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 results when particles move 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.

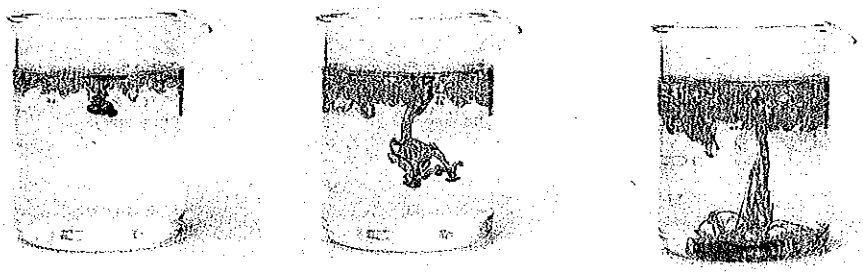


Figure 1.30 As diffusion continues, the ink particles will become evenly dispersed among the water particles. Then all the liquid in the beaker will appear ink-coloured.

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.

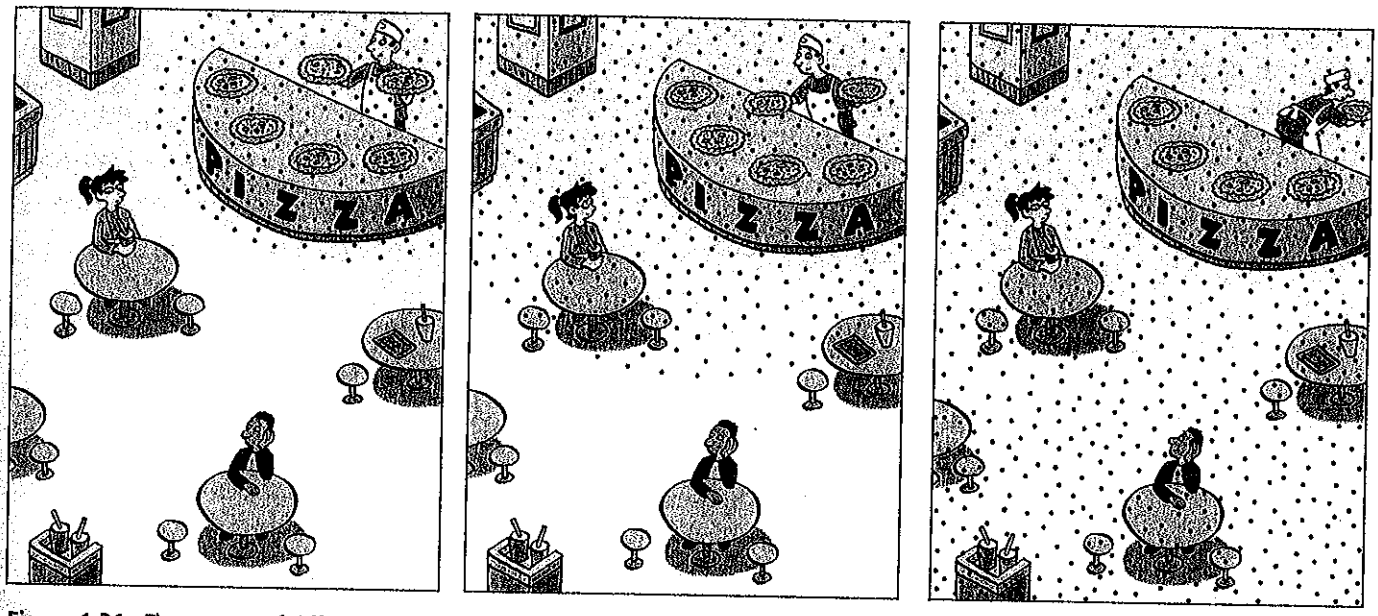


Figure 1.31 The process of diffusion

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. Repeat this step 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.

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.

Did You Know?

