S5 BIOLOGY NOTES (DIFFUSION CONTINUED…)

Significance of diffusion

- It's a means by which gaseous exchange occurs in plants through the stomata, across the alveoli in mammals and across the gill filaments in gills of fish,
- Absorption of certain digested food materials e.g. glucose in the ileum.
- A means of exchange of materials between blood in capillaries and the tissues
- Exchange of ions such as sodium and potassium ions across the nerve cells facilitating generation of nerve impulses and ensuring transmission of nerve impulses from one neuron to another
- It ensures excretion of waste products e.g. ammonia in fresh water fishes
- It's the main means of transportation of materials within the cell's cytoplasm e.g. in unicellular
- Absorption of mineral salts by plants from the soil

FACTORS AFFECTING THE RATE OF DIFFUSION

1. **The concentration gradient**

   This refers to the relative concentration on either side of the membrane or between two points. The greater the difference in concentration between two regions of a substance the, the faster the rate of diffusion and if the difference is less, the slower the diffusion rate.

   A high concentration gradient can be achieved by maintaining a fresh supply of a substance to be absorbed by creating a stream over the diffusion surface. Equally, the substance, once absorbed, must be rapidly transported away.

2. **Temperature**

   When increased, temperature causes an increased rate of diffusion, as the particles acquire increased kinetic energy which increases speed of movement hence increasing the rate of diffusion.

   At low temperatures, the kinetic energy is very low and the speed of movement by particles is low.

3. **Area across which diffusion occurs**

   The larger the surface area over which the molecules are exposed, the faster the rate of diffusion. Diffusion surfaces frequently have features for increasing their surface area and hence the rate at which they exchange materials. These include:- being numerous, increasingly in folded, having villi and microvilli

4. **Distance over which diffusion takes place**

   This is the distance over which the molecules are to travel i.e. the surface thickness across which the molecules move. The shorter the distance between two regions of a substance the greater the rate of diffusion. The rate is proportional to the reciprocal of the square of the distance, therefore any structure in an organism across which diffusion regularly takes place must therefore be thin.

5. **Size and nature of diffusing molecules**

   The smaller the size of the diffusing particles, the faster they diffuse i.e. smaller particles move faster while the large ones move slowly. Fat-soluble ones diffuse more rapidly through cell membranes than water-soluble ones.

6. **Permeability**

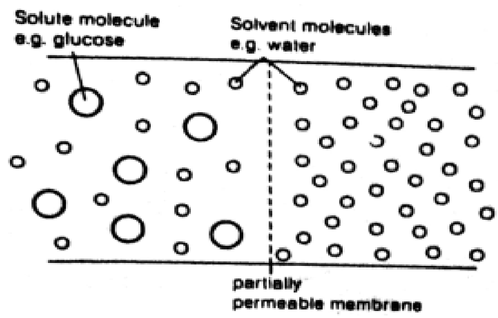
   The more porous a surface is, the greater the number of particles that diffuse through it hence the greater the rate of diffusion

2. OSMOSIS

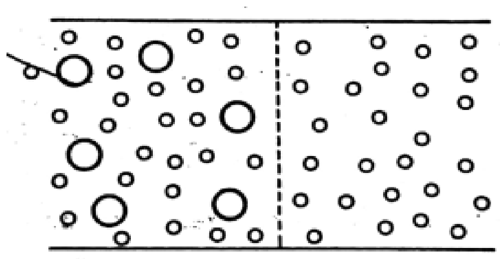
This is the net movement of solvent molecules from a region where they are at a higher concentration i.e. dilute solution / region of higher water potential to a region where they are at a lower concentration i.e. concentrated solution / region of lower water potential across a selectively permeable membrane

A **selectively permeable membrane** is one that allows unrestricted passage of water molecules but no passage of solute molecules.

