SECTION TWO CORE UNIT THREE

CELL PHYSIOLOGY

INTRODUCTION TO MOVEMENT IN AND OUT OF THE CELLS

Major concept

Understand physiological process by which materials move in and out

Specific objectives

Learn the chemical composition of the membrane—Lipids and its types.
Learn about proteins present and types:
(i) Integral membrane proteins
(ii) Peripheral membrane proteins
(iii) Transmembrane proteins
Transport mechanisms
1. Passive or simple diffusion
2. Facilitated diffusion
3. Active transport—Learn about Uniport system, and co-transport system—symport and Antiport
(c) Mechanisms of transport of macromolecules
1. Exocytosis
2. Endocytosis: Learn about
(i) Phagocytosis
(ii) Pinocytosis—Mechanism of receptor mediated absorptive pinocytosis

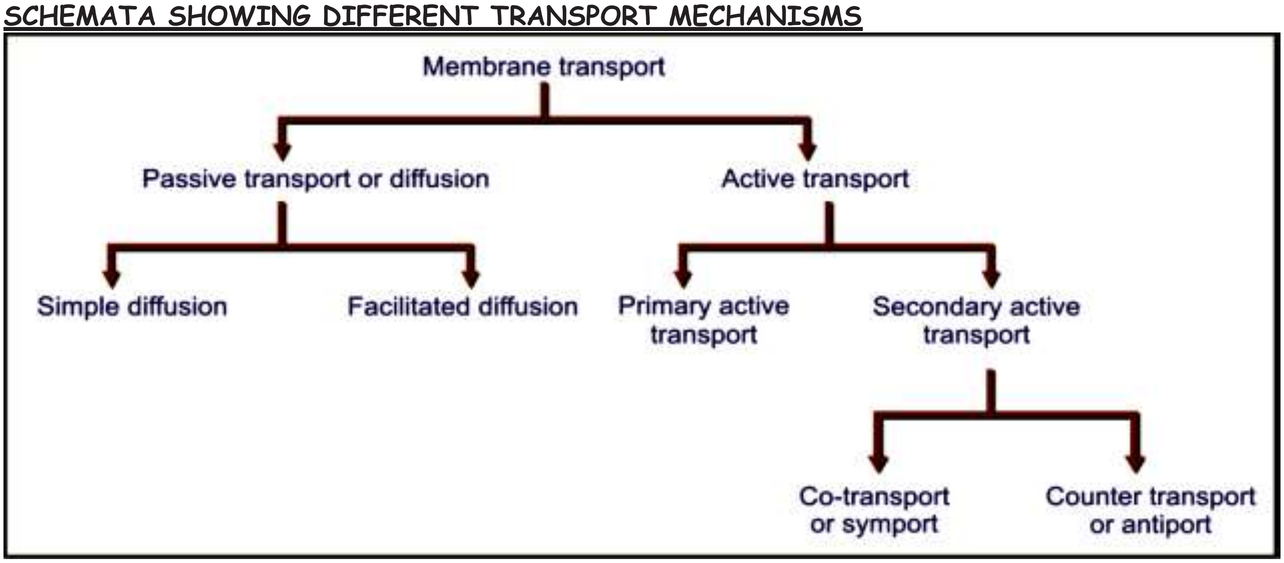
GENERAL INTRODUCTION TO CELL PHYSIOLOGY

An essential role of bio-membranes is to allow movement of all compounds necessary for the normal function of a cell across the membrane barrier. Compounds like sugars, amino acids, fatty acids, steroids, cations and anions.

IMPORTANCE OF TRANSPORT ACROSS BIO-MEMBRANES

Maintains suitable P^H (potential of hydrogen) and ionic concentration with cells for effective enzyme activity (Ions involved include: hydrogen ions/sodium/calcium)/Homeostasis
Obtain food supplies such as aminocids/glucose for energy supply; and function as raw materials eg fatty acid used to make cholesterol in liver cells;
Excrete toxic substances/wastes if permeated to accumulate damage to cells occurs;
Secrete useful substances such as hormones/enzymes required for cell physiology/biochemistry;
Generate ionic gradient for nervous and muscular activity by allowing exchange of ions (sodium and potassium ions)

SCHEMATA SHOWING DIFFERENT TRANSPORT MECHANISMS



PASSIVE TRANSPORT OR PASSIVE DIFFUSION

Passive transport is the process by which molecules move across a membrane without energy (ATP) from a region of higher concentration to one of lower concentration down a diffusion gradient. There are two types

- Simple diffusion

- Facilitated diffusion.

SIMPLE DIFFUSION

Lipid soluble, i.e. lipophilic molecules pass through cell membrane, without any interaction with carrier proteins in the membrane. Such molecules will pass through membrane along the concentration gradient, i.e. from a region of higher concentration to one of lower concentration.

FACILITATED DIFFUSION/CARRIER MEDIATED DIFFUSION

Refers to the movement of water soluble molecules and ions across the membrane through specific carrier and channel proteins, But it differs from passive diffusion in that it requires a carrier or transport protein. Hence the rate of diffusion is faster than simple diffusion. The process does not require any energy and can operate bidirectionally.

CARRIER PROTEINS
FEATURES

Span the cell membrane
Specific receptor/biding sites of specific molecules
Undergo rapid shape changes when in contact with a particular solute;
Movement independent of the ATP;
Movement along diffusion/concentration/electrochemical gradient

CHANNEL PROTEINS
FEATURES

Span the plasma membrane;
Fixed shape molecules;
Highly selective/stereo-specificity
Gated channels;
Hydrophilic pores.

REASON(S) BEHIND SPECIFICITY OF MATERIALS FOR TRANSPORT

Channel and carrier proteins are highly selective/specific **because they open under certain conditions or in the presence of the specific materials they transport, the absence of the specific molecule/ion they stay closed; eg channel proteins are gated and these open under certain conditions like in a nerve stimulation changes the potential across the plasma membrane causing sodium gates open and subsequent influx of sodium ions; receptor sites/binding sites accommodate specific molecules with specific shapes;**

EFFECTS OF INHIBITORS ON FACILITATED DIFFUSION

Respiratory inhibitors such as potassium cyanide have no effect on facilitated because the process is purely passive/No ATP required; but competitive inhibitors with the same shape as the genuine molecule they carry/transport reduces the rate of facilitated diffusion; because it competes for the receptor sites/binding sites of the genuine molecules for example protein permease **transports glucose but molecules with shape similar to glucose inhibit its transport.**

