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Cells and Their Environment

Section 1: Passive Transport

Objectives

- **Relate** concentration gradients, diffusion, and equilibrium.
- **Predict** the direction of water movement into and out of cells.
- **Describe** the importance of ion channels in passive transport.
- **Identify** the role of carrier proteins in facilitated diffusion.

Diffusion

- One way cells maintain homeostasis is by controlling the movement of substances across their cell membrane.
- Cells must use energy to transport some substances across the cell membrane.
- Other substances move across the cell membrane without any use of energy by the cell.

Random Motion and Concentration

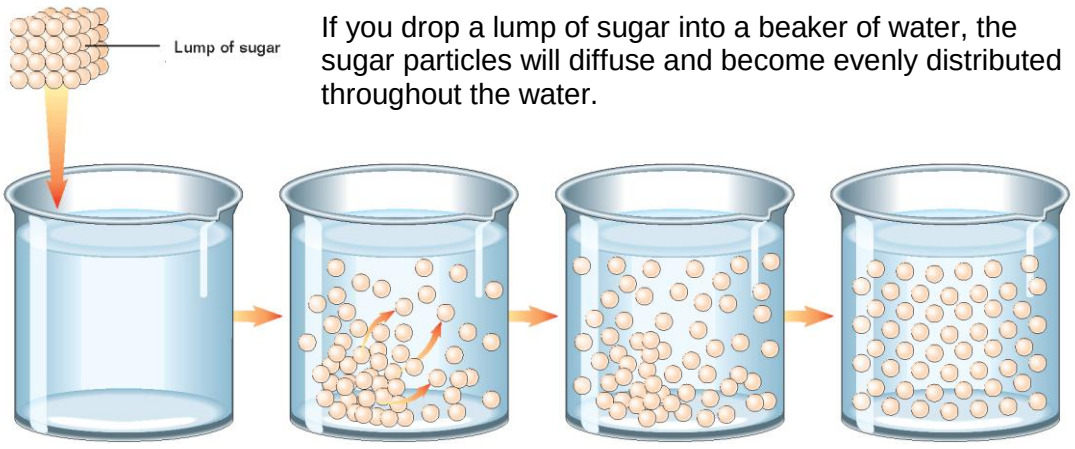
- Movement across the cell membrane that does not require energy from the cell is called **passive transport.**
- A difference in the concentration of a substance, such as the balls, across a space is called a **concentration gradient.**
- **Equilibrium** is a condition in which the concentration of a substance is equal throughout a space.

Equilibrium I

- Equilibrium is a condition of balance.
- Changes in temperature, pressure or concentration can cause a shift in the equilibrium.

Movement of Substances

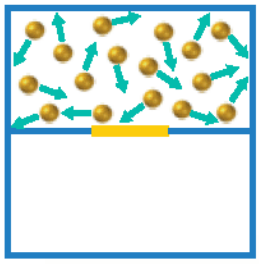
- The movement of a substance from an area of high concentration to an area of lower concentration caused by the random motion of particles of the substance is called **diffusion.**
- Many substances, such as molecules and ions dissolved in the cytoplasm and in the fluid outside cells, enter or leave cells by diffusing across the cell membrane.



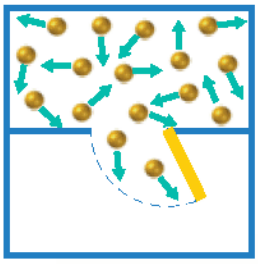
If you drop a lump of sugar into a beaker of water, the sugar particles will diffuse and become evenly distributed throughout the water.

- Because of diffusion, food coloring (blue) will gradually move through uncolored gelatin (yellow), as shown in the beakers below.

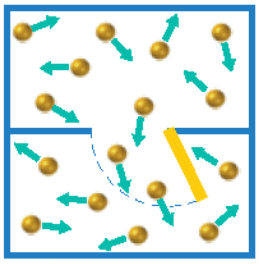
1. Randomly bouncing balls are distributed evenly throughout a closed room.



2. If the door to an adjoining room is opened, the balls begin to enter, or diffuse into, that room.

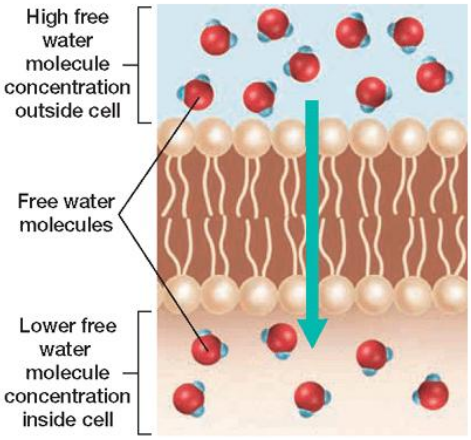


3. At equilibrium, the concentration of balls inside the two rooms will be equal.



Osmosis

Water diffuses across the cell membrane by osmosis.