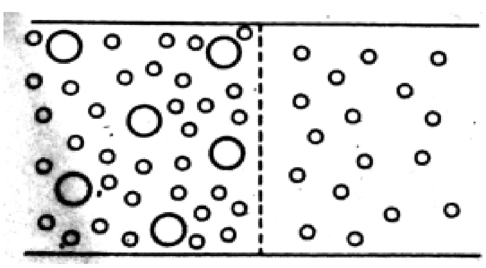
Explanation of osmosis



Both solvent (water) and solute (glucose) molecules are in random motion, but only solvent (water) molecules are able to cross the partially permeable membrane. This they do until their concentration is equal on both sides of the membrane



Once the water molecules are evenly distributed, in theory a dynamic equilibrium should be established. However, the water molecules on the left of the membrane are impeded to some extent by the glucose molecules from crossing the membrane. With no glucose present on the right of the membrane, water molecules move easily to the left than in reverse direction.



A situation is reached where by additional water molecules accumulate on the left of the membrane until their greater concentration offsets the blocking effect of the glucose. The probability of water molecules moving in either direction is the same, and a dynamic equilibrium is established.

COMMON TERMS USED IN OSMOSIS

- **Hypotonic solution**: Is a solution whose solute concentration is lower than that of another system with which it is in contact.
- **Hypertonic solution:** Is a solution whose solute concentration is higher than that of another system with which it is in contact.
- **Isotonic solution:** Is a solution whose solute concentration is the same as that of another system in which it is in contact.
- **Endosmosis:** This is the osmotic flow of water into a cell
- **Exosmosis:** This is the osmotic flow of water out of a cell

- **Osmotic pressure**

  Is the pressure which must be applied to stop water from entering the solution, if a solution is separated from its pure solvent by a selectively permeable membrane. The more concentrated a solution the greater is its osmotic pressure. The preferred term is osmotic potential which refers to potential of a solution to pull water into it, it always has negative value thus a more concentrated solution therefore has a more positive osmotic pressure but a more negative osmotic potential.
- **Water potential:** The Greek letter psi, ψ, can be used to mean water potential.

  This is the tendency of water molecules to enter or leave a solution by osmosis. Or from thermodynamics, is defined as a measure of the free kinetic energy of water molecules in a solution.

Water diffuses from a region of high-water potential to a region of lower water potential, and the steeper the water potential gradient the greater will the tendency for water to diffuse in this direction

At standard temperature and pressure pure water is given a water potential of zero. Adding solute molecule to the water has the effect of lowering the water potential i.e. making it negative.

Reason: solute molecules attract water molecules, reducing the number of water molecules which can diffuse freely

COMPONENTS OF WATER POTENTIAL

Factors that determine water potential of solutions

- Presence of dissolved solutes or how much water the solution contains in relation to solutes (giving rise to solute potential)
- Mechanical pressure acting on water (pressure potential)

The components are related as shown in the equation below

$$\textit{Water potential} = \textit{Solute potential}(\Psi s) + \textit{Pressure potential}(\Psi p)$$

$$\Psi = \Psi s + \Psi p$$

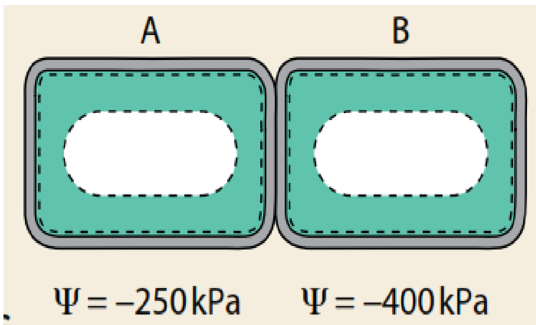
Solute potential of a solution

This is the negative component of water potential due to the presence of solute molecules. Solute potential is therefore the extent to which the solute molecules decrease the water potential of the solution. The more solute there is, the lower the tendency for water to move out of the solution.

This becomes more negative as more solutes are added to the system.

Example

1. Two neighboring plant cells are shown in the figure below.



(a) In which direction would there be net movement of water molecules? Explain your answer.