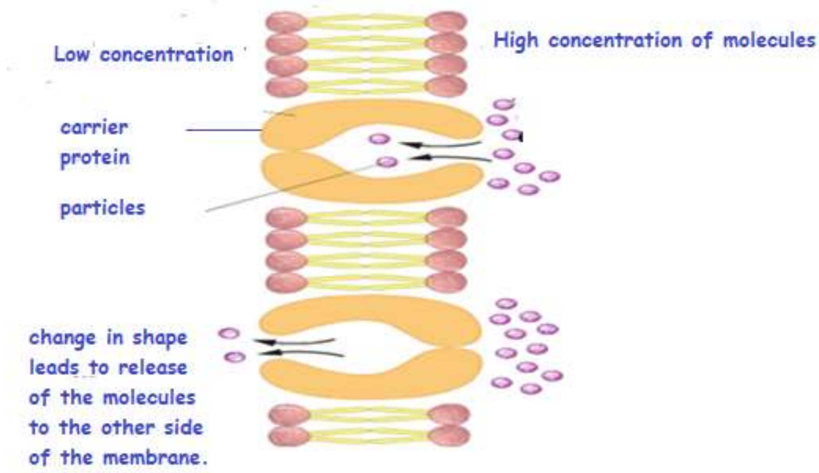
ADAPTATIONS OF CARRIER,CHANNEL PROTEINS AND PUMPS

Carrier proteins; have binding sites for specific molecules eg glucose; change shape and transport molecule to inside/outside membranes;
ATPase (Pumps); hydrolyses ATP forming energy required for active movement of materials;
Channel protein; have pores/hydrophilic channels; through which polar molecules enter cells eg ions;
Open only in the presence of specific molecules they transport and stay closed in the absence of the specific molecules

DETAILED MECHANISM OF FACILITATED DIFFUSION

Mechanism of facilitated diffusion has been explained by Ping-Pong **model. Example: D-fructose is absorbed from intestine by facilitated diffusion.**
Carrier Protein exists in two principal conformations depending on the solute concentration. Pong state and Ping state.
Pong state**, exposed to high concentrations of solutes, and molecules of solutes bind to specific sites on the 'carrier protein'. Inner side, a conformational change occurs to Ping state and the solute is discharged to the side favouring new equilibrium. The empty carrier protein then reverts to the original conformation "Pong" state to complete the cycle**

SCHEMATA SHOWING FACILITATED DIFFUSION



FACTORS AFFECTING DIFFUSION OF MATERIALS

Concentration gradient; greater the difference between two regions, greater amount that diffuse in a given time;

Distance over which diffusion occurs; shorter the distance; the faster the diffusion;

Area over which diffusion occurs; the greater the area the faster the diffusion;

Structure through which diffusion occurs; greater the number of pores and larger the pores faster the diffusion;

Size and type of diffusing molecule; smaller molecules diffuse faster than larger molecules; fat soluble molecules diffuse faster than water soluble molecules

Charge of the Ions Rate of diffusion is inversely proportional to the charge of the ions. Greater the charge of the ions, lesser is the rate of diffusion. For example, diffusion of calcium ions is slower than the sodium (Na+) ions.

Temperature; Rate of diffusion is directly proportional to the body temperature. Increase in temperature increases the rate of diffusion.

FICK'S LAW

The relationship between concentration gradient, area over which diffusion occurs and distance over which diffusion occurs is expressed.

Remember that other factors affecting diffusion such as nature of the plasma membrane and size of the diffusing molecule must be kept constant

$$\frac{\text{surface area} \times \text{difference in concentration}}{\text{length of diffusion path}}$$

COMPARISON OF SIMPLE DIFFUSION AND FACILITATED DIFFUSION

SIMILARITIES

- in both the rate depends on concentration gradient;
- in both equilibrium is reached when the concentrations are equal;
- in both energy from ATP is not needed;
- both can move molecules in either directions;

DIFFERENCES

Simple diffusion	Facilitated diffusion
Does not require protein carriers;	Requires protein carriers;
Occur in both living and non- living tissues;	Occurs only in living tissues;
No saturation;	saturation is reached;

Non- specific/stereo-specificity	Highly specific/stereo-specificity;
No competition for carrier proteins;	Competition occur between similar molecules or different molecules requiring same carriers;
No competitive inhibition	Competitive Inhibition possible;
Same molecules move at the same rate	Specific molecules move at different rates;

COMPARISONS OF FACILITATED DIFFUSION WITH ACTIVE TRANSPORT

Similarities

- Both appear to involve carrier proteins.
- Both show specificity.
- Both resemble a substrate-enzyme type of reaction.
- Both have specific binding sites for solutes.
- 'Carrier' is saturable so it has maximum rate of transport.
- There is a binding constant for solute.
- Structurally similar competitive inhibitors block transport.

Differences

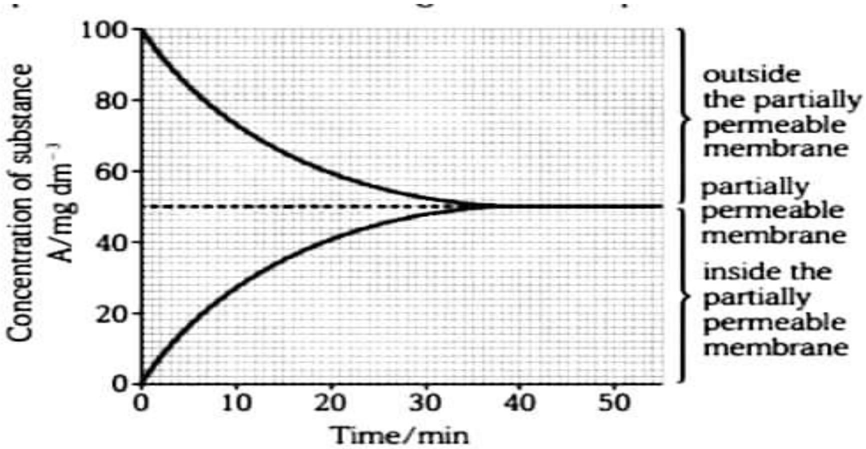
Facilitated diffusion	Active transport
Facilitated transport can act bi-directionally	Active transport is unidirectional
Occurs along a concentration gradient	Occurs against an electrical or chemical gradient
Active transport requires energy	facilitated diffusion exploits kinetic energy of molecules/does not require energy

Role of the plasma membrane in transport of materials

- Selective barrier; allowing passage of specific molecules into cells;
- Establishment of concentration gradient; determining direction of movement of materials/substances;
- Carrier/channel proteins; for movement of materials into and outside cells;
- Receptors for binding of materials which have to be moved inside cells;
- Non-polar to allow movement of non- polar materials eg steroid hormones;
- fluidity/flexibility to allow movement of transport proteins spanning the membrane easily/phagocytosis possible;
- Stability to avoid collapse of membrane;
- membranes budded off forming vesicles during endocytosis to move materials inside cells;
- flexible and fluidity to fuse with other membranes to allow transport of materials
  Microvilli; increasing surface area for absorption of materials to be transported;

GRAPHS SUMMARIZING DIFFUSION

1) The graph below shows the changes in concentration of substance A on the inside and outside of a partially permeable membrane, during a 50 minute period.



a) Explain the RELATIONSHIP between the concentration of materials inside and outside the partially permeable membrane.

