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Modes of transport across cell membrane

Transport across cell membrane is referring to the mechanisms that regulate the passage of solutes such as ions and small molecules through cellular membranes.

The cell membrane is selective permeability. Permeability means the ability to permit certain substances to pass into and out of the cell but to restrict the passage of other substances, hence, the permeability of plasma membrane is dependent on:

1-Size of molecules: small molecules easier to pass through cell membrane than large molecules (such as proteins).

2-Solubility in lipids: the substances that dissolved in lipids (O_2, CO_2, steroid hormones) can pass through cell membrane faster than others which not dissolved in lipids (amino acids and glucose).

3-Charge of molecules: the molecules that to carry opposite charge to protein of cell membrane will be attracted than that to carry the same.

The passage of material across cell membrane by two methods: passive transport and active transport.

A- Passive transport

Passive transport is movement molecules across the cell membrane and doesn't require energy, it is dependent on the permeability of the cell membrane. The four main kinds of passive transport are simple diffusion, facilitated diffusion, filtration, and osmosis.

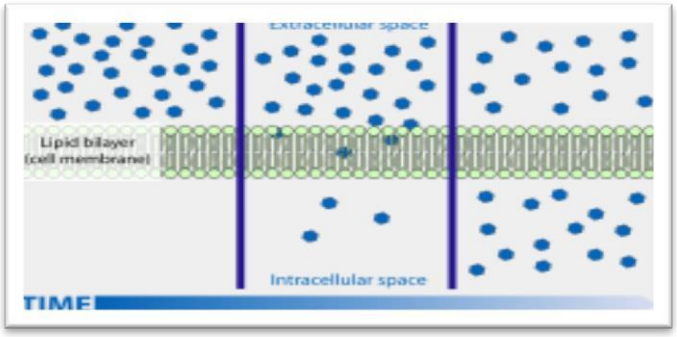
1- Simple diffusion

Diffusion is the transport of molecules (such as lipid-soluble molecules, gases) from an area of high concentration to an area of lower concentration. The difference of concentration between the two areas is often termed as the **concentration gradient**, and diffusion will continue until this gradient has been eliminated.

The rate of diffusion depends upon:

- **Concentration gradient:** the higher concentration gradient between the two regions lead to faster rate of movement.
- **Distance:** if the distance between the two regions is smaller, a faster rate of movement will occur.
- **Surface Area:** the more surface area available, the faster the rate will occur.

- **Temperature**: means more molecular energy is present making the rate of transfer faster.

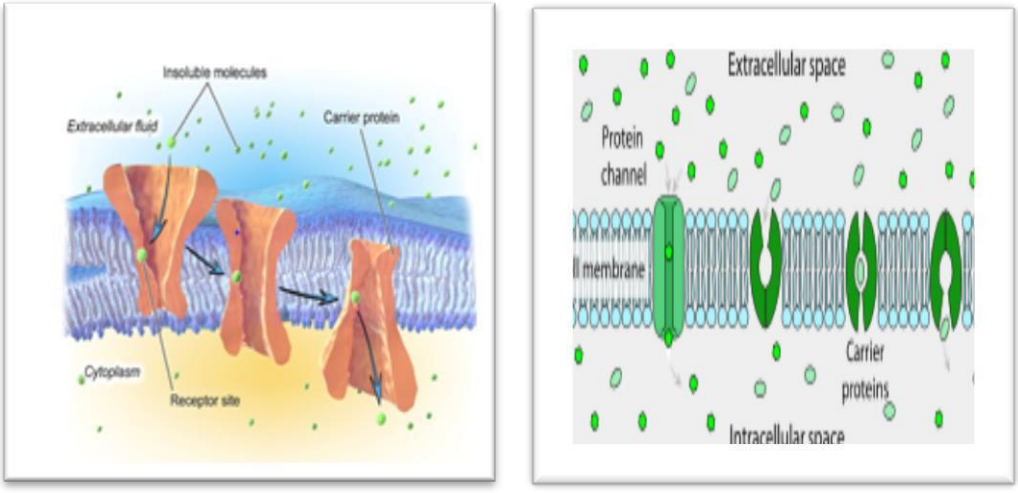


Passive diffusion on a cell membrane

2- Facilitated Diffusion

- Certain types of molecules, such as **charged particles, large molecules** like sugar (glucose), amino acids and ions, don't pass through the membrane naturally because they don't dissolve in lipid, hence, this molecules can pass cell membrane by **carrier protein or channel protein**.

