CHAPTER 2

Plant Cells

LABORATORY ACTIVITIES

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Activity 2.6: Tomato Epidermis
Activity 2.7: *Zebrina* Stem Tissue
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GOALS

Following this exercise, students should be able to:

- Identify the major parts of a plant cell.
- Describe the functions of the major plant organelles.
- Make a wet mount of a sample.
- Estimate the size of a cell.
- Understand osmosis and its importance in plants.
- Distinguish between hypotonic, hypertonic, and isotonic solutions.

INTRODUCTION

In this exercise, you will learn about the structure of plant cells and the function of the various organelles. Plants are **Eukaryotes**, meaning the cells have a membrane-enclosed **nucleus** as well as many other intracellular compartments called **organelles** (Figure 2-1). Each organelle functions to help compartmentalize the cell's activities, allowing it to become more efficient.

For this exercise, you need to make **wet mounts** of your samples. For each item obtain a small piece of tissue (the smaller, the better). Place the sample on the surface of a clean, dry slide. Add one to two drops of water (or dye) to the sample. Carefully place a coverslip on top of the sample and water. To avoid excess air bubbles under the coverslip, hold the coverslip at a 45-degree angle above the slide surface. Lower the coverslip until it touches the edge of the liquid and drop the coverslip. Your instructor will demonstrate this technique.

You will be observing the following samples: cork cells, onion epidermis, *Elodea* leaf, potato tuber cells, tomato pulp, tomato epidermis, and *Zebrina* stem tissue.