At 0 minute the concentration of substance A inside is 0 A/mgdm^{-3} while outside is very high; no net movement of substance A by diffusion had occurred from 0 minute to about 10 minutes concentration of substance A increases rapidly in the inside while decreases rapidly on the outside because of the high concentration gradient substance A diffuses very rapidly to the inside; from 10 minute to about 35 minutes concentration inside increases gradually while outside decreases gradually because the steepness of the concentration gradient decreases as more materials enter the plasma membrane so few materials outside the membrane from 40 minute to 50 minute concentration remains constant because materials inside equals to outside/equilibrium established hence no diffusion

b) In an experiment, the rate of uptake of glucose by the blood using simple and facilitated diffusion at varying extracellular concentration of glucose was measured. The results are shown in figure 1. Study the information and answer the questions that follow.

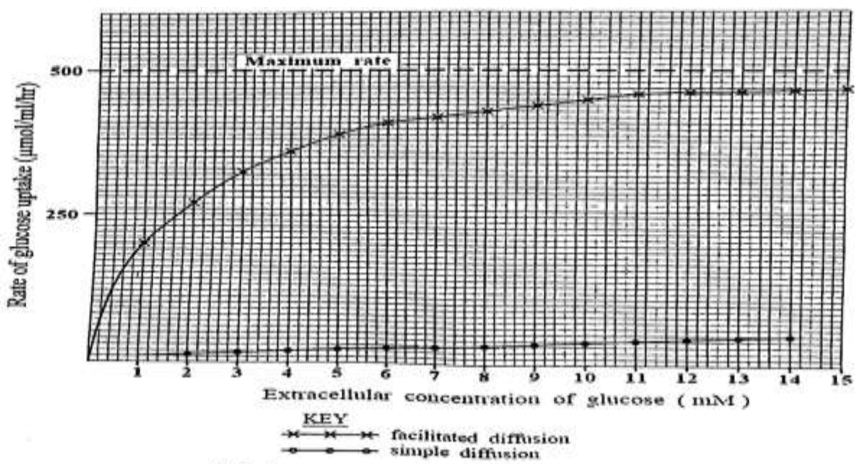


Fig. 1

(a) Describe the rate of glucose uptake with increasing extracellular concentration when diffusion is facilitated.

At 1mM; glucose uptake is low; glucose in extracellular fluid increases rapidly to 5mM; rate of glucose uptake increases rapidly;

4/5 up to 10/11; rate of glucose uptake increases gradually; 11 up to 15mM; rate of glucose uptake is very slow/ almost constant;

(c) Explain the effect of increasing extracellular concentration of glucose on the uptake of glucose, when diffusion is facilitated.

Results in more rapid uptake of glucose; because protein molecules; offer glucose transport channels/ carriers; all not saturated; steep concentration gradient; rapid diffusion;

Above 4-6mM; low rate of glucose uptake; because most protein channels are saturated;

(ii) The cell membrane is able to carry out facilitated diffusion.

Cell membrane has special protein molecules; which are large; and traverse; the lipid bilayer; these proteins are of two types; channels proteins; have fixed shape; but with hydrophilic pores; and for selective transport of ions; Carrier proteins; rapidly change shape; to bind specifically to the molecules they assist to carry over;

IMPORTANCE OF DIFFUSION

Gaseous exchange in plants and animals e.g. in plants diffusion of gases occur through the stomata
Absorption of digested food materials e.g. glucose in the ileum
Generation of the nerve impulse, sodium ions diffuse into the nerve cells causing depolarization
Facilitates synaptic transmission in chemical synapses
Excretion of waste products e.g. ammonia in fresh water fishes
Transportation of materials within the cell's cytoplasm e.g. in unicellular organisms

Absorption of mineral salts by plants from the soil

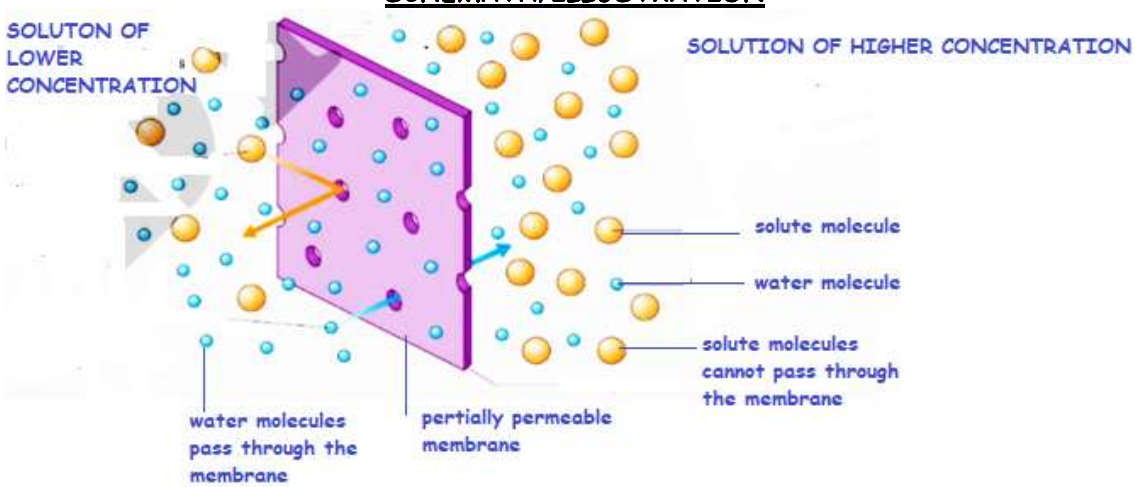
OSMOSIS

Osmosis is the net passage of water from region where it has a higher water potential to a region where it has lower water potential through a selectively permeable membrane along a water potential gradient

EXPLANATION OF OSMOSIS

Consider a hypothetical situation of a partially permeable membrane separating two solutions.
Membrane on the left/A has a low concentration of solute molecules while on the right/B has a high concentration of solutes molecules
Both solutes and water molecules are in a random motion due to kinetic energy
Partially permeable membrane allows water not solutes to cross through it
Water diffuses from the left side which has high water potential to right hand side with a lower water potential i.e. along a water potential gradient.
At a point where water molecules on the either side of the plasma membrane are equal, dynamic equilibrium is established and no net movement of water molecules

SCHEMATA/ILLUSTRATION



WATER POTENTIAL

Is the measure of the free kinetic energy of water in a system or tendency of water to leave a system, measured in kPa (kilopascals) and given symbol (Ψ)/psi. The water potential of pure water under standard conditions (25^0c and 100kPa) is said to be zero. This is a reference point, rather like the redox potential system used in chemistry.