(b) Explain what would happen if both cells were placed in;

(i) pure water

(ii) a 1 mol dm^{-3} sucrose solution with a water potential of -3510 kPa.

Solution

(a) ***From cell A to cell B;*** *cell A has a higher water potential than cell B (-250 is less negative than -400) and water always moves by osmosis from regions of higher water potential (cell A) to lower water potential (cell B).*

(b)

(i) Pure water has a water potential of zero; which is higher than that of both cells A and B; There is therefore a net movement of water into cells A and B by osmosis through their partially permeable cell surface membranes; As water enters, the volume of the protoplasts will increase, exerting pressure on the cell walls and raising the pressure potential of the cells. This increases the water potential of the cells. This will continue until an equilibrium is reached when the contents of the cells reach the same water potential as the water, namely zero. The cells will then be turgid.

(ii) *1 mol dm^{-3} sucrose solution has a lower water potential than that of cells A and B; there is therefore a net movement of water out of cells A and B by osmosis through their* *partially permeable cell surface membranes; As water leaves the cells, the protoplasts shrink and the pressure they exert on the cell walls drops; in other words, the pressure potential of the cells decreases; This decreases the water potential of the cells. Eventually, the pressure potential drops to zero and the cells are at incipient plasmolysis; As shrinkage continues, the protoplasts pull away from the cell walls, this is plasmolysis; The sucrose solution can pass freely through the permeable cell walls and remains in contact with the protoplasts; As water leaves the cells, the contents of the protoplasts get more and more concentrated and their water potential gets lower and lower (more and more negative); Equilibrium is reached when the water potential of the cells equals that of the sucrose solution.*

2. **A plant cell with a solute potential of -1240kPa and a pressure potential of 350kPa was immersed in a sucrose solution whose water potential was -530kPa.**
   - **(i)** **Calculate the water potential gradient between the cell and the sucrose solution**
   - (ii) **State the direction in which the water will flow**.

Solution

(i) *Water potential of the cell*

$$\Psi = \Psi s + \Psi p$$

= -1240+ 350

= -890kPa

Water potential gradient = water potential of cell- water potential of solution

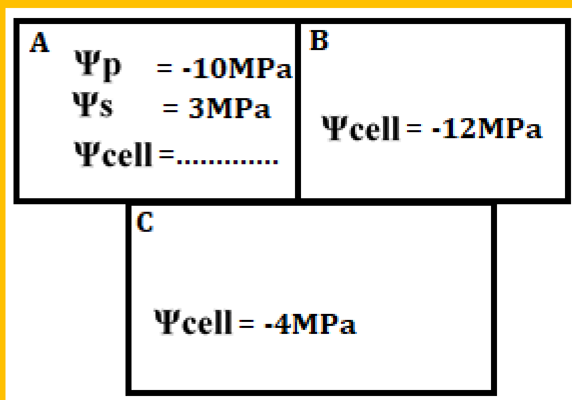
= -890-(-530)

= -360 kPa

(ii) water molecules will move from sucrose solution into the cell

Exercise 1

1. Plant cell A has a solute potential of -300kPa and a pressure potential of 200kPa. Lying next to it is plant cell B which has a solute potential of -400kPa and a pressure potential of 100kPa. Use the water potential equation to predict the direction of net movement of water in each cell.
2. The diagram below shows three adjacent plant cells

