KEY CONCEPT

2.3 Materials move across the cell's membranes.

BEFORE, you learned

- All cells have an outer covering called the cell membrane
- Cells need starting materials for life-sustaining processes
- Cells need to get rid of waste products

NOW, you will learn

- How materials move into and out of the cell through the cell membrane
- How energy is involved in transporting some materials into and out of cells
- How surface area affects transport in cells

VOCABULARY

diffusion p. 56
passive transport p. 58
osmosis p. 59
active transport p. 60

EXPLORE Diffusion

How do particles move?

PROCEDURE

1. Fill the beaker with tap water.
2. Add 3 drops of food coloring to the water.
3. For 10 minutes, observe what happens. Write down your observations.

MATERIALS

- beaker
- water
- food coloring

WHAT DO YOU THINK?

- What changes did you observe?
- What might have caused the changes?

Some materials move by diffusion.

VOCABULARY
Add a word triangle for *diffusion* to your notebook. Your triangle could include a sketch of the sun.

When you walk toward the shampoo section in a store, you can probably smell a fragrance even before you get close. The process by which the scent spreads through the air is an example of diffusion. **Diffusion** (dih-FYOO-zhuhn) is the process by which molecules spread out, or move from areas where there are many of them to areas where there are fewer of them.

Diffusion occurs because the molecules in gases, liquids, and even solids are in constant motion in all directions. This random movement of molecules tends to spread molecules out until they are evenly distributed. But diffusion does more than just spread a scent around a room. Cells use diffusion to carry out important life functions. Diffusion helps cells maintain conditions necessary for life. For example, the oxygen needed for respiration enters cells by diffusion. Similarly, the carbon dioxide produced by respiration leaves cells by diffusion.

Concentration

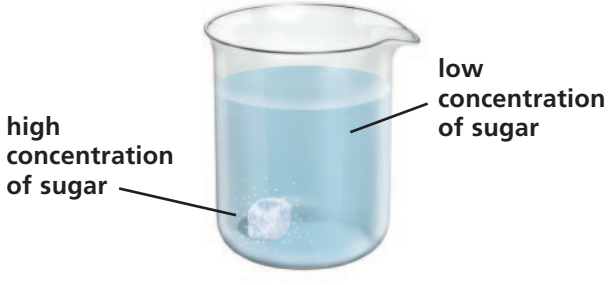
Diffusion occurs naturally as particles move from an area of higher concentration to an area of lower concentration. The concentration of a substance is the number of particles of that substance in a specific volume. For example, if you dissolved 9 grams of sugar in 1 liter of water, the concentration of the sugar solution would be 9 g/L. When there is a difference in the concentration of a substance between two areas, diffusion occurs.

Generally, the greater the difference in concentration between two areas, the more rapidly diffusion occurs. As the difference in concentration decreases, diffusion slows down. The number of particles moving to one area is balanced by the number moving in the other direction. Particles are still moving in all directions, but these movements do not change the concentrations.

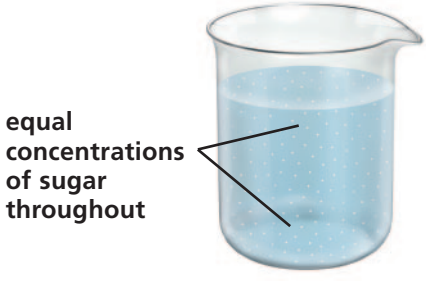
CHECK YOUR READING Summarize what happens during diffusion. (Remember, a summary includes only the most important information.)

Concentration and Diffusion

A sugar cube dissolving in water provides an example of diffusion.



1 Shortly after a sugar cube is placed in a beaker of water, the concentration of sugar is high near the sugar cube and very low elsewhere in the beaker.



2 Over time, diffusion causes the concentration of sugar to become the same throughout the beaker. Particles are still moving.

Diffusion in Cells

Diffusion is one way by which materials move in and out of cells. Small molecules such as oxygen can pass through tiny gaps in the cell membrane by diffusion. For example, consider the conditions that result from photosynthesis in a leaf cell.

- Photosynthesis produces oxygen inside the cell.
- The concentration of oxygen molecules becomes higher inside the cell than outside.
- Oxygen molecules move out of the cell by diffusion.

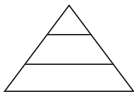
RESOURCE CENTER CLASSZONE.COM
Learn more about diffusion.