FACTS ABOUT WATER POTENTIAL

Pure water has a water potential arbitrary given by value 0
Addition of solutes lowers the water potential of the system/becomes negative
Water potential of the solution (solute+water) must be always less than zero/more negative
Water will move by osmosis from a region of high water potential to a region of lower water potential long a water potential gradient.(-10kpa to -200kpa)
If more solutes are added the water potential becomes more negative

ADVANTAGES OF WATER POTENTIAL

Movement of water is considered from system point of view rather than from the environment
Comparisons between systems can be made eg between the atmosphere, the air in the space of the leaf and the leaf mesophyll cells

SOLUTE POTENTIAL

Refers to the measure of change in water potential/reduction in water potential of the system due to the presence of dissolved solute molecules

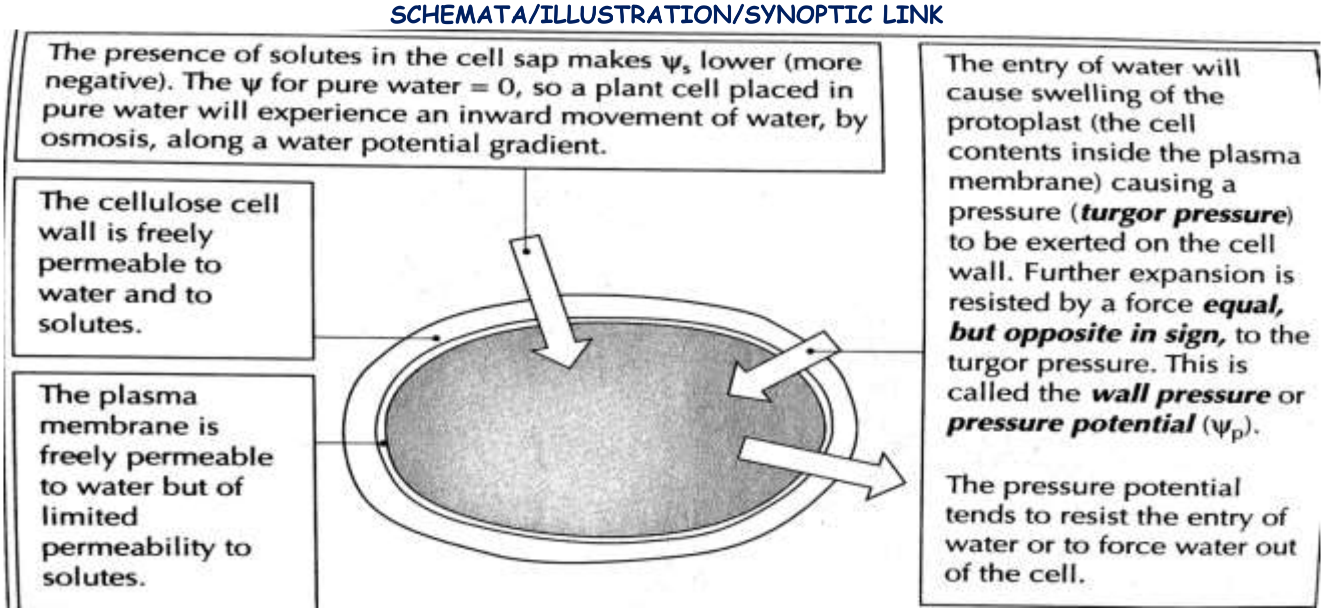
SOLUTE POTENTIAL FACTS

The more solute concentration the more negative the solute potential.
The solutes attract the water molecules and hence water potential of the system significantly lowered.
Remember the water potential of pure water is 0 and anything that reduces water potential lowers the tendency of water to leave a system/accounts why solutions have lower water potential

PRESSURE POTENTIAL

Is the hydrostatic pressure exerted on the cell contents by the cell wall and cell membrane
The cellulose cell wall is freely permeable to water and solutes while the plasma membrane is freely permeable to water molecules but of limited permeability to solutes. Presence of solutes in the cell sap makes the water potential lower/more negative and so plant cell experiences an inward movement of water by osmosis, along a water potential gradient. Entry of water will cause swelling of the protoplast causing a pressure/turgor pressure to exerted to the cell wall and the cell wall responds by exerting equal but opposite in sign wall pressure/pressure potential which tends to resist further entry of water/forces water out of the cell

SCHEMATA/ILLUSTRATION/SYNOPTIC LINK



TURGIDITY

When a plant cell is placed/put in distilled water or weak solution/hypotonic solution
Water potential inside the cell will be lower than water potential of external solution;
Influx of water molecules causing cell to swell
Contents press against the cell wall producing a pressure potential
As more water enters, pressure potential rises until its equal and opposite to solute potential
Water potential is now zero
No more water enters the cell
Cell is turgid in this state

PLASMOLYSIS

When a plant cell is placed in a strong solution/hypertonic solution
External solution has lower water potential than inside sap;
Water passes out of the cell by osmosis/exosmosis
As water leaves the cell, the cell surface membrane starts to shrink away from the rigid cell wall;
Pressure potential is now zero, cell is FLACCID
As more water leaves the cell, the cell contents continue to shrink
Cell membrane peels away from the cell wall

Cell is plasmolysed, plant wilts

PLAMOLYSIS AND WILTING

Plasmolysis loss of water as a result of osmosis while wilting loss of water by evaporation

Plasmolysis occur to cells surrounded by hypertonic solution while wilting on hot sunny days

Plasmolysis results into only cell membrane peeling off from cell wall while in wilting the whole cell collapses/shrinks.