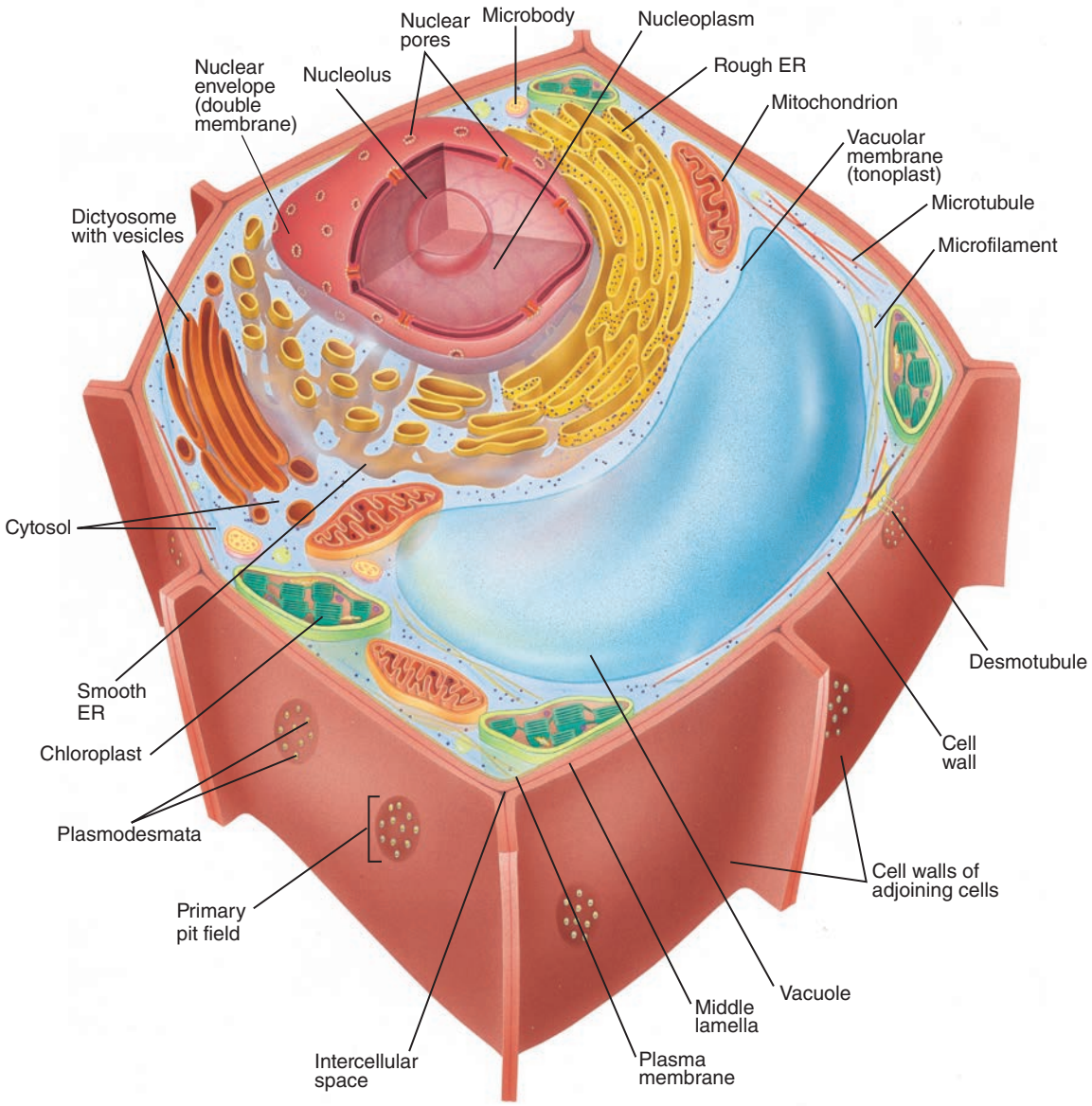

FIGURE 2-1 A generalized plant cell.

ACTIVITIES

Name _____

Date _____ Section _____

Activity 2.1: Cork Cells

Materials:

- Cork
- Wet-mount supplies (slides, coverslips, razor blade, water, pipette)
- Microscope

Cork cells make up the bulk of the outer bark of a woody plant. These cells are dead; however, they continue to function in supporting the plant and protecting it from pathogens and desiccation. A fully formed cork cell will accumulate large amounts of waterproofing compounds in their cell wall, which eventually leads to the cell's death. At maturity the cells are dead and have no cytoplasm or any internal structures.

The **cell wall** is the outermost part of a plant cell. It provides support to the cell and helps prevent osmotic lysis, as you will see later in this lab.

1. Cut a thin section of cork, and make a wet mount. The thinner the section, the better you can see individual cells.
2. Observe the cells under low power. Locate an area of the specimen where the cells are one or a few layers and can easily be viewed in sharp focus.
3. In the space provided, draw a few cork cells. Label the cell wall.

4. Use the following procedure to estimate the size of a single cell:
   a. Using the high dry power objective lens (40×), count the number of cells that span the field of view.
   b. To estimate the size of a cell, you need to know the diameter of the field of view. To measure the diameter of the field of view, place the centimeter side of a thin plastic ruler under the field of view and count how many tick marks are visible through the microscope. Each tick mark within a centimeter is a millimeter. Or, you can refer back to Activity 1.4 where you measured the diameter of the field of view.
   c. Calculate the approximate size of a single cell by dividing the size of the field of view by number of cells visible.

   size of a single cell = diameter of field/number of cells visible

Activity 2.2: Onion (*Allium*) Epidermis

Materials:

- Onion epidermis
- Wet-mount supplies
- IKI (iodine-potassium iodide)
- Microscope

The onion bulb is composed of layers of thick leaves. Bulbs are modified as storage organs for the plant. The leaves are the storage compartment of the bulb. They surround a short, central stem. The layer you want to observe is the covering of the leaf, called the epidermis.

1. Obtain a small sample of onion epidermis, taken from the inside of one onion bulb scale. This tissue is thin and has a tendency to curl at the edges. Be sure to place it flat on the surface of the slide. Add one to two drops of IKI solution to the onion epidermis. The iodine provides increased contrast and makes the nucleus easier to see.
2. Examine the slide with low power. Find a region of the sample where the cells are flat on the surface of the slide and the area appears focused. Switch to high power.
3. Try to locate the following structures.
   a. Cell wall
   b. Cytoplasm
   c. Nucleus
   d. Nucleolus

The **cell wall** is the outermost part of a plant cell. It provides support to the cell and helps prevent osmotic lysis, as you will see later in this lab. Inside the cell wall is a plasma membrane, which is not visible at this magnification. The plasma membrane encloses the living part of the cell: the **cytoplasm**. The cytoplasm contains a fluid portion, called the cytosol, as well as numerous organelles.

