

The Cell Membrane



Collaborate Think about another system that controls inputs and outputs. Why is it necessary to control inputs and outputs in this system?

To maintain homeostasis, cells need to take in some substances while expelling others. But how do cells manage the import and export of materials? The **cell membrane**, or plasma membrane, has a specialized structure that allows the cell to control the passage of materials into and out of the cell. Different types of carbon-based molecules, including lipids, proteins, and carbohydrates, make up the cell membrane.

Cell Membrane Structure

The cell membrane consists of a double layer of phospholipids. The hydrophilic heads of the phospholipids face the watery environment outside the membrane, and the hydrophobic tails face the inside of the membrane. However, the types of substances that could pass through the membrane, and their rates of passage, would be quite limited if the membrane was only composed of phospholipids. To solve this problem, the cell membrane also contains carbohydrates, proteins, and cholesterol.

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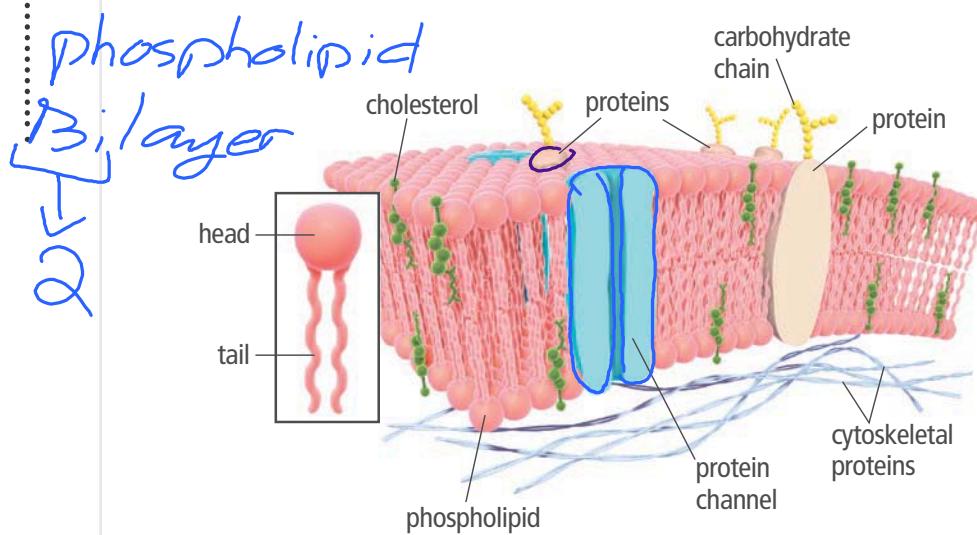


Hands-On Lab



Modeling the Cell Membrane

Membrane Make a model to investigate the properties of the cell membrane.



A cell membrane needs multiple passageways for substances to enter and exit the cell. This task is accomplished by proteins. Some proteins embedded in the phospholipid bilayer transport materials across the membrane. Others, in the form of enzymes, speed up chemical reactions that take place on the membrane. Still others act as receptors for specific molecules, such as hormones.



Explain How do the structures within the cell membrane help the cell function within a larger system?

Carbohydrates on the cell membrane serve as identification tags, which allow cells to distinguish one type of cell from another. They also enable neighboring cells to adhere to each other. Cholesterol gives strength to the cell membrane by limiting the movement of the phospholipids, preventing the membrane from becoming too fluid. Cholesterol also protects the cell membrane at low temperatures by preventing it from becoming solid if the cell is exposed to cooler than normal temperatures.

The structure of the cell membrane gives it the property of selective permeability. This means it allows some, but not all, materials to cross. Selective permeability enables a cell to maintain stable conditions in spite of unpredictable, changing conditions outside the cell. Molecules and other materials cross the membrane in several ways. Some of these methods require the cell to expend energy; others do not. How a particular molecule crosses the membrane depends on the molecule's size, polarity, and concentration inside versus outside the cell.



