LEARNSMART LABS BIOLOGY

Exercise 4

The Cell
Structure and Function

Learning Objectives

By the end of this exercise you should be able to:

1. Understand the differences between prokaryotes and eukaryotes and identify structures characteristic of each.
2. Prepare a wet mount to view cells with a compound microscope.
3. Explain the function of organelles within eukaryotic cells visible with a light microscope.
4. Examine a cell's structure and determine whether it is from a plant or animal.
5. Observe representatives of the protists, a large group of eukaryotic organisms that are heterotrophic or autotrophic.

Please visit connect.mheducation.com to review online resources tailored to this lab.

Cells are the basic unit of living organisms because they perform all of the processes we collectively call "life." All organisms are made of cells. Although most individual cells are visible only with the aid of a microscope, some may be a meter long (e.g., nerve cells) or as large as a small orange (e.g., the yolk of an ostrich egg). Despite these differences, all cells are designed similarly and share fundamental features.

Cytology is the study of cellular structure and function. The major tools of cytologists are light microscopy, electron microscopy, and cell chemistry. By studying the anatomy of a cell, we can find clues to how the cell works.

In today's lab you will study some of the features and variations among living cells. Prior to this exercise, review in your textbook the general features of cellular structure and function.

PROKARYOTIC CELLS

Bacteria and cyanobacteria are **prokaryotes** (fig. 4.1), and their diversity is considerable (>5000 species). Prokaryotes

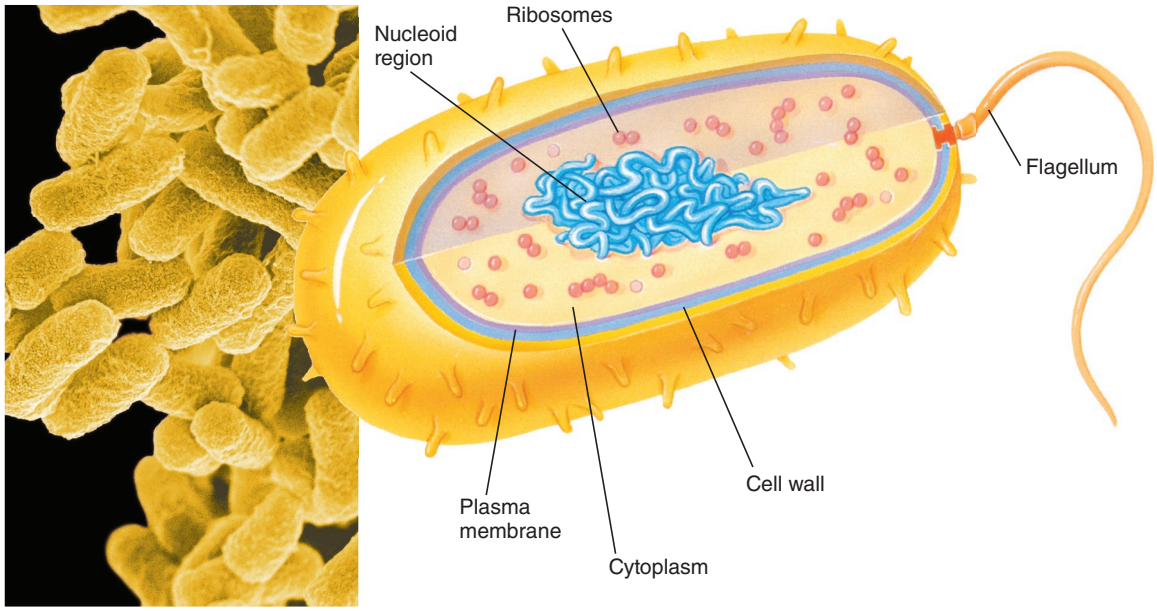


Figure 4.1 The structure of a bacterial cell. Bacteria lack a nuclear membrane. All prokaryotic (bacterial) cells have a nucleoid region, ribosomes, plasma membrane, cytoplasm, and cell wall, but not all have flagella (1500×) Many bacterial cells are surrounded by a gelatinous capsule and have pili as well as flagella.

do not contain a membrane-bound nucleus or any other membrane-bound **organelles.** Organelles are organized structures of macromolecules having specialized functions and are suspended in the **cytoplasm.** The cytoplasm of prokaryotes is enclosed in a **plasma membrane** (cellular membrane) and is surrounded by a supporting **cell wall** covered by a gelatinous **capsule. Flagella** and hairlike outgrowths called **pili** are common in prokaryotes; flagella are used for movement, and pili are used to attach some types of bacteria to surfaces or to exchange genetic material with other bacteria. Within the cytoplasm are **ribosomes** (small particles involved in protein synthesis) and **nucleoid regions** (concentrations of DNA). Prokaryotes do not reproduce sexually, but they have mechanisms for genetic recombination (see Exercise 16).

Cyanobacteria

The largest prokaryotes are **cyanobacteria,** formerly called blue-green algae. They contain chlorophyll *a* and accessory pigments for photosynthesis, but these pigments are not contained in membrane-bound chloroplasts. Instead, the pigments are held in photosynthetic membranes called **thylakoids** (fig. 4.2). Cyanobacteria are often surrounded by a **mucilaginous sheath.** Their ability to photosynthesize made them the primary contributors to the early oxygenation of the ancient earth's atmosphere.

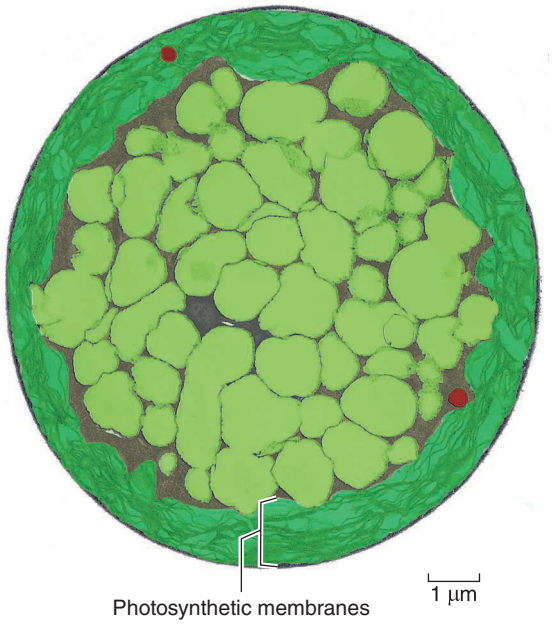


Figure 4.2 Electron micrograph of a photosynthetic bacterial cell, *Prochloron,* showing extensively folded photosynthetic membranes. The DNA is in the clear area in the central region of the cell; it is not membrane-bound (5200×).

SAFETY FIRST Before coming to lab, you were asked to read this exercise so you would know what to do and be aware of safety issues. In the space below, briefly list the safety issues associated with today's procedures. If you have questions about these issues, contact your laboratory assistant before starting work.

Procedure 4.1 Examine cyanobacteria

1. Examine a prepared slide of *Oscillatoria,* a filament of cells, and one of *Gloeocapsa,* a loosely arranged colony (fig 4.3). Review Exercise 3 and the associated videos for the proper way to use the microscope.
2. Focus with the low-power objective.
3. Rotate the high-power objective into place to see filaments and masses of cells.

