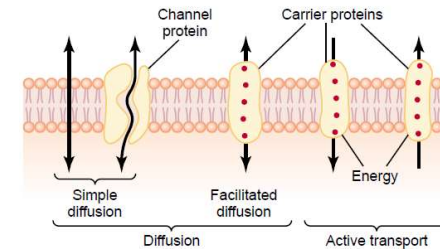


GENERAL PHYSIOLOGY

BY

Dr. NGANDA P ERNEST

TRANSPORT ACROSS THE CELL MEMBRANE



Transport cont'd

- There are two mechanisms of transport of substances across cell membranes

1. Passive transport mechanisms
2. Active transport mechanisms

PASSIVE TRANSPORT MECHANISMS

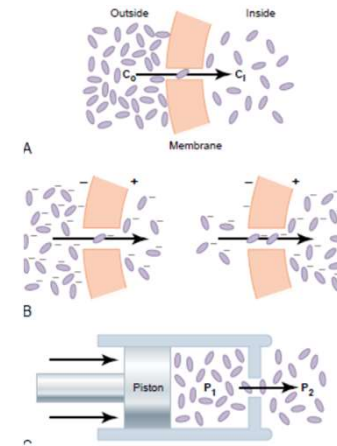
- These do not require expenditure of energy by the cells

1. Simple diffusion
2. Facilitated diffusion
3. Osmosis
4. Bulk flow
5. Filtration

Passive transport cont'd

1. Simple diffusion

- This is the net movement of substance molecules from an area of high concentration to an area of low concentration.
- The substances move along a concentration gradient



Simple diffusion cont'd

- The rate of simple diffusion through the cell membrane is dependent on
 1. Concentration gradient
 2. Electrical potential gradient of the diffusing ions
 3. Cross-sectional area through which diffusion occurs
 4. Temperature
 5. Molecular weight of a substance (size of the molecules)

Simple diffusion cont'd

- Simple diffusion through the lipid bilayer
 - Involves fat soluble substances like alcohol, oxygen and carbondioxide
 - The rate of substance movement across the membrane is directly proportional to the fat solubility of the substance.

Simple diffusion cont'd

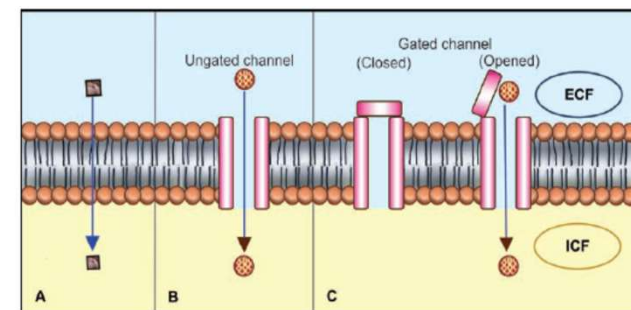
- Simple diffusion through the protein layer
- Involves water soluble substances like electrolytes passing through integral membrane protein channels.

Simple diffusion cont'd

- These channels are selectively permeable allowing specific electrolytes to go through e.g. sodium channels, potassium channels, calcium channels etc.

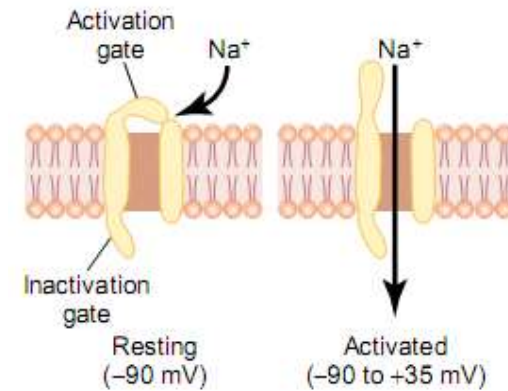
Simple diffusion cont'd

1. Some channels are open throughout (hence, un-gated channels)
 2. While others channels are kept closed (referred to as gated channels).
- Gated channels open when there is a stimulus (mechanical, voltage or chemical)



Voltage gated channels

- These open when the membrane potential changes beyond a certain threshold value.
- Channels of this type are involved in the conduction of action potentials along nerve axons
- Sodium and potassium channel



Ligand gated ion channels

- These cannot open unless they first bind to a specific agonist(ligand).
- The opening of the gate is produced by a conformational change in the protein induced by the ligand binding.

