TOPIC
1.3

How are cells different from one another?

The Endeavour Hydrothermal Vents are located 2200 m below sea level and about 250 km southwest of Vancouver Island. With water temperatures ranging from 115°C to 300°C and no light, it is hard to imagine anything able to survive for long, if at all, around these volcanic vents. Yet, hundreds of different organisms thrive here, including microscopic bacteria. How can bacteria and other organisms survive in such extreme conditions? Scientists study the unique ecosystems at hydrothermal vents to answer questions like this. The Endeavour Hydrothermal Vents are considered so important that they became Canada's first Marine Protected Area in 2003.

Key Concepts

- Scientists classify cells into two types based on the presence or absence of a nucleus.
- Bacteria are prokaryotic cells.
- Plant and animal cells are eukaryotic cells.

Curricular Competencies

- Measure and control variables through fair tests.
- Observe, measure, and record data with accuracy.
- Construct and use a range of methods to represent patterns or relationships in data.
- Reflect on investigation methods, including the adequacy of controls on variables and the quality of the data collected.
- Demonstrate an understanding and appreciation of evidence.

Starting Points

Choose one, some, or all of the following to start your exploration of this topic.

1. **Identifying Preconceptions** Reflect on this statement: All cells have everything they need to carry out life processes. What does that statement mean to you? What are life processes, and what does a cell need to carry them out?
2. **Communicating** There are different types of extreme environments where you live, as well as in other places around the world. Describe three extreme environments that you have visited or know something about. What adaptations (features and behaviours) do you think different types of cells have to survive in these places?
3. **Analyzing Information** How is the shape of cells related to their functions in the human body? Look at some pictures of different kinds of cells—for example, skin cells, blood cells, and nerve cells. Why do you think they have the shapes they do?

Key Terms

There are four key terms that are highlighted in bold type in this Topic:

- prokaryotic cell
- eukaryotic cell
- photosynthesis
- cellular respiration

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

CONCEPT 1

Scientists classify cells into two types based on the presence or absence of a nucleus.

Activity

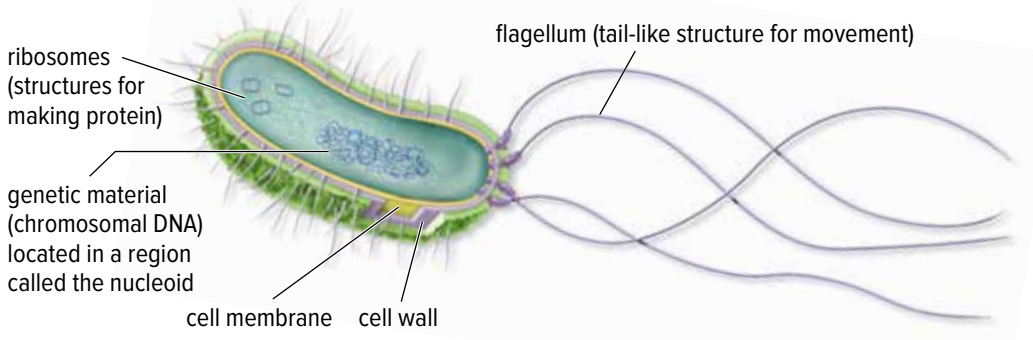
Asking Questions About Cells

As a scientist, you observe the two cells shown in **Figure 1.10**. Record at least three observations you can make. What questions can you ask based on your observations? What hypothesis would you state based on your observations and questions? How would you test your hypothesis?