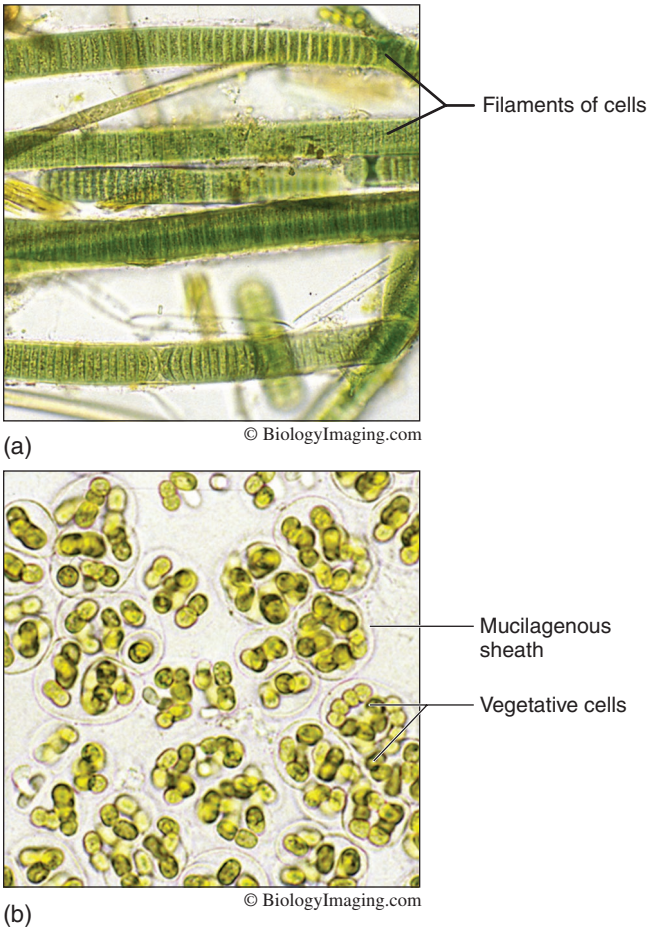


Figure 4.3 Common cyanobacteria. (*a*) *Oscillatoria* (100×). (*b*) *Gloeocapsa* (400×).

4. Prepare a wet mount of *Oscillatoria* and one of *Gloeocapsa.* Review procedure 3.5 in Exercise 3 for preparing a wet mount.
5. Observe the cellular structures and draw the cellular shapes and relative sizes of *Oscillatoria* and *Gloeocapsa* in the following space. Use an ocular micrometer to measure their dimensions.

Oscillatoria *Gloeocapsa*

Question 1

a. Where are the pigments located in these cyanobacteria?

b. Are nuclei visible in cyanobacterial cells?

c. Which of these two genera has the most prominent mucilaginous sheath?

d. How many cells are held within one sheath of *Gloeocapsa?*

Bacteria

Most bacteria are much smaller than cyanobacteria and do not contain chlorophyll. Yogurt is a nutrient-rich culture of bacteria. The bacterial cells composing most of the yogurt are *Lactobacillus,* a bacterium adapted to live on milk sugar (lactose). *Lactobacillus* converts milk to yogurt. Yogurt is acidic and keeps longer than milk. Historically, *Lactobacillus* has been used in many parts of the world by peoples deficient in lactase, an enzyme that breaks down lactose. Many Middle Eastern and African cultures use the more digestible yogurt in their diets instead of milk.

Procedure 4.2 Examine bacteria

1. Place a tiny dab of yogurt on a microscope slide.
2. Mix this small amount of yogurt in a drop of water, add a coverslip, and examine the yogurt with a compound microscope. Review Exercise 3.
3. Focus with the low-power objective.
4. Rotate the high-power objective (40×) into place to see masses of rod-shaped cells.
5. Observe the simple, external structure of the bacteria and draw their cellular shapes in the following space:

Question 2

How does the size of *Lactobacillus* compare with that of *Oscillatoria* and *Gloeocapsa?*

EUKARYOTIC CELLS

Eukaryotic cells are structurally more complex than prokaryotic cells. Although some features of prokaryotic cells are in eukaryotic cells (e.g., ribosomes, cell membrane), eukaryotic cells also contain several organelles not found in prokaryotic cells (table 4.1).

Eukaryotic cells contain membrane-bound **nuclei** and other organelles (figs. 4.4, 4.5). Nuclei contain genetic material of a cell and control metabolism. **Cytoplasm** forms the matrix of the cell and is contained by the plasma membrane. Within the cytoplasm are a variety of organelles. **Chloroplasts** are elliptical green organelles in plant cells. Chloroplasts are the site of photosynthesis in plant cells and are green because they contain chlorophyll, a photosynthetic pigment capable of capturing light energy. **Mitochondria** are organelles found in plant and animal cells. These organelles are where aerobic respiration occurs. When viewed with a conventional light microscope, mitochondria are small, dark, and often difficult to see. All of the material and organelles contained by the plasma membrane are collectively called the **protoplast.**

PLANT CELLS

Procedure 4.3 Examine living *Elodea* cells and chloroplasts

1. Remove a young leaf from the tip of a sprig of *Elodea*. *Elodea* is a common pond-weed used frequently in studies of photosynthesis, cellular structure, and cytoplasmic streaming.
2. Place this leaf, with the top surface facing up, in a drop of water on a microscope slide. The cells on the upper surface are larger and more easily examined. Add a coverslip, but do not let the leaf dry. Add another drop of water if necessary.

Table 4.1

Some of the Major Differences between Prokaryotic and Eukaryotic Cells and between Plant and Animal Cells

	Prokaryote	Eukaryote	
		Animal	Plant
Exterior Structures			
Cell wall	Present (protein-polysaccharide)	Absent	Present (cellulose)
Cell membrane	Present	Present	Present
Flagella	May be present (single strand)	May be present	Absent except in sperm of a few species
Interior Structures			
ER	Absent	Usually present	Usually present
Ribosomes	Present	Present	Present
Microtubules	Absent	Present	Present
Centrioles	Absent	Present	Absent
Golgi complex	Absent	Present	Present
Other Organelles			
Nucleus	Absent	Present	Present
Mitochondria	Absent	Present	Present
Chloroplasts	Absent	Absent	Present
Chromosomes	A single circle of naked DNA	Multiple; DNA-protein complex	Multiple; DNA-protein complex
Vacuoles	Absent	Absent or small	Usually a large single vacuole

3. Examine the leaf with your microscope. Review Exercise 3 and the associated videos. First use low, then high, magnification to bring the upper layer of cells into focus (fig. 4.6). Each of the small, regularly shaped units you see are cells surrounded by cell walls made primarily of **cellulose** (fig. 4.7). Cellulose is a complex carbohydrate made of glucose molecules attached end-to-end. The plasma membrane lies just inside the cell wall. Sketch what you see.

b. Examine various layers of cells by focusing up and down through the layers. About how many cells thick is the leaf that you are observing?

c. What are the functions of the cell wall?

d. Use an ocular micrometer or refer to the dimensions of the field of view calculated in Exercise 3 to measure the dimensions of an *Elodea* cell. What are the cell's approximate dimensions?

Question 3

a. What three-dimensional shape are *Elodea* cells?

4. Chloroplasts appear as moderately sized green spheres within the cells (figs. 4.6, 4.8). Locate and sketch cells having many chloroplasts; estimate the number of chloroplasts in a healthy cell. Remember that a cell is three-dimensional, and some chloroplasts may obscure others.