In a plant cell, some of the oxygen produced by photosynthesis is used in cellular respiration. The remaining oxygen diffuses out of the cell. Much of it escapes to the air. Some of it diffuses to other cells where there is a lower concentration of oxygen. This process of diffusion continues from one cell to the next.

Diffusion is a form of passive transport. In **passive transport,** materials move without using the cell's energy. Cells benefit from passive transport because some materials can move through various cell membranes without any input of energy. Whether or not a substance can diffuse across a cell membrane depends on how well the substance dissolves in the lipids that make up the cell membrane. A special form of passive transport allows polar substances, such as glucose, salts, and amino acids, to pass through cell membranes.

All cells need the food energy supplied by glucose. Yet glucose is produced in just some plant cells. Polar substances move into the cell through protein channels—or openings—in their membranes that are specific for each substance. This type of diffusion is still passive transport because it uses no energy.

VOCABULARY
Add a word diagram for *passive transport* to your notebook. You may want to use words instead of a sketch in part of your triangle.



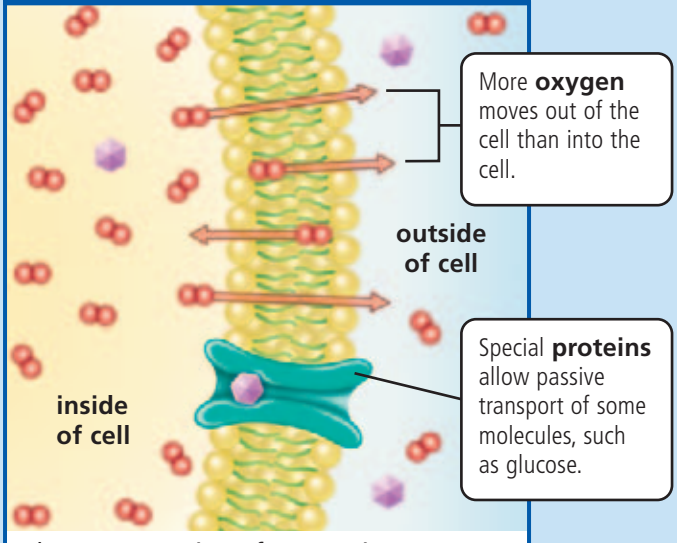
CHECK YOUR READING What is passive transport? Your answer should mention energy.

Passive Transport

Materials move across a cell membrane continuously.

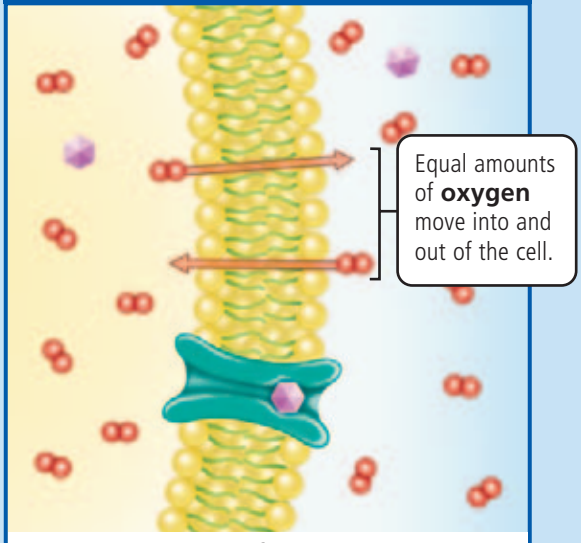
= oxygen
= glucose

Different concentrations



The concentration of oxygen is greater inside the cell than outside.

Equal concentrations



The concentration of oxygen is the same inside and outside the cell.

Osmosis

You have read about the importance of water. Water molecules move through cell membranes by diffusion. The diffusion of water through a membrane is given a special name, **osmosis** (ahz-MOH-sihs). If the concentration of water is higher outside a cell than inside, water moves into the cell. If the concentration of water is lower outside a cell, water moves out of the cell.

You can easily observe the effect of osmosis on plants. If you forget to water a plant, it wilts. Why? The soil dries out, and the plant's roots have no water to absorb. As a result, water leaves the plant cells by osmosis and they shrink. If you water the plant, water becomes available to enter the shrunken cells by osmosis. The leaves will return to normal as water moves into the cells.