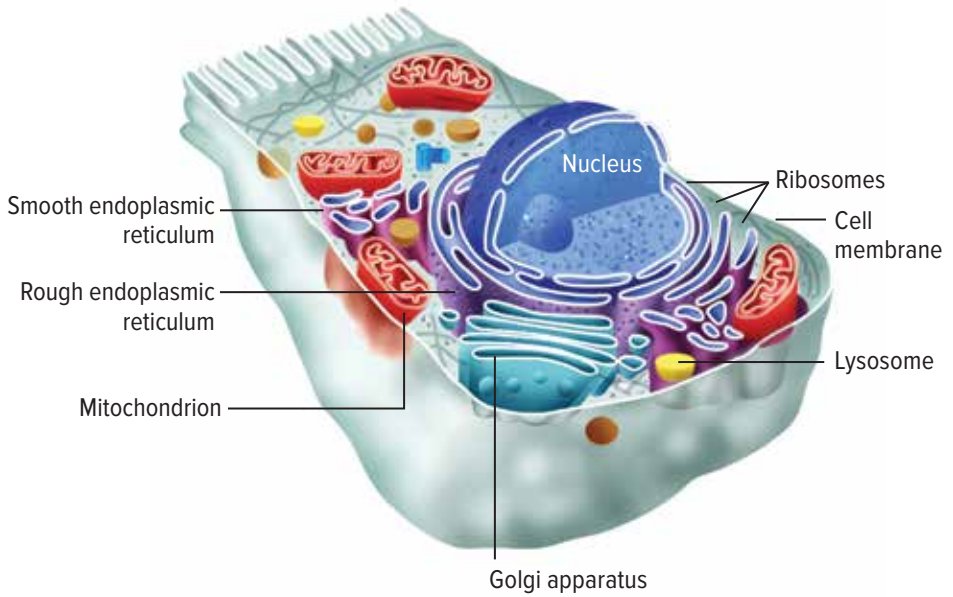
As scientists have studied millions of cells, they have developed criteria that let them classify all cells into two main types. These two types—prokaryotic cells and eukaryotic cells—are compared in **Figure 1.10**.

Figure 1.10 The two main types of cells

Prokaryotic Cell



Eukaryotic Cell



Prokaryotic Cells

A **prokaryotic cell** does not have a separate nucleus. In fact, the word prokaryotic comes from the words *pro-*, which means before, and *karyon*, which means nucleus. In addition to lacking a nucleus, prokaryotic cells are simpler than the other type of cells. They have fewer internal structures.

prokaryotic cell a type of cell without a nucleus and whose internal parts are not surrounded by membranes

Eukaryotic Cells

A **eukaryotic cell** has a nucleus, which contains the cell's genetic material. The nucleus is surrounded by a membrane. The *eu-* part of the word means proper, so a eukaryotic cell is one that has a proper or actual nucleus. Eukaryotic cells also contain other internal structures called organelles, which carry out cell processes. Eukaryotic cells are about 10 times as large as prokaryotic cells, and they are more complex. Table 1.2 compares these two types of cells.

eukaryotic cell a type of cell whose nucleus and other internal parts are surrounded by membranes

Table 1.2 Comparison of Prokaryotic and Eukaryotic Cells

Characteristic	Prokaryotic Cell	Eukaryotic Cell
Genetic material contained in nucleus surrounded by a membrane	no	yes
Organelles surrounded by membranes	no	yes
Size and complexity	smaller and less complex	about 10 times as large and more complex
Can carry out all processes needed to stay alive	yes	yes
Example	bacterium	liver cell of an animal

Activity

Cell Models

Build a model of an organism that either is or contains prokaryotic or eukaryotic cells. Use materials you bring from home, those provided by your teacher, or computer software to make your model. How can you connect the components of your model to the processes of life?

Before you leave this page . . .

1. Use a Venn diagram to compare and contrast prokaryotic and eukaryotic cells.
2. Write three statements that are true of both prokaryotic and eukaryotic cells.

CONCEPT 2

Bacteria are prokaryotic cells.

Activity

Describing Bacteria

Observe the different types of bacteria cells shown below. How would you describe each cell? How are they similar? How are they different?



Could you live in boiling water or super–salty lakes? You could if you belonged to the archaea. These prokaryotic organisms live in extreme environments. You may be more familiar with the other group of prokaryotic organisms: bacteria.

Bacteria

A typical bacterial cell looks like the prokaryotic cell in **Figure 1.10** (on page 24). It has a cell wall and a cell membrane that surround its jelly-like cytoplasm. Genetic material and protein-making structures called ribosomes float within the cytoplasm. Some bacteria have whip-like flagella for movement.

Archaea

Like bacteria, archaea lack a nucleus and have a cell wall. But there are some important differences between them. Molecules found in archaea are more like the molecules found in eukaryotic cells than those of bacterial cells. Archaea also have molecules in their cytoplasm that are not found in any other type of organism.

Before you leave this page . . .

1. Make a T-chart to compare and contrast bacteria and archaea.
2. What new questions do you have about bacteria and archaea?