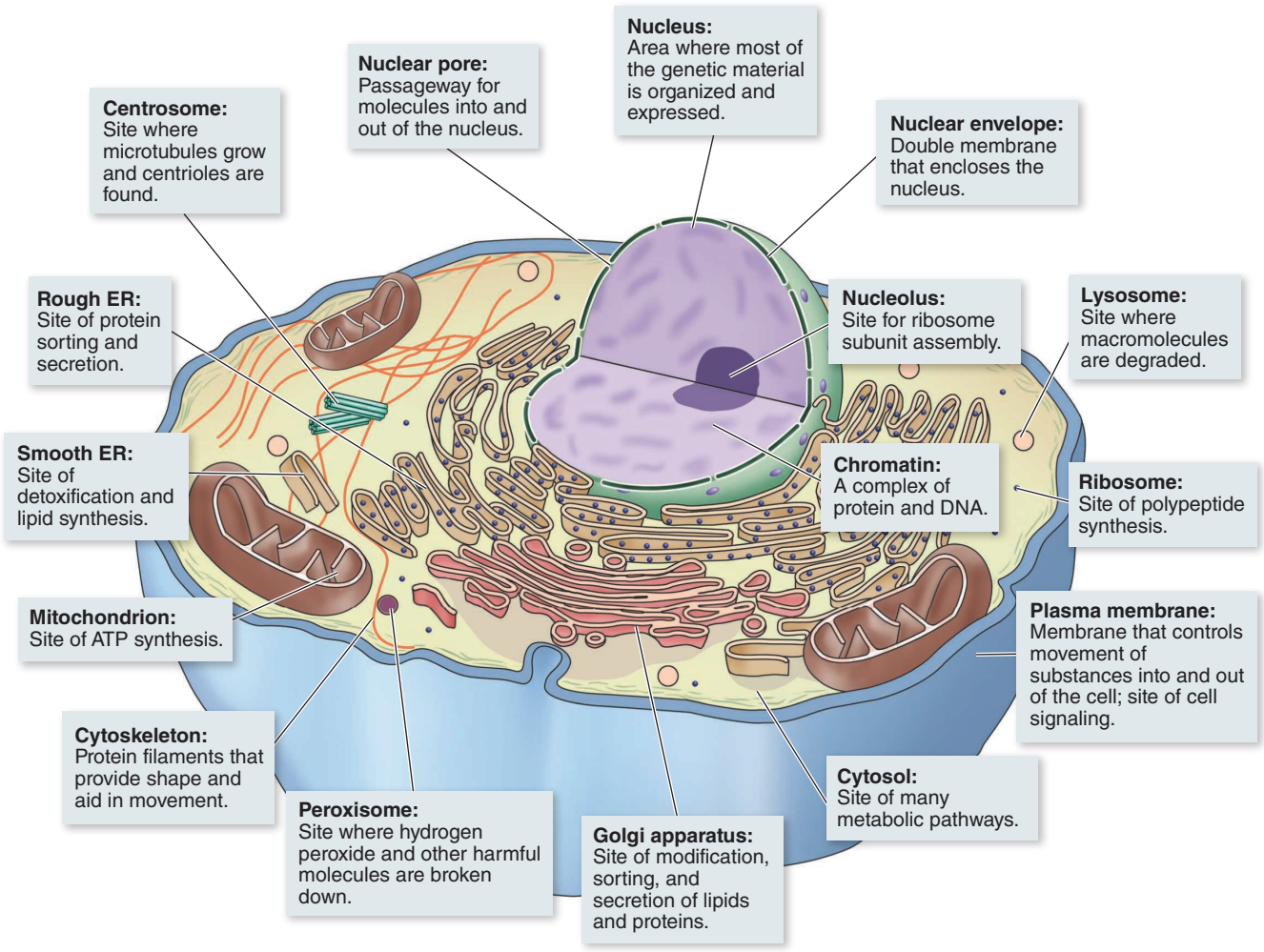


Figure 4.4 Structure of animal cells. Cells are surrounded by a bilayered plasma membrane containing phospholipids and proteins. The nucleus houses chromosomal DNA and is surrounded by a double-membraned nuclear envelope. Centrioles organize spindle fibers during cell division. Endoplasmic reticulum (ER) is a system of membranes inside the cell. Rough ER has many ribosomes, and smooth ER has fewer ribosomes. Mitochrondria are sites of oxidative respiration and ATP synthesis. Microvilli are cytoplasmic projections that increase the surface area of some specialized animal cells. Golgi complexes are flat sacs and vesicles that collect and package substances made in the cell. Ribosomes are aggregations of proteins that conduct protein synthesis. Lysosomes contain enzymes important in recycling cellular debris.

Question 4

a. What shape are the chloroplasts? What is their function?

b. Where are the chloroplasts located within the *Elodea* cell—toward the perimeter or center of the cell?

5. Determine the spatial distribution of chloroplasts within a cell. They may be pushed against the margins of the cell by the large **central vacuole** containing mostly water and bounded by a **vacuolar membrane.** The vacuole occupies about 90% of the volume of a mature cell. Its many functions include storage of organic and inorganic molecules, ions, water, enzymes, and waste products.

6. Search for a **nucleus;** it may or may not be readily visible. Nuclei usually are appressed to the cell wall as a faint gray sphere the size of a chloroplast or larger. Staining the cells with a drop of iodine may enhance the nucleus. If your preparation is particularly good, a **nucleolus** may be visible as a dense spot in the nucleus.