Without water, a plant droops. The cells have little water in their vacuoles, shown in blue. (magnified 1200×)

Water moves into leaf cells by osmosis and fills the vacuoles, shown in blue. (magnified 1200×)

Some transport requires energy.

Not all materials that move in and out of a cell can do so by diffusion. For cells to carry out life functions, materials must often move from areas of low concentration into areas of high concentration. This process of moving materials against a concentration requires energy.

OUTLINE
Remember to include the heading *Some transport requires energy* and notes on the red headings in your outline.

Active Transport

Active transport is the process of using energy to move materials through a membrane. This process is different from diffusion and other types of passive transport, which do not require energy.

CHECK YOUR READING How is active transport different from passive transport?

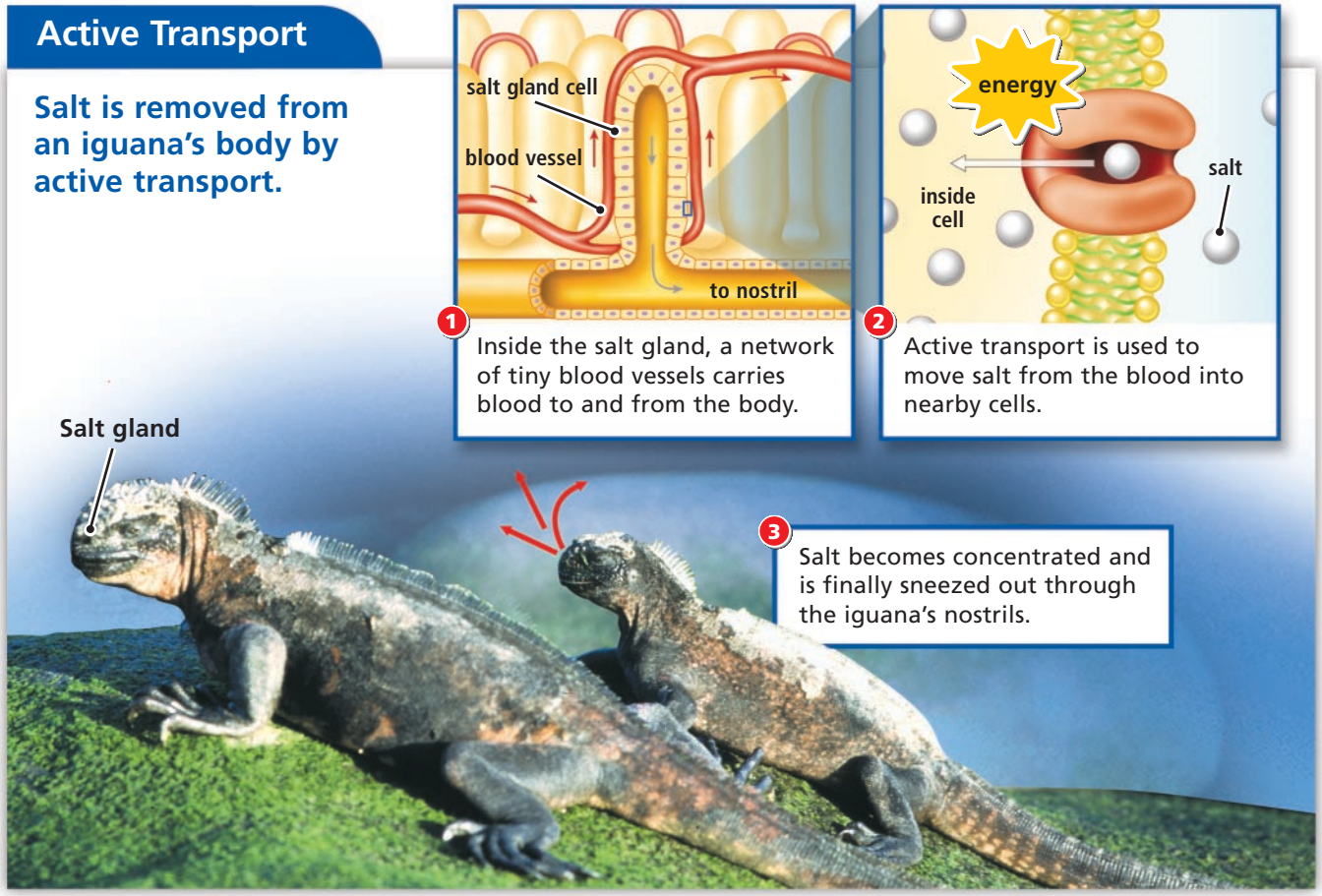
VISUALIZATION CLASSZONE.COM
Observe active transport at work.