CONCEPT 3

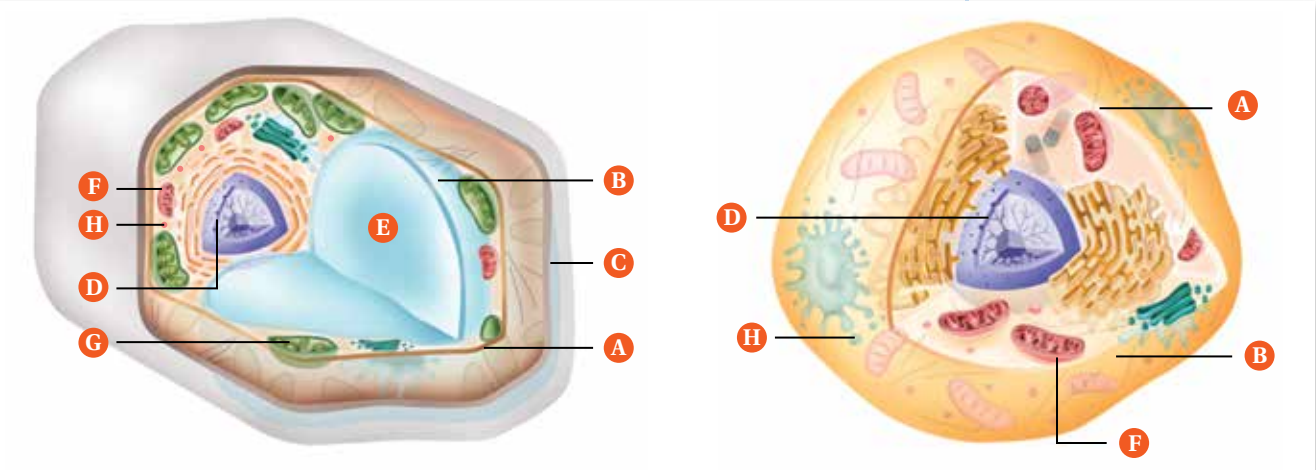
Plant and animal cells are eukaryotic cells.

Activity

Considering Plant and Animal Cells

Observe the plant and animal cells in **Figure 1.11**. Look at all the labelled features. Summarize the key similarities and differences.

Figure 1.11 shows the two main types of eukaryotic cells.



Cell Organelle	Structure and Function
A cell membrane	• surrounds and protects the contents of the cell • helps to control the movement of foods, wastes, and other substances into and out of the cell
B cytoplasm	• jelly-like fluid in which internal organelles float
C cell wall	• tough, rigid structure surrounding the cell membrane, giving plant cells a regular, box-like shape
D nucleus	• large, often round structure containing the genetic material that controls a cell's growth, reproduction, and other life-sustaining activities
E vacuoles	• balloon-like spaces within the cytoplasm to store wastes, food, and substances the cell cannot use right away • smaller and more numerous in animal cells
F mitochondria	• bean-shaped structures that release energy from food molecules to power cell processes
G chloroplasts	• structures containing chlorophyll (a green substance), which captures energy from the Sun to produce food (sugars) in the leaves and green stems of plants
H vesicles	• small sacs that transport materials and sometimes help materials enter and leave the cell

Figure 1.11 Some common organelles of plant and animal cells. Organelles help cells carry out their life processes.

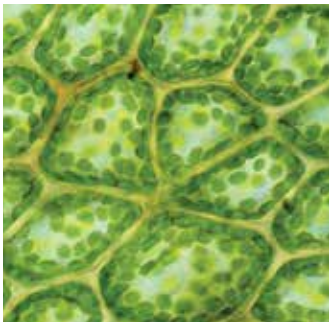


Figure 1.12 Chloroplasts are green-coloured structures in plant cells.

Plant Cells

Plant cells have organelles that carry out all of the processes needed for the whole plant to survive. Plant cells also have some structures that animal cells don't. Plant cells have thick, rigid cell walls to provide support. They also have a large vacuole, which is a structure that stores water and other substances.

Plant cells have a type of organelle that animal cells do not: the chloroplast. Chloroplasts, like the ones shown in **Figure 1.12**, capture the energy in sunlight. This energy is needed to power a process that takes place in chloroplasts: photosynthesis.

Photosynthesis

photosynthesis a chemical reaction in the cells of plants that converts the Sun's light energy into chemical energy that organisms can use

Photosynthesis is a chemical reaction that uses the energy of sunlight to change carbon dioxide and water into sugar and oxygen. As shown in **Figure 1.13**, plants take in carbon dioxide from the air and absorb water through their roots. Light energy comes from the Sun. Plants need the sugar produced by photosynthesis for use as food. The oxygen is a waste by-product that is released into the air.