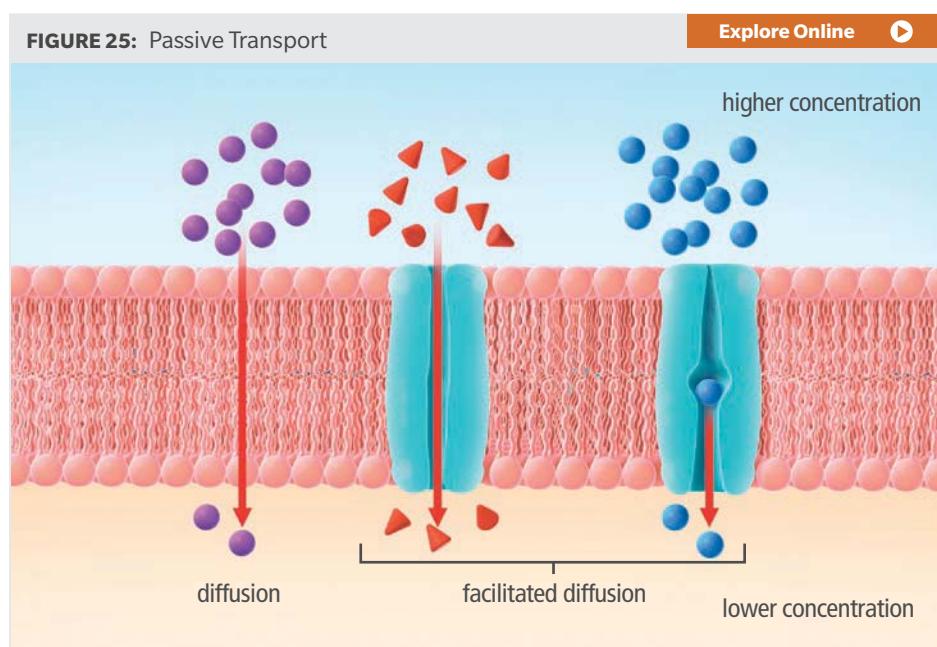
Model Draw a model to illustrate the concept of a semipermeable membrane.

Passive Transport

Cells almost continually import and export substances across the cell membrane. If they had to expend energy to move every molecule, cells would require an enormous amount of energy to stay alive. Fortunately, some molecules enter and exit a cell without energy input from the cell in a process called passive transport. This type of transport results from the diffusion of molecules across a membrane.

Diffusion

Diffusion is the movement of molecules in a fluid or gas from a region of higher concentration to a region of lower concentration. It results from the natural motion of particles, which causes molecules to collide and scatter. Concentration is the number of molecules of a substance in a given volume. A concentration gradient is the difference in the concentration of a substance from one location to another. Molecules diffuse down their concentration gradient—that is, from a region of higher concentration to a region of lower concentration.



Analyze Compare and contrast the way molecules move in diffusion and facilitated diffusion. Discuss concentration and mode of transport across the membrane.

Some molecules cannot simply diffuse across a membrane. Facilitated diffusion is the diffusion of molecules across a membrane through transport proteins. Some proteins form openings, or pores, through which molecules can move. Other proteins bind to specific molecules to be transported on one side of the membrane. When the correct molecule binds, these proteins change their shape, and this allows the molecule to pass through the membrane to the other side. Each protein in the membrane is specific to a certain type of molecule or particle.



Hands-On Lab

MATERIALS

- beaker, medium (3)
- food coloring
- hot plate
- ice
- timer
- water



Heat and Diffusion

You can see diffusion in action when you add food coloring to water. In this lab, you will measure the rate of diffusion in water at three different temperatures.



Predict Which solution will have the greatest rate of diffusion: a hot, cold, or room-temperature one? Explain your answer.

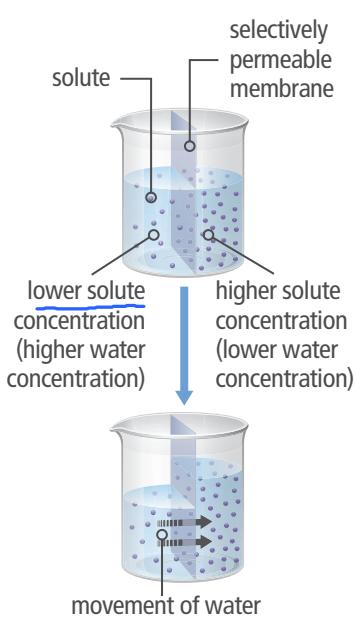
PROCEDURE

1. Place the same amount of water in three beakers.
2. Place Beaker 1 on the hot plate until it is warm, but not boiling. Place Beaker 2 in an ice bath or refrigerator. Leave Beaker 3 at room temperature.
3. With the timer ready, add one drop of food coloring in the room-temperature water. Record how long it takes the food coloring to evenly disperse throughout the solution. Repeat for the other two solutions.
4. Record your data in a data table.

ANALYZE

1. How could you tell that molecules were diffusing in this lab?
2. In which solution did diffusion occur most rapidly?
3. Explain your results in terms of the movement of water and food coloring molecules in each beaker. How did temperature affect this movement?

FIGURE 26: Osmosis is the movement of water toward areas of higher solute concentration.