- The diffusion of water through a selectively permeable membrane is called **osmosis.**
- Like other forms of diffusion, osmosis involves the movement of a substance—water—down its concentration gradient.
- Osmosis is a type of passive transport.
- There are three possibilities for the direction of water movement:
    - Water moves out. When water diffuses out of the cell, the cell shrinks. A solution that causes a cell to shrink due to osmosis is a **hypertonic solution.**
    - Water moves in. When water diffuses into the cell, the cell swells. A solution that causes a cell to swell because of osmosis is called a **hypotonic solution.**
    - No net water movement. A solution that produces no change in cell volume because of osmosis is called an **isotonic solution.**

Hypertonic, Hypotonic, and Isotonic Solutions

If the fluid outside the cell has…	Then outside fluid is…	Water diffuses…	Effect on cell
…lower free water molecule concentration than cytoplasm	…hypertonic.	…out of cell. H_2O	Cell shrinks.
…higher free water molecule concentration than cytoplasm	…hypotonic.	…into cell. H_2O	Cell swells.
…same free water molecule concentration as cytoplasm	…isotonic.	…into and out of cell at equal rates. H_2O	Cell stays same size.

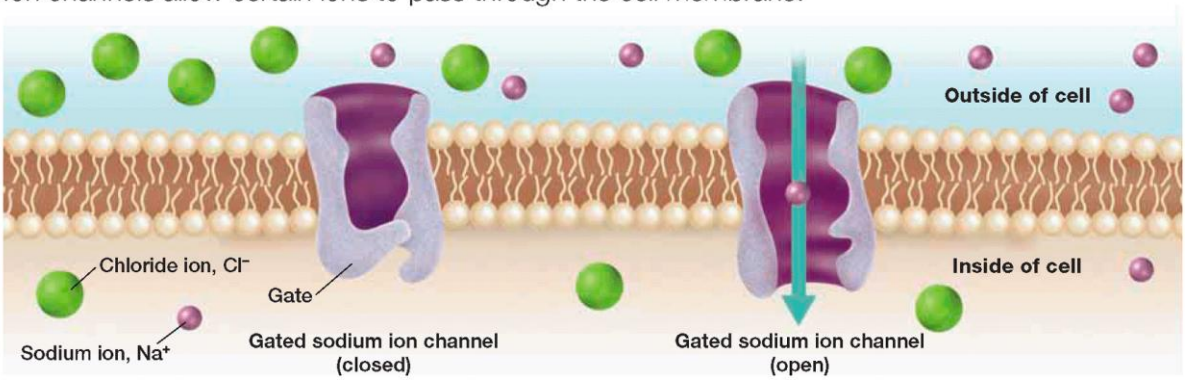
Crossing the Cell Membrane

Diffusion Through Ion Channels

- An **ion channel** is a transport protein with a polar pore through which ions can pass.
- The pore of an ion channel spans the thickness of the cell membrane.
- An ion that enters the pore can cross the cell membrane without contacting the nonpolar interior of the lipid bilayer.

Ion Channels

Ion channels allow certain ions to pass through the cell membrane.



Diffusion Through Ion Channels (Video Clip)

- Some transport proteins form channels through the lipid bilayer. These channels allow certain particles to cross the cell membrane.
- Ions have a charge. Charged particles cannot pass through a lipid bilayer. But ions can move into and out of cells through a channel protein.