Ligand gated ion channels cont'd

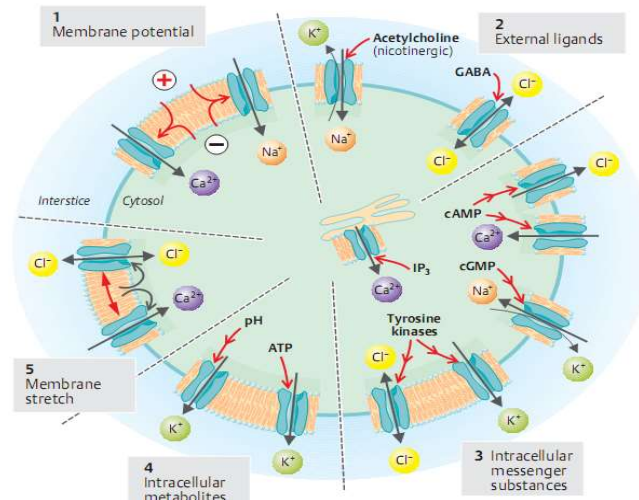
- The ligand can be a neurotransmitter arriving from the extracellular medium.
- It also can be an intracellular second messenger, produced in response to some cell activity or hormone action, that reaches the ion channel from the inside of the cell

Ligand gated ion channels cont'd

- The nicotinic acetylcholine receptor channel found in the postsynaptic neuromuscular junction is a ligand gated ion channel that is opened by an extracellular ligand (acetylcholine).
- Glutamate(cation channels)
- Glycine or GABA (Cl⁻ channels)

Stretch gated receptors

- The direct or indirect effects of stretch play a role in calcium channels of smooth muscle fibers and generally in normal K⁺ and Cl⁻ channels in swelling cells

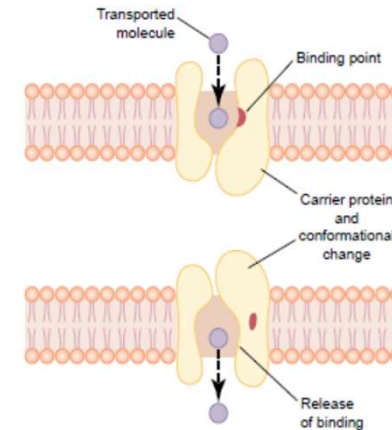


FACILITATED (CARRIER MEDIATED) DIFFUSION

- Movement of water soluble substances across a cell membrane from an area of high concentration to an area of low concentration with the help of membrane carrier proteins.

Facilitated Diffusion Cont'd

- The molecules to be transported bind with carrier membrane proteins and cause some conformational changes
- The molecules are then dragged to the other side of the membrane.



Facilitated Diffusion Cont'd

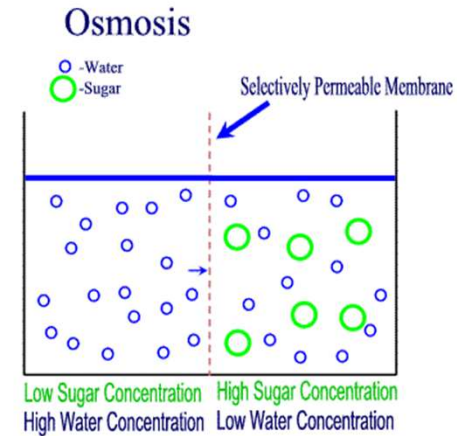
- Transport maximum (T_{max}) refers to the point at which increase in concentration of a substance does not result in an increase in movement of a substance across a cell membrane

OSMOSIS

- This is the movement of water molecules across a semi-permeable membrane from a region of low solute concentration to a region of high solute concentration

Osmosis cont'd

- Osmosis depends upon osmotic pressure, which is the pressure exerted by the solutes in a fluid preventing further movement of solvent molecules into the fluid



BULK FLOW

- This is the diffusion of large quantity of substances along a pressure gradient across a cell membrane
1. Gaseous exchange in the lungs
 2. In the tissue capillaries.

FILTRATION

- This is the movement of both water and solute molecules along a hydrostatic pressure gradient.

