

1.3

Diffusion, Osmosis, and the Cell Membrane

Diffusion is the movement of particles from an area of higher concentration to an area of lower concentration. Osmosis is the movement of water from an area of higher concentration to an area of lower concentration. The cell membrane is selectively permeable and allows for the transport of materials through it.

Key Terms

concentration
diffusion
osmosis
selectively permeable
membrane

In section 1.2, you helped solve the problems of the imaginary colony of Newo. One of these problems was with the Protection Dome—the solid barrier surrounding the colony. It had only one entrance and exit. The Food and Nutrient Fluid Transportation Group had to find other ways to get materials through the Protection Dome, and the Waste Control Group had to find new ways to pass wastes out of the colony.

A cell would have similar problems if its cell membrane had only one entrance and exit. Not only would this create a traffic jam of materials trying to get in and out of the cell, it would also block processes such as diffusion, which the cell needs for survival.

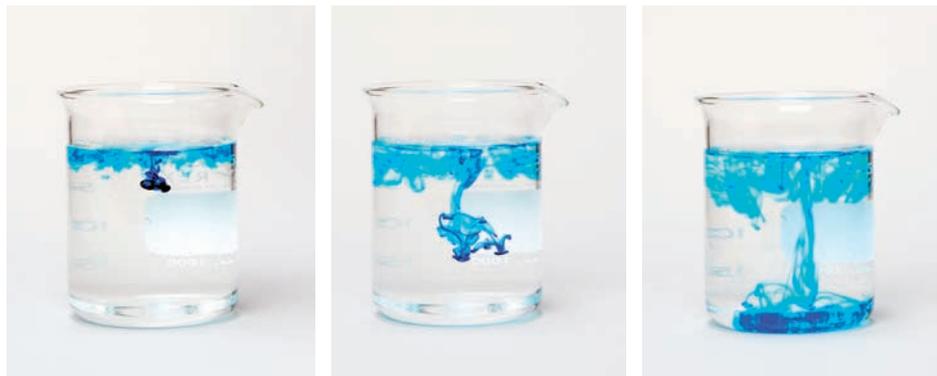
What Is Diffusion?

Diffusion is the movement of particles from an area of higher concentration to an area of lower concentration. **Concentration** refers to the amount of a substance in a given space. The more you have in a given space, the higher the concentration. The particle model of matter states that all particles are constantly moving. Now imagine an area where there is a greater concentration of a certain type of particle. The particles in the area of higher concentration will move to an area of lower concentration. Figure 1.30 shows this process of diffusion.

Connection

Section 7.1 has more information about the particle model of matter.

Figure 1.30 As diffusion continues, the ink particles will become evenly dispersed among the water particles. Then all the liquid in the beaker will appear ink-coloured.



The process of diffusion occurs often in the world around us. For example, imagine you are sitting near a restaurant or in a food fair at a local mall. Your friend is 10 m farther away from you. Suddenly, you catch the odour of your favourite food being prepared. Your friend does not smell anything. A short time later, your friend finally smells the food. Figure 1.31 shows how the food odour particles have spread out through the room because of diffusion.