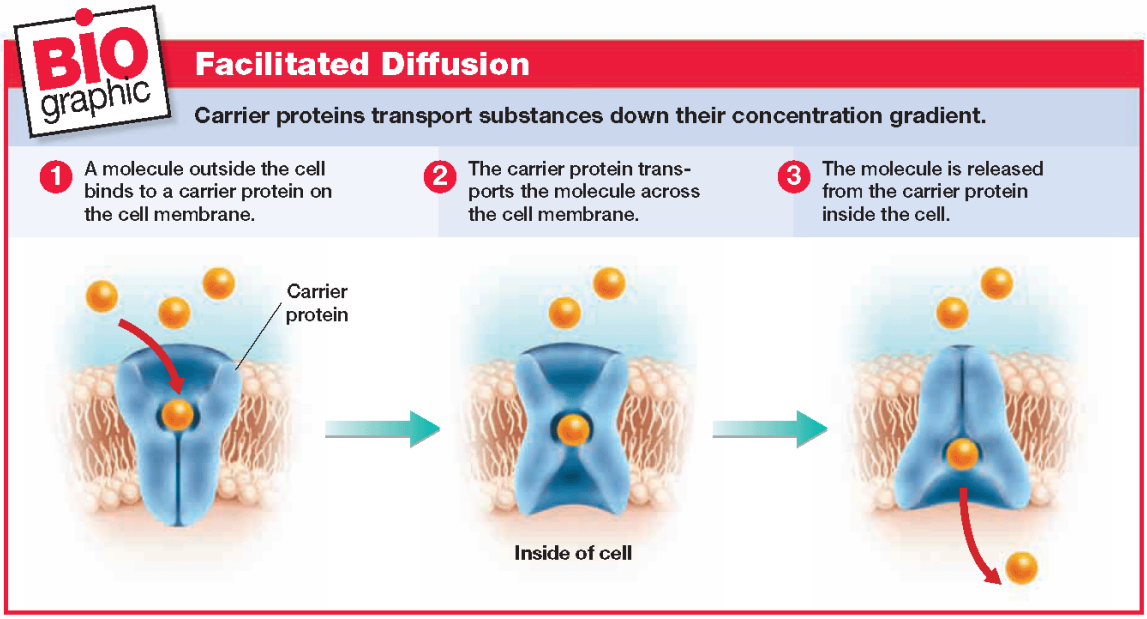
Electrical Charge and Ion Transport

- The movement of a charged particle, such as an ion, across the cell membrane is also influenced by the particle's positive or negative electrical charge.
- A more positively charged ion located outside the cell is more likely to diffuse into the cell, where the charge is negative.

- A more negatively charged ion located inside the cell is more likely to diffuse out of the cell.

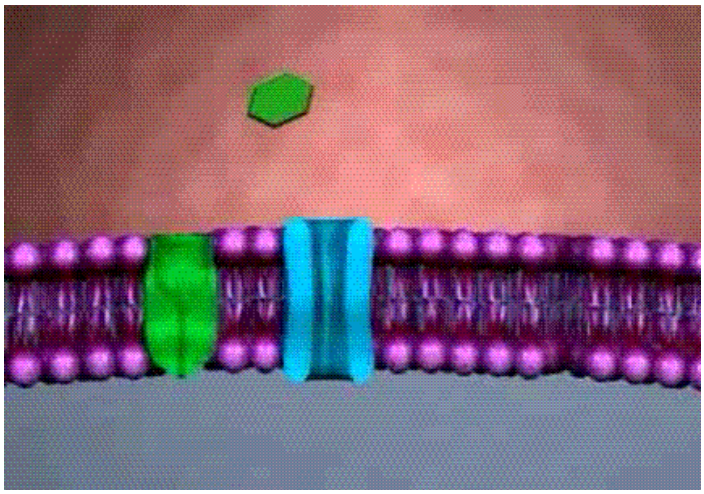
Facilitated Diffusion

- Most cells also have a different kind of transport protein, called **carrier proteins,** that can bind to a specific substance on one side of the cell membrane, carry the substance across the cell membrane, and release it on the other side.
- When carrier proteins are used to transport specific substances—such as amino acids and sugars—down their concentration gradient, that transport is called **facilitated diffusion.**



(Video Clip)

- Other transport proteins act as carriers.
- When specific molecules attach to them, they change shape.
- The molecules are then carried across the lipid bilayer.
- Glucose molecules move across the cell membrane with the help of a carrier protein.



Section 2: Active Transport

Objectives

- **Compare** active transport with passive transport.
- **Describe** the importance of the sodium-potassium pump.
- **Distinguish** between endocytosis and exocytosis.
- **Identify** three ways that receptor proteins can change the activity of a cell.

Movement Against a Concentration Gradient

- The transport of a substance across the cell membrane against its concentration gradient is called **active transport.**
- Unlike passive transport, active transport requires the cell to use energy because the substance is being moved against its concentration gradient.
- Most often, the energy needed for active transport is supplied directly or indirectly by ATP.