- **Channel Proteins:** These are **water filled channels** and because they are **hydrophilic** it means that any molecules which are soluble in water can dissolve and then pass through this membrane. Channel proteins create a passage that allows molecules and ions to diffuse through the cell membrane, allowing passage with various signals. while the **Carrier proteins** bind to a molecule in order to transport it through the cell membrane.



Facilitated diffusion in cell membrane

3- Osmosis

Osmosis is the movement of water through cell membrane from an area of higher water concentration to an area of lower water concentration. Osmosis is dependent on pressure in and out of the cells which create force exerted on a selectively permeable membrane called osmotic pressure, such as, absorption of water from digestive tract to bloodstream. There are three different solutions are known to occur: **Isotonic solution**

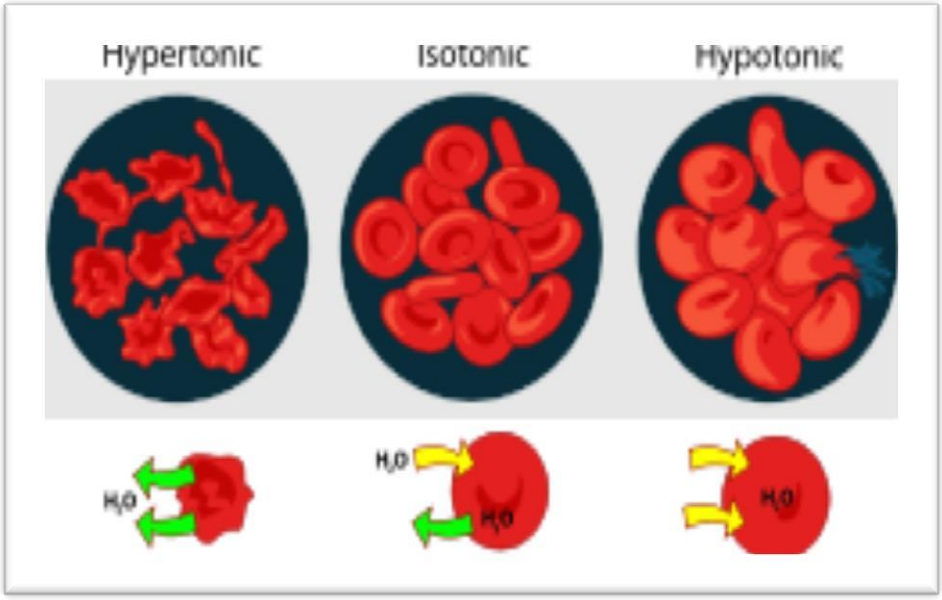
Isotonic solution (solute plus solvent) is occurring when the extracellular solute concentration is balanced with the concentration inside the cell. In the Isotonic solution, the water molecules still moves between the solutions, but the rates are the same from both directions, thus the water movement is balanced between the inside of the cell as well as the outside of the cell, this cause neither shrinking or swelling of cells or tissue. Normally, body fluids are isotonic to cells for maintain on their size and shape.

Hypotonic solution

It occurs when the solution that cause cells to swell or even to burst due to an intake of water. If red blood cells are placed in a hypotonic solution, which has a higher concentration of water (lower concentration of solute) than do the cells, water enters the cells and they swell to bursting. **Hemolysis,** then, is disrupted red blood cells.

Hypertonic solution

Its occur when the solutions that cause cells to shrink due to a loss of water. If red blood cells are placed in a hypertonic solution, which has a lower concentration of water (higher concentration of solute) than in cells, water leaves the cells and they shrink.