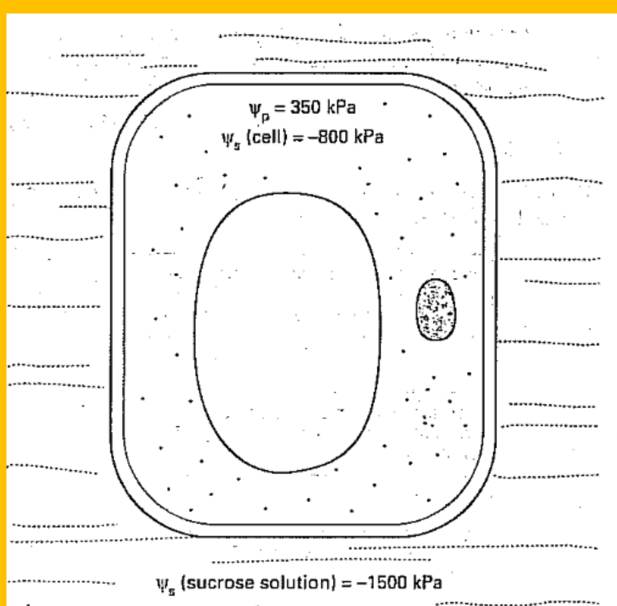


(i) calculate the water potential of cell A. write tour answer on the diagram.

(ii) show by means of arrows on your diagram. The direction of water movement between these cells

(iii) explain why the water potential of a sucrose solution has a negative value.

3. The diagram below shows a plant cell immersed in a sucrose solution. The pressure potential (***Ψp***)**of** the cell and the solute potential (***Ψs***) of the cell and of the sucrose solution are shown in the diagram.



Calculate the water potential of this cell. Show your working

(a) State whether water will move into or out of the cell. Explain your answer.

(b) State the water potential of this cell at the point of incipient plasmolysis. Assume that changes in solute potential of the cell are negligible.

OSMOSIS IN ANIMAL CELLS

- When a cell is bathed in an external solution which has the same water potential as its cytosol (the liquid part of cytoplasm), the external solution is said to be **isotonic** with the cytosol since it does not cause change in the volume of the cell. This is because the water potential inside and outside the cell is the same and there is no net flow of water in or out.
- When an animal cell is bathed in an external solution with higher water potential than the cytosol such as fresh water, the solution is said to be **hypotonic** to the cytosol, there is net movement of water molecules into the cell, causing the cell volume to increases, a pressure potential builds up, as animal cells have no cell wall to protect them from rupture, their plasma membrane is unable to resist the pressure potential that develops, the cells swell until they burst a process known as **lysis**.

  However, for organisms whose natural environment is fresh water, they will have a mechanism for eliminating excess water which has entered the cell by osmosis e.g. amoebae that live in ponds have contractile vacuole which collects and gets rid of excess water, keeping the volume of the cell constant.
- When an animal cell is placed in an external environment with lower water potential than the cytosol e.g. very salty water, the solution is said to be **hypertonic** to the cytosol, there is a net movement of water molecules out of the cell, causing the cell to shrink and shrivel. In red blood cells the shrinking of the cell volume leads to crinkling of the plasma membrane called **crenation**

OSMOSIS IN PLANT CELLS

Unlike animal cells, plant cells are surrounded by cell walls, which are very strong and rigid.

- When a plant cell is placed in pure water or a dilute solution. The water or solution has a higher water potential than the plant cell, and water therefore enters the cell through its partially permeable cell surface membrane by osmosis. Just like in the animal cell, the volume of the cell increases, but in the plant cell the cell wall pushes back against the expanding protoplast (the living part of the cell inside the cell wall), and pressure starts to build up rapidly. This is the pressure potential, and it increases the water potential of the cell until the water potential inside the cell equals the water potential outside the cell, and equilibrium is reached. The cell wall is so inelastic that it takes very little water to enter the cell to achieve this. The cell wall prevents the cell from bursting, unlike the situation when an animal cell is placed in pure water or a dilute solution. When a plant cell is fully inflated with water it is described as fully turgid.

- When a plant cell is placed in a solution of lower water potential e.g. a concentrated sucrose solution. In such a solution, water will leave the cell by osmosis. As it does so, the protoplast gradually shrinks until it is exerting no pressure at all on the cell wall. At this point the pressure potential is zero, so the water potential of the cell is equal to its solute potential. Both the solute molecules and the water molecules of the external solution can pass through the freely permeable cell wall, and so the external solution remains in contact with the shrinking protoplast. As the protoplast continues to shrink, it begins to pull away from the cell wall. This process is called plasmolysis, and a cell in which it has happened is said to be plasmolysed The point at which pressure potential has just reached zero and plasmolysis is about to occur is referred to as incipient plasmolysis. Eventually, as with the animal cell, an equilibrium is reached when the water potential of the cell has decreased until it equals that of the external solution.

