Name: Date: Class: 6

Chemical Activity in the Cell

INTRODUCTION TO THE CELL MEMBRANE

The inside of a single-celled organism is very much alive. However, the physical environment outside the cell is the opposite—a nonliving place where many changes occur. What stands between a cell and the sometimes hostile environment that surrounds it? An ultrathin, extremely important layer separates the living world inside a cell from the nonliving world outside. This is the **cell membrane**, or plasma membrane.

The cell membrane performs two primary, yet very different, functions: it separates the cell from its environment and it enables communication and movement of materials between the cell and its environment. (See Figure 6-1.) Without a cell membrane, there could be *no* cell. Protein molecules, which float within lipids in the membrane, enable much of the movement of materials across the cell membrane. These protein molecules often extend from one side of the membrane to the other.

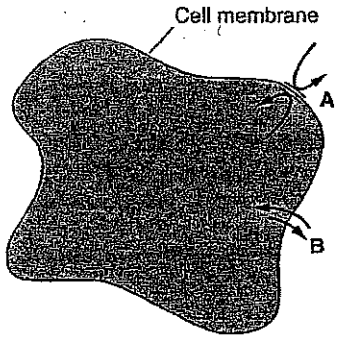


Figure 6-1 The cell membrane acts as a barrier, separating the inside of the cell from the outside (A) and as a bridge, allowing molecules to move in and out of the cell (B).

TRANSPORT ACROSS THE CELL MEMBRANE

For a cell to remain alive, it must have a very special collection of chemicals inside it. These chemicals may be quite different from the chemicals located in the outside environment. Some substances that are abundant outside the cell are not found inside the cell. Other substances that are scarce outside the cell are present in larger quantities inside the cell. The cell membrane creates and maintains this special environment inside the cell. *How does it do this?*

The cell membrane allows some substances—that is, molecules—to pass through but keeps other substances out. This ability to determine which molecules can pass through is called *selective permeability*. The cell membrane is selectively permeable—it determines which molecules move through it and whether the molecules go into or out of the cell. It also makes possible the rapid transport of some molecules across it, while other molecules pass through slowly.

PASSIVE TRANSPORT

Typically, there is an overall or net movement of molecules from an area of high concentration—a place where molecules are crowded together—to an area of low concentration. This kind of movement is called **diffusion**. Molecules are constantly in motion and they naturally move from where they are more concentrated to where they are less concentrated. This movement happens automatically with a cell if its membrane is permeable to the molecules and if there is a difference in concentration of the molecules on either side of the membrane. This is called passive transport, be-

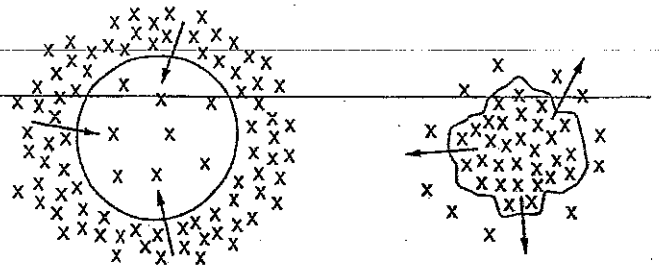


Figure 6-2 Diffusion is the movement of molecules from an area of higher concentration to an area of lower concentration.

cause no energy is used by the cell and no work is done. For example, one of the basic needs of most cells is oxygen. There are few oxygen molecules inside a cell, but there is usually an abundance of oxygen molecules in the water or other liquid that surrounds the cell. Thus, oxygen molecules diffuse across the cell membrane into the cell by passive transport. (See Figure 6-2.)

The diffusion of water molecules across a cell membrane—so important for living cells—is given a special name, *osmosis*. When plant cells are put in a strong salt solution, the abundant fresh water inside the plant cells automatically moves out of the cells, to where there is more salt and relatively fewer water molecules. Plant cell membranes can be seen pulling away from the cell walls as the cells lose water.

The reverse happens when limp celery stems are put in fresh water. The celery stems are limp because their cells have too little water in them. When the celery is put in the water, osmosis occurs and water molecules move into the cells. The cells expand, the cell membranes push against the cell walls, and the cells—and thus the celery stems—become firm again.

ACTIVE TRANSPORT

The movement of a substance against the concentration gradient is known as **active transport.** When substances are moved from an area of low concentration to an area of high concentration, energy is used and work is done. This kind of transport of materials across the cell membrane is one of the most important activities of cells. Other than using energy from your food to keep you warm, the most important use of energy in your body is to help pump substances across the membranes of your cells by active transport—a process that goes on all the time.