Effect of osmosis on blood cells under different solution

4- Filtration.

Filtration is the movement of liquid (water and solute molecules) across the cell membrane from high pressure to low pressure. Depending on the size of the membrane pores, only solutes of a certain size may pass through it. Most important case of filtration is seen in the blood capillaries, a blood pressure pushing water and dissolved solutes out of the capillary, through tiny pores between capillary cells to the tissue fluid, as well as, the kidneys filter wastes from the blood. Capillaries hold back larger particles such as blood cells and proteins.

B-Active transport:

Its mean move the molecules against the concentration gradient, hence, this requires energy from the cell (ATP) and carrier protein for keeps unwanted ions or other molecules out of the cell that are able to diffuse through the cell membrane. Cells involved in active transport have a large number of mitochondria near the plasma membrane at which active transport is occurring.

1-Primary active transport: (Sodium-Potassium Pump)

One of the most important pumps in animal cells is the sodium-potassium pump, this type of transport process uses ATP as an energy source, Not only does the sodiumpotassium pump maintain correct concentrations of Na+ and K+ in living cells, but it also plays a major role in generating the voltage across the cell membrane in animal cells and establishment this voltages which known as electrogenic pumps. The sodium-potassium

pump transports sodium out of and potassium into the cell in a repeating cycle of conformational (shape) changes. In each cycle, three sodium ions exit the cell, while two potassium ions enter. This pump is especially associated with nerve and muscle cells.

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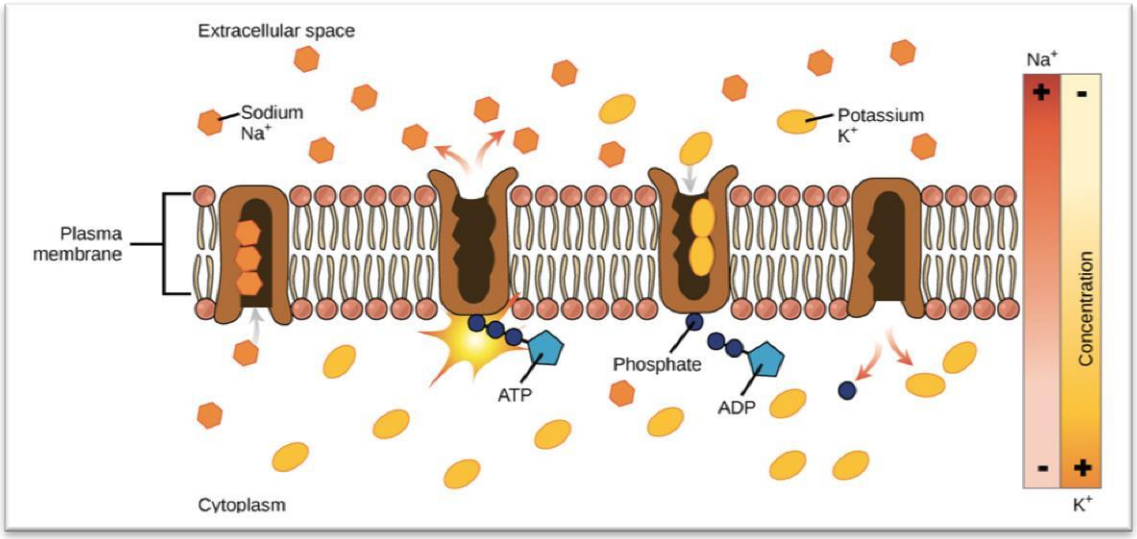
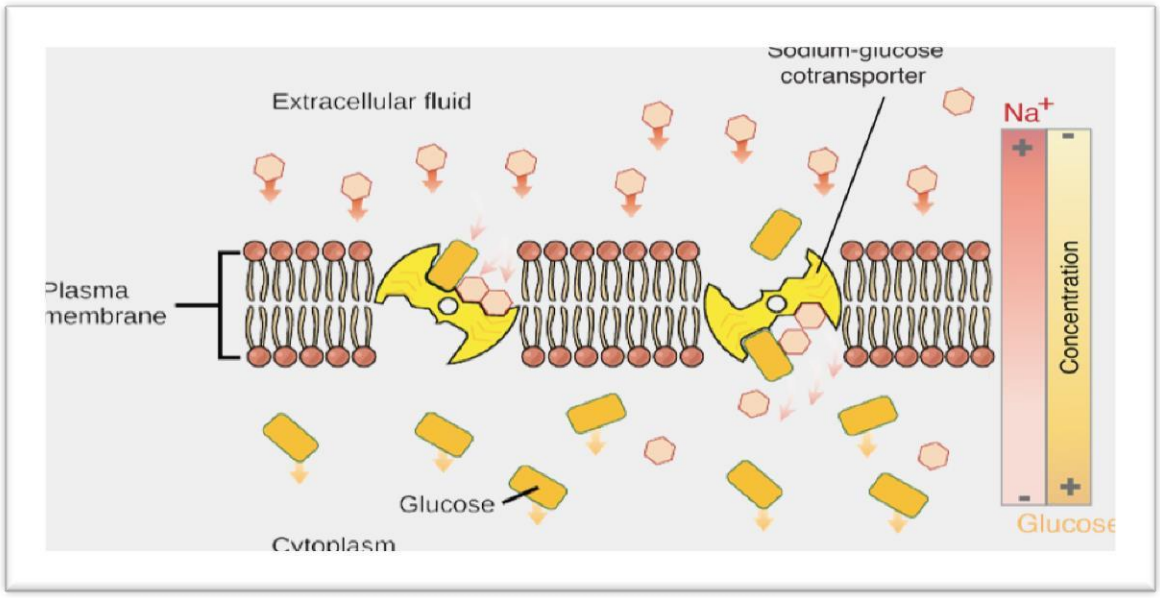