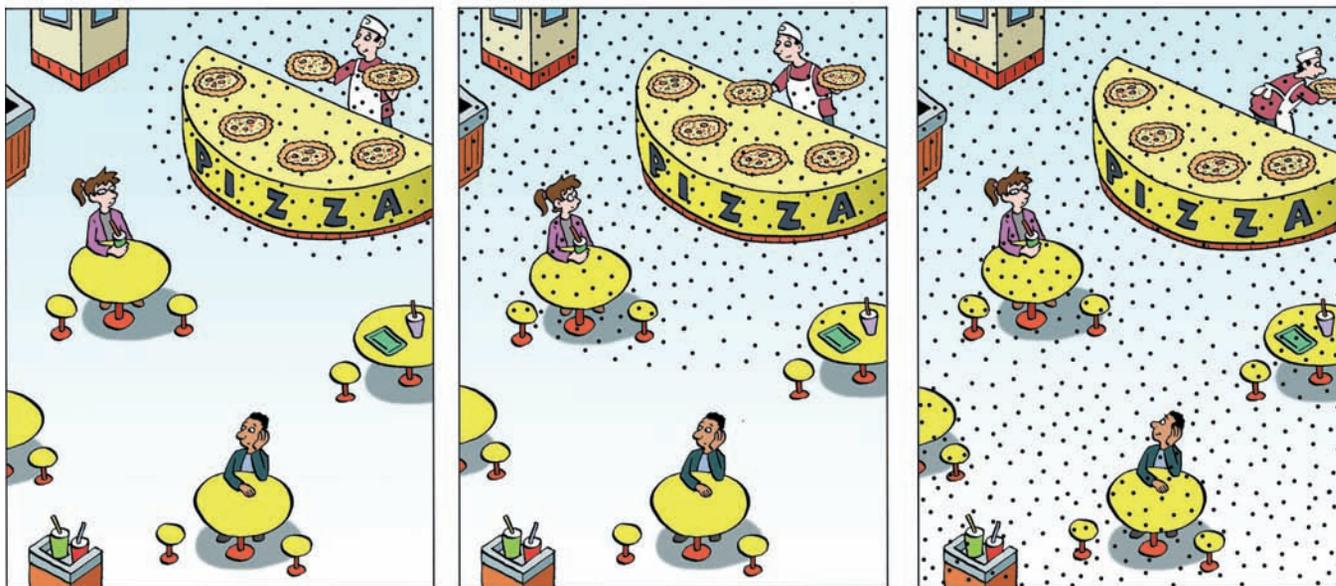


Figure 1.31 The process of diffusion

1-8 Observing Rates of Diffusion

Find Out ACTIVITY

In this activity, you will observe diffusion in a liquid and try to determine other methods of increasing the rate of diffusion within a liquid.

What to Do

1. To observe the process of diffusion, place a drop of food colouring into a beaker of cold water.
2. Develop a chart to record and illustrate your observations immediately after the food colouring is added. Continue recording your observations every 5 min for 15 min, or until your teacher tells you to stop.
3. With a partner, discuss a test you could perform that would allow you to speed up or slow down the diffusion of the drop of food colouring.

4. Write down the plan for your test. Ask your teacher to approve it and then perform the test.
5. When you have completed your test, discuss your results with your class.

What Did You Find Out?

1. Based on your observations, describe what happens when diffusion occurs.
2. Using your observations and any new information you learned from your class discussion, describe the factors that can change the rate of diffusion.

Science Skills

Go to Science Skill 2 for information about conducting a fair test.

Did You Know?

Eight thousand plant cell membranes stacked on top of one another are about the thickness of a page of this textbook.

Diffusion and the cell membrane

One of the cell membrane's most important functions is to allow the materials from outside the cell to move inside the cell. The cell membrane has a number of openings through which these materials pass. The cell membrane is called a **selectively permeable membrane** because it allows some materials to pass through it but keeps other materials out. You can compare a selectively permeable membrane to a coffee filter. Hot water moves through the filter, but the coffee grounds do not.

Diffusion is one way materials are transported across the cell membrane. Particles will move across the selectively permeable membrane if there is a higher concentration of particles on one side of the membrane (see Figure 1.32). Do you see that there are more particles on the left side of the membrane? Over time, the smaller particles will diffuse through the openings in the membrane to the other side. Eventually, there will be an equal number of particles on both sides. This is called **equilibrium**. Particles will still move back and forth, but the number of particles on both sides of the membrane continues to stay the same.