EXTENSION

HYPERTONIC, ISOTONIC AND HYPOTONIC SOLUTIONS

HYPERTONIC SOLUTON

Solution with a lower concentration of water but more solute molecules

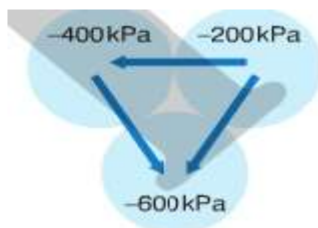
ISOTONIC SOLUTION

Solutions with the same concentration of water

HYPOTONIC SOLUTION

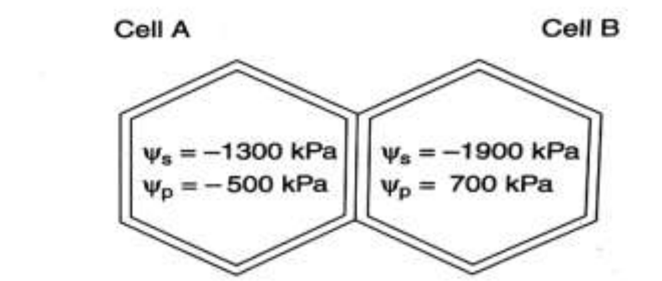
Solution with a higher concentration of water molecules and fewer solutes

CALCULATION/DETERMINATION OF DIRECTION OF WATER MOVEMENT



Water movement between cells:

1. Calculate ψ for each cell from ψ_s and ψ_p.
2. Predict direction of water movement since water moves ***down the gradient of water potential.***



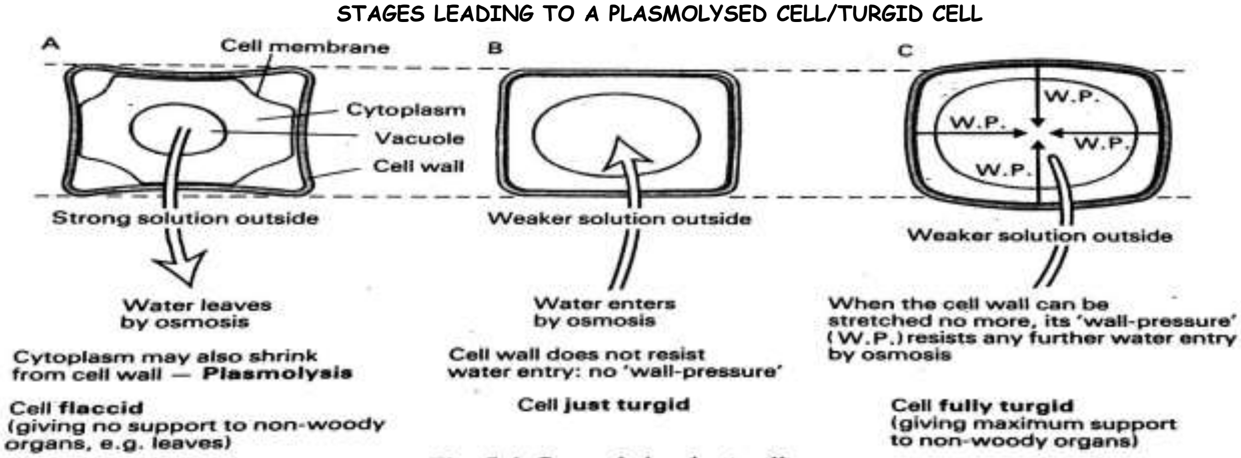
$\psi = -1300 + 500 = -800$ kPa

$\psi = -1900 + 700 = -1200$ kPa

Since -800 is a higher number than -1200 ***water will move by osmosis down a water potential gradient from A → B.***

EXTENSION

STAGES LEADING TO A PLASMOLYSED CELL/TURGID CELL

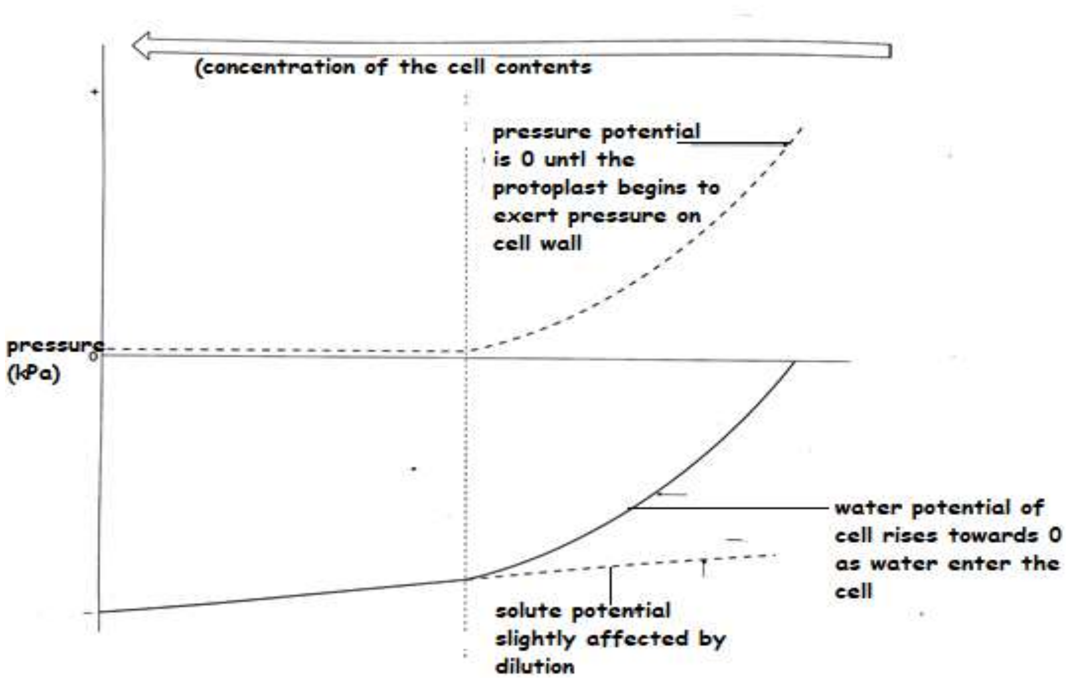


OSMOSIS IN ANIMAL CELLS

Animal cells lack cell wall and hence cannot become turgid as plant cells. The cell wall is rigid and tougher than cell surface membrane. When animal cell is placed in distilled water, water enters by osmosis because the cell has negative solute potential and so low water potential; distilled water has a water potential of zero so inflow of water causes the cell to swell and burst. The bursting could have been prevented if they had a cellulose cell wall. If the red cells swell and burst it is called heamolysis

If animal cell is placed in a strong solution; it has a higher water potential and so loss of water to the surrounding solution by osmosis along a water potential gradient and so the cells become crinkled/crenated

RELATIONSHIP BETWEEN WATER POTENTIAL, SOLUTE POTENTIAL AND PRESSURE POTENTIAL



EXTENSION

1.a) Compare the effect of dilution on pressure potential and water potential of the cell.

(b) Explain the changes in each of the following as dilution increases:

(i) Pressure potential

(ii)Water potential

(iii)Solute potential

ACTIVE TRANSPORT

Movement of molecules or ions in and out of the cells from a region of their lower concentration to region of their higher concentration using energy and carrier proteins

FEATURES

Metabolic energy supplied by ATP

Materials moved against the concentration gradient

Carrier proteins which act as pumps are involved

Carrier proteins undergo through change in shape/conformational changes in shape

Very selective, with specific molecules transported

Active transport is classified into two types according to the source of energy used as follows:

i. Primary active transport

ii. Secondary active transport.

