The Cell Membrane

The **cell membrane** is a thin structure that surrounds the cell. It is made mainly of fats (lipids), with some proteins embedded throughout. Some of the functions of the cell membrane include

- separating the contents of the cell from the outside environment
- controlling the transport of materials—including waste products—into and out of the cell
- recognizing and responding to chemical signals

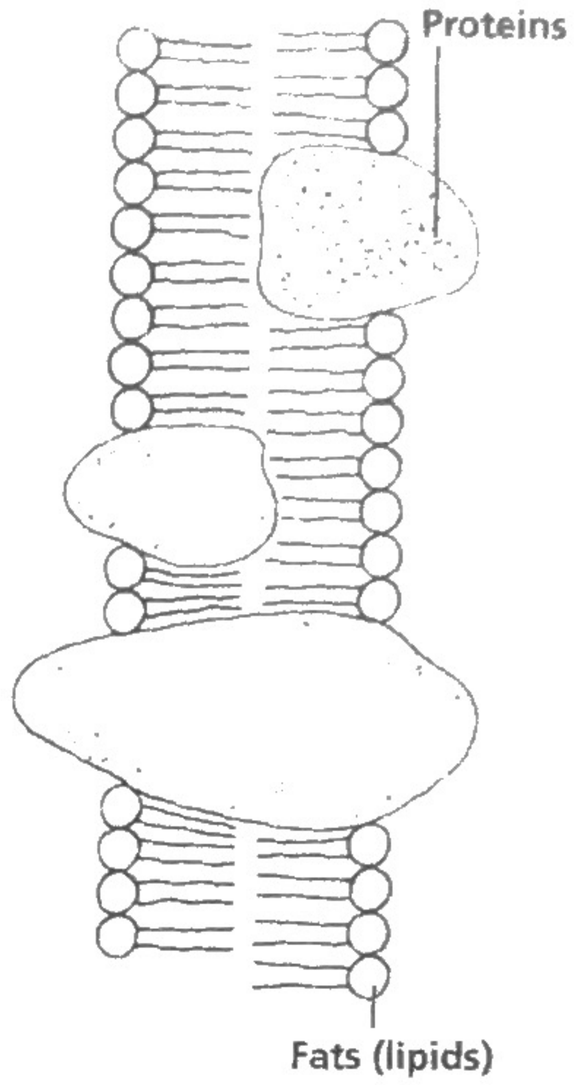


Figure 1-3. The cell membrane

Maintaining Separation Cells are organized internally. Without the cell membrane, this organization would be lost.

Unlike animals, plants and most bacteria and fungi have a cell wall outside the cell membrane. This wall of plant cells is made of nonliving material (a carbohydrate called cellulose) that surrounds the cell and gives it strength and rigidity. If the plant gains too much water, its membranes could burst. The cell wall helps prevent this.

Controlling Transport In and Out of the Cell If the cell is to survive, the membrane cannot totally separate the cell from its environment. Some materials, such as water, oxygen, and nutrients, must pass through the membrane and into the cell. Other materials, such as waste products, must pass out of the cell. Molecules can enter or leave a cell through either diffusion or active transport.

Diffusion Molecules are constantly in motion. As they jiggle, they bump into one another, then bounce away like bumper cars at an amusement park. In time, the molecules will have bumped and bounced until they are evenly distributed. The result is that the concentration of molecules in any container remains approximately the same everywhere in the container.

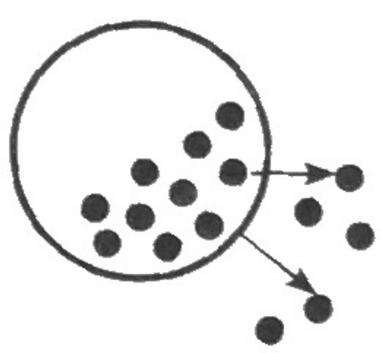


Figure 1-4. Diffusion: These molecules are moving from an area of high concentration to an area of low concentration.