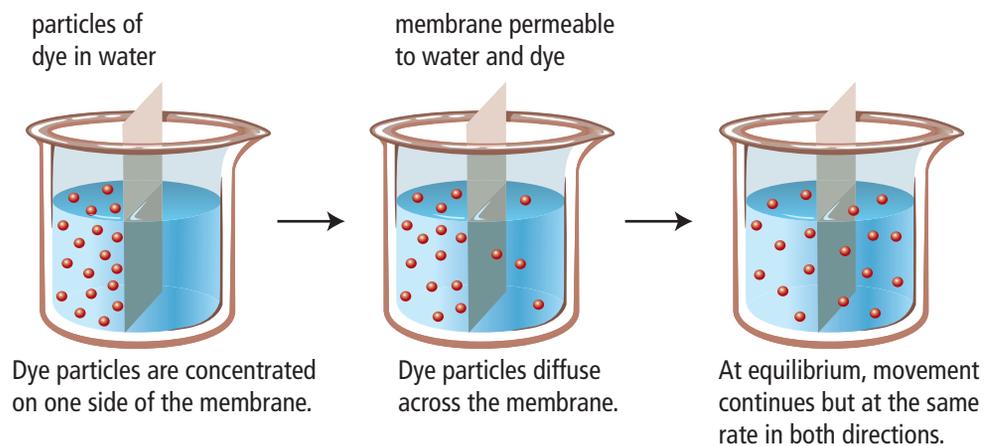


Figure 1.32 Diffusion through a selectively permeable membrane

Word Connect

In Latin, the prefix *equi* means the same, equal, similar, or even.

An example of diffusion in your body occurs in your lungs when oxygen is transferred to your blood, and your blood carries the oxygen to the rest of your body. When the oxygen reaches the appropriate place in your body, the process reverses. Oxygen diffuses out of the blood and into the cells. Section 2.3 has more information about diffusion in your body.

Osmosis

Osmosis is the diffusion of water particles through a selectively permeable membrane. In osmosis, water particles move from an area of higher concentration to an area of lower concentration (see Figure 1.33). Osmosis is a special term that scientists use when referring to the movement of water particles through a selectively permeable membrane.

Figure 1.34 shows an example of osmosis. The hand on the left is holding a limp piece of carrot. The carrot is limp because its cells have lost water. If this carrot is placed in a beaker full of water, the water will move from the beaker (higher concentration of water) to inside the carrot cells (lower concentration of water) through the process of osmosis. This means the carrot cells take in water. The hand on the right is holding a carrot with enough water in its cells. Notice that the piece of carrot has returned to its normal shape and structure.

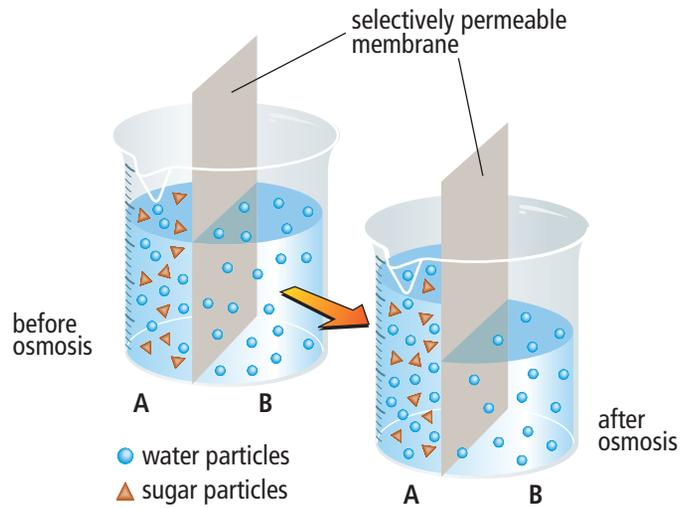
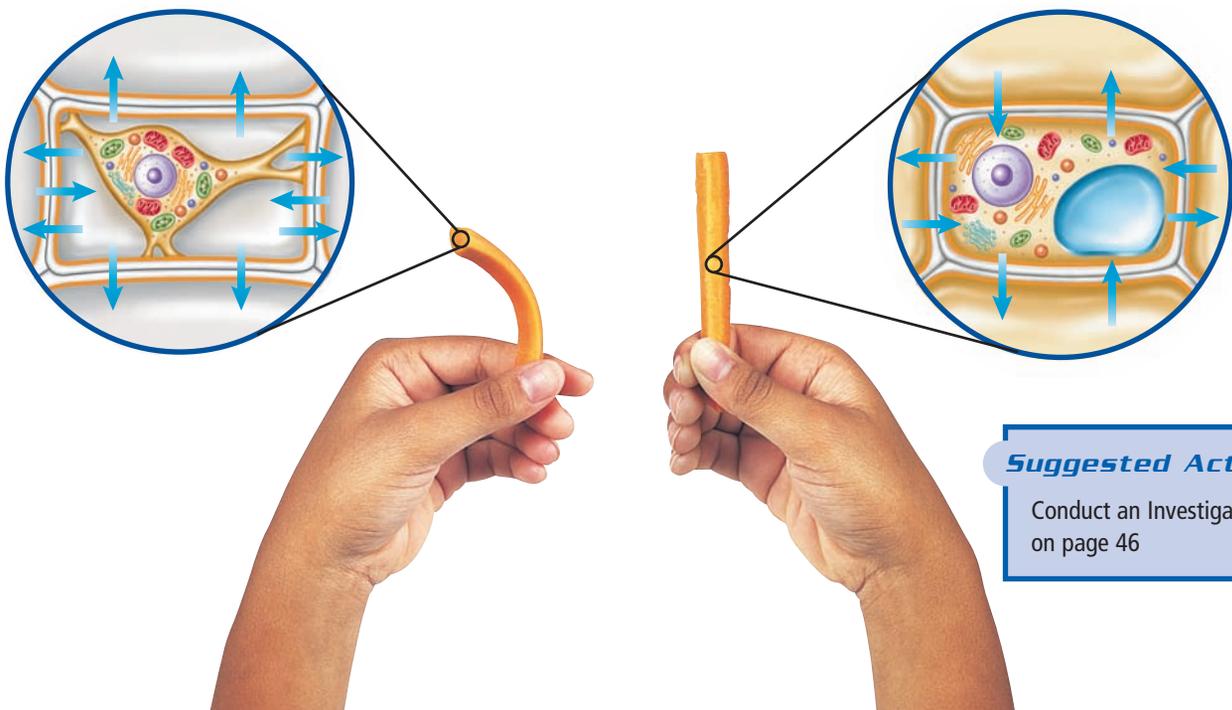


