vent hood, use a water bath to boil some samples of green, brown, and red algae in separate beakers of alcohol to dissolve their pigments. Take three disks of filter paper large enough to cover the tops of the beakers, and in each, cut two parallel slits 0.5 cm apart. Bend each paper strip so that it extends into the liquid and acts as a wick. Within a class period, the streaks of the different pigments can be seen. Have students observe and compare the pigments on the filter paper. Then, ask: **What pigment(s) seem to be present in every type of alga?** *(Chlorophylls)* **Why aren't all algae green?** *(The other pigments—the accessory pigments—mask the color of the chlorophyll.)* **Why do algae have pigments other than chlorophyll?** *(The accessory pigments are capable of absorbing wavelengths of light that chlorophyll cannot, making photosynthesis more efficient.)* L2

20–3 Plantlike Protists: Unicellular Algae

Guide for Reading

Key Concepts
- What is the function of chlorophyll and accessory pigments in algae?
- What are the distinguishing features of the major phyla of unicellular algae?

Vocabulary
accessory pigment
eyespot
pellicle
phytoplankton

Reading Strategy: Summarizing As you read, make a list of the types of unicellular algae. Write a sentence about each type.

Many protists contain the green pigment chlorophyll and carry out photosynthesis. Many of these organisms are highly motile, or able to move about freely. Despite this, the fact that they perform photosynthesis is so important that we group these protists in a separate category, the plantlike protists. Plantlike protists are commonly called "algae."

Some scientists place those algae that are more closely related to plants in the kingdom Plantae. In this textbook, we will consider all forms of algae, including those most closely related to plants, to be protists. There are seven major phyla of algae classified according to a variety of cellular characteristics. The first four phyla, which contain unicellular organisms, are discussed in this section. These four phyla are the euglenophytes, the chrysophytes, the diatoms, and the dinoflagellates. The last three phyla include many multicellular organisms and will be discussed in the next section.

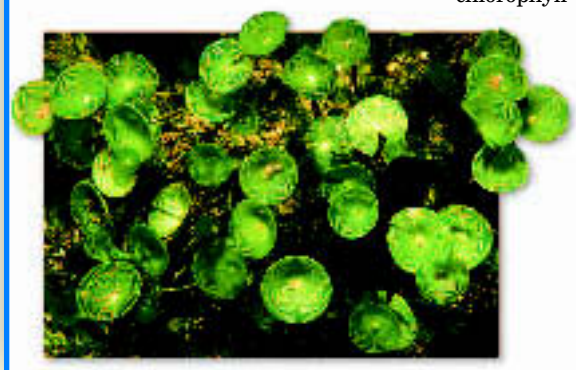
Chlorophyll and Accessory Pigments

One of the key traits used to classify algae is the type of photosynthetic pigments they contain. As you will remember, light is necessary for photosynthesis, and it is chlorophyll and the accessory pigments that trap the energy of sunlight.

Life in deep water poses a major difficulty for algae—a shortage of light. As sunlight passes through water, much of the light's energy is absorbed by the water. In particular, sea water absorbs large amounts of the red and violet wavelengths. Thus, light becomes dimmer and bluer, in deeper water. Because chlorophyll *a* is most efficient at capturing red and violet light, the dim blue light that penetrates into deep water contains very little light energy that chlorophyll *a* can use.

In adapting to conditions of limited light, various groups of algae have evolved different forms of chlorophyll. Each form of chlorophyll—chlorophyll *a*, chlorophyll *b*, and chlorophyll *c*—absorbs different wavelengths of light. The result of this evolution is that algae can use more of the energy of sunlight than just the red and violet wavelengths.

Many algae also have compounds called **accessory pigments** that absorb light at different wavelengths than chlorophyll. Accessory pigments pass the energy they absorb to the algae's photosynthetic machinery. **Chlorophyll and accessory pigments allow algae to harvest and use the energy from sunlight.** Because accessory pigments reflect different wavelengths of light than chlorophyll, they give algae a wide range of colors.