Osmosis

Water molecules, of course, also diffuse. They move across a semipermeable membrane from an area of higher water concentration to an area of lower water concentration. They are also moving from an area of lower solution concentration to an area of higher solution concentration. This process is called osmosis. It is important to recognize that the higher the concentration of dissolved particles (solutes) in a solution, the lower the concentration of water molecules in the same solution. The membrane is only permeable to some solutes, so water must cross the membrane to equalize the concentrations of the two solutions.

Plants use osmosis to move water into the cells of their roots. Proteins in the cell membranes of root cells transport certain molecules into the cell. These molecules become more highly concentrated on the inside of the root cells than outside, and water follows the molecules into the cells. Water is always drawn toward areas of higher solute concentration.



Model Red blood cells burst when placed in pure water. Draw a model explaining this phenomenon. Label semipermeable membrane, solute concentration, and movement of water on your model.

Active Transport

Sometimes a cell must move a substance against a concentration gradient in order to maintain homeostasis. Then it must use a process called active transport. Active transport drives molecules across a membrane from a region of lower concentration to a region of higher concentration using transport proteins. Unlike facilitated diffusion, the activity of transport proteins must be powered by chemical energy. An input of energy is necessary because the transport proteins have to overcome the natural tendency of substances to move with a concentration gradient. ATP often provides the energy for active transport.

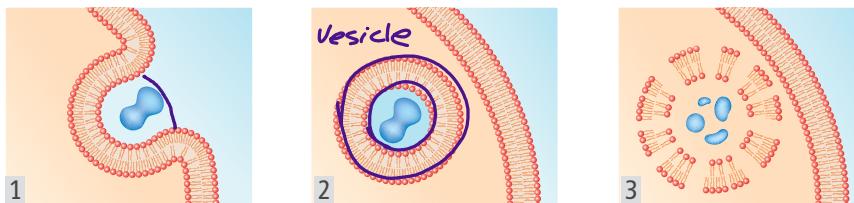
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Endocytosis

A cell may also use energy to move large substances across the cell membrane using vesicles. Endocytosis is the process of taking liquids or fairly large molecules into a cell by engulfing them in a membrane. The cell membrane folds inward around the substance and pinches off inside the cell, forming a vesicle. The vesicle then fuses with a lysosome or similar vesicle. The vesicle membrane and content are broken down (if necessary) and released into the cell.

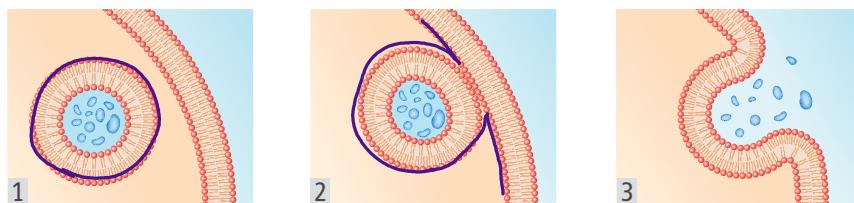
FIGURE 28: Endocytosis allows cells to take in materials.



Exocytosis

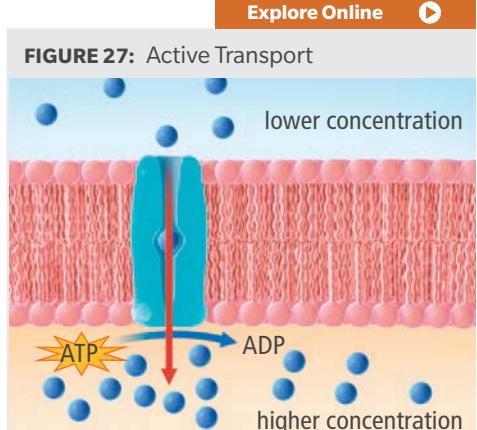
Exocytosis is the release of substances out of a cell by the fusion of a vesicle with the membrane. A vesicle forms around materials to be sent out of the cell. The vesicle then moves toward the cell's surface, where it fuses with the membrane and releases its contents.

FIGURE 29: Exocytosis allows cells to expel materials.



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FIGURE 27: Active Transport



Analyze Make a table to compare passive and active transport in terms of energy, concentration, and the role of proteins in the membrane.



Predict Which would be more likely to carry out endocytosis: a white blood cell engulfing foreign materials or a cell that excretes hormones? Explain.



Explain Cystic fibrosis is a disease that occurs when a protein that normally transports ions across the cell membrane does not function properly. A change to the tertiary structure of the protein prevents it from transporting chloride ions out of cells. This leads to a lack of water outside the cells, which causes a sticky mucus to form in the lungs. Explain how diffusion and osmosis are related to the symptoms of cystic fibrosis.