Filtration cont'd

- The weight of the fluid exerts the hydrostatic pressure of the fluid.
- 1. Transcapillary movement of fluids and dissolved substances into the interstitial space
- 2. Glomerular filtration

ACTIVE TRANSPORT MECHANISMS

- These involve the use of energy to move molecules across cell membrane against a concentration gradient.
- For example the efflux of sodium ions from the cells yet the sodium concentration is higher in the extracellular fluid (ECF)

Active Transport Cont'd

- Carrier proteins involved in active transport are of two types:
- 1. Uniport Carrier proteins which carry only one substance in a single direction.
- Also referred to as uniport pump.

Active Transport Cont'd

- Symport or Antiport proteins that transport two substances at a time
- Carrier protein that transports two different substances in the same direction is called symport
- Carrier protein that transports two different substances in opposite directions is called antiport

Primary Active Transport

- This is the type of active transport of substances in which the energy required is generated directly from the breakdown of ATP.
- It is by this method that substances like sodium, potassium, calcium, hydrogen and chloride are transported across the cell membrane

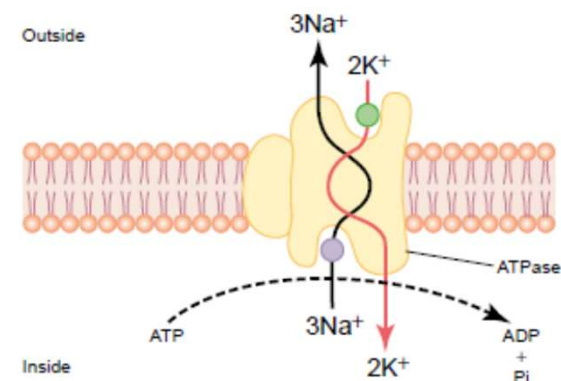
The sodium-potassium pump

- Sodium and potassium ions are transported in opposite directions across the cell membrane by means of a common carrier protein referred to as Na⁺-K⁺ ATPase.
- It transports three sodium ions from inside to outside of the cell and two potassium ions from outside to inside of the cell.

The sodium-potassium pump

- The pump has three receptor sites for binding sodium ions on the portion of the protein inside of the cell.
- It has two receptor sites for binding potassium ions on the outside.
- The inside portion of this protein near the sodium binding sites has ATPase activity

The sodium-potassium pump cont'd



The Hydrogen pump

- This transports H^+ ions across the cell membrane obtaining energy from ATP.
- Examples;
 1. In the Stomach, the Hydrogen pumps in parietal cells of the gastric glands are involved in the formation of hydrochloric acid.
 2. In the Kidney, the Hydrogen pumps are involved in the secretion of hydrogen ions from blood into urine

The Calcium pump

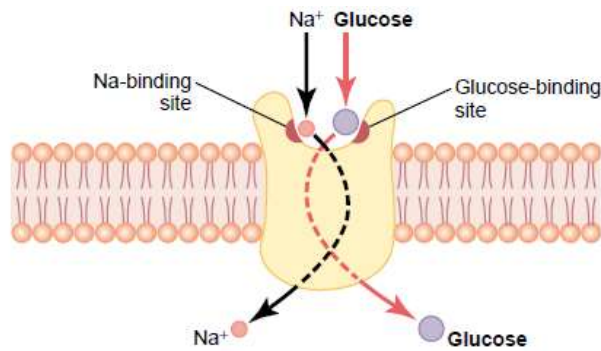
- This pump actively transports Calcium from inside to outside of the cell deriving the energy from ATP.
- Calcium pumps are also present in some organelles of the cell like the sarcoplasmic reticulum and the mitochondria

SECONDARY ACTIVE TRANSPORT

- This is the transport of a substance simultaneously with sodium ion, by means of a common carrier protein
- The two substances may move in the same direction (co-transport) or in the opposite directions (counter transport)

Sodium Co-transport

- Sodium cotransport is the process in which, along with sodium, another substance is transported by a carrier protein called **symport**
- The carrier protein has two receptor sites on the ECF side.