▼ **Figure 20–9 Chlorophyll and other pigments allow algae to collect and use energy from sunlight.** These green algae of the species *Acetabularia calyculus* live on the roots of mangrove trees in Florida.

SECTION RESOURCES

Print:
- ***Teaching Resources,*** Section Review 20–3, Enrichment
- ***Reading and Study Workbook A,*** Section 20–3
- ***Adapted Reading and Study Workbook B,*** Section 20–3
- ***Lesson Plans,*** Section 20–3

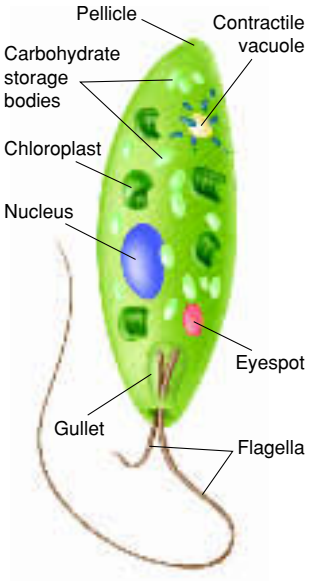
Technology:
- ***iText,*** Section 20–3
- ***Transparencies Plus,*** Section 20–3

Euglenophytes

Members of the phylum Euglenophyta (yoo-GLEE-nuh-fyt-uh), or euglenophytes, are closely related to the animallike flagellates. **Euglenophytes are plantlike protists that have two flagella but no cell wall.** Although euglenophytes have chloroplasts, in most other ways they are like zooflagellates.

The phylum takes its name from the genus *Euglena*. Euglenas are found in ponds and lakes throughout the world. A typical euglena, such as the one shown in **Figure 20–10,** is about 50 micrometers in length. Euglenas are excellent swimmers. Two flagella emerge from a gullet at one end of the cell, and the longer of these two flagella spins in a pattern that pulls the organism rapidly through the water. Near the gullet end of the cell is a cluster of reddish pigment known as the **eyespot,** which helps the organism find sunlight to power photosynthesis. If sunlight is not available, euglenas can also live as heterotrophs, absorbing the nutrients available in decayed organic material. Euglenas store carbohydrates in small storage bodies.

Euglenas do not have cell walls, but they do have an intricate cell membrane called a **pellicle.** The pellicle is folded into ribbonlike ridges, each ridge supported by microtubules. The pellicle is tough and flexible, letting euglenas crawl through mud when there is not enough water for them to swim. Euglenas reproduce asexually by binary fission.



▲ **Figure 20–10** Euglenophytes are plantlike protists that have two flagella but no cell wall. The green structures inside the euglena shown are chloroplasts, which allow the organism to carry on photosynthesis. Like paramecia, euglenas expel excess water through a contractile vacuole.

Chrysophytes

The phylum Chrysophyta (KRIS-oh-fyt-uh) includes the yellow-green algae and the golden-brown algae. The chloroplasts of these organisms contain bright yellow pigments that give the phylum its name. Chrysophyta means "golden plants." **Members of the phylum Chrysophyta are a diverse group of plantlike protists that have gold-colored chloroplasts.**

The cell walls of some chrysophytes contain the carbohydrate pectin rather than cellulose, and others contain both pectin and cellulose. Chrysophytes generally store food in the form of oil rather than starch. They reproduce both asexually and sexually. Most are solitary, but some form threadlike colonies.

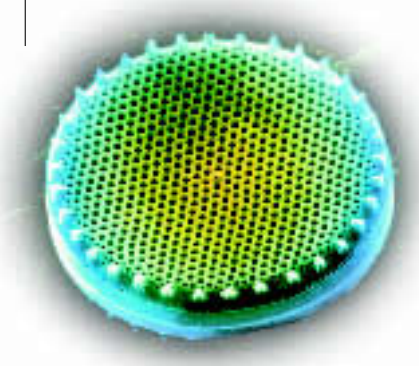
Diatoms

Members of the phylum Bacillariophyta (buh-sil-LAHR-ee-oh-fyt-uh), or diatoms, are among the most abundant and beautiful organisms on Earth. **Diatoms produce thin, delicate cell walls rich in silicon (Si)—the main component of glass.** These walls are shaped like the two sides of a petri dish or flat pillbox, with one side fitted snugly into the other. The cell walls have fine lines and patterns that almost seem to be etched into their glasslike brilliance, as shown in **Figure 20–11.**

CHECKPOINT *How are diatoms and glass alike?*

▼ **Figure 20–11** Tiny jewellike diatoms such as this centric diatom have cell walls rich in silicon.