Figure 1.33 In this simplified diagram, water moves by osmosis from side B to side A inside the beaker.



Suggested Activity

Conduct an Investigation 1-9 on page 46

Figure 1.34 The process of osmosis. The cells in the piece of carrot on the left lack water. The cells in the piece of carrot on the right are in equilibrium.

Water flow through the cell membrane

To predict the direction of water flow through a cell membrane, you have to compare the water concentrations on both sides of the membrane. In any situation where only water can pass through a membrane, you need to remember that water will flow from an area of higher concentration to an area of lower concentration. Figure 1.35 on the next page shows three situations where there is movement of water particles through a membrane. Notice that the water particles are small enough to pass through the membrane, but the larger red sugar particles cannot.

Example 1 has equal concentrations of water inside and outside the membrane. The movement of water through the membrane is the natural, random movement of particles in the liquid. Notice that both the red blood cells and the plant cell are normal. Example 2 has a higher concentration of water outside the cell than inside. The result is that water flows through the membrane and into the cell and the cell begins to swell. Notice that the red blood cells and the plant cell both increase in size because of the extra water. Example 3 has more water particles inside the cell than outside. As a result, water flows out of the red blood cells and the plant cell, causing both types of cells to shrink.

Suggested Activity

Conduct an Investigation 1-10 on page 47

Connection

Section 8.2 has more information about pressure.

Application of osmosis

The antibiotic drug penicillin uses the process of osmosis to destroy harmful bacteria. Penicillin acts by preventing the bacteria from producing a substance that strengthens their cell walls. Your body has a higher concentration of water than there is in the bacterial cells. As a result, water flows into the bacteria causing it to swell. With weakened cell walls, the bacteria burst and die.

Reverse osmosis

If you have ever read the label on a water bottle, you may have noticed a statement telling you the water is filtered by reverse osmosis. Now that you know about the process of osmosis, you can probably figure out the process of reverse osmosis just from the words. Reverse osmosis occurs when water flows from an area of lower concentration to an area of higher concentration across a selectively permeable membrane. This flow can happen only when the pressure on the lower concentration side of the membrane is increased. The change in pressure forces the water back through the membrane.

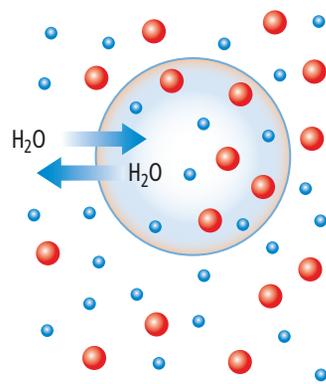
Reverse osmosis is used to desalinate water, which is the process of filtering the salt out of seawater. In areas where drinking water needs to be purified, reverse osmosis can be used to ensure people have clean water to drink. New uses for reverse osmosis continue to be invented and include purifying maple syrup, increasing the concentration of fruit juices, and treating sewage.