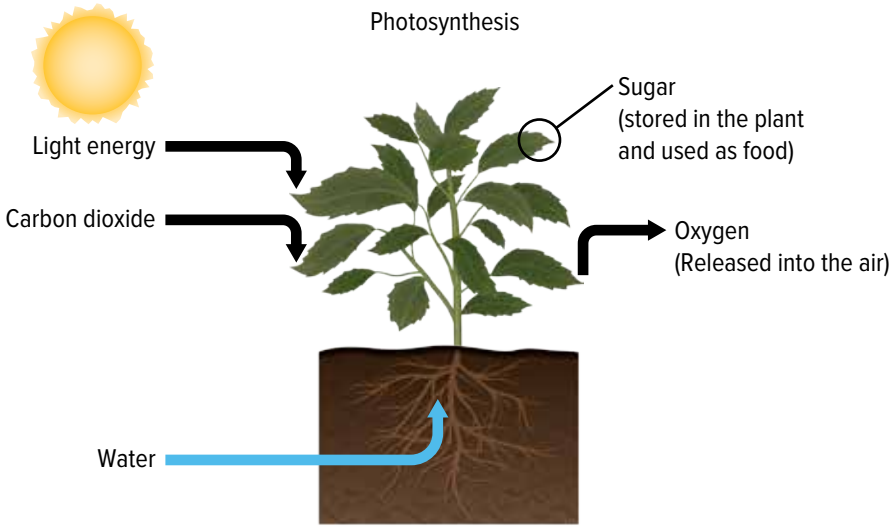


Figure 1.13 Photosynthesis converts the energy of sunlight into chemical energy (in the form of sugar).

Animal Cells

Animal cells have organelles that carry out all of the processes needed for the whole animal to survive. Animal cells have a cell membrane that controls the movement of substances into and out of a cell. Vesicles break down waste materials, which may be recycled or moved out of the cell.

In plant and animal cells, the nucleus directs cell activities and contains genetic material for reproduction. Plant and animal cells also have mitochondria. These organelles play a key role in another important life process called cellular respiration.

Connect to Investigation 1-B on Pages 34–35

Connect to Investigation 1-C on pages 36–37

Cellular Respiration

Cellular respiration is a chemical reaction in which sugar and oxygen in cells are changed into carbon dioxide and water. As part of this reaction, energy is released. The energy produced from cellular respiration is used by organisms to carry out life functions. Carbon dioxide and water are waste by-products.

cellular respiration a chemical reaction in the cells of most organisms that releases the energy needed to carry out life processes

Photosynthesis and Cellular Respiration

Figure 1.14 shows the relationship between photosynthesis and cellular respiration. These two processes function together as part of an important cycle. Most living things depend on this cycle to survive.

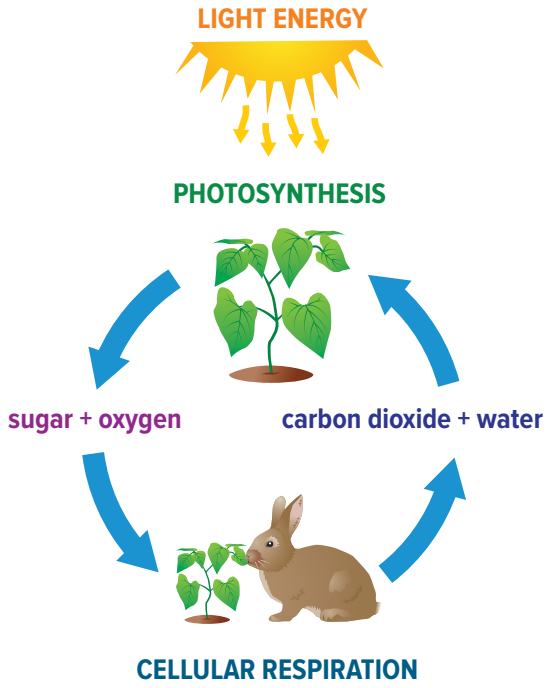


Figure 1.14 Photosynthesis stores energy, and cellular respiration releases energy. As well, each process makes the raw materials that the other process needs to store or release energy.

Plants and other organisms use the carbon dioxide and water produced by cellular respiration as part of photosynthesis.

Plants, animals, and other organisms use the sugar and oxygen produced by photosynthesis as part of cellular respiration.