However, when the concentration of molecules is greater in one part of a substance, molecules will spread into areas where their concentration is lower. This movement of molecules from areas of high concentration to areas of low concentration is called **diffusion.** (See Figure 1-4.) Because diffusion results from the normal jiggling of molecules, it requires no outside energy. It is like sledding downhill.

Many molecules diffuse into and out of cells. One of the most important of these molecules is water. The diffusion of water into and out of cells is important to the maintenance of homeostasis. For example, plant cells maintain a stable balance of water and dissolved minerals. This is typically about 98% water and 2% dissolved materials. When salt is spread on roads and walkways, that balance changes. The runoff water from these salted roads may reach concentrations of 5% salt (which means only 95% water). Damage can occur when water in the plant cells diffuses from the higher (98%) concentration in the cell to the lower (95%) concentration outside the cell. Under these conditions, the loss of water places serious stress on the plant. In some cases the plant may die.

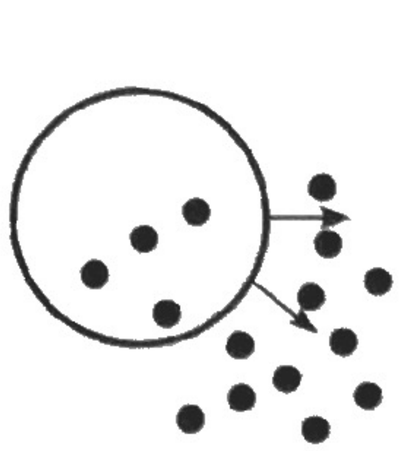


Figure 1-5. Active transport: These molecules are moving from an area of low concentration to an area of high concentration.

Active Transport Moving a molecule from an area of low concentration to an area of high concentration is like pulling a sled uphill. (See Figure 1-5.) It requires energy. Cells must use energy from ATP to transport molecules

from areas of low concentration through the cell membrane to areas of high concentration. The process is called **active transport.**

Many desert plants use active transport to bring water (which is at low concentrations in the soil) into root cells where the water concentration is higher. Some pond organisms use active transport to "collect" calcium or other minerals that are in very low concentrations in the pond water.

Molecules in Cells Both organic and inorganic substances are dissolved in cells and are involved in the chemical reactions that maintain life. Some organic molecules, such as proteins and starches, are too large and complex to enter the cell. Large molecules must first be broken down into simpler molecules in the process known as **digestion**.