Cells use active transport to perform important life functions, including the removal of excess salt from the body. Consider the example of active transport in marine iguanas, shown below. These lizards swim and feed in the salty ocean. As a result they soak up a lot of salt. Too much salt would seriously damage the iguanas' cells, so the cells must get rid of the excess.

The solution to the marine iguana's salt problem is found in two small glands above its eyes. Cells in these glands remove excess salt from the blood by active transport. Even when cells in these glands have a higher concentration of salt than that of the blood, the cells use chemical energy to continue taking salt out of the blood. The gland forms a droplet of salt, which the iguana easily blows out through its nostrils.

Active Transport

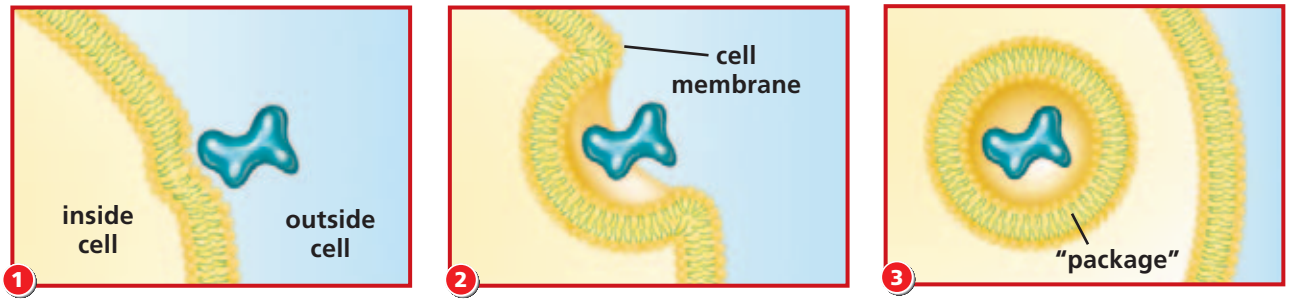
Salt is removed from an iguana's body by active transport.



You may not be able to blow salt out of your nostrils, but your kidneys help to keep healthy salt levels in your body. Kidneys filter wastes from your blood by active transport. Cells in the kidneys remove excess salt from the blood.

Endocytosis

Cells also need to move materials that are too large to go through the cell membrane or a protein channel. As the diagram below illustrates, endocytosis (EHN-doh-sy-TOH-sihs) occurs when a large bit of material is captured within a pocket of the membrane. This pocket breaks off and forms a package that moves into the cell. Cells in your body can use endocytosis to fight bacteria and viruses by absorbing them.



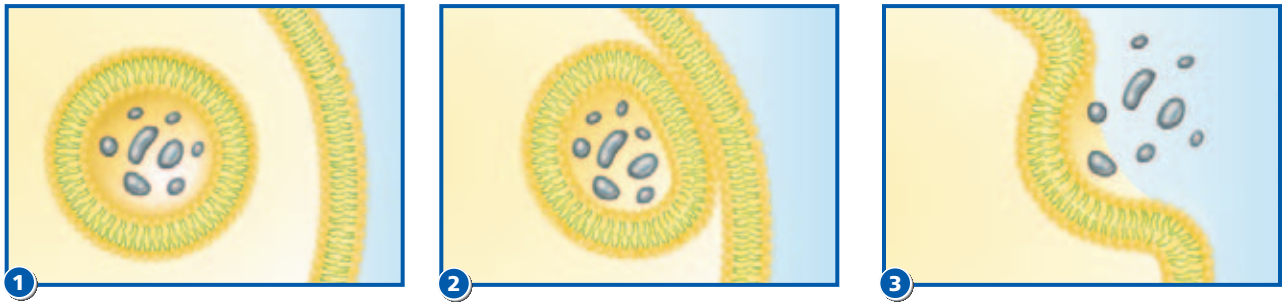
1 As a particle approaches, the cell membrane folds inward, creating a pocket.

2 The particle moves into the pocket, and the membrane closes around it, forming a "package."

3 The "package" breaks away from the cell membrane, bringing the particle into the cell.

Exocytosis

When a cell needs to get rid of large materials, the process of endocytosis is reversed. In exocytosis (EHK-soh-sy-TOH-sihs), a membrane within the cell encloses the material that needs to be removed. This package moves to the cell membrane, joins with it, and the material is expelled. Cells often use exocytosis to flush out waste materials or to expel proteins or hormones made by the cell.