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

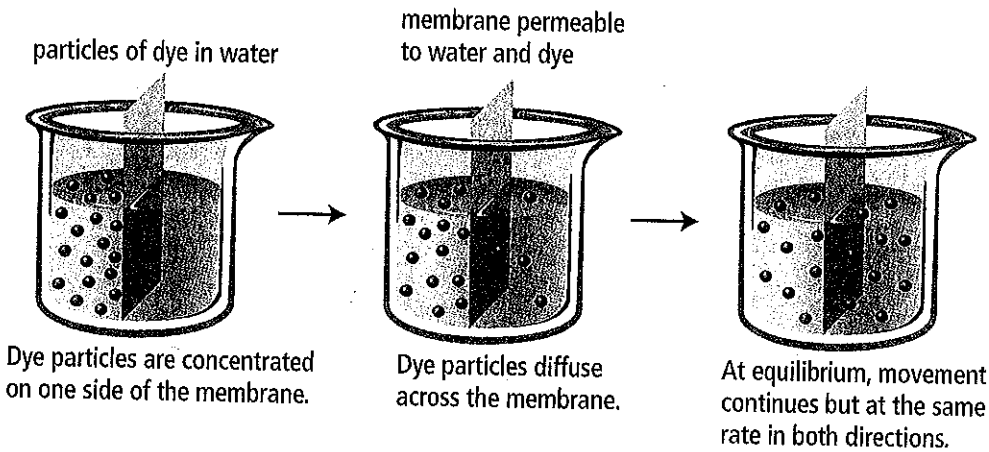


Figure 1.32 Diffusion through a selectively permeable membrane

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, particles also 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.

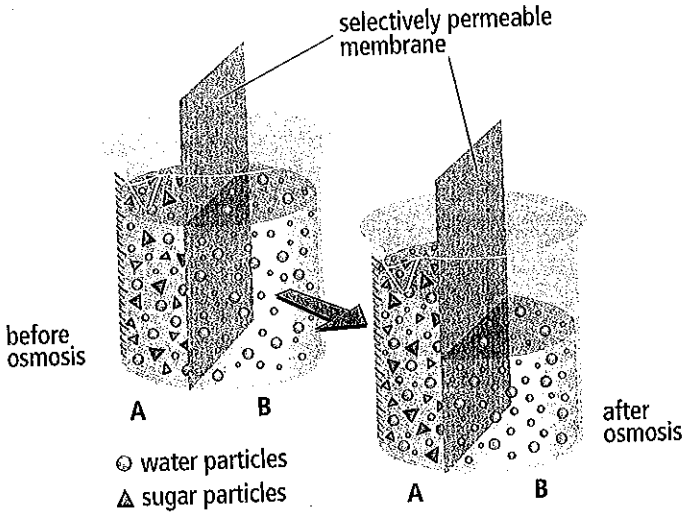


Figure 1.33 In this simplified diagram, water moves by osmosis from side B to side A inside the beaker.