The most prominent structure inside the cell is the **nucleus**, which contains the cell's genetic information. Within each nucleus you should see one or a few nucleoli. Each **nucleolus** is a region of the nucleus responsible for producing ribosomal RNA, which forms part of the ribosome (the organelle responsible for producing proteins). The nucleoli appear as dark spots within each nucleus.

These are storage cells, so each should have a large central **vacuole**. The vacuole is a membrane-bound structure that contains fluids and dissolved substances. These substances vary from cell to cell but are often referred to as the cell sap. The vacuole in these cells appears as a light-colored area in the center of the cell. The vacuole is surrounded by the **vacuolar membrane**, sometimes referred to as the **tonoplast**. You cannot see the vacuole directly, but you should be able to determine its location by the absence of any other structures in this area.

4. Diagram a single epidermal cell in the following space. Label the **cell wall**, **nucleus**, **nucleolus**, and **central vacuole**.

COMPARE AND CONTRAST

1. How does the shape of cork cells differ from that of epidermal cells?

2. How can both of these cells continue to function when one is alive and the other is dead?

3. Describe one similarity in the functions of these two cell types.

Activity 2.3: *Elodea* Leaf

Materials:

- *Elodea* leaf
- Wet-mount supplies
- Microscope

Elodea is an aquatic plant that is widespread in pond environments. It is often called *Anacharis*. It lives entirely submerged under water and is a common addition to aquariums. The leaves of *Elodea* are quite thin at only two cell layers thick. This makes *Elodea* an ideal specimen for observing photosynthetic cells and organelles.

1. Make a wet mount of an entire *Elodea* leaf.
2. Examine it on low power. The best area to observe is between the edge of the leaf and the midrib (vein). When it is in focus, switch to high power.
3. Identify the following structures:
   a. Cell wall
   b. Cytoplasm
   c. Central vacuole
   d. Chloroplasts
   e. Nucleus

Chloroplasts are one example of a **plastid**. Plastids are a group of organelles found in plant cells and some protists. These plastids are surrounded by double membranes, contain DNA, control their own replication cycles, and perform specialized functions within the cell. Throughout the next several samples, you will be introduced to several types of plastids.

The **chloroplast** is the organelle that is responsible for photosynthesis. **Chlorophyll** is a green pigment that is primarily responsible for absorbing light during photosynthesis. Chloroplasts contain large quantities of chlorophyll and will typically appear green. They are ovoid organelles surrounded by two membranes. Inside the outer membranes is a third set of membranes forming stacks called **grana**. These are the **thylakoid membranes** that actually contain chlorophylls. Because each chloroplast contains such large numbers of grana, the entire organelle will appear green at this magnification.

In some cells, you should be able to see the chloroplasts moving around the periphery. This phenomenon is due to **cytoplasmic streaming**, the constant flow of cytoplasm within a cell. Many substances are moving within the cytoplasm, but the chloroplasts are simply easier to observe than most.

The nucleus is very difficult to see in these cells. It is colorless and requires careful adjustment of the fine focus to be seen. The **central vacuole** is easy to identify by the lack of chloroplasts in the central region of the cell. The chloroplasts are near the cell wall because the central vacuole occupies most of the central cytoplasm within the cell.

Diagram a typical *Elodea* cell in the space below. Label the cell wall, cytoplasm, chloroplast, and central vacuole.

4. Estimate the length and width of a single *Elodea* cell.

COMPARE AND CONTRAST

1. The previous two types of cells you have seen are both from leaves. These cells appear to be quite different from each other. Why do you believe that may be? Hint: think about the locations and functions of these cells in the living plant.

2. Would you expect to find chloroplasts in the cells of the onion bulb scale directly (not the epidermis coving the scales). Why or why not?

Activity 2.4: Potato Tuber Cells

Materials:

- Potato
- Wet-mount supplies
- Microscope

White potatoes are modified stems that grow underground and are used for storing starch as a food reserve for the plant. These modified stems are called **tubers**. Because these stems are modified for storing starch, they are composed primarily of **parenchyma** cells. As you observe your specimen, pay attention to the spacing and arrangement of the cells. In the *Elodea* leaves and onion epidermis, you saw tightly packed cells. In the potato tuber the cells are farther apart and less organized. This results in **intercellular spaces** between the cell walls of adjacent cells.