Explore More

There are other mechanisms by which particles move through the cell membrane. Investigate active transport, facilitated diffusion, endocytosis, and exocytosis at www.bcsience8.ca.

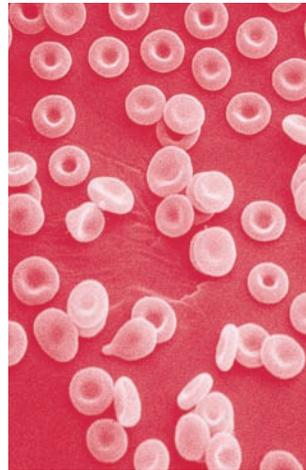
Example 1

Water particles move in and out of the cell at the same rate (A), and the cell retains its normal shape. Notice the bowl-like shape of the red blood cells (B). The plant cell is in its normal state (C).

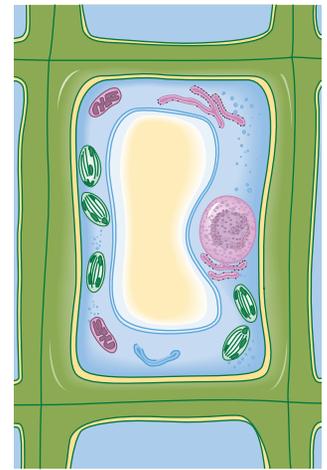


● water particle
● sugar particle

A



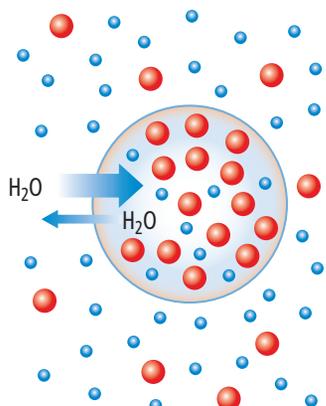
B



C

Example 2

Water particles move in and out of the cell by osmosis (A), causing the cell to swell. Red blood cells may continue to swell (B) and eventually may burst. The plant cell swells beyond its normal size (C).

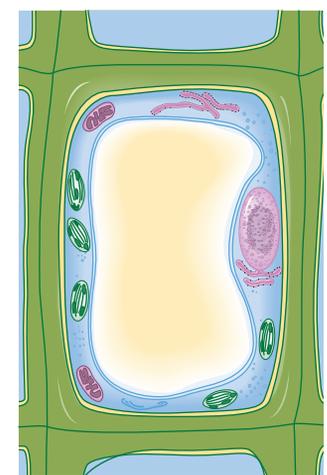


● water particle
● sugar particle

A



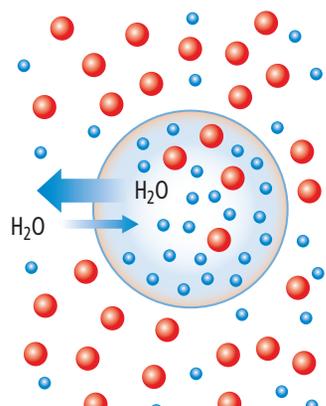
B



C

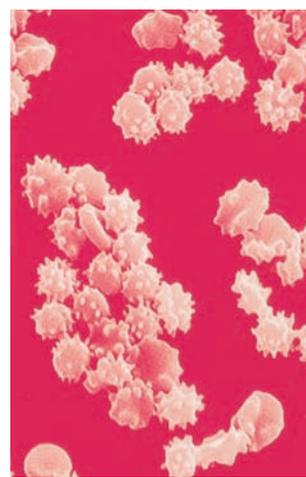
Example 3

Water particles leave the cell by osmosis (A), causing the cell to shrink. Red blood cells shrivel up as they lose water (B). The plant cell membrane shrinks away from the cell wall (C).

