

Guide for Reading

Focus on this question as you read:

▶ How do raw materials pass into cells and how do waste products pass out of cells?

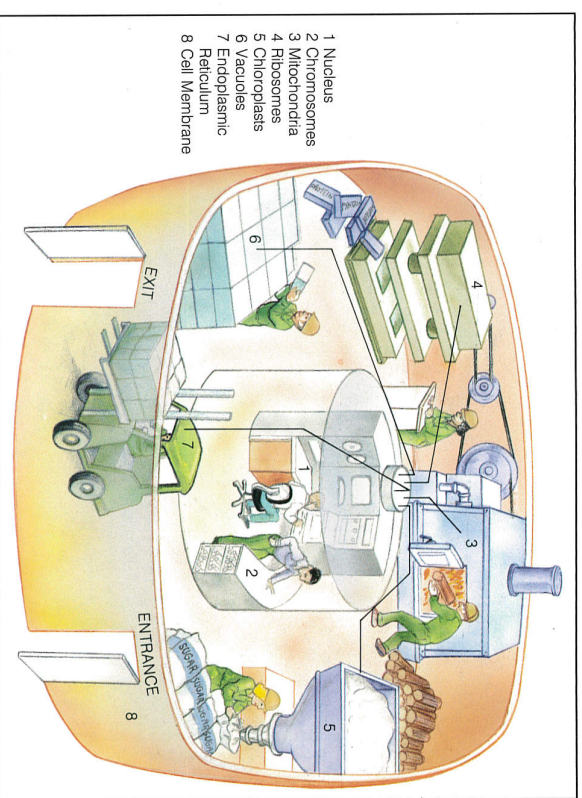
3-1 Moving Materials Into and Out of the Cell

Even while you sleep, you need energy to keep you alive. Where does this energy come from? Cells provide it. Although cells cannot make energy, they can change energy from one form to another. Cells obtain energy from their environment and convert it into a usable form. (You will learn more about cell energy in Chapter 4.)

The energy-conversion process in cells is very complex. It involves many chemical reactions. Some reactions break down molecules. Other reactions build new molecules. In Chapter 1 you learned that the sum of all the building-up and breaking-down activities that occur in a living cell is called metabolism.

Metabolism cannot just happen. In order for cells to perform their many functions, the parts of a

Figure 3-1 A cell is like a miniature factory that carries out all the activities necessary to life. Is the factory in the diagram a representation of a plant cell or an animal cell? How do you know?



need raw materials. And they also need to eliminate poisonous wastes. As you may recall from Chapter 2, the cell membrane forms a barrier between the inside of a cell and the outer environment. So it is a logical assumption (and a correct one) that materials must enter and leave a cell through the cell membrane. **Materials enter and leave a cell by one of three methods: diffusion, osmosis, or active transport.**

Diffusion

Although the cell membrane forms a protective barrier around the cell, it cannot be a total barrier. If it were, nothing could get into or out of the cell. Cell membranes in living things are permeable (per-me-uh-bil) membranes. A permeable membrane allows materials to pass through it. Because it is permeable, the cell membrane allows food molecules, oxygen, water, and other substances to enter or leave the cell. These materials pass through the pores (openings) in the cell membrane.

The driving force behind the movement of many substances into or out of a cell is called **diffusion** (dih-FYOO-zhun). **Diffusion is the process by which molecules of a substance move from areas of higher concentration of that substance to areas of lower concentration of that substance.**

Why does diffusion occur? Molecules of all substances are in constant motion, continuously colliding with one another. This motion causes the

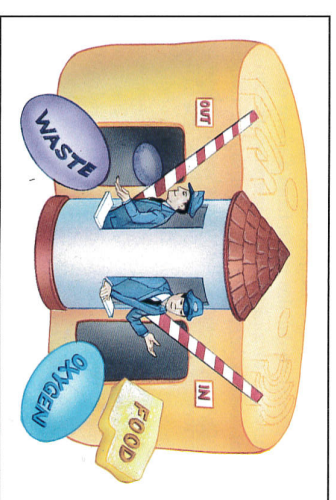


Figure 3-2 The cell membrane is selective, permitting oxygen and food molecules to enter and waste materials to leave.

ACTIVITY

DOING

Seeing and Smelling

Diffusion

You can see diffusion at work. To observe diffusion, drop some ink into a glass of water and watch what happens. Record and explain your observations.

You can also smell the effects of diffusion. To do so, open a perfume bottle or a bottle of ammonia at one end of a large room. Leaving the container open, move to the other end of the room. How can you tell if diffusion has occurred? Explain your answer.

Activity Bank

Coming and Going, p. 109

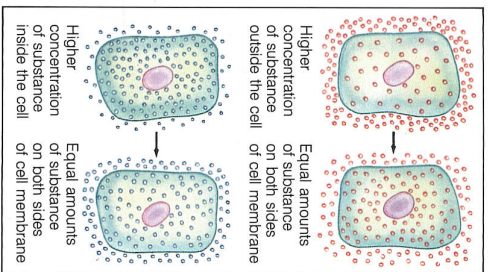


Figure 3-3 Diffusion is the movement of molecules of a substance into a cell (top) or out of a cell (bottom). Substances move from places where they are more concentrated to places where they are less concentrated.

molecules to spread out. The molecules move from an area where there are more of them (higher concentration) to an area where there are fewer of them (lower concentration). See Figure 3-3.