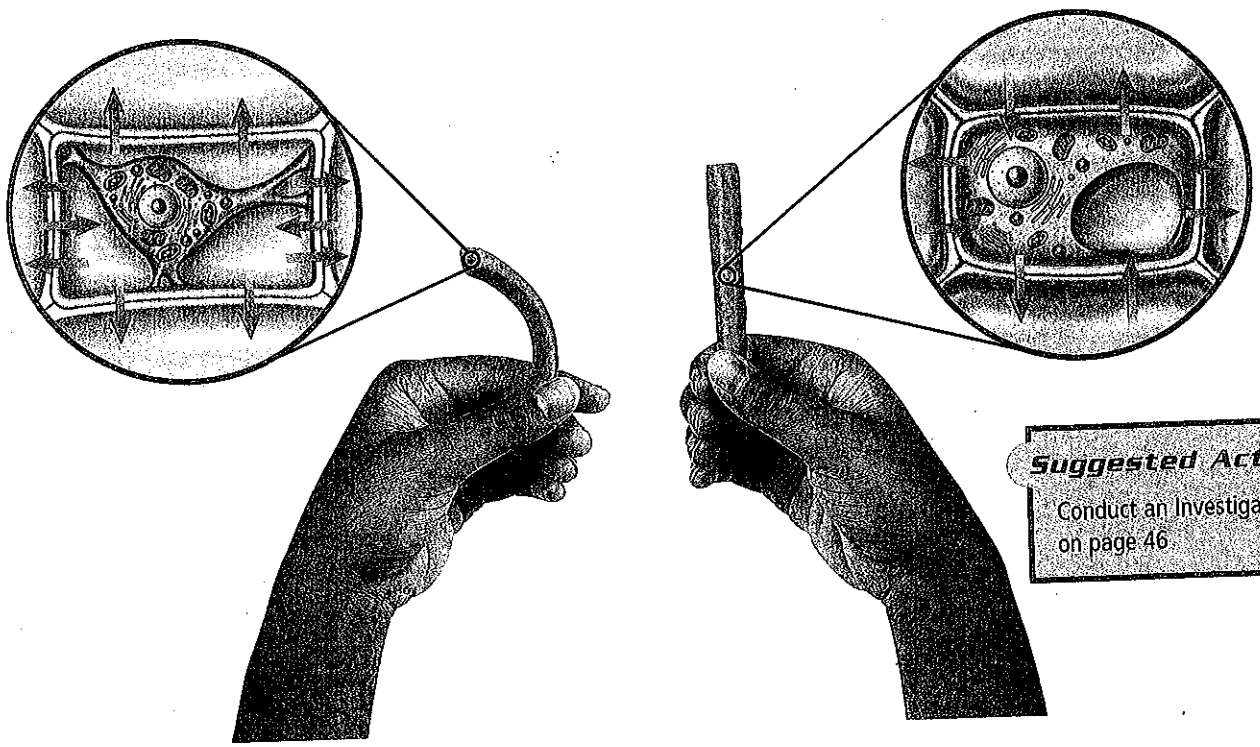


Figure 1.34 The process of osmosis. The cells in the piece of carrot on the left lack water. The cells in the piece of carrot on the right are in equilibrium.

Suggested Activity

Conduct an Investigation 1-9 on page 46

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

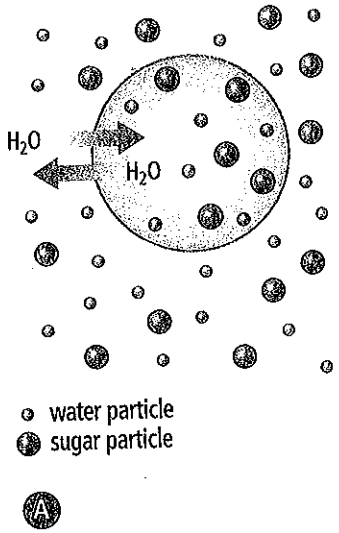
If you have ever read the label on a water bottle, you may have noticed a statement telling you the water is filtered by reverse osmosis. Now that you know about the process of osmosis, you can probably figure out the process of reverse osmosis just from the words. Reverse osmosis occurs when water flows 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.

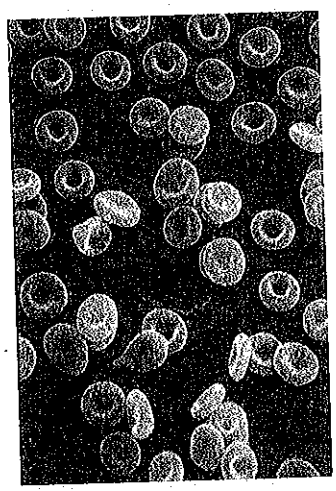
Reverse osmosis is used to desalinate water, which is the process of filtering the salt out of seawater. In areas where drinking water needs to be purified, reverse osmosis can be used to ensure people have clean water to drink. New uses for reverse osmosis continue to be invented and include purifying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

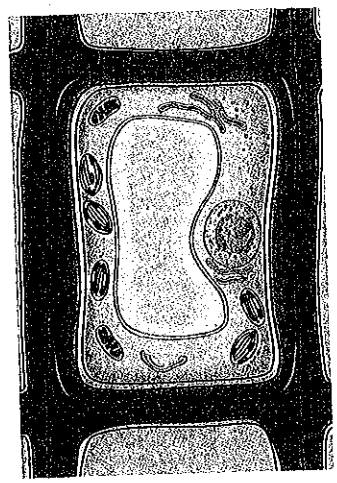
Explore More

There are other mechanisms by which particles move through the cell membrane. Investigate active transport, facilitated diffusion, endocytosis, and exocytosis at **www.bcscience8.ca.**

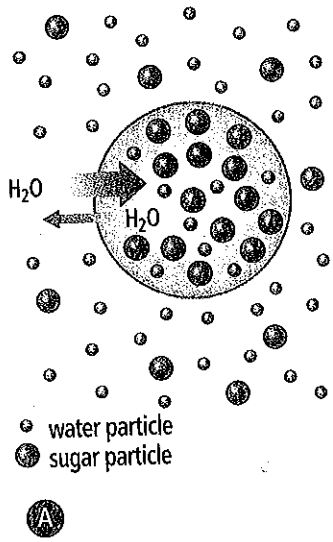
Example 1
Water particles move in and out of the cell at the same rate (A), and the cell retains its normal shape. Notice the bowl-like shape of the red blood cells (B). The plant cell is in its normal state (C).