Before you leave this page . . .

1. Identify and describe the key similarities and differences of plant and animal cells.
2. Explain how chloroplasts are related to cellular processes.
3. Some people describe photosynthesis and cellular respiration as the reverse of each other. Use well-reasoned arguments to explain why you agree or disagree with this idea.

AT ISSUE

How does excess carbon dioxide affect plants?

What's the Issue?

The amount of carbon dioxide in Earth's atmosphere has increased more than 70% since the early part of the 18th century. This gas is a key driver of climate change. But since plants need carbon dioxide, you might wonder if they gain any benefit—how does excess carbon dioxide affect plants?

Studies show that plants grown in air with more carbon dioxide have higher rates of photosynthesis and increased growth. But carbon dioxide is just one factor. Plants need other things to grow, such as light, water, nutrients, and space. It turns out that plants will increase in growth in response to extra carbon dioxide, but only until they cannot get enough of one or more of the other factors they need. The lack of a critical factor will then limit their growth.

Growth is not the only issue, though. In response to more carbon dioxide, plants absorb *less* nitrogen. This nutrient is a key part of proteins. Studies conducted on crops, grasslands, and forests all showed that plants had less protein after growing in conditions of increased carbon dioxide.

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. Some of the studies described in the At Issue section have been done in laboratory settings, and others have been carried out in natural settings.
   - **a)** What are some advantages and disadvantages of carrying out an experiment in each type of setting?
   - **b)** What kinds of differences do you think there are in planning and conducting experiments in these two settings?
   - **c)** How might those differences affect results and how results are processed and analyzed?
2. Much of the world's population relies directly and indirectly on proteins from plants, such as wheat, rice, and corn (maize). How might a decrease in plant protein affect our ability to feed ourselves?
3. Plants are producers in most ecosystems. How do you think ecosystems could change in response to excess carbon dioxide?
4. What questions do you have about the information in the At Issue section? (For example, what do you think "studies" could mean?) How could you find answers to your questions?

Check Your Understanding of **Topic 1.3**

QP Questioning and Predicting PC Planning and Conducting PA Processing and Analyzing E Evaluating
AI Applying and Innovating C Communicating

Understanding Key Ideas

1. Describe the basic function of the following organelles. PA
   - **a)** the nucleus
   - **b)** the cell membrane
   - **c)** the cell wall
   - **d)** mitochondria
   - **e)** chloroplasts
   - **f)** vacuoles

2. Imagine that scientists discover a new unicellular organism in the Lakelse Hot Springs near Terrace. Its characteristics are described below. Decide whether the microbe is more likely to be a type of bacteria or archaea. Explain how you made your decision. PA C
   - It has a cell wall.
   - It has no nucleus.
   - Some of its molecules are similar to molecules found in eukaryotic cells.
   - Some of its molecules are not found in any other type of organism.

3. Scientists often compare organisms in terms of their complexity. In other words, some living things are considered to be simple and others are considered to be more complex. This idea of complexity refers to the structures and functions of the organisms. QP PA AI C
   - **a)** Justify the following statement: Eukaryotic cells are more complex than prokaryotic cells.
   - **b)** Reflect on the kinds of organisms that are made up of these two types of cells. Then explain why your answer to part a) is sensible.

4. A meteorite strikes Earth. Photosynthesis is reduced by 50% due to the release of dust into the atmosphere. Predict what will happen to animal life. Explain your answer in terms of cellular processes. QP PA AI

5. As you study a cell under a microscope, you observe a nucleus and a large vacuole. What features would you look for to decide what type of cell this is? Explain your reasoning. QP E

Connecting Ideas

6. Write a script for a skit in which four people act out the processes of photosynthesis and cellular respiration. PA AI C

7. As we search for signs of life on other planets, do you think we are more likely to find prokaryotic or eukaryotic forms of life? Justify your opinion. QP AI C

Making New Connections

8. One of the things western science does well is explain the microscopic parts (such as cells and atoms) that make up the world. One of the things the Traditional Ecological Knowledge (TEK) of First Peoples does well is explain how all living things are connected with one another, this world, and all other worlds. In this Topic, you learned about microscopic cells. You also learned about a cycle that connects and sustains life on Earth. Write a conversation between two characters, West-Sci and TEK, who are trying to develop a better understanding of each other's view of life and the world. QP PA E AI C

INVESTIGATION
1-B

STRUCTURED INQUIRY

How are plant cells and animal cells similar and how are they different?