Inside these parenchyma cells are numerous plastids. Plastids that function in storing complex molecules, other than pigments, are termed **leucoplasts**. Typically, leucoplasts are numerous and appear as small ovoid structures within the cell. Those that specifically function in starch storage are **amyloplasts**.

1. Cut a small, thin section from the interior of a potato (not the "skin"). Make a wet mount. Note: if your sample is too thick, it will be difficult to see the individual cells and amyloplasts.

2. Examine the slide at low power. Find an area where you can see intact cells clearly. The best place to look is toward the edge of the specimen.
3. Look within the cells to see the amyloplasts. You might want to use high power to view the amyloplasts in more detail; however, they are numerous and can be difficult to focus on clearly with high power.
4. If you have difficulty seeing the amyloplasts, add a small drop of IKI to the specimen. Iodine turns starch dark purple. This will make the entire specimen quite dark, but you will be able to visualize how much starch is present within these cells.
5. Diagram a few potato tuber cells below. Label the cell walls, amyloplasts, and intercellular spaces.

COMPARE AND CONTRAST

1. How does the shape of the potato tuber cells differ from that of the onion epidermal cells? Explain how the shape and spacing of these cells is advantageous to the plant organs in which they are found.

2. Why is the central vacuole not as prominent in the potato tuber cells relative to the *Elodea* leaf cells?

Activity 2.5: Tomato Pulp Cells

Materials:

- Tomato pulp
- Wet-mount supplies
- Microscope

Many fruits and flowers are brightly colored. These red and yellow colors result from the presence of specific pigments within the cells of these organs. Those pigments are contained within **chromoplasts**, plastids that contain pigments other than chlorophyll. Chromoplasts vary in their intracellular location; however, there is usually a cluster that forms around the nucleus.

1. Make a wet mount of the pulp of the tomato fruit. The region closest to the epidermis (the "skin") is best. Do not include any of the tomato epidermis in your sample.
2. Observe the cells under low power. When you have focused on an area of the sample where the cells can be clearly seen, switch to high power.

3. Draw a tomato pulp cell. Label the cell wall and chromoplasts.

COMPARE AND CONTRAST

1. Do these cells more closely resemble those of the potato or of the onion?

2. Compare the size, shape, and color of chromoplasts with chloroplasts and amyloplasts.

Activity 2.6: Tomato Epidermis

The epidermis of the tomato is the outer covering of the fruit; it is often referred to as the "skin." These cells, and many others in plants, are interconnected by small extensions of the plasma membrane that extend through holes in the cell wall, called **plasmodesmata**. In some plant cells plasmodesmata are clustered in a region called a **primary pit field**. The primary pit field is an area of the cell wall where the cell wall is particularly thin.

1. Make a wet mount of a thin section of tomato epidermis.
2. Observe the cells under high power. It is best to locate the thinnest region of the specimen, usually toward the torn edge.
3. In the space below, draw two tomato epidermal cells. Label the cell wall, cytoplasm, and plasmodesmata.

COMPARE AND CONTRAST

1. Which cells are more similar in appearance to the tomato epidermal cells, the onion or the potato? Why do you believe this is so?

2. How do the cell walls of tomato pulp cells differ from those of the tomato epidermal cells?

Activity 2.7: *Zebrina* Stem Tissue

Materials:

- *Zebrina* stem section
- Wet-mount supplies
- Microscope

Plants do not have an excretory system to carry away metabolic wastes. Instead, many plants avoid harmful accumulation of these toxic metabolic wastes by converting them to insoluble substances. These insoluble forms crystallize and can be stored in the plant cell without damaging the cell. One of these metabolic wastes is **oxalic acid**, which can be converted to calcium oxalate crystals.

Some crystals function as defensive mechanisms for plants. When these plant tissues are chewed by humans or other animals, the crystals of **calcium oxalate** and other compounds produce a burning sensation and can lead to inflammation and swelling of the mouth and airways.

Zebrina is a common plant used for groundcovers and hanging baskets. Some varieties are variegated, some have purple leaves and stems, and some are low-growing green plants. *Zebrina* produces long, thin, needle-like crystals of calcium oxalate. These crystals are usually referred to as **raphides** because of their elongated shape. You cannot see these crystals within intact cells by using a compound light microscope; however, you can see them extending out of damaged cells.