Sodium-potassium pump cycle

2-Secondary active transport

In secondary active transport (**ion-coupled transport**), the movement of the sodium ions or hydrogen ion down their gradient is coupled to the uphill transport of other substances by a shared carrier protein **(a cotransporter**). In this type of transport the coupling between the driving and driven species is obligatory. That is to say that both the driving and driven species must be bound to the transporter for translocation across the membrane to occur. For example a carrier protein lets sodium ions move down their gradient, but simultaneously brings a glucose molecule up its gradient and into the cell. **The carrier protein uses the energy of the sodium gradient to drive the transport of glucose molecules**. In secondary active transport, the two molecules being transported may move

either in the same direction (both into the cell or out of cell), or in opposite directions (one into and one out of the cell). When they move in the same direction, the protein that transports them is called a **symporter**, while if they move in opposite directions, the protein is called an **antiporter.**



Secondary active transport

3- Bulk transport

Its type of active transport which requiring energy and includes endocytosis (phagocytosis, pinocytosis and receptor-mediated endocytosis) and exocytosis **A-**

Endocytosis:

1-Phagocytosis (cell eating)

During phagocytosis, cells engulf large particles such as bacteria, cell debris or other macromolecules (proteins or polysaccharides). Binding of the particle to receptors on the surface of the phagocytic cell triggers the extension of pseudopodia for surround the particle, then, the membranes fuse to form a large intracellular vesicle called a phagosome. The phagosomes then fuse with lysosomes, producing phagolysosomes in which the ingested material is digested by the action of lysosomal acid hydrolases. Phagocytosis is also used by WBCs, macrophage and neutrophil when they engulf harmful microbes, aged