7. Search for some cells that may appear pink due to water-soluble pigments called anthocyanins. These

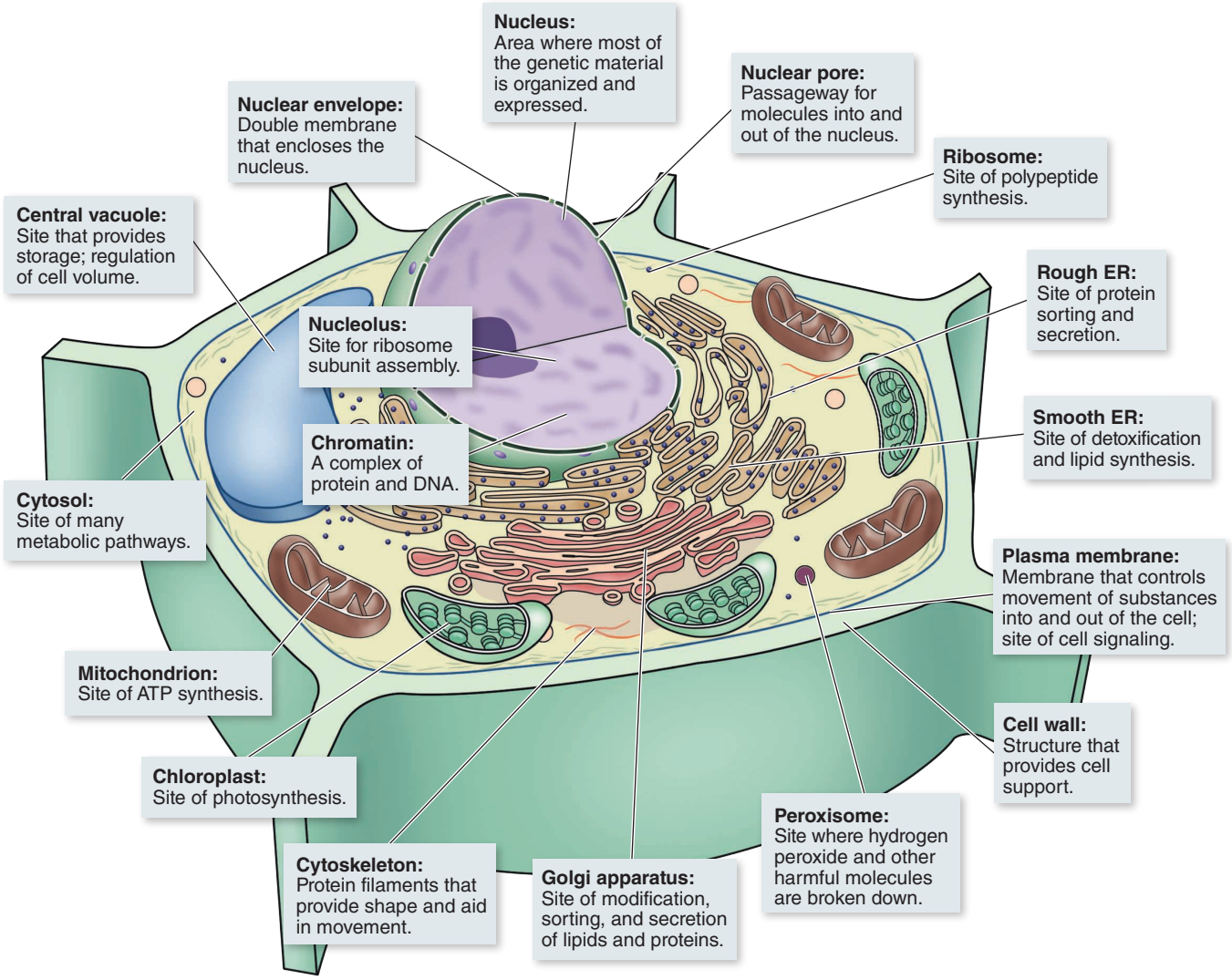


Figure 4.5 Structure of plant cells. Most mature plant cells contain large central vacuoles, which occupy most of the volume of the cell. Cytoplasm is often a thin layer between the vacuole and the plasma membrane. Cytoplasm contains the cell's organelles.

pigments give many flowers and fruits their bright reddish color.

8. Warm the slide with intense light for about 10 min and search for movement of the chloroplasts. You may need to search many cells or make a new preparation. This movement is called **cytoplasmic streaming,** or **cyclosis.** Chloroplasts are not motile; instead, they are being moved by the activity of the cytoplasm. Add water if the cells appear to be drying out.

9. In the following space sketch a few cells of *Elodea;* compare the cells with those shown in figure 4.6.

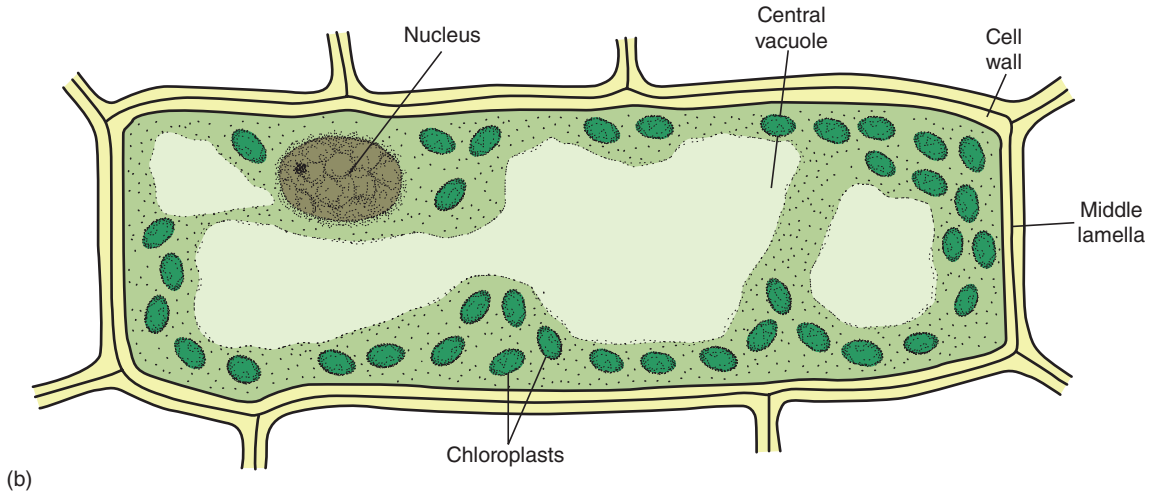
10. When you are finished examining *Elodea,* dispose of the *Elodea* as specified by your instructor.

Question 5

a. Can you see nuclei in *Elodea* cells?

b. What are the functions of nuclei?

(a)



(b)

Figure 4.6 (*a*) *Elodea* cells containing abundant chloroplasts (150×). (*b*) The cellular structure of *Elodea* (400×).

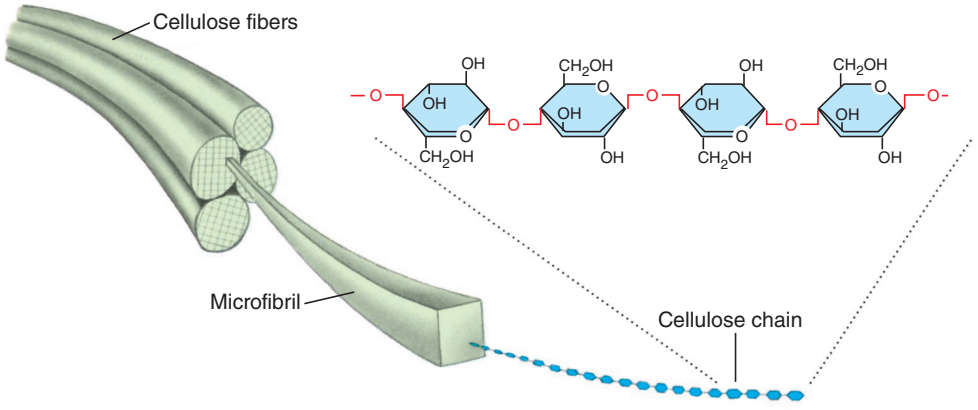


Figure 4.7 Cellulose is the most abundant organic compound on earth and is a polymer of glucose molecules. Free hydroxyl (OH^-) groups of the glucose molecules form hydrogen bonds between adjacent cellulose molecules to form cohesive microfibrils. Microfibrils align to form strong cellulose fibers that resist metabolic breakdown. Because humans cannot hydrolyze the bonds between glucose molecules of cellulose, cellulose is indigestible and its energy is unavailable. Cellulose passes through the human digestive tract as bulk fiber.