Comparing Active and Passive Transport (Video Clip)

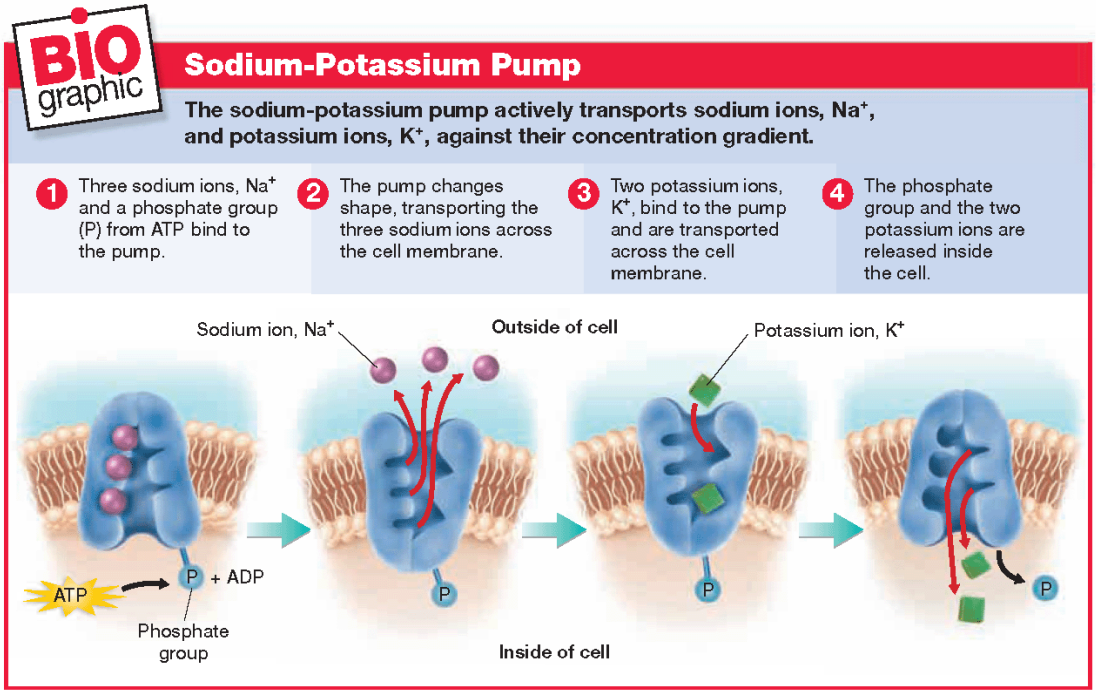
- Particles move down a concentration gradient without an input of energy. This is passive transport.
- Cells must use energy to pump particles against a concentration gradient. This is called active transport.

Active Transport (Video Clip)

- A carrier protein called a sodium-potassium pump moves sodium ions and potassium ions against their concentration gradient.
- This requires the cell to use energy and is therefore a type of active transport.
- The energy needed to operate a sodium-potassium pump comes from ATP.

Sodium-Potassium Pump

- One of the most important membrane pumps in animal cells is a carrier protein called the **sodium-potassium pump.**
- In a complete cycle, the sodium-potassium pump transports three sodium ions, Na^+, out of a cell and two potassium ions, K^+, into the cell.
- The sodium-potassium pump has four steps:
    1. Three sodium ions inside the cell bind to the sodium-potassium pump.
    2. The pump changes shape, transporting the three sodium ions across the cell membrane and releasing them outside the cell.
    3. Two potassium ions outside the cell bind to the pump.
    4. The two potassium ions are transported across the cell membrane and are released inside the cell.



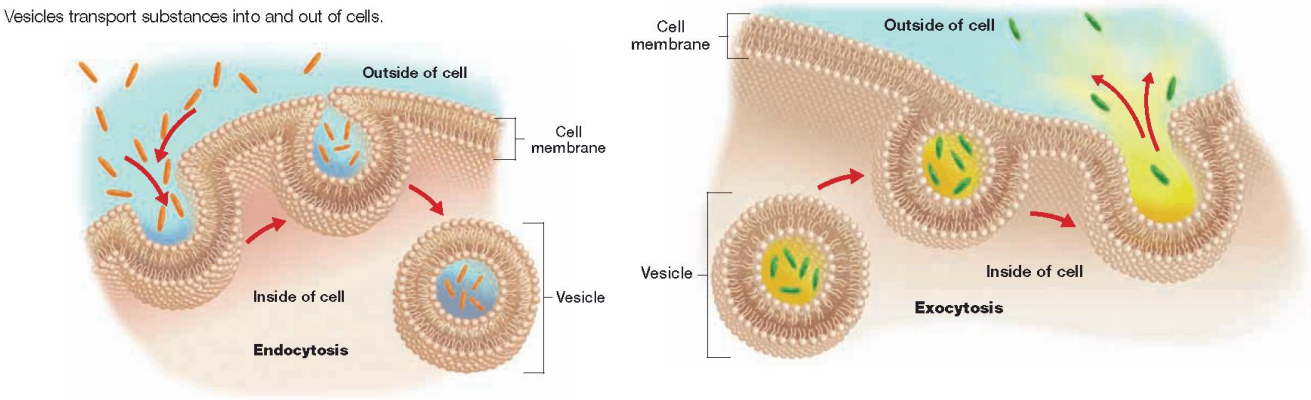
(Video Clip)