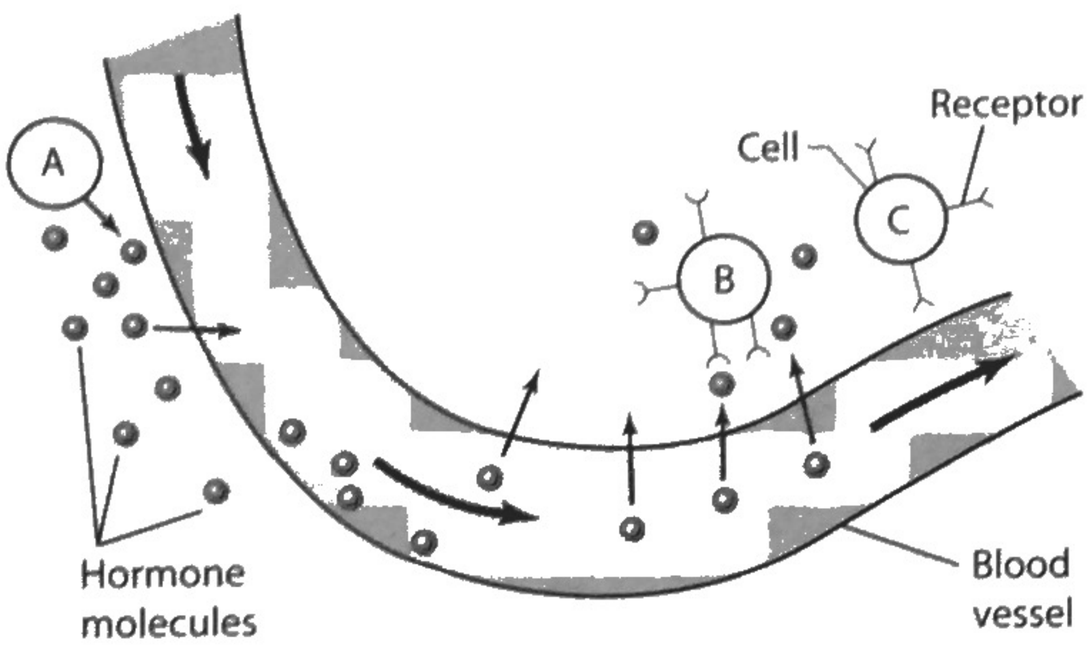


Figure 1-6. Receptor molecules: Specific receptor molecules on the membranes of some cells detect hormones that stimulate the cell to respond. In this case, only cell B (not cell C) will respond to the hormone from cell A.

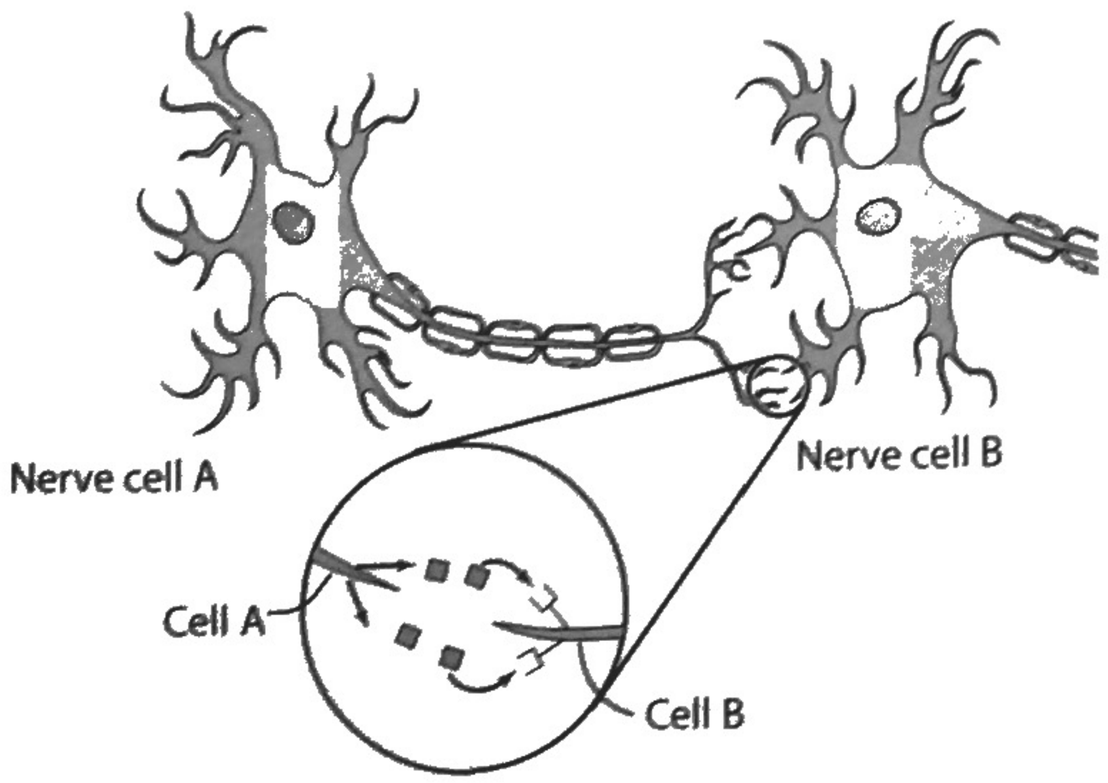


Figure 1-7. Receptor molecules: Nerve cells secrete chemicals that signal adjacent nerve, muscle, or gland cells. These secretions are detected by specific receptor molecules on cell membranes.