A light microscope enables you to observe many of the structures in cells. Increasing the magnification means you see a smaller portion of the object, but lets you see more detail. As you see more details, you are better able to compare and contrast different cell types.

Skills and Strategies

- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Communicating

Safety

What You Need

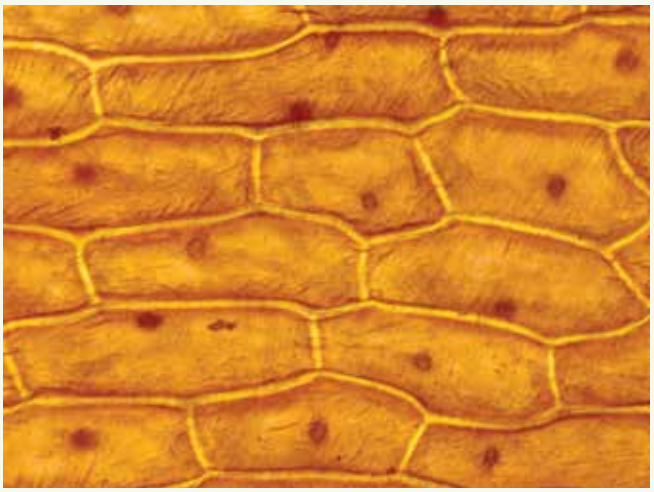
- microscope
- prepared slide of plant cells
- prepared slide of animal cells

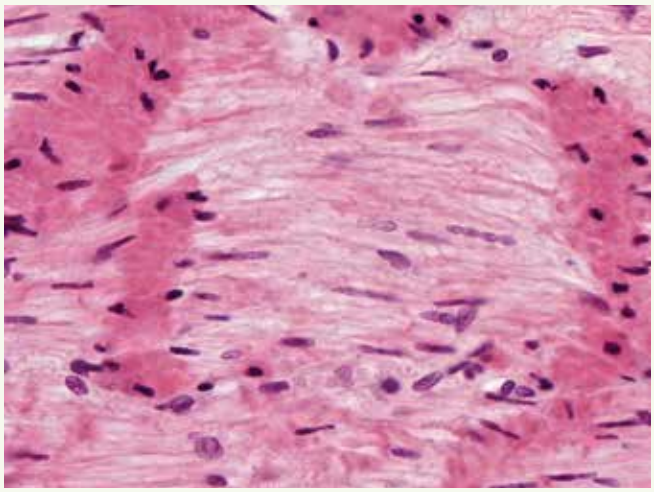
Question

How can you compare and contrast plant cells and animal cells?

Procedure

1. Use a microscope to observe the plant cells on low power. Focus on the top layer of cells.
2. Switch to high power and focus on one cell. The large organelle in the centre of the cell is the central vacuole. Surrounding the central vacuole are green, disc-like objects called chloroplasts. Try to find the nucleus. It looks like a clear ball.
3. Draw a diagram of one plant cell. Label the cell wall, central vacuole, chloroplasts, cytoplasm, and nucleus. Return to low power and remove the slide. Return it to your teacher, or place it where it is safe.
4. Observe the animal cells under low power.
5. Switch to high power and focus on one cell. Draw a diagram of one animal cell. Label the cell membrane, cytoplasm, and nucleus. Return to low power and remove the slide.





These images show a typical plant cell and animal cell as viewed with a light microscope. How do they compare with what you observe in class? Which organelles do you recognize?

Process and Analyze

1. Based on your diagrams, how do the shapes of the two types of cells compare?
2. Compare and contrast the cell structures in your two diagrams. Which structures did you observe in both cells? Which structures did you observe in only one of the cells?

Conclude and Communicate

3. Share your drawings with your classmates. How do their drawings differ from yours? Are they more accurate? Do they have more detail? Explain your answers.
4. How could you improve your drawings? Why is it important that drawings of observations be made as clearly and accurately as possible?

INVESTIGATION
1-C

GUIDED INQUIRY

Photosynthesis and Light

This Investigation is called Guided Inquiry because you are given a question to guide you. You will use this question to help you plan and conduct an experiment to answer the question.