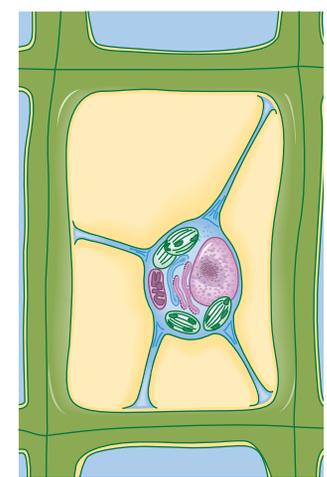


● water particle
● sugar particle

A



B



C

Figure 1.35 Three examples of osmosis

Skill Check

- Observing
- Measuring
- Controlling variables
- Evaluating information

Safety

- Eggs may contain bacteria. Avoid touching your face.
- Wash your hands thoroughly after doing this activity.

Materials

- uncooked egg
- vinegar
- 3 beakers
- 250 mL distilled water
- balance
- spoon
- paper towels
- 250 mL light corn syrup

An egg has a selectively permeable membrane under its shell. In this activity, you will remove the shell and observe osmosis through the membrane. **Note:** Your teacher may decide to do this investigation as a teacher demonstration.

Question

How does osmosis move materials into and out of an egg?

Procedure

1. To remove the shell, place the egg in a beaker and cover it with vinegar. Leave the egg in the vinegar overnight. The shell will slowly dissolve.
2. Copy a table like the one below into your notebook.

	Egg Mass (g) at Start	Egg Mass (g) at End
Distilled water		
Corn syrup		

3. Fill another beaker with 250 mL of distilled water.
4. Determine the mass of the egg without its shell and record it in your table.
5. Use the spoon to place the egg into the beaker of distilled water.
6. Observe immediately and at the end of class. Record your observations in your table. Repeat this step in two days.
7. After two days, take the egg out of the water and carefully dry it off with paper towel. Find the mass of the egg and record it in the table.
8. Place the egg into 250 mL of corn syrup and repeat Procedure steps 6 and 7.
9. Clean up and put away the equipment you have used.

Analyze

1. Using your data, describe the difference between what happened to the egg when you put it in the distilled water with what happened when you put it in the syrup.
2. Calculate the mass of water that moved into the egg.
3. Calculate the mass of water that moved out of the egg.
4. Why did you need to use an egg without a shell for this activity?
5. Do you think a hard-boiled egg would give you the same results? Explain.

Conclude and Apply

1. How did this experiment demonstrate the process of osmosis? Explain your answer using your observations from this activity.

Skill Check

- Predicting
- Modelling
- Evaluating
- Working co-operatively

Safety

- Ask your teacher to approve any procedure you design before you carry it out.
- Wash your hands thoroughly after doing this investigation.

Materials

- white rice
- brown rice
- bird seed
- water
- beakers
- balance

An urban myth is a story that sounds true, but is not. For example, you may have heard that water swirls down a sink in the opposite direction in the southern hemisphere than in the northern hemisphere. In fact, this does not happen.

Another urban myth suggests that birds will be harmed if they eat rice. The reason a bird may potentially be harmed is that after it eats the rice, the rice absorbs water from the bird's stomach through osmosis. The expanding rice, now inside the bird, causes the bird to choke.

In this investigation, you will design an experiment to find out whether rice can be harmful to birds. You will not be using any animals, but rather designing an experiment to determine how much rice expands when placed in water.

Science Skills

Go to Science Skill 2 to learn more about designing experiments.

Question

Is eating rice harmful to a bird?

Procedure

1. Develop an hypothesis for your investigation. Remember that an hypothesis can use the "If ... Then" format.
2. Discuss with your group how you will design a procedure to test your hypothesis.
3. Write down your plan for a controlled experiment to test your hypothesis. Ask your teacher to approve your plan and any material that is not on the materials list above.
4. Carry out your procedure and record your data.
5. Clean up and put away the equipment you have used.

Conclude and Apply

1. Prepare a presentation that shows how your data supports or does not support your hypothesis.

Dr. Nadine Caron

Teamwork, discipline, and hard work are three skills Dr. Nadine Caron learned on the basketball court as a shooting guard in university. She uses these important skills today in her practice as a general and endocrine surgeon and an assistant professor at the University of Northern British Columbia (UNBC) in Prince George. Dr. Caron was the first female Aboriginal graduate from the school of medicine at the University of British Columbia.

Q. What first sparked your interest in science?

A. I was always curious about how things worked. I wanted to understand everything around me. I wanted to know what happened when you ate something—where did it go? What happened to it? Science, especially biology, gave me the answers to these questions. I have always loved science.