If there are many food molecules outside a cell, for example, some will diffuse through the membrane into the cell. At the same time, waste materials that build up in the cell will diffuse out of the cell.

If substances can move into and out of the cell through the cell membrane, why don't cell organelles and the cytoplasm do likewise? What keeps the ribosomes and mitochondria, for example, from passing out of the cell? And what keeps harmful materials from moving in? The answer is simple but quite elegant. The cell membrane is **selectively permeable**. That is, it permits only certain substances—mainly oxygen, water, and food molecules—to diffuse into the cell. Waste products such as carbon dioxide are allowed to diffuse out of the cell.

Osmosis

Water is the most important substance that passes through the cell membrane. In fact, about 80 percent of the cell is made of water. Water passes through the cell membrane by a special type of diffusion called **osmosis** (ahs-moh-sis). Osmosis is the diffusion of water into or out of the cell. During osmosis, water molecules move from a place of higher concentration to a place of lower concentration. This movement keeps the cell from drying out.

Suppose you put a cell into a glass of salt water. The concentration of water outside the cell is lower than the concentration of water inside the cell. This is because there are salt molecules taking up space in the salt water, so there are fewer water molecules. Water leaves the cell, and the cell starts to shrink. If too much water leaves the cell, the cell dries up and dies. Using this information, can you now explain why it is not a wise idea for a person to drink salt water—no matter how thirsty that person is?

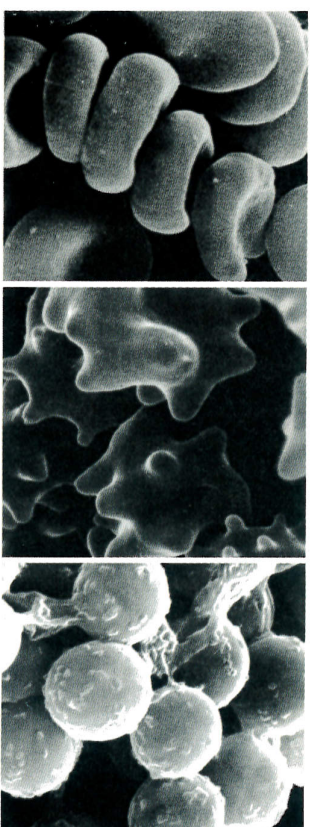


Figure 3-4 Normal red blood cells (left) will shrink (center) if too much water leaves the cells. If too much water enters the cells, the cells will swell (right). By what process does water move into and out of a cell?

If a cell is placed into a glass of pure, fresh water instead of salt water, just the opposite occurs. Water enters the cell, and the cell swells. This happens because the concentration of water is lower inside the cell than it is outside the cell. As you might imagine, if too much water enters the cell, the cell bursts. Do you remember the cell organelle called the vacuole that you read about in Chapter 2? Vacuoles store food and water for the cell. Some of these vacuoles are contractile vacuoles. As their name suggests, contractile vacuoles can contract, or become smaller. As contractile vacuoles that store water contract, they force excess water out of the cell through the cell membrane.

One of the neat things about diffusion and osmosis is that they do not require energy. That is, the movement of substances across the cell membrane does not require the cell to use up any of its energy reserves. The movement just happens whenever there are unequal concentrations inside and outside a cell. Sometimes, however, the cell must obtain raw materials that cannot diffuse through the cell membrane. At such times, the cell must use some of its available energy to get the materials it requires.

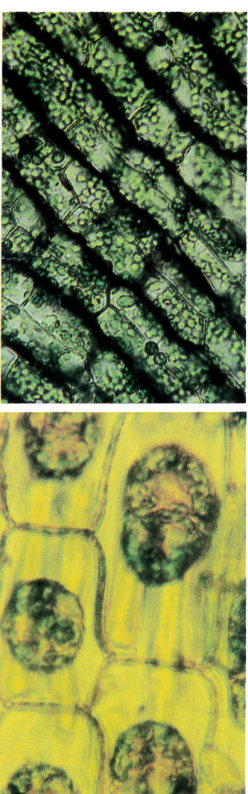


Figure 3-5 Notice how the organelles fill a normal plant cell (left). When too much water leaves the cell, the cell contents shrink away from the cell wall (right).

ACTIVITY

DISCOVERING

Dissolving Power

Many of the substances that diffuse through the cell membrane are dissolved in the watery fluids surrounding the cell. Do all substances dissolve in water?

■ Using several glass tumblers and common substances found around the home (salt, sugar, starch, flour, baking soda, and so on), determine what substances dissolve in water and what substances do not dissolve in water.

PROBLEM Solving

Shipwrecked!

It had been several days since the Peterson family was marooned on the island. Little did they know that their long-awaited sailing trip would end like this! Things had already been tough, but now they were going to get even tougher. The last of the supplies from their capsized sailboat was almost gone. And they were soon to run out of fresh water.