Skills and Strategies

- Questioning and Predicting
- Planning and Conducting
- Processing and Analyzing
- Evaluating
- Communicating

Safety

What You Need

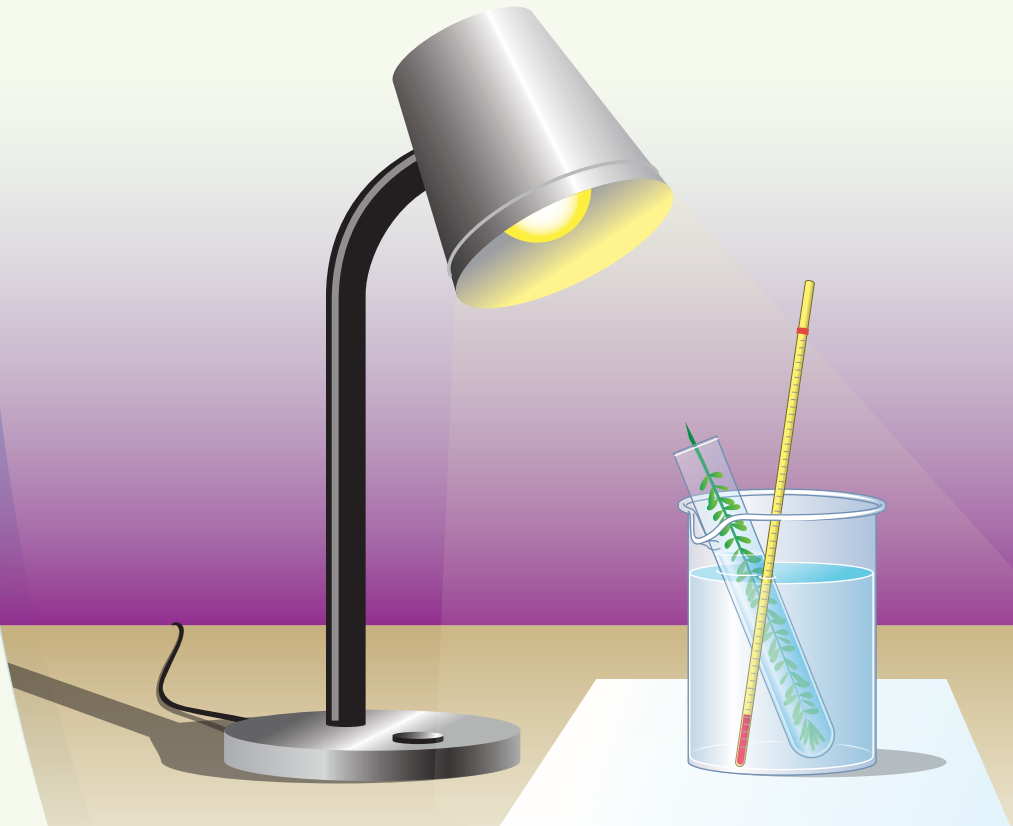
- test tube
- leaf from aquatic plant (e.g., *E. canadensis* or similar)
- scissors
- beaker
- water
- piece of unlined white paper
- lamp
- watch or clock
- thermometer

Question

How does the intensity of light affect photosynthesis?

Procedure

1. Cut the bottom end of your plant stem at an angle, and lightly crush the cut end. Place the leaf in a test tube with the cut end at the top. Fill the test tube with water. Stand the test tube and a thermometer in a beaker filled with water.
2. Place the beaker containing your test tube on a sheet of paper under a lamp. Measure and record the temperature of the water in the beaker.



3. When bubbles of oxygen begin to rise from the plant, start to count the number of bubbles per minute. Continue to record data for 10 min.
4. After 10 min, record the temperature of the water in the beaker.
5. Calculate the average number of bubbles produced per minute by your plant.
6. Use your data to form a hypothesis that relates the amount of light to the rate of photosynthesis.
7. Repeat this experiment, but change the light variable so that you are observing your plant's reaction to getting either more or less light. An increase or decrease in water temperature will indicate a change in the amount of light. Keep all other conditions the same.
8. Record your data in a table similar to the one below, and calculate the average number of bubbles per minute.

Number of Bubbles per Minute

Time	Control	Less Light/More Light
1		
2		

Analyze and Interpret

1. How does the amount of light affect photosynthesis? Support your answer with evidence collected during your investigation.

Evaluate

2. Could the rate of photosynthesis be due to temperature? How could you show that temperature is not involved?

Conclude and Communicate

3. Compile all the class data on one graph to show the effects of varying amounts of light on the rate of photosynthesis.