Multiple Choice

1. An important role of the cell membrane is to
   1 store materials, including all wastes
   2 separate the inside of a cell from the outside
   3 change the rate at which chemical reactions occur
   4 construct proteins for the cell

2. The cell membrane is said to be selectively permeable because it
   1 is ultrathin and flexible
   2 changes its shape and structure over time
   3 allows only certain molecules to move through it
   4 allows all molecules to pass through it, but only very slowly

3. What happens during diffusion?
   1 Molecules move automatically from an area of higher concentration to an area of lower concentration.
   2 Molecules are pumped from an area of lower concentration to an area of higher concentration.
   3 An enzyme joins with a particular molecule.
   4 A catalyst speeds up the rate of a chemical reaction.

4. During passive transport,
   1 the cell uses energy to move molecules across the cell membrane
   2 molecules move across the cell membrane without the cell using any energy
   3 the cell uses energy to break chemical bonds
   4 chemical bonds are broken without the cell using any energy

5. A plant cell shrinks when placed in salt water due to the osmosis of
   1 water molecules out of the cell
   2 water molecules into the cell
   3 salt into the cell
   4 salt out of the cell

6. Placing limp celery in water will make the celery stalk firm again due to
   1 diffusion
   2 osmosis
   3 active transport
   4 catalyst

7. A high concentration gradient means that the concentration of a substance is

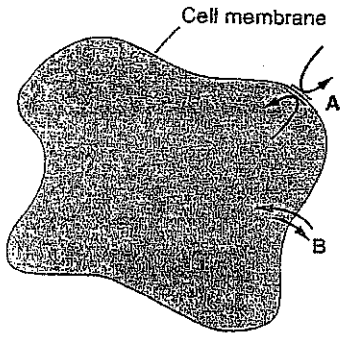
1 low on both sides of the cell membrane
2 high on both sides of the cell membrane
3 about the same on both sides of the cell membrane
4 high on one side of the cell membrane and low on the other side

8. What happens during active transport?

1 Substances are moved from areas of high concentration to areas of low concentration.
2 Substances are moved from areas of low concentration to areas of high concentration.
3 Enzymes are moved to join particular molecules.
4 Substances are moved throughout the cytoplasm.

Thinking and Analyzing

Refer to the diagram below to answer questions 9 and 10



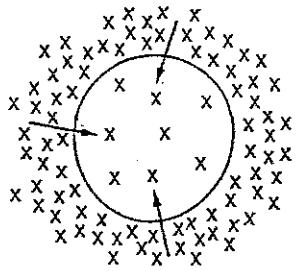
9. Which part of the diagram shows the cell membrane acting to separate the inside of the cell from the outside?

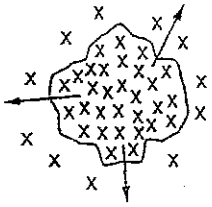
1 A only
2 B only
3 both A and B
4 neither A nor B

10. Which part of the diagram shows the cell membrane acting to allow materials into and out of the cell?

1 A only
2 B only
3 both A and B
4 neither A nor B

Refer to the diagrams below to answer questions 11 and 12.





11. The diagrams represent the movement of molecules from an area of

1 low concentration to an area of high concentration
2 high concentration to an area of low concentration
3 low concentration to an area of low concentration
4 high concentration to an area of high concentration

12. The diagrams could be used to illustrate all of the following types of transport *except*

1 diffusion
2 osmosis
3 active
4 passive

13. Discuss the meaning of "selective permeability" for a cell membrane. Your answer should explain the following:
    - Why the cell membrane is said to be selectively permeable
    - Why this characteristic is important to the health of a cell

14. The following three terms are related to forms of transport across a cell membrane: diffusion; osmosis; passive transport. Identify the one term that includes the other two. Is energy used by the cell in any of these processes? Explain both of your answers.

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B. CELL MEMBRANE. The ***cell membrane*** (or **plasma membrane**) is a double-layered structure that surrounds the cell. It provides a boundary between the cell and its environment. In animal cells it is the outside cell border and in plant cells it is located inside the cell wall (Figure 5-1). The function (job) of the membrane is to regulate or control the passage of materials into and out of the cell and to help maintain cell shape. The cell membrane is **semi-permeable**, that is, some substances can pass through it and others cannot. Because it is involved with the passage of materials into and out of the cell *the cell membrane is part* of the transport system. The selectivity of the cell membrane allows particular substances to pass through some of the time but not other times. The selective permeability of cell membranes aids cells in maintaining homeostasis.

The currently accepted model (representation) of cell membrane structure is called the **fluid-mosaic model.** According to this model the cell membrane is made up of a double lipid layer containing large floating protein molecules (Figure 5-2). *Various kinds of small* molecules, such as water and carbon dioxide, can easily pass through the cell membrane. Most large molecules, such as proteins and starch, cannot pass through the membrane. These substances must be digested before they can enter or leave a cell. In addition to molecular size, factors that *affect the passage of molecules* through the cell membrane are electrical charge and solubility in fats.