PRIMARY ACTIVE TRANSPORT

In primary active transport, the energy is derived directly from hydrolysis of ATP. Sodium, potassium, calcium, hydrogen and chloride ions are transported by primary active transport

PRIMARY ACTIVE TRANSPORT OF NA+ AND K+ (SODIUM-POTASSIUM PUMP)

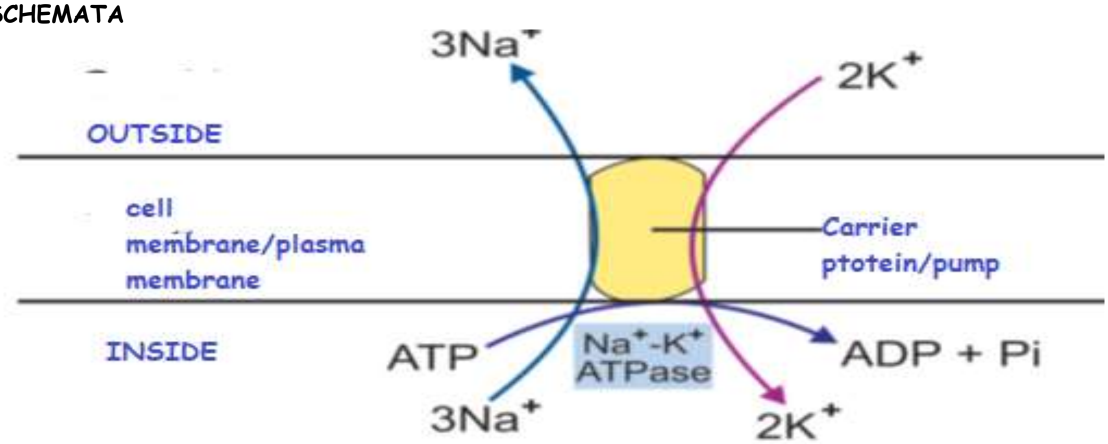
Na+-K+ Pump, a primary active transport process that pumps Na+ ions out of the cell and at the same time pumps K+ ions from outside to the inside generating an electrochemical gradient.

Carrier protein of Na+-K+ pump has three receptor sites for binding sodium ions on the inside of the cell and two receptor sites for potassium ions on the outside. The inside portion of this protein has ATPase activity. The pump is called Na+-K+ ATPase because the hydrolysis of ATP occurs only when three Na+ ions Bind on the inside and two K+ ions bind on the outside of the carrier proteins. The energy liberated by the hydrolysis of ATP leads to conformational change in the carrier protein molecule, extruding the three Na+ ions to the outside and the two K+ ions to the inside.

Physiological importance of Na+-K+ pump

The active transport of Na+ and K+ is of great physiological significance. The Na+-K+ gradient created by this pump in the cells, controls cell volume. It carries the active transport of sugars and amino-acids Potassium ions needed in many physiological processes such as respiration/glycolysis/krebcycle

SCHEMATA



SECONDARY ACTIVE TRANSPORT

Secondary active transport uses an energy generated by an electrochemical gradient. It is not directly coupled with hydrolysis of ATP. Secondary active transport is classified into two types:

1. Co-transport or symport, in which both substances move simultaneously across the membrane in the same direction e.g. transport of Na+ and glucose to the intestinal mucosal cells from the gut.
2. Counter transport or antiport, in which both substances move simultaneously in opposite direction e.g. transport of Na+ and H+ occurs in the renal proximal tubules and exchange of Cl- and HCO3 in the erythrocytes.

CO-TRANSPORT IN TRANSFER CELLS

Hydrogen ions are actively pumped out of the companion cells into the apoplast using ATP, establishing proton gradient; hydrogen ions diffuse rapidly back into the companion cell by way of specific carrier protein that only function if they co-transport sucrose. Sucrose diffuses down a concentration gradient into the companion cells; water follows by osmosis creating a very hydrostatic pressure at the source;

ABSORPTION OF PRODUCTS OF DIGESTION

Sodium ions are actively pumped out of the epithelial cells of the villus; by sodium-potassium pump; sodium ions are at the higher concentration outside the epithelial cells than inside; a gradient of sodium ions exists across the plasma membrane; carrier protein in the membrane accepts both glucose and sodium ions glucose is transported from lumen into enterocytes sodium ions and glucose dissociates from the carrier protein and pass into the cytostol of epithelial cell; glucose molecule combines with the carrier protein in the membrane of the base of epithelial cells transported across into the blood capillary network of the villus by facilitated diffusion;

CARRIER MEDIATED TRANSPORT

Involves facilitated diffusion, primary and secondary active transport.

CHARACTERISTICS OF CARRIER MEDIATED ACTIVE TRANSPORT

saturation; transport rate increases as solute increases until all carriers are saturated/cannot further take up molecules;

Competition; structurally similar or related solutes compete for site on carrier molecule; eg galactose is a competitive inhibitor of glucose in the small intestine;

Stereo -specificity; specific, molecules being moved eg D-glucose (natural isomer moves by facilitated diffusion but L-isomer moves by diffusion;

FACILITATED DIFFUSION

CHARACTERISTICS

Down an electrochemical gradient/concentration gradient;
Does not require metabolic energy;
More rapid movement of materials than simple diffusion;
Carrier mediated so exhibit stereo -specificity/saturation/competition;

PRIMARY ACTIVE TRANSPORT

CHARACTERISTICS

Occurs against an electrochemical gradient/uphill;
Requires direct input of metabolic energy inform of ATP;
Carrier mediated so exhibits stereo -specificity/competition/saturation;

SECONDARY ACTIVE TRNSPORT

CHARACTERISTICS

Transport of two or more solutes is coupled;
One of the solute/sodium ions transported downhill provides energy for uphill Transport of other/glucose;
If solutes move in the same direction across the plasma membrane this is Symport/co-transport;
If solutes move in opposite direction across the plasma membrane this is called counter transport/Antiport eg sodium- calcium ion exchange;

SIMPLE DIFFUSION

CHARACTERISTICS

Occurs down an electrochemical gradient/downhill;
Not carrier mediated;
Does not depend on metabolic energy;
No stereo -specificity/competition and saturation;

CARRIER PROTEINS INVOLVED IN ACTIVE TRANSPORT

Carrier proteins involved in active transport are of two types:

1. Uniport
2. Symport or antiport.

1. Uniport

Carrier protein that carries only one substance in a single direction is called Uniport. It is also known as

Uniport pump.

2. Symport or Antiport

Symport or antiport is the carrier protein that transports two substances at a time.