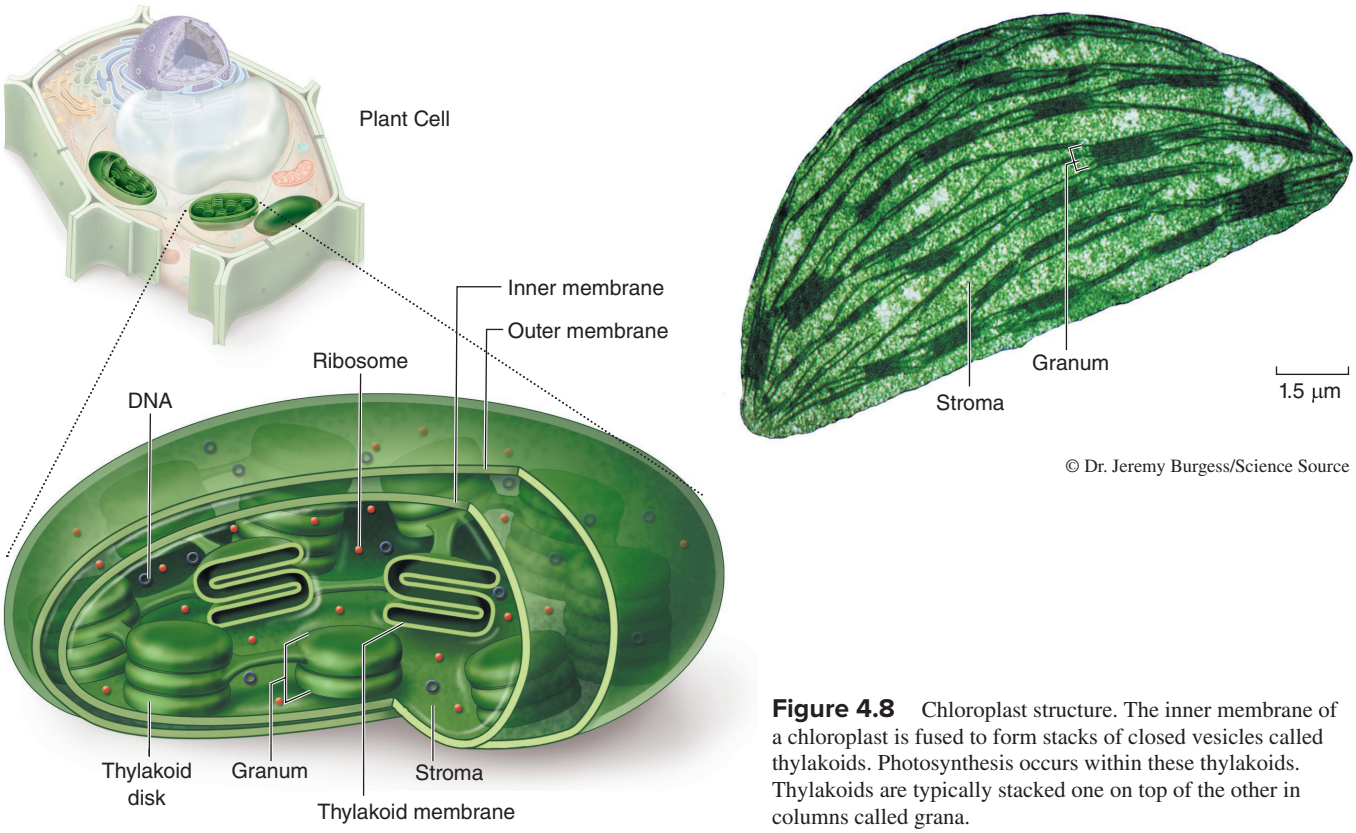


Figure 4.8 Chloroplast structure. The inner membrane of a chloroplast is fused to form stacks of closed vesicles called thylakoids. Photosynthesis occurs within these thylakoids. Thylakoids are typically stacked one on top of the other in columns called grana.

c. Which are larger, chloroplasts or nuclei?

d. What is the approximate size of a nucleus?

e. Why is the granular-appearing cytoplasm more apparent at the sides of a cell rather than in the middle?

Question 6

a. Are all cellular components moving in the same direction and rate during cytoplasmic streaming?

b. What do you conclude about the uniformity of cytoplasmic streaming?

Cell Walls

Cell walls include an outer **primary cell wall** deposited during growth of the cell and a **middle lamella,** the substance holding walls of two adjacent cells together. The protoplasm of adjacent cells is connected by cytoplasmic strands called **plasmodesmata** that penetrate the cell walls (fig. 4.9).

Procedure 4.4 Examine cell walls and plasmodesmata

1. Prepare a wet mount of *Elodea* and examine the cell walls. Always begin your examination at the lowest magnification and cautiously move to higher magnifications. The middle lamella may be visible as a faint line between cells.
2. Obtain a prepared slide of tissue showing plasmodesmata. This tissue may be persimmon (*Diospyros*) endosperm, which has highly thickened primary walls. Sketch what you see.

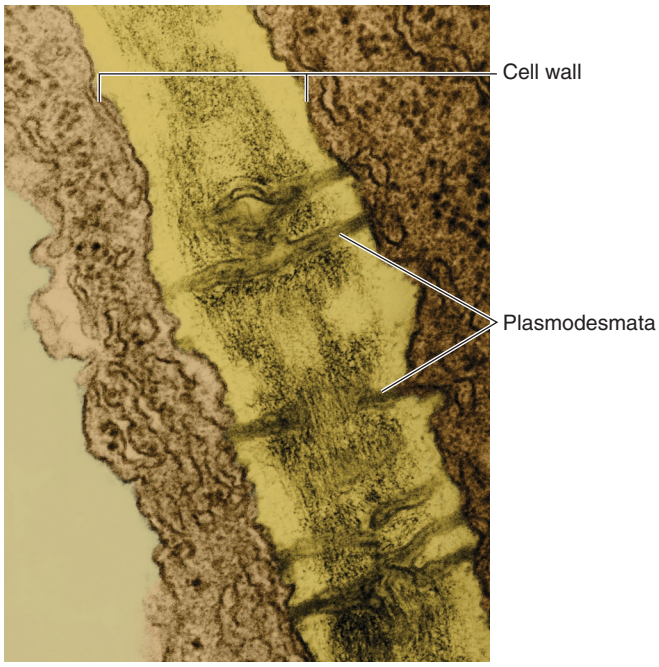


Figure 4.9 This electron micrograph of the thickened primary cell walls of persimmon endosperm shows plasmodesmata connecting adjacent cells (130,000×).

3. Locate the middle lamella as a faint line between cell walls.
4. Locate the plasmodesmata appearing as darkened lines perpendicular to the middle lamella and connecting the protoplasts of adjacent cells (fig. 4.9).

Question 7

a. What are the functions of plasmodesmata?

b. Why do you suspect that there are so many plasmodesmata connecting the cells in this fruit?

Onion Cells

Staining often reveals the structure of cells and cell organelles more clearly. A specimen is **stained** by adding a dye that preferentially colors some parts of the specimen but not others. Neutral red is a common stain that accumulates in the cytoplasm of the cell, leaving the cell walls clear. Nuclei appear as dense bodies in the translucent cytoplasm of the cells.

Procedure 4.5 Examine stained onion cells

1. Cut a red onion into eighths and remove a fleshy leaf.
2. Snap the leaf backward and remove the thin piece of the inner epidermis formed at the break point (fig. 4.10), as demonstrated by your lab instructor.
3. Place this epidermal tissue in a drop of water on a microscope slide, add a coverslip, and examine the tissue. This preparation should be one cell thick. Always begin your examination with the lowest magnification.
4. Stain the onion cells by placing a small drop of 0.1% neutral red at the edge of the coverslip. Draw the neutral red across the specimen by wicking. To wick the solution, hold the edge of a small piece of paper towel at the opposite edge of the coverslip and it will withdraw some fluid. This will cause the neutral red to flow over the onion and will not disturb the tissue under the coverslip.
5. Stain the tissue for 5–10 min.
6. Carefully focus to distinguish the vacuole surrounded by the stained cytoplasm.
7. Search for the nucleus of a cell (fig. 4.11). The nucleus may appear circular in the central part of the cell. In other cells it may appear flattened.