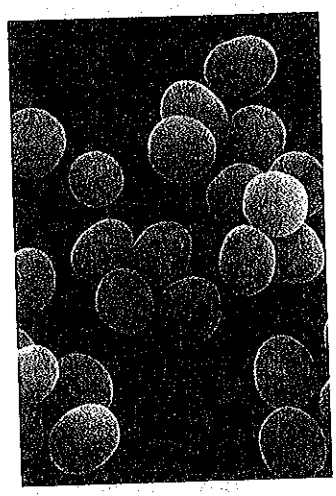


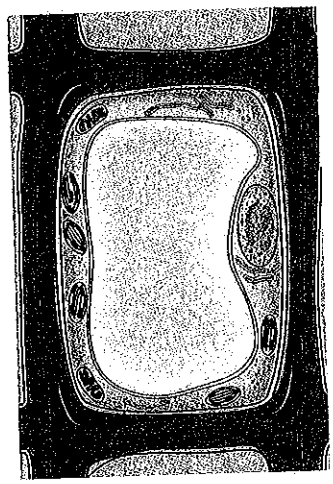




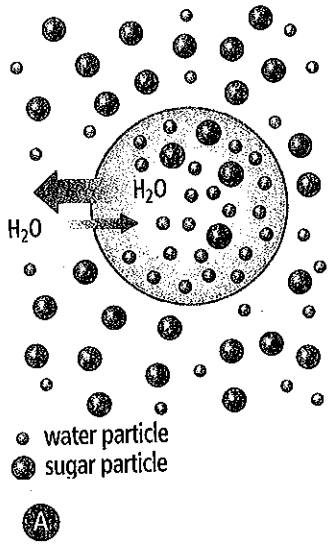
Example 2
Water particles move in and out of the cell by osmosis (A), causing the cell to swell. Red blood cells may continue to swell (B) and eventually may burst. The plant cell swells beyond its normal size (C).

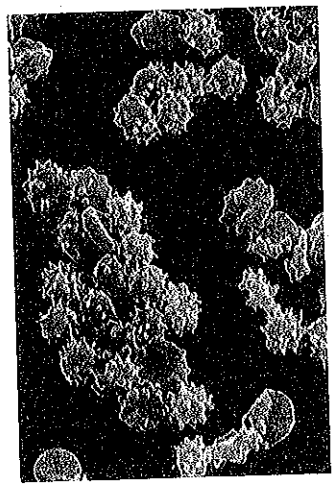






Example 3
Water particles leave the cell by osmosis (A), causing the cell to shrink. Red blood cells shrivel up as they lose water (B). The plant cell membrane shrinks away from the cell wall (C).





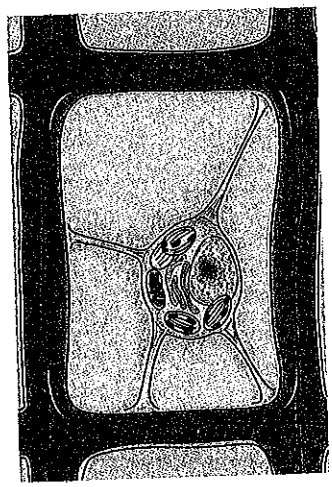
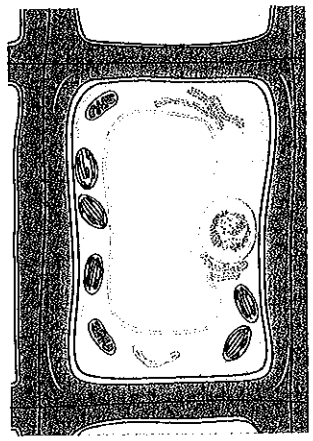


Figure 1.35 Three examples of osmosis

Checking Concepts

1. The cell membrane cannot be a 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.

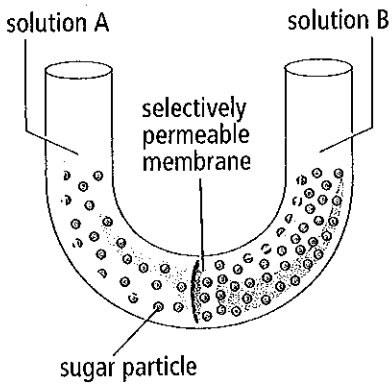
(b) The plant cell is placed in a solution where the concentration of water is greater than the concentration of water inside the cell.

(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.