(magnification: 2200×)



ESL SUPPORT FOR ENGLISH LANGUAGE LEARNERS

Vocabulary: Science Glossary

Beginning Write the following Vocabulary terms on the board: *eyespot* and *pellicle*. Say each term aloud, and have students repeat it after you. Help students identify these structures in Figure 20–10. Then, distribute unlabeled copies of Figure 20–10. Have students write the two terms as labels. Finally, students can write definitions of each term in their science glossary and paste their labeled copies of the illustration next to the definition. L1

Intermediate Students should complete the beginning-level activity. Working with an English-proficient student, they can extend the activity by writing two complete sentences, one using each of the Vocabulary terms. Then, to give students an opportunity to practice pronunciation, ask for individuals to volunteer to read their sentences aloud. L2

Section 20–3

Euglenophytes

Build Science Skills

Observing Provide students with a prepared slide of a euglena. Ask them to use a microscope to observe the slide and make a labeled drawing of what they see. Point out that students should use the labeled drawing in Figure 20–10 to help them find the structures of a euglena. L2 L3

Chrysophytes

Make Connections

Chemistry Ask students: **What is unusual about the way chrysophytes store food?** *(They generally store food in the form of oils rather than starch.)* **How do the energy-storing abilities of oils compare to those of starch?** *(Oils, which are lipids, can store more than twice as much energy per gram as starches, which are carbohydrates.)* L2

Diatoms

Build Science Skills

Observing Ask students how they think they could collect diatoms to observe. Suggest that they look for brownish-yellow, crusty coatings on rocks, twigs, or shells in shallow ocean, lake, or pond water. Have students follow these steps to collect and observe diatoms:

1. Place a coated rock, twig, or shell and some of the water in a jar.
2. In the lab, drain off most of the water, and then float a clean glass coverslip in the remaining water. If left for 1–2 days, diatoms will attach to the coverslip.
3. Scrape the coverslip with a scalpel, spread the material on a slide, and observe with a microscope.

Have students make drawings and try to identify the diatoms they observe. L2 L3

Answers to . . .

CHECKPOINT *The cell walls of diatoms are rich in silicon, which is the main component of glass.*

Dinoflagellates

Use Visuals

Figure 20–12 Have students examine the figure and read the caption. Then, ask: **Which protist phylum includes the dinoflagellates?** *(Pyrrophyta)* **What is a luminescent organism?** *(An organism that produces light)* **Which group of animallike protists are dinoflagellates most like? Explain why.** *(They are most like the zooflagellates, because both groups of protists use flagella for movement.)* L1 L2

Ecology of Unicellular Algae

Analyzing Data

Fertilizer in runoff from agricultural fields as well as from lawns in suburban areas can cause algal blooms in lakes and other bodies of water. The experiment described in this Analyzing Data is typical of those investigating such pollution problems. L2

Answers

1. The responding variable in the students' experiment is the amount of undiluted liquid plant fertilizer added to a container of pond water.