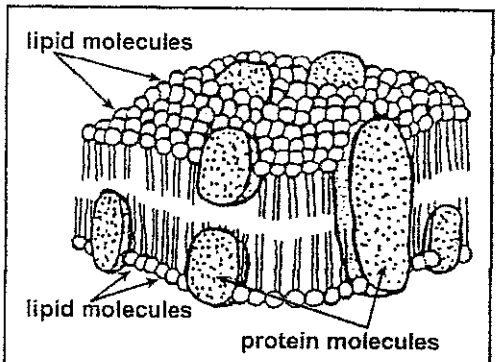

FIGURE 5-2. FLUID-MOSAIC MODEL.

The cell membrane has both passive and active roles in transporting materials into and out of cells. The passage of materials through the cell membrane without the use of energy by the cell is called **passive transport.** Passive transport most commonly involves **diffusion**—the movement of *molecules or ions from an area of high* concentration to an area of low concentration. Diffusion occurs because the molecules and ions are in constant random motion. Where there are many particles (areas of high concentration) the particles bump into each other and bounce off in all directions. In this way they spread out to areas of low concentration. The difference in concentration between two areas is called the **concentration gradient.** Eventually the particles become evenly distributed in the space. At that point **equilibrium** is reached and there is no further net change in concentration. *Equilibrium occurs when equal numbers of* particles move into and out of an area. The diffusion of water through a membrane is called **osmosis.**

Active transport is a process in which cellular energy is used to move particles through a membrane. This movement occurs from a region of lower concentration toward a region of higher concentration. The movement is against the concentration gradient. Carrier proteins that are embedded in the cell membrane help in the transport of materials. **Pinocytosis** and **phagocytosis** are two types of active transport processes. In pinocytosis large *dissolved* molecules are taken into the cell by the formation of vacuoles. The cell membrane forms an indentation containing

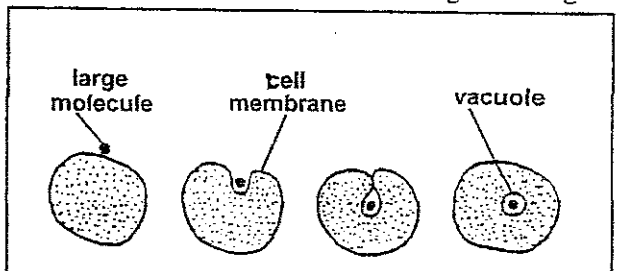

FIGURE 5-3. PINOCYTOSIS.

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the molecule to be taken in (Figure 5-3). This folded in section of the cell membrane then pinches off inside the cell forming a vacuole. In phagocytosis the cell surrounds and engulfs large *undissolved* particles by flowing around them and enclosing them in a vacuole.

Review Questions

1. Describe the cell membrane. _____

2. Explain the following terms:

   passive transport _____

   diffusion _____

   equilibrium _____

   osmosis _____

   active transport _____

   pinocytosis _____

   phagocytosis _____

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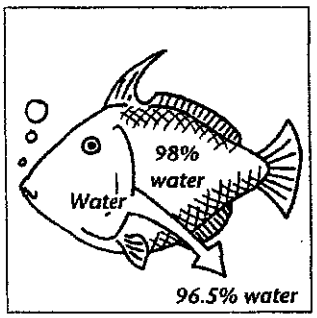
SECTION 2-2 REVIEW AND REINFORCE

The Cell in Its Environment

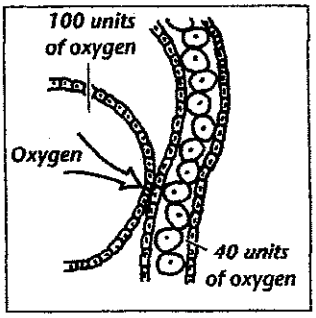
◆ Understanding Main Ideas

Fill in the blank to identify the process illustrated in each of the following figures.



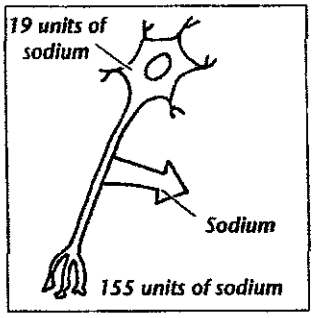
Water moves out of the cells of a saltwater fish and into the ocean.

1. _____



Oxygen moves from the lungs into the bloodstream.

2. _____



Sodium is pumped out of a nerve cell.

3. _____

Answer the following questions on a separate sheet of paper.

4. Explain how osmosis differs from diffusion.

5. Compare and contrast active and passive transport.

6. Identify two methods of active transport.

◆ Building Vocabulary

If the statement is true, write true. If the statement is false, change the underlined word or words to make the statement true.

_____ **8.** If a membrane is <u>selectively permeable</u>, it lets some but not all substances pass through.

_____ **9.** <u>Osmosis</u> is the process by which molecules tend to move from an area of higher concentration to an area of lower concentration.

_____ **10.** The process by which water moves across a selectively permeable membrane is called <u>diffusion</u>.

_____ **11.** Diffusion and osmosis are types of <u>active transport</u>.

_____ **12.** <u>Passive transport</u> requires energy.