The digestion of proteins results in smaller molecules of **amino acids;** the digestion of starches results in **simple sugars.** Digestion is vital because only small molecules, such as amino acids and simple sugars, can enter blood vessels or cells.

When some nutrients from our food enter a cell, they become the building blocks of compounds necessary for life. This process, called cell synthesis, is like manufacturing. Simple molecules (such as amino acids and sugars) are assembled or reassembled into more complex molecules of proteins, starches, DNA, or other substances necessary for life.

Not all nutrients are used as building blocks. Some nutrients that enter a cell are broken down even more to release the energy stored in their chemical bonds. This is the process of cell respiration. All of these processes will be reviewed in detail in later topics.

Recognizing Signals Scientists have learned that certain protein molecules in the cell membrane can receive chemical messages from other cells. These molecules are called **receptor molecules.**

When cells are part of a larger organism, receptor molecules play an important role in the interactions between cells. As shown in Figures 1–6 and 1–7, chemicals produced in the endocrine glands—**hormones**—and chemicals produced by nerve cells are primarily responsible for communication between cells. If nerve or hormone signals are blocked, cellular communication is interrupted, and the organism's homeostasis may be affected.

Review Questions

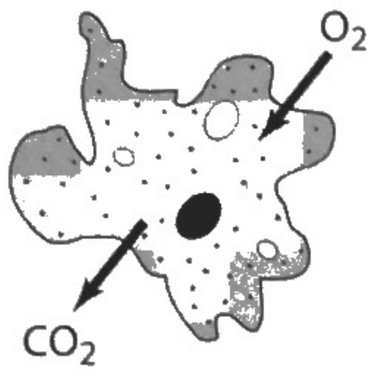
20. Defective receptor proteins on a cell membrane have the *least* effect on

(1) homeostasis
(2) muscle activity
(3) nerve signals
(4) diffusion

21. In the following diagram, nerve cell A is communicating with nerve cell B. Identify the structures present on the membranes of nerve cell B that enable it to detect a message from nerve cell A.

22. Which process accomplishes the movement of gases illustrated by the arrows in the diagram?

(1) excretion
(2) diffusion
(3) active transport
(4) chemical digestion



23. In both plant and animal cells, the cell membrane

(1) produces enzymes
(2) controls reproduction
(3) is composed of sugars
(4) regulates diffusion

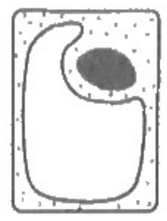
24. Since the relative concentration of water in the pond in which a paramecium (a single-celled organism) lives is greater than the concentration of water in its cytoplasm, water molecules constantly move from the pond into the paramecium. The best long-term solution to the problem of maintaining a stable internal environment is for the paramecium to

(1) change the water into carbon dioxide and excrete it
(2) store water molecules
(3) incorporate water molecules into its structure
(4) actively transport water molecules out of its cell

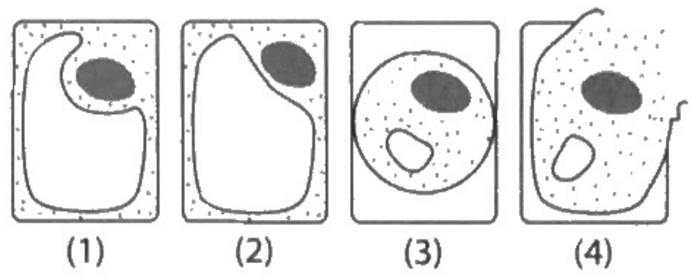
25. A biologist diluted a blood sample with distilled water. While observing the sample with a microscope, she noted that the red blood cells had burst. This bursting is most likely the result of which process?

(1) staining
(2) diffusion
(3) digestion
(4) active transport

26. A student using a compound light microscope to study plant cells observed that most of the cells resembled the one shown in the following diagram.