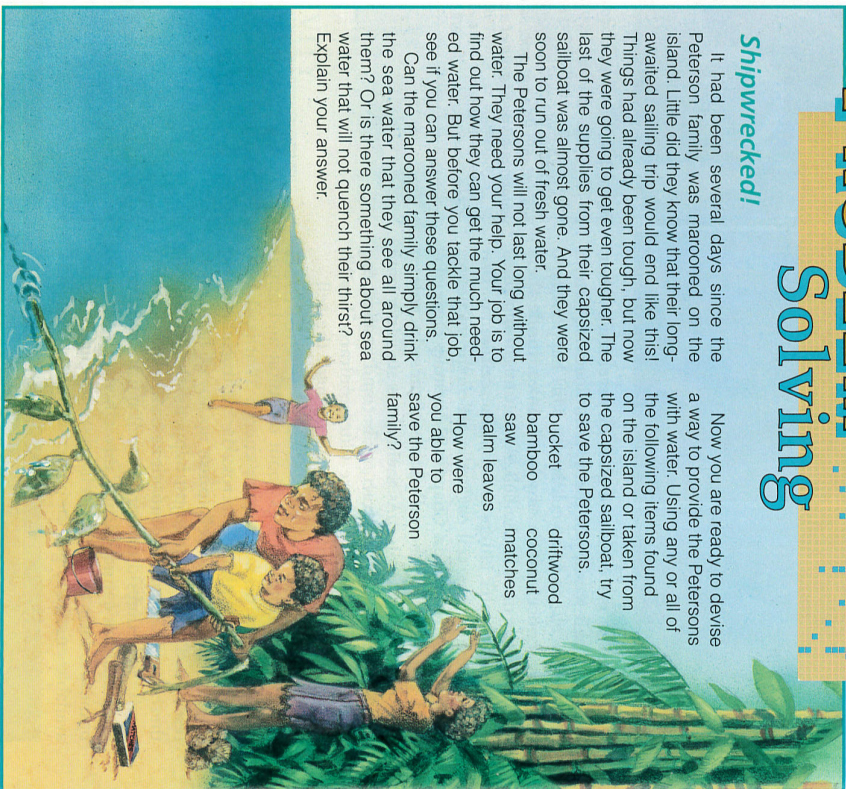
The Petersons will not last long without water. They need your help. Your job is to find out how they can get the much needed water. But before you tackle that job, see if you can answer these questions.

Can the marooned family simply drink the sea water that they see all around them? Or is there something about sea water that will not quench their thirst? Explain your answer.

Now you are ready to devise a way to provide the Petersons with water. Using any or all of the following items found on the island or taken from the capsized sailboat, try to save the Petersons.

bucket
bamboo
saw
palm leaves
driftwood
coconut
matches

How were you able to save the Peterson family?



Active Transport

As you have just learned, the cell membrane is selectively permeable. It can “select” the materials that will pass into or out of the cell. But what if the cell requires substances that cannot simply diffuse through the cell membrane because the membrane

is not permeable to those substances? Or what if the cell membrane is permeable, but the concentration of the substances outside the cell is not high enough to cause diffusion to occur? Is the cell out of luck? Not really. In both cases, the cell can use a process called **active transport** to “carry” the substance into the cell. Unlike diffusion and osmosis, however, active transport requires the cell to use some of its energy reserves.

There are several methods of active transport available to cells. In the most common method, special transport molecules in the cell membrane actually pick up the substance outside the cell and pull it through the cell membrane. Some substances needed by the cell that are carried in this manner are calcium, potassium, and sodium. Active transport is also used to eliminate substances inside the cell that cannot pass through the cell membrane by diffusion. Regardless of whether materials are passing into or out of the cell, the important thing to remember is that active transport requires energy. Unlike diffusion and osmosis, active transport does not just happen on its own.

3-1 Section Review

1. How do materials move into and out of a cell?
2. Compare diffusion, osmosis, and active transport.
3. Red blood cells require potassium to function properly. The concentration of potassium molecules inside a red blood cell, however, is usually higher than the concentration of potassium in the blood. Explain how potassium molecules are likely to enter a red blood cell.

Connection—Science and Technology

4. Waste products in the blood are filtered out by the kidneys. In the past, kidney failure always led to death because of the buildup of poisonous wastes in the blood. Today, however, doctors use dialysis machines to filter wastes out of the blood. Dialysis machines use artificial membranes. Are the membranes in a dialysis machine permeable or selectively permeable? Explain.



Figure 3-6 Amoebas use a form of active transport in which a large food particle is surrounded by pockets of the cell membrane. Once the food is surrounded, the pocket breaks away from the cell membrane and forms a vacuole within the amoeba.

ACTIVITY

DISCOVERING

Eggs-periment

Carefully peel two hard-boiled eggs. Obtain a string, a metric ruler, 2 beakers, some water, and salt.

- Using these materials, design and perform an experiment in which you show that during osmosis, water molecules move from an area of higher concentration to an area of lower concentration. (For best results, you should perform your experiment over a period of about five days.)