2. The container to which no fertilizer was added serves as the control.

3. The algae grew the most in the container in which 2 mL of fertilizer were added.

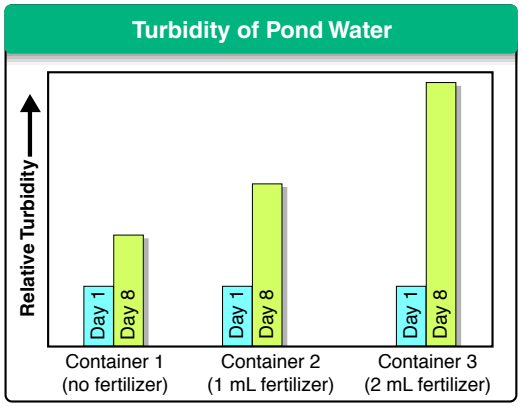
4. Students should draw the conclusion that fertilizers increase the growth of algae.

Analyzing Data

Fertilizers and Algae

The growth of algae in bodies of water is affected by the addition of plant fertilizers—a pollutant. A group of students collected three large, clear containers of pond water. They used a turbidity meter to measure the cloudiness of the water. The cloudiness, or turbidity, is a rough indicator of the amount of algae present.

The students did not add anything to the first container. To the second container, they added 1 mL of undiluted liquid plant fertilizer. To the third container, they added 2 mL of fertilizer. They then left the containers in a window for 1 week and measured the turbidity again on the eighth day. Their data are summarized in the table.



1. **Controlling Variables** What is the responding variable in the students' experiment?
2. **Designing Experiments** What is the role of the first container of water, to which no fertilizer was added?
3. **Using Tables and Graphs** In which container did the algae grow the most?
4. **Drawing Conclusions** What can you conclude about the effect of fertilizers on the growth of algae?

(magnification: 1280×)

▲ **Figure 20–12** **Some dinoflagellates are photosynthetic, whereas others are heterotrophs.** The paired flagella of a dinoflagellate lie in grooves around its circumference, shown here in red. The flagella propel the organism, spinning, through the water.

Dinoflagellates

Dinoflagellates are members of the phylum Pyrrophyta (PIR-oh-fyt-uh). **About half of the dinoflagellates are photosynthetic; the other half live as heterotrophs.** Dinoflagellates generally have two flagella, and these often wrap around the organism in grooves between two thick plates of cellulose that protect the cell, as shown in **Figure 20–12.** Most dinoflagellates reproduce asexually by binary fission.

Many dinoflagellate species are luminescent, and when agitated by sudden movement in the water, give off light. Some areas of the ocean are so filled with dinoflagellates that the movement of a boat's hull will cause the dark water to shimmer with a ghostly blue light. This luminescent property gives the phylum its name, *Pyrrophyta*, which means "fire plants."

Ecology of Unicellular Algae

Plantlike protists are common in both fresh and salt water, and thus are an important part of freshwater and marine ecosystems. A few species of algae, however, can cause serious problems.

Plantlike protists play a major ecological role on Earth. They are important organisms whose position at the base of the food chain makes much of the diversity of aquatic life possible. They make up a considerable part of the phytoplankton.

BIO INSIGHTS — FACTS AND FIGURES

The base of the ocean's food web

Oceans cover about three fourths of Earth. In the deep ocean, relatively few species live far below a few meters. But much life can be found at and near the ocean's surface in a collection of floating organisms known as plankton. In fact, most of Earth's biomass can be found drifting with ocean currents. The zooplankton include various protozoa, larvae and eggs, and tiny invertebrates. The phytoplankton, the photosynthesizing portion of the plankton, consists of plantlike algae, including dinoflagellates, diatoms, and many other forms. These producers capture the energy of sunlight and, in so doing, provide the basis of the food web in the marine ecosystem. The zooplankton depend on the phytoplankton for food, and the other organisms in the sea gain their sustenance from the zooplankton.

Phytoplankton (fyt-oh-PLANK-tun) constitute the population of small, photosynthetic organisms found near the surface of the ocean. About half of the photosynthesis that occurs on Earth is carried out by phytoplankton, which provide a direct source of nourishment for organisms as diverse as shrimp and whales. Even such land animals as humans get nourishment indirectly from phytoplankton. When you eat tuna fish, you are eating fish that fed on smaller fish that fed on still smaller animals that fed on plantlike protists.