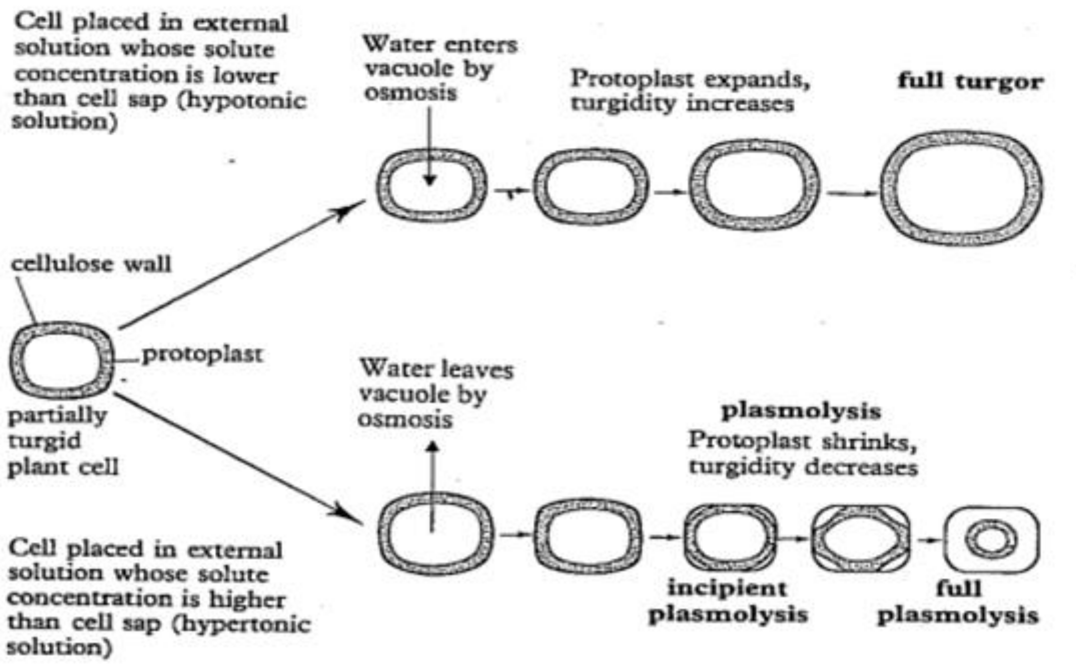


Figure: summary of osmosis in plant cells

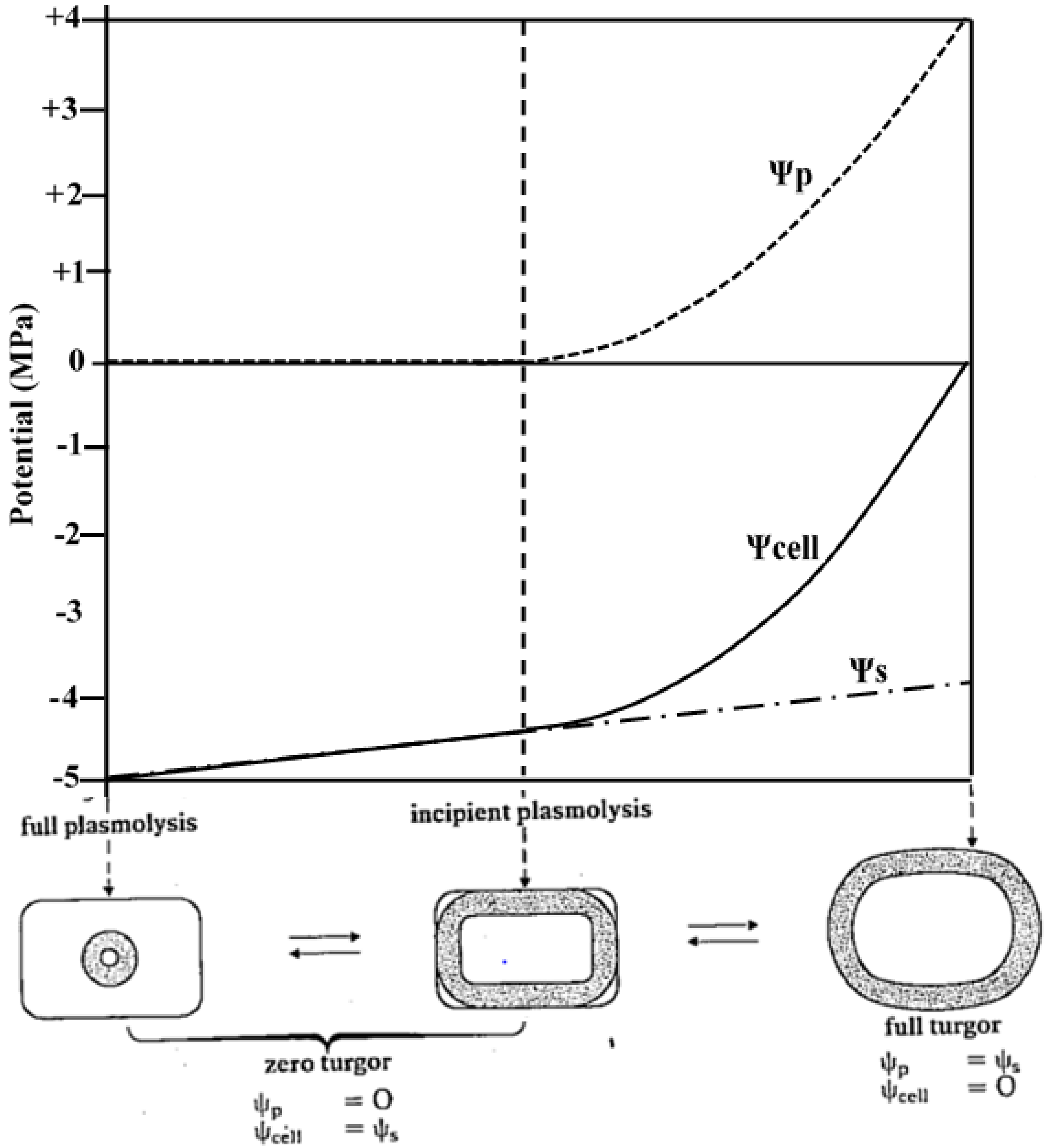
PLANT WATER RELATIONS

Here three forces i.e. water potential of the whole cell, pressure potential and solute potential of the sap must be accounted for

Assuming a plant cell has just been plasmolysed by immersing it in a strong sucrose solution. Then the cell is taken out of the solution and placed in pure water, and the protoplast begins to expand