1. Make a wet mount of a thin cross section of *Zebrina* stem.
2. Observe the slide under low power. The raphides are most visible along the cut edges of the stem. They are colorless and appear as thin, elongated structures, usually with pointed ends.
3. If you cannot observe the raphides, use a razor blade to chop the stem section on the slide. Add a drop of water, replace the coverslip, and observe under low power.
4. Sketch a few raphides below.

COMPARE AND CONTRAST

1. How are raphides different from plastids? Refer to their respective functions and structures.

2. Why would you not expect to find raphides in tomatoes or peppers?

Activity 2.8: Osmosis and Plant Cells

Materials:

- *Elodea* leaf
- Wet-mount supplies
- 10% NaCl (sodium chloride) solution

Osmosis is the diffusion of water across a selectively permeable membrane. The plasma membrane of cells is a selectively permeable membrane that allows free passage of some substances and limits the passage of others. In this exercise, you will observe the effects of osmosis on plant cells.

1. The relative concentrations of solutes in two areas can be compared using **tonicity**. In biology we typically use tonicity to compare solute concentrations inside the cell with those of the cell's surroundings. An isotonic solution has the same concentration of solutes as is found within the cell's cytoplasm. When a cell is placed in an **isotonic** solution, water molecules move across the cell membrane in both directions at the same rate. The cell experiences neither a net loss nor a net gain of water. A **hypertonic** solution contains more dissolved solutes than does the cytoplasm. A cell placed in a hypertonic solution experiences **plasmolysis** due to a net loss of water as water osmoses from the cytoplasm into the solution surrounding the cell. **Hypotonic** solutions contain a lower solute concentration than is present within the cytoplasm. A cell placed in a hypotonic solution becomes **turgid** because of a net gain of water as water osmoses from the solution into the cytoplasm. As water enters the cell, osmotic pressure, or **turgor pressure**, can build up within the cell. Water will continue to enter the cell until this turgor pressure pushing outward on the cell wall equals the resistance of the cell wall pushing back on the cell membrane and cytoplasm. This situation is characteristic of a turgid cell. Obtain another *Elodea* leaf.
2. Make a wet mount of this leaf with distilled water. Distilled water is hypotonic to the cytoplasm.
3. Sketch a representative cell below.

4. Now add 10% NaCl solution to the slide. You can accomplish this by applying the NaCl solution to the edge of the coverslip. The salt solution will flow under the coverslip due to capillary action. A 10% NaCl solution is hypertonic to the cytoplasm.

5. Sketch a representative cell below.

6. How can you explain the differences in the cells drawn in numbers 3 and 5?

7. What do you think would happen if you were to flood the slide with pure distilled water? Make a hypothesis, and develop a procedure to answer this question if enough lab time remains.

CASE STUDY—The Soggy Fries

Kevin loves crispy, golden french fries from his favorite restaurant and wants to make some at home. He gets some russet potatoes and cuts them into long thin slices the same way the restaurant serves them. He heats up some oil and fries up his fresh potatoes until they are a dark brown but is disappointed when his fries turn out soggy, not crispy at all. His brother tells him that next time he should try soaking the freshly cut potatoes in salty water for 15 minutes before he fries them up and his fries will turn out crispy and delicious.

1. Why did the fries turn out soggy? He fried them longer than the recipe called for and they still never became crispy.

2. What will the salty water do to the cells of the cut potatoes?

3. How will the effect of the salty water make his fries turn out crispy?

STUDY GUIDE

- Be able to define the terms in bold.
- Be able to identify the structures labeled in the drawings.
- Be able to describe the function and location of the cell structures observed during this lab.
- Be able to answer each of the questions asked in the lab exercise.

Conclusions

1. What is the primary role of the cell wall? How can you use this information to explain the differences in the thicknesses of the cell walls seen in the various specimens?

2. What is a plastid? What characteristics are shared by all of the plastids studied today?

3. What is the function of the epidermis? How does the epidermis differ from cells deeper within a plant organ like a fruit?

4. Describe the role of plasmodesmata? How do plasmodesmata impact the individuality of the cells?

5. Compare and contrast chromoplasts and chloroplasts with respect to cell type, color, and function.

6. Is an amyloplast more similar to a chloroplast or a chromoplast? Why?

7. Describe two benefits of crystal formation in plants.

8. Describe the impact of hypotonic, isotonic, and hypertonic solutions on plant cells. Which is most likely to lead to the death of a plant cell after prolonged exposure?