Carrier protein that transports two different substances in the same direction is called symport or symport pump. Carrier protein that transports two different substances in opposite directions is called antiport or antiport pump.

IMPORTANCE OF ACTIVE TRANSPORT

Absorption of food materials in the mammalian gut

Absorption of mineral salts by plant root hairs and the root epidermal cells

Excretion of waste materials from the cells to the extracellular fluids against a concentration gradient e.g. excretion of urea

Muscle contractions and relaxations where there's active pumping in and out of calcium ions inside the cytoplasm (sarcoplasm) of the muscle.

Loading and unloading of materials in the plants phloem tissue

Transmission of nerve impulses along nerve cells

Opening and closure of stomata.(Potassium ions)

SPECIAL TYPES OF ACTIVE TRANSPORT/VESICULAR TRANSPORT

Special categories of active transport:

1. Endocytosis
2. Exocytosis
3. Transcytosis.

ENDOCYTOSIS

Endocytosis is defined as a transport mechanism by which the macromolecules enter the cell. Macromolecules (substances with larger molecules) cannot pass through the cell membrane either by active or by passive transport mechanism. Endocytosis is divided into phagocytosis and pinocytosis or receptor-mediated endocytosis.

MECHANISM OF PINOCYTOSIS/CELL DRINKING

Macromolecules (in the form of droplets of fluid) bind to the outer surface of the cell membrane

ii. Now, the cell membrane evaginates around the droplets

iii. Droplets are engulfed by the membrane

iv. Engulfed droplets are converted into vesicles and vacuoles, which are called endosomes

v. Endosome travels into the interior of the cell

vi. Primary lysosome in the cytoplasm fuses with endosome and forms secondary lysosome

vii. Now, hydrolytic enzymes present in the secondary lysosome are activated resulting in digestion and degradation of the endosomal contents

PHAGOCYTOSIS/PATHOGEN(BACTERIA)

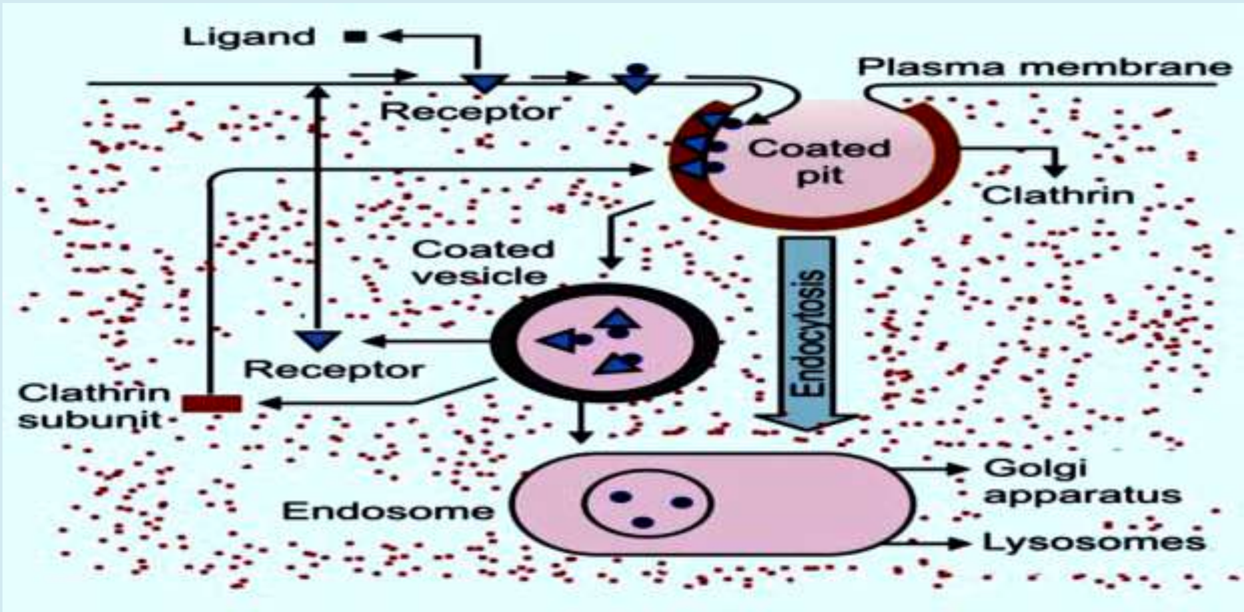
When bacteria or foreign body enters the body, first the phagocytic cell sends cytoplasmic extension (pseudopodium) around bacteria or foreign body Then; these particles are engulfed and are converted into endosome like vacuole. Vacuole is very large and it is usually called the

Phagosome. Phagosome travels into the interior of cell. Primary lysosome fuses with this phagosome and forms secondary lysosome. Hydrolytic enzymes present in the secondary lysosome are activated resulting in digestion and degradation of the phagosomal contents

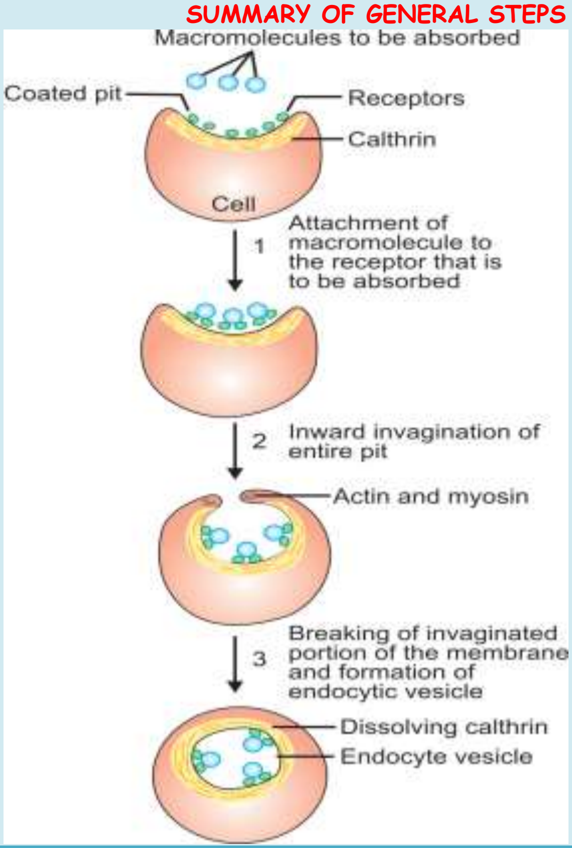
RECEPTOR MEDIATED EDOCYTOSIS

Receptor-mediated endocytosis is induced by substances, ligands; Ligand molecules approach the cell and bind to receptors in the coated pits form Ligand-receptor. Complex; Ligand-receptor complex gets aggregated in the coated pits; pit is detached from cell membrane and becomes the coated vesicle; coated vesicle forms the endosome; Endosome travels into the interior of the cell; Primary lysosome in the cytoplasm fuses with endosome and forms secondary lysosome; hydrolytic enzymes present in secondary lysosome are activated resulting in release of ligands into the cytoplasm; Receptor may move to a new pit of the cell membrane;