Q. What does a day in your life look like?

A. It depends on the day. I could be treating patients in the emergency room, seeing patients in my clinic, or performing surgery. I could be teaching health-care issues or clinical skills at UNBC. Or I could be doing research in the fields of cancer, trauma, or Aboriginal health.



Q. What is endocrine surgery?

A. It is surgery related to the endocrine system. The endocrine system regulates hormones. For example, the thyroid gland, which is located in the front of the neck, releases a hormone that regulates how the body functions. I can help people who have thyroid problems.

Q. Why do you take your pathology lab to communities in British Columbia?

A. I take human specimens from the pathology lab to schools to help students understand what they are learning. There is a huge difference between telling students that smoking can damage the lungs and showing them. They can compare a healthy set of lungs that are pink to the lungs of a heavy smoker that are black and yellowish-grey. They can see the damage caused by smoking.

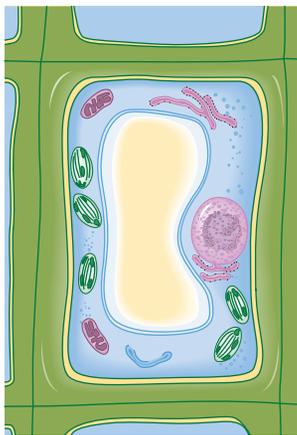
Questions

1. What are some of the skills Dr. Caron learned through sport that she uses in her work life?
2. What does the endocrine system do?
3. Which part of Dr. Caron's work would you find most interesting? Why?

Check Your Understanding

Checking Concepts

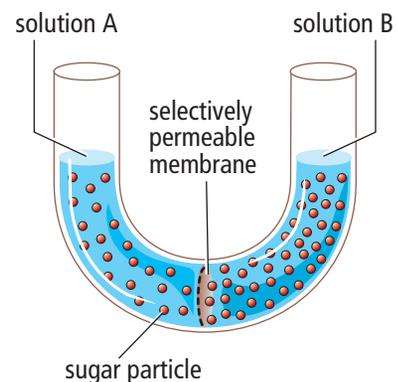
1. The cell membrane cannot be a completely solid structure. Explain why.
2. Describe the process of diffusion using an example of your choice.
3. Describe osmosis. Why is it important to a cell?
4. When a tea bag is placed in hot water to make tea, the bag swells in size. Explain why this is a model of osmosis.
5. Which way will water flow through the membrane of this plant cell for each of the situations described below?



- (a) The plant cell is placed in a solution where the concentration of water equals the concentration of water inside the cell.
 - (b) The plant cell is placed in a solution where the concentration of water is greater than the concentration of water inside the cell.
 - (c) The plant cell is placed in a solution where the concentration of water is less than the concentration of water inside the cell.
6. Explain what is wrong with the following statement and write a new, correct statement. "When equilibrium is reached, particles stop moving back and forth through the cell membrane."

Understanding Key Ideas

7. At a shopping mall, you notice a faint smell of perfume from the cosmetics section, which is at least 75 m away. Explain why you can smell the perfume.
8. Why does your skin wrinkle up if you spend too much time in a warm bath?
9. Describe how diffusion and osmosis are the same and how are they different.
10. What do you think will happen when a wilted piece of celery is placed into a glass of water?
11. Which way will the water flow in the diagram below?



12. In the produce section of many grocery stores, the vegetables are occasionally sprayed with a fine mist of water. Why is this done? Explain your answer.

Pause and Reflect

Think back to the solution you developed for the problem of transporting materials through the Protection Dome into the colony of Newo. What did you suggest as a new design for the Protection Dome? Was it similar to the cell membrane? What was the same and what was different? Make a drawing or write a paragraph to compare your design to the cell membrane.