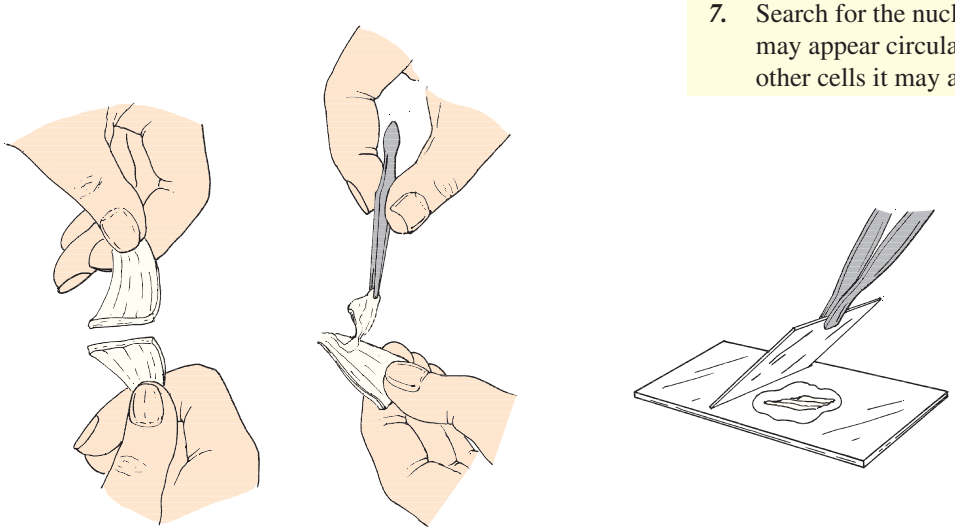
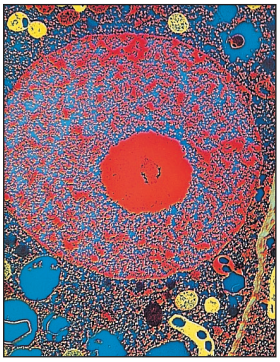


Figure 4.10 Preparing a wet mount of an onion epidermis.



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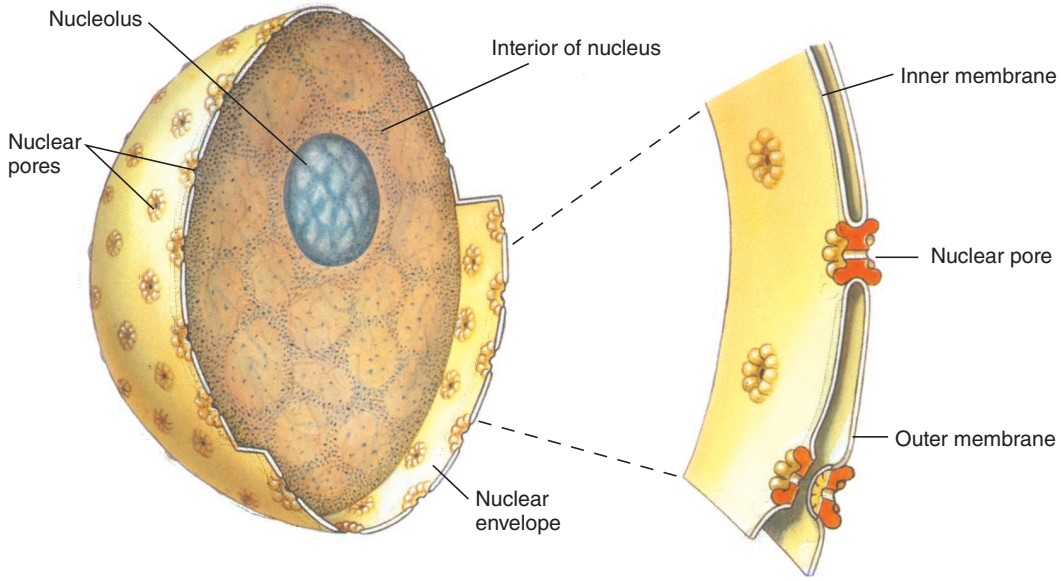


Figure 4.11 The nucleus. The nucleus consists of a double membrane, called a nuclear envelope, enclosing a fluid-filled interior containing the DNA. In the cross section, the individual nuclear pores extend through the two membrane layers of the nuclear envelope; the material within the pore is protein, which controls access through the pore (1765×).

Question 8
How do you explain the differences in the apparent shapes and positions of the nuclei in different cells?

8. Repeat steps 1–7 and stain a new preparation of onion cells with other available stains, such as methylene blue.

9. In the following space sketch a few of the stained onion cells.

Question 9

a. What cellular structures of onion are more easily seen in stained as compared to unstained preparations?

b. Which of the available stains enhanced your observations the most?

c. Do onion cells have chloroplasts? Explain.

d. Use an ocular micrometer or the dimensions of the field of view (FOV) calculated in Exercise 3 to measure the dimensions of an onion epidermal cell. Are these cells larger or smaller than the *Elodea* cells you examined in procedure 4.3?

Mitochondria

Mitochondria are surrounded by two membranes (fig 4.12). The inner membrane folds inward to form **cristae,** which hold respiratory enzymes and other large respiratory molecules in place. Some DNA also occurs in mitochondria. Chloroplasts also are double-membraned and contain DNA.

Procedure 4.6 Examine mitochondria in onion cells

1. On a clean glass slide mix two or three drops of the stain Janus Green B with one drop of 7% sucrose.

2. Prepare a thin piece of onion epidermis (as instructed in procedure 4.5) and mount it in the staining solution. The preparation should be one cell thick. For

mitochondria to stain well, the onion cells must be healthy and metabolically active. Add a coverslip.

3. Search the periphery of cells to locate stained mitochondria. They are small blue spheres about 1 µm in diameter. The color will fade in 5–10 min, so examine your sample quickly and make a new preparation if needed.

Plastids

Plastids are organelles where food, especially sugars and starch, is made and stored. You have already examined chloroplasts, a type of plastid in which photosynthesis occurs. Other plastids have different functions. We will examine **amyloplasts,** plastids that store starch and therefore will stain darkly with iodine.

Procedure 4.7 Examine amyloplasts

1. Use a razor blade to make a thin section of a potato tuber. Make the section as thin as you can.
2. Place the section in a drop of water on a microscope slide and add a coverslip. Add another drop of water to the edge if needed.
3. Locate the small, clam-shaped amyloplasts within the cells. High magnification may reveal the eccentric lines distinguishing layers of deposited starch on the grains.
4. Stain the section by adding a drop of iodine to the edge of the coverslip. Iodine is a stain specific for starch (see Exercise 6, "Biologically Important Molecules"). If necessary, pull the stain under the coverslip by touching a paper towel to the water at the opposite edge of the coverslip.

Question 10

a. Are any cellular structures other than amyloplasts stained intensely by iodine?

b. What can you conclude about the location of starch in storage cells of potato?

c. What are the functions of amyloplasts in potatoes?

d. Why are potatoes a good source of carbohydrates?

ANIMAL CELLS

Animals, like plants, are eukaryotes. They share many similarities, and also have several differences (see table 4.1).

Human Epithelial Cells

Human epithelial cells are sloughed from the inner surface of your mouth. They are flat cells with a readily visible nucleus.