1 A membrane-enclosed "package" carries materials from inside the cell to the cell membrane.

2 The membrane of the "package" attaches to the cell membrane, and the two membranes merge.

3 The materials are pushed out of the cell as the membrane of the "package" becomes part of the cell membrane.

Cell size affects transport.

Most cells are very small. In fact, most cells are too small to be seen without a microscope. The average cell in your body is about 50 micrometers (0.05 mm) in diameter. Most of the cells on this planet are bacteria, which are only 3 to 5 micrometers in diameter. How can something as important as a cell be so tiny? Actually, if cells were not so small, they could never do their jobs.

Everything the cell needs or has to get rid of has to go through the cell membrane. The amount of cell membrane limits the ability of cells to either get substances from the outside or transport waste and other materials to the outside. This ability is related to surface area. The relationship between surface area and volume controls cell size. As a cell gets larger, its volume increases faster than its surface area if the cell maintains the same shape. Why does this matter?

INVESTIGATE Cells

How does cell size affect transport?

Demonstrate how small size helps make it possible for cells to get resources.

SKILL FOCUS
Modeling

MATERIALS
- 2 hard-boiled, peeled eggs
- knife
- ruler
- 100 mL water
- glass beaker
- dark blue food coloring
- spoon
- paper towel

TIME
30 minutes

PROCEDURE

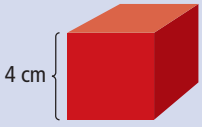
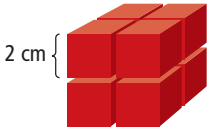
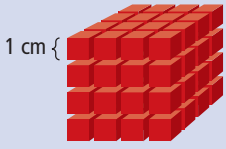
1. Cut a large piece of egg white from the egg.
2. Use a knife to trim the egg white into one small cube, about 1 cm square, and one large cube, about 2 cm square.
3. Pour 100 mL of water into the beaker. Add 10 drops of blue food coloring and stir. Place both cubes into the solution. Let both stand in the colored water overnight.
4. Remove each gently from the water with a spoon. Place both on a paper towel. With the knife, cut each in half. Use the ruler to measure how far the blue water penetrated into the surface of each one.

WHAT DO YOU THINK?

- Record your observations. Which piece of egg was penetrated more, compared to its total diameter, by the blue water?
- Why was there a difference in water penetration?

CHALLENGE What do you predict would happen to an egg left in its shell?

Surface Area and Volumes of Cubes

	Number of Cubes	Side Length	Surface Area	Volume
	1	4 cm	96 cm^2	64 cm^3
	8	2 cm	192 cm^2	64 cm^3
	64	1 cm	384 cm^2	64 cm^3

As the cell gets bigger, there comes a time when its surface area is not large enough to allow resources to travel to all parts of the cell. So the cell stops growing. Bird eggs and frog eggs are much larger than typical cells, but they have a storehouse of food and also rapidly divide to give rise to multicellular embryos. In fact, this multicellular embryo is a good illustration of another way cells get around the surface-area-to-volume problem: they divide. The ratio of surface area to volume in newly divided cells is much higher, giving more surface area for exchanging materials with the outside of cells.

A cell's shape also affects its surface area. For example, some single-celled organisms are thin and flat, providing increased surface area. Other cells, such as nerve cells and muscle cells, are long and skinny, which also gives them a higher ratio of surface area to volume.

READING TiP

Look at the chart above. Notice that the volumes are all the same, but the surface area changes.

2.3 Review

KEY CONCEPTS

1. How are the processes of diffusion and osmosis alike?
2. What is the difference between active and passive transport? Use the term *energy* in your answer.
3. How does the surface area of a cell limit the growth of the cell?

CRITICAL THINKING

4. **Apply** If you put a bouquet of carnations in water, through what process does the water enter the stems?
5. **Predict** If a marine iguana were to spend a few days in a freshwater tank, would it continue to blow salt droplets from its nostrils? Why or why not?

CHALLENGE

6. **Predict** Freshwater protozoa, which are unicellular organisms, have a greater concentration of salt inside them than does the surrounding water. Does water diffuse into or out of the protozoa?