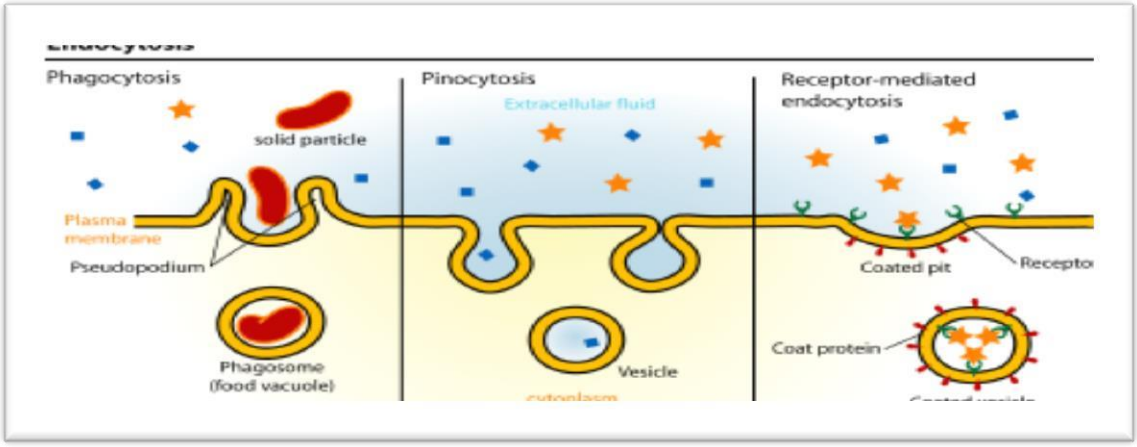
and dead cell from the tissues, also many amoebas use phagocytosis to capture food particles.

2- Pinocytosis (cell drinking)

A mechanism by which cells ingest extracellular fluid and its contents; it involves the formation of invaginations by the cell membrane, which close and form tiny vesicle or sac around each droplet, then, taken into the interior of the cytoplasm. These pinocytotic vesicles subsequently fuse with lysosomes to hydrolyze (break down) the particles, such as the cells in kidney and urinary bladder**.**

3- Receptor-Mediated Endocytosis

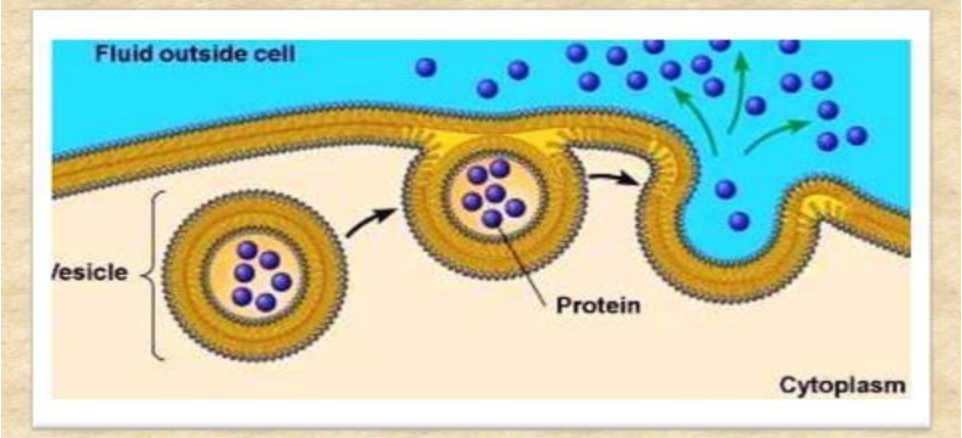
Also called clathrin-mediated endocytosis, this mechanism for the selective uptake of specific macromolecules (hormones, cholesterol and some viruses). The macromolecules to be internalized first bind to specific cell surface receptors. These receptors are concentrated in specialized regions of the plasma membrane, called clathrin-coated pits. These pits bud from the membrane to form small clathrin-coated vesicles containing the receptors and their bound macromolecules (ligands). The clathrin-coated vesicles then fuse with early lysosomes to digest the engulfed material and release it into the cytosol or recycling to the plasma membrane. Mammalian cells use receptor-mediated endocytosis to take cholesterol into cells.



Different types of endocytosis

B-Exocytosis

Exocytosis is the process by which cells release particles from within the cell into the extracellular space, exocytosis is the opposite of endocytosis as it involves releasing materials (enzymes or neurotransmitters) from the cell. In exocytosis, the substance has been packaged within a vesicle by the Golgi body. The plasma membrane of the vesicle then fuses with the cell membrane and its contents are expelled.



Exocytosis