Procedure 4.8 Examine human epithelial cells

1. Gently scrape the inside of your cheek with the broad end of a clean toothpick.

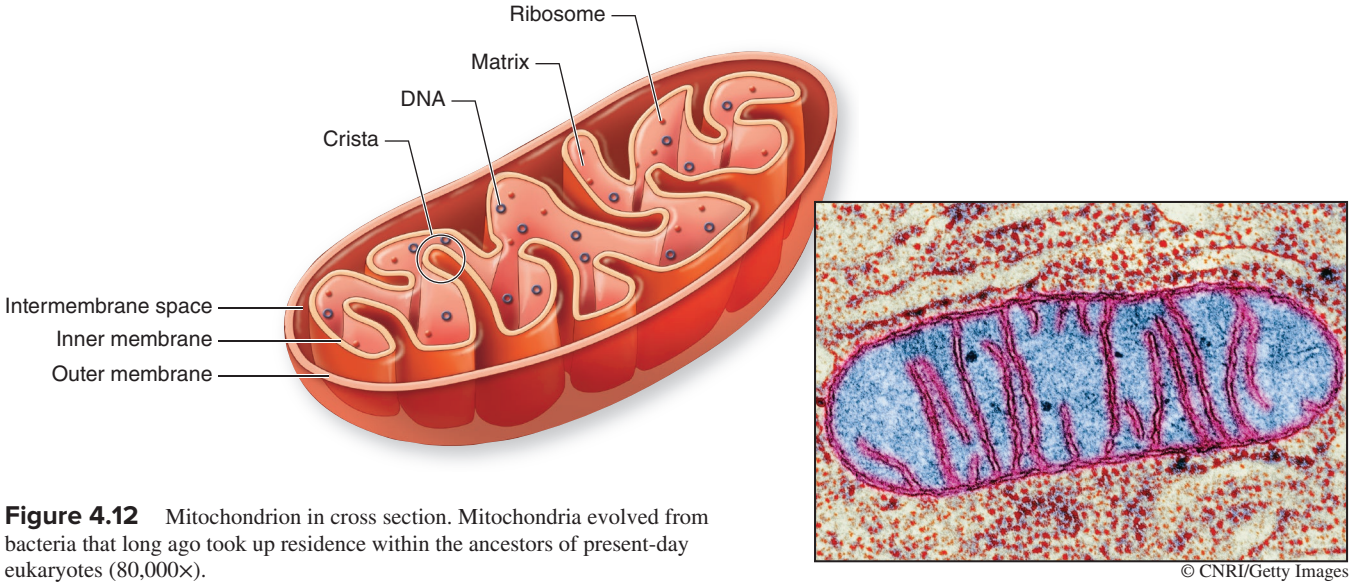


Figure 4.12 Mitochondrion in cross section. Mitochondria evolved from bacteria that long ago took up residence within the ancestors of present-day eukaryotes (80,000×).

2. Stir the scrapings into a drop of water on a microscope slide, add a coverslip, and examine with your compound microscope. Dispose of used toothpicks in a container designated by your instructor.
3. Stain the cells by placing a small drop of methylene blue at one edge of the coverslip and drawing it under the coverslip with a piece of absorbent paper towel placed at the opposite side of the coverslip.
4. Prepare another slide and stain the cells with Janus Green B. Observe the mitochondria.
5. Use an ocular micrometer or the dimensions of the FOV calculated in Exercise 3 to measure the dimensions of a human epithelial cell.

Question 11

a. What structures visible in the stained preparation were invisible in the unstained preparation?

b. Were mitochondria as abundant in human epithelial cells as in onion epidermal cells (procedure 4.6)? Explain.

c. What similarities and differences are there between plant and animal cells?

d. How do the size and shape of a human epithelial cell differ from those of the *Elodea* and onion cells that you examined earlier?

e. Why do *Elodea* and onion cells have more consistent shapes than human epithelial cells?

6. After viewing the preparation, put the slides and coverslips in a container of 10% bleach.

PROTISTS

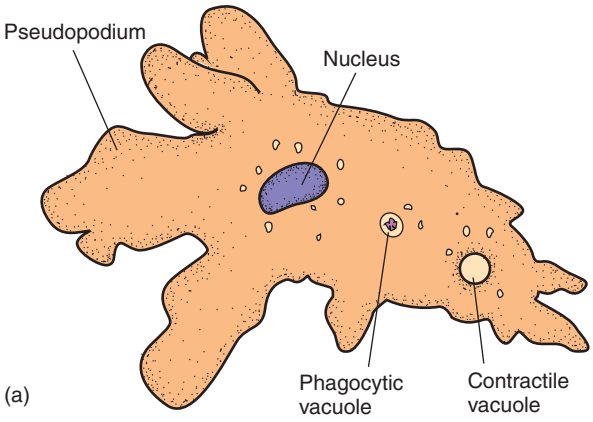
Amoeba, Paramecium, and *Spirogyra* are members of a large group of eukaryotic organisms called protists. You will learn more about protists in Exercises 25 and 26. In today's exercise, you'll examine *Amoeba, Paramecium,* and *Spirogyra*.

Amoeba

Amoeba is an irregularly shaped protist with many internal organelles (fig. 4.13). *Amoeba* move via amoeboid movement. **Amoeboid movement** occurs by means of **pseudopodia,** which are temporary protrusions of the cell. Pseudopodia also surround food particles and create food vacuoles, where food is digested. Another important structure in *Amoeba* is the **contractile vacuole** that accumulates and expels water and waste products.

Procedure 4.9 Examine *Amoeba*

1. Use an eyedropper to obtain a few drops from the bottom of an *Amoeba* culture. Examining the culture with a dissecting microscope may help you locate some organisms.
2. Place the organisms on a microscope slide.
3. Add a coverslip and use a compound microscope to locate a living *Amoeba*. Your instructor may allow



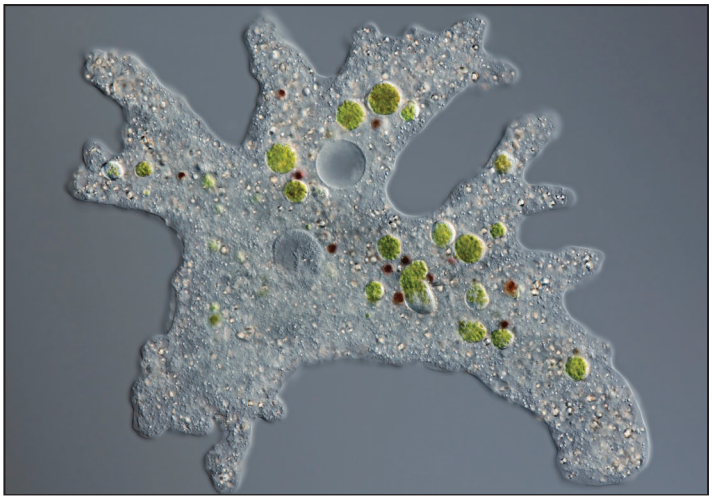

(b)

Figure 4.13 (*a*) Diagram of *Amoeba*. (*b*) Light micrograph of a living *Amoeba* (160×).

you to view the *Amoeba* without using a coverslip, but view them *only* on 4× or 10× magnification.

4. Decrease the light intensity and observe an *Amoeba* for a few minutes.
5. Locate the structures shown in figure 4.13.
6. Examine a prepared slide of stained *Amoeba;* then observe a demonstration of *Amoeba* on a dark-field microscope if one is available.
7. Sketch an *Amoeba* in the following space.

Question 12

a. List the organelles found in plant cells, in *Amoeba,* and common to both.

b. Does *Amoeba* have a cell wall? How can you tell?

c. How do the appearances of *Amoeba* differ in live cells and preserved cells?

Paramecium

Like *Amoeba, Paramecium* is also a single-celled organism (fig. 4.14).