Prepare Your Own Summary

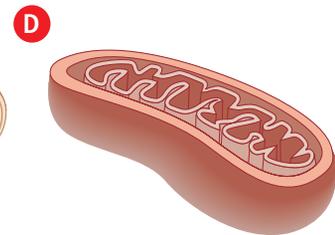
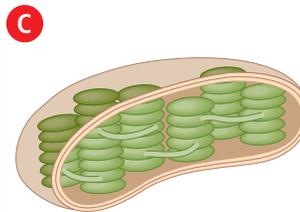
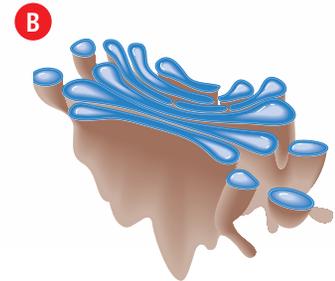
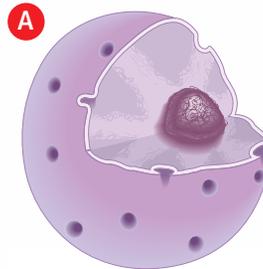
In this chapter, you investigated the cell as the basic unit of life. Create your own summary of the key ideas from this chapter. You may include graphic organizers or illustrations with your notes. (See Science Skill 10 for help with using graphic organizers.) Use the following headings to organize your notes:

1. Characteristics of Living Things
2. The Microscope
3. Cell Theory
4. Cell Organelles
5. Diffusion and Osmosis

Checking Concepts

1. How are living things different from non-living things?
2. Give an example of a unicellular organism and a multicellular organism.
3. List the five characteristics of living things.
4. Why must living things reproduce?
5. The coarse focus knob on a microscope should be used with which objective lens(es)?
6. A slide on the microscope is moved toward you. In which direction does the object you are viewing through the eyepiece move?
7. Why should an objective lens never touch the slide?
8. What is a wet mount slide?
9. Who was the first scientist to use the term “cell”?
10. Where did this scientist get the idea for the term “cell”?
11. What organelles do plants have that animals do not?
12. Which part of the cell stores food and waste materials?
13. Which organelle provides energy for the cell?

14. Which of the cell structures illustrated below controls the life functions in a cell?



15. What is the difference between a prokaryotic and eukaryotic cell?
16. How are osmosis and diffusion similar? How are they different?
17. What process causes water to enter or leave the cell?

Understanding Key Ideas

18. Why is the cell considered to be the basic unit of life?
19. An explorer from another galaxy has arrived on Earth and believes cars are living things. Explain why the explorer might think that a car has the five characteristics of life. How would you explain that a car is not a living thing?
20. A unicellular organism takes up one third of the field of view at medium power. What is the actual size of the organism?

21. (a) A student has made a wet mount slide of some pond water. She notices several clear, round shapes with a dark outline in the field of view. What might these be?
 (b) How could the student avoid having these shapes appear on the slide?
22. Compare and contrast the processes of respiration and photosynthesis.
23. Why are vacuoles usually larger in plant cells than in animal cells?
24. During class someone peels an orange. Why will everyone in the class not smell the orange at the same time?
25. Can you give a plant too much fertilizer? Explain why or why not.
26. You have just bought a tropical fish for your freshwater aquarium. Unfortunately, you do not realize it is a saltwater fish. Using your knowledge of osmosis, explain why this fish will not survive in your aquarium.
27. The tables on this page show the results of an experiment to find the effect of osmosis on potato cells. Two cubes of potato were weighed and placed in distilled water, and another two cubes were weighed and placed in salt water. The mass of each potato cube was then measured every 15 minutes for an hour.

Time (min)	Distilled Water		
	Cube 1 Mass (g)	Cube 2 Mass (g)	Average Mass (g)
0	51	52	
15	51	52	
30	52	53	
45	53	54	
60	55	53	

- (a) Calculate the average mass of the potato cubes in distilled water and the average mass of the potato cubes in salt water for each time interval.
- (b) Plot the data on a graph. Show the average mass of the cubes along the *y*-axis (vertical axis) and time along the *x*-axis (horizontal axis).
- (c) What happened to the mass of the potato cubes in distilled water? What happened to the mass of the potato cubes in salt water? Why?

Time (min)	Salt Water		
	Cube 1 Mass (g)	Cube 2 Mass (g)	Average Mass (g)
0	59	60	
15	58	58	
30	50	55	
45	50	54	
60	50	53	

Pause and Reflect

By studying cells with microscopes, we can develop better medicines to treat various illnesses. This is an example of how a new technology has improved our scientific understanding of cells. How has the improvement in microscope technology further improved our understanding of the structures of cells?