Algal Blooms Many protists grow rapidly in regions where sewage is discharged. These protists play a vital role in recycling sewage and other waste materials. When the amount of waste is excessive, however, populations of euglenophytes and other algae may grow into enormous masses known as blooms. These algal blooms deplete the water of nutrients, and the cells die in great numbers. The decomposition of these dead algae can rob water of its oxygen, choking its resident fish and invertebrate life. As a result, these microorganisms disrupt the equilibrium of the aquatic ecosystem.

Great blooms of the dinoflagellates *Gonyaulax* and *Karenia* have occurred in recent years on the east coast of the United States, although scientists are not sure of the reason. These blooms, such as the one shown in **Figure 20–13,** are known as "red tides." These species produce a potentially dangerous toxin. Filter-feeding shellfish such as clams can trap *Gonyaulax* and *Karenia* for food and become filled with the toxin. Eating shellfish from water infected with red tide can cause serious illness, paralysis, and even death in humans and fish.

Figure 20–13 Blooms of the dinoflagellate *Karenia brevis* (inset) can produce red tides. *Karenia* contains a toxin that becomes concentrated in the tissue of filter feeders such as clams and oysters. **Inferring** ***How can red tides be harmful to humans?***

20–3 Section Assessment

1. **Key Concept** What do chlorophyll and accessory pigments do in algae?
2. **Key Concept** What are the four phyla of unicellular plantlike protists?
3. How do most unicellular algae get food? How does this differ from the way most animallike protists get food?
4. What is the role of unicellular algae in the environment?
5. **Critical Thinking** **Problem Solving** Identify two ways to reduce the problem of algal blooms in fresh water.
6. **Critical Thinking** **Problem Solving** Summarize the role of a red tide in disrupting an ecosystem.

Writing in Science

Comparing and Contrasting
Four of the seven phyla of unicellular algae are described in this section. Write one or more paragraphs that compare and contrast the distinguishing features of these phyla. *Hint:* You may wish to develop a table or an outline before you begin writing.

20–3 Section Assessment

1. They allow algae to harvest and use the energy from sunlight.
2. Euglenophyta, Pyrrophyta, Chrysophyta, Bacillariophyta
3. Most unicellular algae use the energy of sunlight to produce food. Animallike protists get food by absorbing, capturing, or trapping it.
4. They are at the base of aquatic food chains, and they make up a considerable part of the phytoplankton. Unicellular algae also form symbiotic relationships with other organisms.
5. Sample answer: Eliminate sewage discharge and reduce the amount of plant fertilizers.
6. The dinoflagellates that cause a red tide produce a potentially dangerous toxin. Filter-feeding shellfish become filled with the toxin, and fish that eat those shellfish can become seriously ill.

Use Visuals

Figure 20–13 After students have studied the photo and read the caption, ask: **What are red tides?** *(Red tides are great blooms of the dinoflagellates* Gonyaulax *and* Karenia.*)* **How might people who live in the area of a red tide be harmed?** *(Filter-feeding shellfish trap the dinoflagellates for food and become filled with the toxin. When people eat the shellfish, they can become seriously ill.)* L2

3 ASSESS

Evaluate Understanding

Call on students to name the phylum, describe the characteristics, and give examples for each of the groups of plantlike protists discussed: the euglenophytes, the dinoflagellates, the chrysophytes, and the diatoms.

Reteach

Have students compare the labeled illustration of a euglena in Figure 20–10 with that of a paramecium in Figure 20–5. Help students see the similarities and differences between these two organisms. Focus on the chloroplast within the euglena, which explains why euglenas are considered plantlike and not animallike protists.

Writing in Science

Students' paragraphs may vary, though all should compare and contrast the four phyla discussed in the section: Euglenophyta, Chrysophyta, Bacillariophyta, and Pyrrophyta. Advise students to focus on the boldface Key Concepts in the descriptions of each phylum, because those sentences contain the important distinguishing features.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 20–3.

Answer to . . .

Figure 20–13 *Toxins from the algae that produce red tides can get into clams and cause illness, paralysis, and death in humans who eat the clams.*