Procedure 4.10 Examine *Paramecium*

1. Place a small ring of methylcellulose on a microscope slide to slow the *Paramecium.*
2. Place a drop from a culture containing *Paramecium* inside the methylcellulose ring.
3. Use a toothpick to mix the methylcellulose with the drop of water from the culture of *Paramecium.*
4. Add a coverslip and examine *Paramecium* with your compound microscope. On the surface of *Paramecium* are cilia, which are short hairlike structures used for locomotion.
5. Examine a prepared slide of stained *Paramecium.*
6. In the following space, sketch a *Paramecium.*

Question 13

a. How does movement of *Paramecium* compare to that of *Amoeba?*

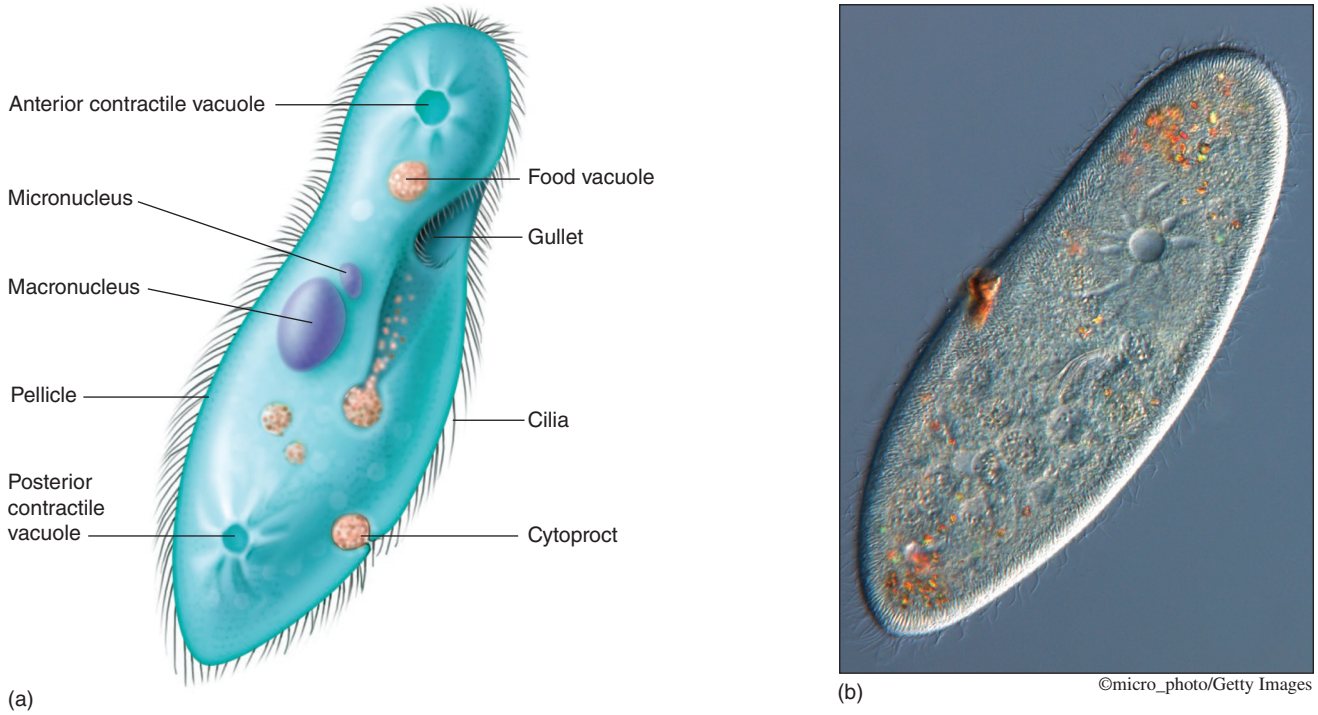


Figure 4.14 (*a*) Diagram of *Paramecium* (150×). (*b*) Light micrograph of a living *Paramecium*. Note the abundant cilia (150×).

b. How do shape and body consistency differ between *Amoeba* and *Paramecium?*

c. What structures in *Amoeba* and *Paramecium* also occur in plant cells? What structures in *Amoeba* and *Paramecium* do not occur in plant cells?

Spirogyra

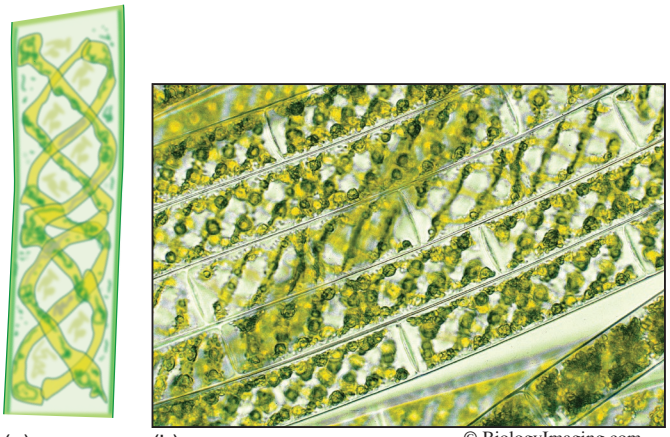
Spirogyra (fig. 4.15) is a filamentous green alga that is named for the spiral arrangement of its chloroplasts. *Spirogyra* is common in freshwater ponds and streams, where it is a major part of "pond scum."

Procedure 4.11 Examine *Spirogyra*

1. Place a drop from a culture containing *Spirogyra* on a microscope slide.
2. Add a coverslip and examine *Spirogyra* with your compound microscope.
3. Sketch *Spirogyra* in the space below.

Question 14

a. Is *Spirogyra* branched or unbranched?



(a) (b)

Figure 4.15 (*a*) Diagram of a *Spirogyra* cell (250×). (*b*) Light micrograph of a living *Spirogyra*. Note the spiral-shaped chloroplast for which the alga is named (200×).

b. In what shapes are the cells?

c. Do the cells have a cell wall? If so, how can you tell?

d. What organelles visible in *Spirogyra* are not visible in *Amoeba* and *Paramecium?*

Procedure 4.12

You will be given a slide of an unknown organism. Use what you've learned in today's lab to identify the cells as prokaryotic or eukaryotic; if eukaryotic, identify the cells as plant, animal, or protist. Complete table 4.2 before leaving the lab. If instructed to do so, turn in table 4.2 before leaving the lab.

INVESTIGATION

The Responses of Single-Celled Organisms to Environmental Stimuli

Observation: Single-celled protists such as *Paramecium* and *Amoeba* live in water and are sensitive to environmental stimuli.

Question: How are the movements of single-celled protists affected by temperature?

a. Establish a working lab group and obtain Investigation Worksheet 4 from your instructor.

b. Discuss with your group well-defined questions relevant to the preceding observation and question. Choose and record your group's best question for investigation.

c. Translate your question into a testable hypothesis and record it.

d. Outline on Worksheet 4 your experimental design and supplies needed to test your hypothesis. Ask your instructor to review your proposed investigation.

e. Conduct your procedures, record your data, answer your question, and make relevant comments.

f. Discuss with your instructor any revisions to your questions, hypothesis, or procedures. Repeat your work as needed.

TABLE 4.2

USING DISTINGUISHING FEATURES TO IDENTIFY AN UNKNOWN ORGANISM

OVERALL DESCRIPTION OF SPECIMEN:

NAME _____

UNKNOWN NO: _____

LAB SECTION: _____

BASED ON THE ABOVE, MY UNKNOWN ORGANISM IS A: (Circle One)	Prokaryote	Eukaryote	
IF THE SPECIMEN IS A EUKARYOTE, IT IS A(N): (Circle One)	Plant	Animal	Protist

Questions for Further Thought and Study

1. What is a cell?

2. Describe the structure and function of each cellular part that you observed in this lab.

3. Would you expect a cell of a multicellular organism to be more complex than the cell of a unicellular organism? Less complex? Why?

4. What is the purpose of using a biological stain when microscopically examining cellular components?

5. How are eukaryotic cells different from prokaryotic cells? How are they similar?

6. *Amoeba, Paramecuim,* and *Spirogyra* are diverse. Why, then, are they all classified as protists?

DOING BIOLOGY YOURSELF

Determine the total surface areas and volumes of the chloroplasts in a typical *Elodea* cell. Assume that each chloroplast is a sphere of 5 μm diameter. (The surface area of a sphere = πd^2; the volume of a sphere = $(\frac{4}{3})\pi r^3$.) What is the significance of these surface areas and volumes? Would it be advantageous for a cell to be filled with chloroplasts? Why or why not?

WRITING TO LEARN BIOLOGY

What criteria might you use to distinguish colonial organisms, such as many cyanobacteria, from truly multicellular organisms?