- The sodium-potassium pump moves sodium ions and potassium ions in opposite directions.
- The pump moves sodium ions out of the cell and potassium ions into the cell.

Movement in Vesicles

- Many substances, such as proteins and polysaccharides, are too large to be transported by carrier proteins. These substances are moved across the cell membrane by vesicles.
- The movement of a substance into a cell by a vesicle is called **endocytosis.**
- The movement of a substance by a vesicle to the outside of a cell is called **exocytosis.**

Endocytosis and Exocytosis



(Video Clip)

- Endocytosis – the cell membrane surrounds material and encloses it in a vesicle, which pinches off.

    - It may fuse with a lysosome, as in the case of phagocytosis.
    - If the vesicle contains a fluid, the endocytosis is known as pinocytosis.
- Exocytosis – a vesicle is moved through the cytosol to the plasma membrane and the two membranes fuse.
    - The contents of the vesicle spill to the outside of the cell.
    - The outer plasma membrane regains its original shape.

Membrane Receptor Proteins

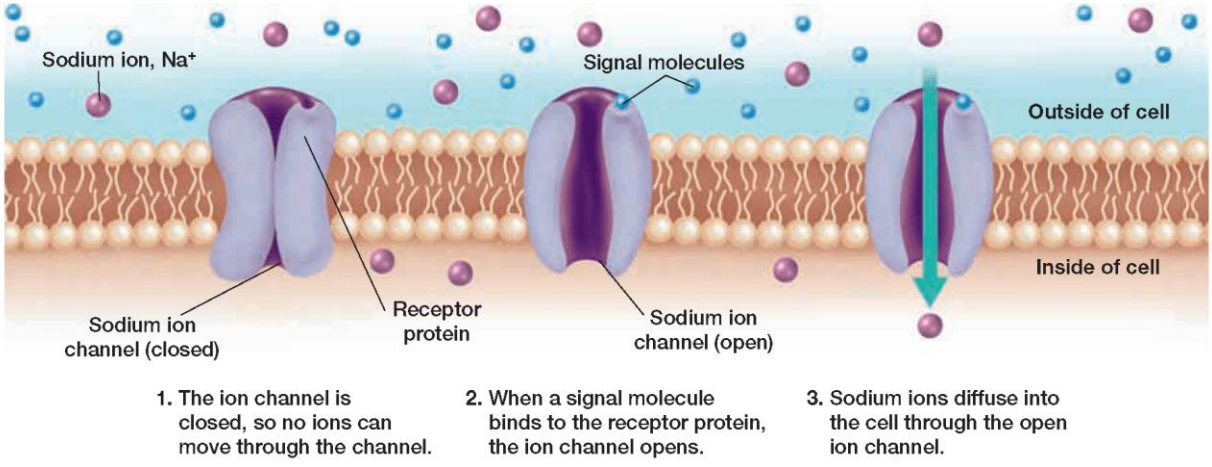
- Cells must also respond to important information and filter out unimportant information.
- Cells can receive the messages carried by certain signal molecules because the cell membrane contains specialized proteins, called receptor proteins, that bind these signal molecules.
- A **receptor protein** is a protein that binds to a specific signal molecule, enabling the cell to respond to the signal molecule.

Functions of Receptor Proteins

- Changes in Permeability: The binding of a signal molecule to the receptor protein causes an ion channel to open, allowing specific ions to cross the cell membrane.
- Second Messengers: The receptor protein may cause the formation of a **second messenger** inside the cell. The second messenger acts as a signal molecule and amplifies the signal of the first messenger—that is, the original signal molecule.
- Enzyme action: The receptor protein may act as an enzyme. When a signal molecule binds to the receptor protein, the receptor protein may speed up chemical reactions inside the cell.

Changes in Permeability

Some receptor proteins are coupled with ion channels.



Second Messengers

Some receptor proteins trigger the production of second messengers.