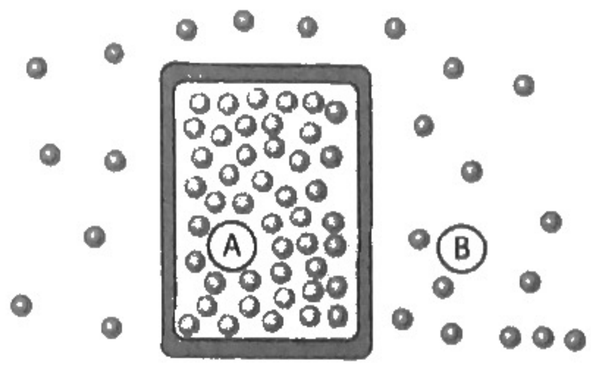
Which diagram best illustrates how the plant cell will appear after being placed in a solution that has a lower water concentration than the cell?



27. Amino acids tend to diffuse from a blood capillary to the adjacent cell because

(1) this is the only direction they can move
(2) the brain directs the movement into cells
(3) the cell needs the amino acids to make protein
(4) the concentration of amino acids is lower in the cell

28. In the following diagram of a plant cell, the small circles represent water molecules.



Which statement *best* describes the behavior of most of these water molecules?

(1) They move from region A to region B.
(2) They move from region B to region A.
(3) They do not move in either direction.
(4) Their overall movement is equal in both directions.

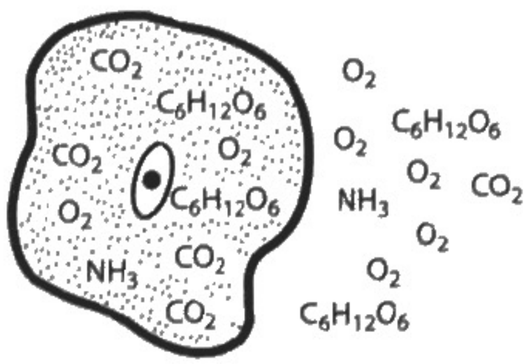
29. Nutrients that are not used as building blocks for the cell may be broken down to release the energy stored in their chemical bonds. This process, which provides cells with energy, is called

(1) chemical synthesis
(2) cell respiration
(3) digestion
(4) homeostasis

30. Cytoplasm in a plant cell will shrink if the cell is

(1) placed in a concentrated salt solution
(2) kept warm and moist and in medium light
(3) placed in distilled water
(4) exposed to a different concentration of nitrogen gas

31. The diagram below represents a cell in water. Formulas of molecules that can move freely across the membrane are shown. Some molecules are located inside the cell and others are in the water outside the cell.



Based on the distribution of molecules, what would most likely happen to these molecules after a few hours?

(1) The concentration of $C_6H_{12}O_6$ will increase inside the cell.
(2) The concentration of CO_2 will increase outside the cell.
(3) The concentration of NH_3 will increase inside the cell.
(4) The concentration of O_2 will increase outside the cell.

32. A cell containing 98% water in its cytoplasm is placed in a 2% salt solution. It should

(1) lose water
(2) gain water
(3) neither lose nor gain water
(4) gain salt because of the high rate of diffusion

33. A cell is placed in distilled water and then transferred to a 5% salt solution. As a result of this procedure, the cell would be likely to

(1) get larger
(2) get smaller
(3) get larger, then smaller
(4) get smaller, then larger

34. A high concentration of calcium salts is normally found within the cytoplasm of a certain protozoan, while the surrounding environment contains a lower concentration of the calcium salts. The higher concentration in the protozoan is most probably the result of

(1) diffusion
(2) excretion
(3) active transport
(4) cellular dehydration

35. A student prepared a normal wet mount slide of an *Elodea* leaf and observed it with a compound microscope. He then made drawing A from his observations. His second drawing, B, shows his observations of the same cell after it was mounted in a 5% salt solution.

The results are most fully explained by

(1) loss of water from the cell
(2) entrance of water into the cell
(3) shrinkage of the cell wall
(4) entrance of salt into the cell