Sodium Co-transport cont'd

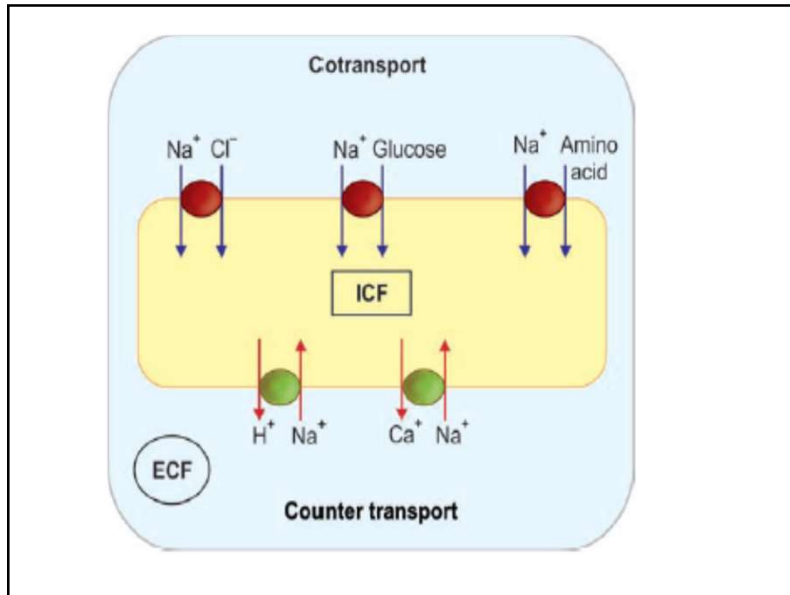
1. Sodium co-transport of glucose occurs during absorption of glucose from the intestine
2. Sodium co-transport of amino acids also occurs during the absorption of amino acids from the intestine
3. Sodium cotransport with chloride, iodine, iron and urate also occurs

Sodium Counter

- Sodium counter transport is the process by which the substances are transported across the cell membrane in exchange for sodium ions by carrier proteins called antiport

Sodium Counter

- The carrier protein has one binding side on either side of the cell membrane
 - One site for sodium ions and the other site for another substance ion
1. Sodium Counter Transport of calcium, hydrogen, magnesium



ENDOCYTOSIS

- This is the ingestion of substances by the cell into the cytoplasm.
- It involves engulfing and formation of endocytic vesicles.
- It requires energy supplied by the ATP molecules (adenosine triphosphate)

Endocytosis Cont'd

1. Phagocytosis

- This is the ingestion of larger particles by the cells e.g. bacteria.
- It involves formation of larger (phagocytic) vesicles

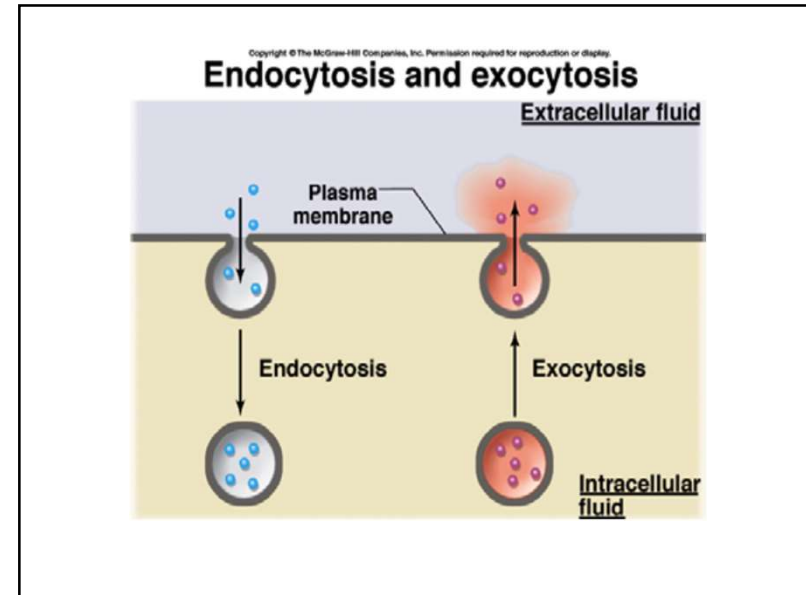
Endocytosis Cont'd

2. Pinocytosis

- This is the cellular ingestion of smaller particulate substances into the cytoplasm
- It involves formation of pinocytic (smaller) vesicles

Exocytosis

- Exocytosis is the egestion of substances from the cell
- They may be indigestible materials, communication/signaling molecules like hormones or neurotransmitters
- The exocytic vesicle fuses with the cell membrane and release the materials into the extracellular space.



Transcytosis

- This is a transport mechanism in which an extracellular molecule enters through one side of the cell, migrates through the cytoplasm and exits through the other side.
- It combines endocytosis and exocytosis e.g. the movement of proteins from capillary blood into interstitial fluid