SCHEMATA/ILLUSTRATION OF RECEPTOR MEDIATED ENDOCYTOSIS



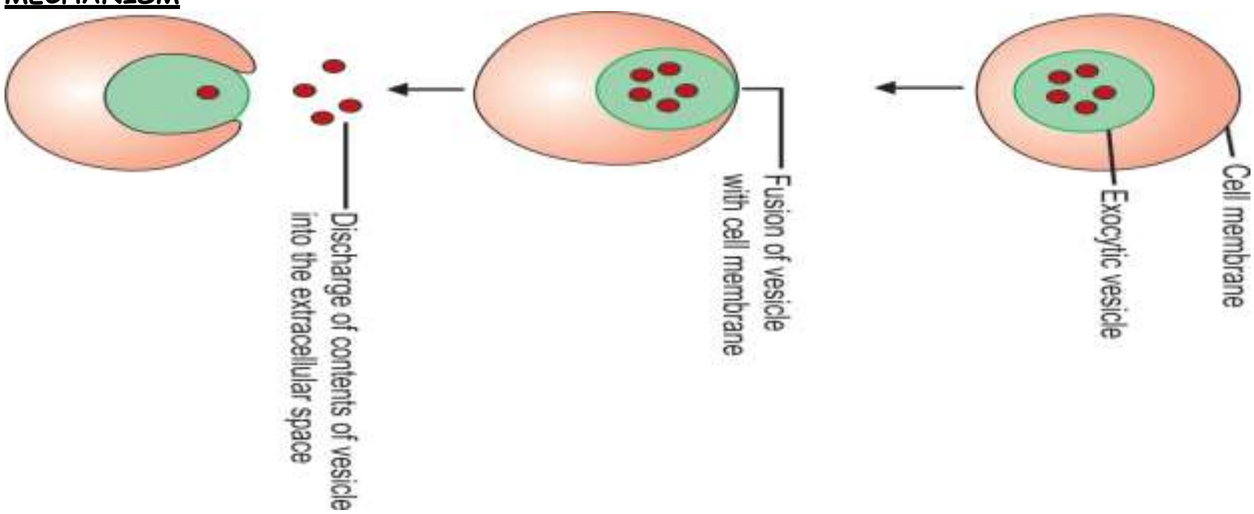
SUMMARY OF GENERAL STEPS OF PINOCYTOSIS AND PHAGOCYTOSIS



EXOCYTOSIS

Exocytosis is involved in the release of secretory substances from cells. Secretory substances of the cell are stored in the form of secretory vesicles in the cytoplasm. When required, the vesicles approach the cell membrane and get fused with the cell membrane. Later, the contents of the vesicles are released out of the cell

MECHANISM



ROLE OF CALCIUM IN EXOCYTOSIS

Calcium ions play an important role during the release of some secretory substances such as neurotransmitters. The calcium ions enter the cell and cause exocytosis. However, the exact mechanism of exocytosis is not clear.

VESICULAR TRANSPORT SUMMARY

Vesicular transport uses vesicles or other bodies in the cytoplasm to move macromolecules or large particles across the plasma membrane. Types of vesicular transport are described below.

Exocytosis; describes the process of vesicles fusing with the plasma membrane releasing their contents to the outside of the cell eg enzyme secretion;

Endocytosis; describes the capture of a substance outside the cell when the plasma membrane emerges to engulf it; Phagocytosis ("cellular eating") occurs when un dissolved material enters the cell; plasma membrane wraps around the solid material and engulfs it, forming a Phagocytic vesicle; Phagocytic cells (such as certain white blood cells) attack and engulf bacteria in this manner; Pinocytosis ("cellular drinking") plasma membrane folds inward to form a channel allowing the liquid to enter cell forming vacoules

Receptor-mediated endocytosis Molecules such as cholesterol; from extracellular environment bind with specific receptor molecules on the cell surface; receptor sites become filled; the surface folds inwards; until a coated vesicle finally separates from the cell surface membrane into the cytoplasm;

IMPORTANCE OF VESICLES AND VACUOLES IN ORGANISMS.

Vacuoles and vesicles are fluid-filled, membrane-bound bodies.

Transport vesicles; move materials between organelles/ between organelles and the plasma membrane;

Food vacuoles; are temporary receptacles of nutrients;

Storage vacuoles; in plants store starch/pigments/toxic substances; (nicotine, for example).

Central vacuoles; When fully filled, exert turgor/pressure, on the cell walls, thus maintaining rigidity in the cell;/also store nutrients/function as lysosomes

Contractile vacuoles; are specialized organelles in single-celled organisms that collect and pump excess water out of the cell;

TRANSCYTOSIS

Transcytosis is a transport mechanism in which an extracellular macromolecule enters through one side of a cell, migrates across cytoplasm of the cell and exits through the other side.

Transcytosis plays an important role in selectively transporting the substances between two environments across the cells without any distinct change in the composition of these environments. Example of this type of transport is the movement of proteins from capillary blood into interstitial fluid across the endothelial cells of Capillary. HIV is transported by this mechanism.

IMPORTANCE OF CYTOSIS

Secretory cells use exocytosis to release their excretory products outside themselves e.g. pancreatic cells manufacture insulin and secrete it into blood by exocytosis

Exocytosis facilitates synaptic transmission during which neuro-transmitter substances like acetylcholine in synaptic vesicles of synaptic knobs fuse with the pre-synaptic membrane to release neuro transmitter substances into the synaptic cleft of the synapse.

Exocytosis delivers cell wall materials to the outside of the cell from the Golgi apparatus/body through vesicles which contain proteins and certain carbohydrates

Exocytosis leads to replenishment of the plasma membrane as the vesicle membrane become part of the plasma membrane become part of the plasma membrane after spilling/discharging their contents to the outside.

ROLE OF DIFFERENT ORGANALLES IN PRODUCTION AND RELEASE OF ENZYMES BY EXOCYTOSIS

Nucleus; contains DNA; template for different mRNA coding for different enzymes;

Mitochondria; supplies energy inform of ATP;

Rough endoplasmic reticulum; supports ribosomes; transports proteins made by ribosomes; proteins fold into 3-D structure inside membranes;

Golgi body; modifies proteins;(remolding the carbohydrate antennae to become markers); packages proteins; budded off as vesicles; fuse with plasma membrane to discharge the content to the outside