9. Label the organelles in the diagram of a cell below.

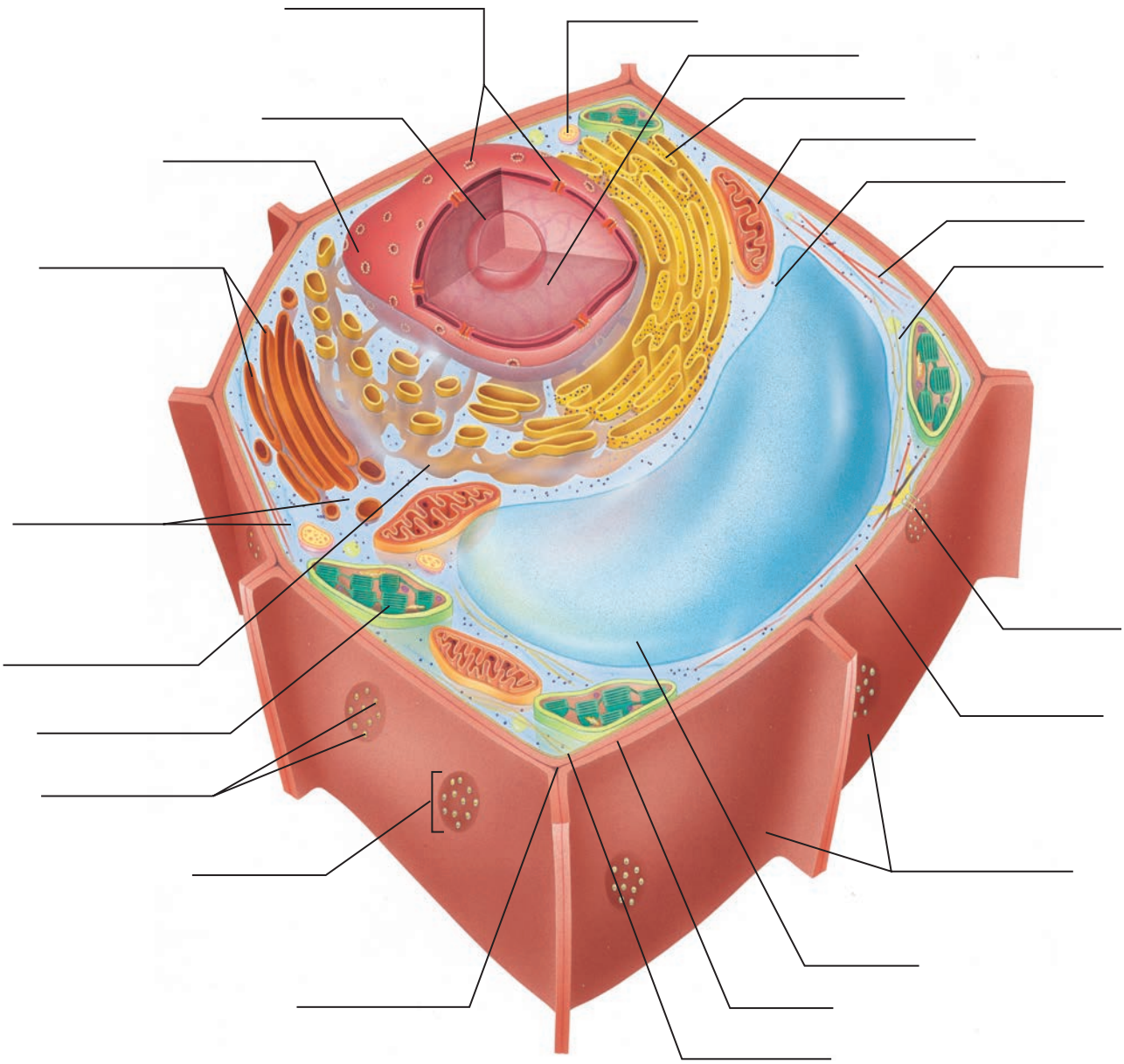

FIGURE 2-2 An unlabeled plant cell.