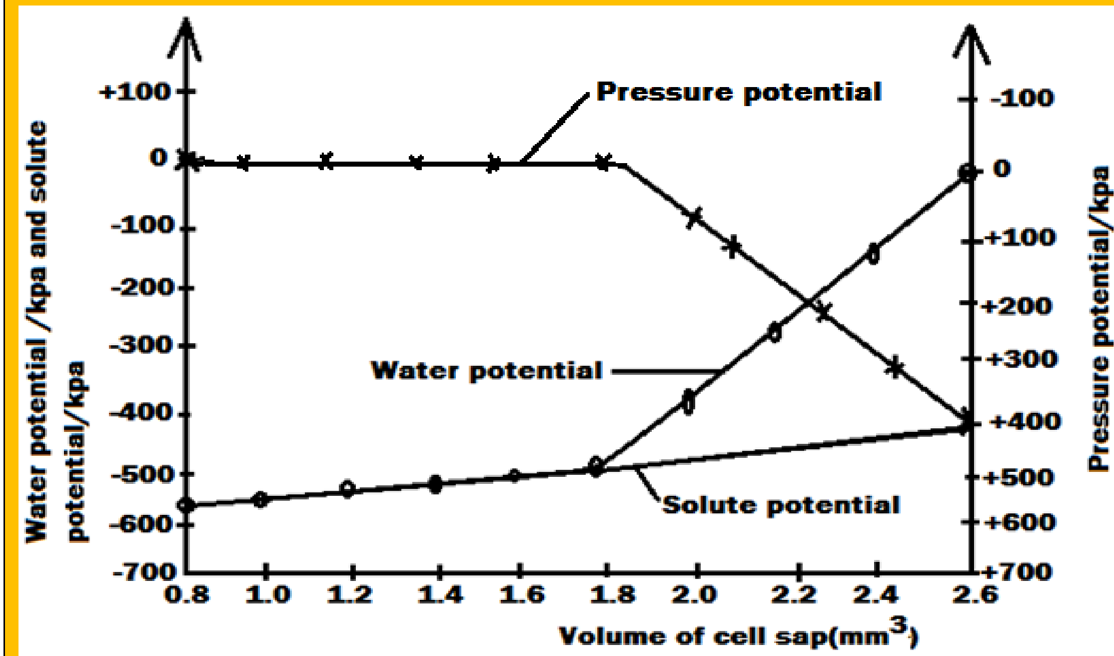
In plasmolysed cell, the water potential of the cell equals the osmotic potential of the sap. As influx of water continues, the protoplast goes on expanding until it comes into contact with the cellulose cell wall. When this point is reached the influx of water starts being opposed by the inward pressure of the cell wall that is the pressure potential. The water potential of the cell now becomes less negative than the osmotic potential of the sap by the amount of the pressure potential. As the cell continues to expand, the pressure potential gets steadily greater and the water potential of the cell gets less and less negative. Eventually full turgor is reached; the cell can expand no more; the water potential of the cell reaches zero and the osmotic potential of the sap is exactly counterbalanced by the pressure potential.

A graph illustrating the relationship between water potential of the cell, osmotic potential of the sap and pressure potential of a plant cell at different states of turgor and plasmolysis.


+4
+3
+2
+1
0
-1
-2
-3
-4
-5
Potential (MPa)
Ψp
Ψcell
Ψs
full plasmolysis
incipient plasmolysis
zero turgor
ψp = O
ψcell = ψs
full turgor
ψp = ψs
ψcell = O

Exercise 2

1. In an investigation, a flaccid epidermal plant cell was placed in pure water. The effect of water uptake on water potential, solute potential and pressure potential with change in the volume of cell sap is illustrated in figure below.



(a)Describe changes in each of the following variables,

(i) Pressure potential. (04 marks)

(ii) Water potential. (04 marks)

(iii) Solute potential. (03 marks)

(b) Explain the relationship between water potential and each of the following,

(i) Pressure potential. (07 marks)

(ii) Solute potential. (04 marks)

(c) Explain the,

(i) changes in volume of cell sap and pressure potential. (07 marks)

(ii) effect of lowering solute potential on the following,

- mechanical support in herbaceous plant. (02 marks)
- aperture of the stoma. (03 marks)

(d) State the importance of change in turgidity to plants. (04 marks)

(e) How do heat and alcohol affect the selective permeability of the plasma membrane? (02 marks)

ROLE OF OSMOSIS IN LIVING ORGANISMS

1. For absorption of water by root hairs and piliferous layer cells of plant roots from the soil.
2. Re-absorb water back into the blood stream across kidney nephrons (tubules) via the blood capillaries leading to water conservation in the body.
3. In herbaceous plants, osmosis brings about turgidity in plant cells due to presence of cell wall leading to provision of support and shape in a whole plant body.
4. Determines form of plant structures (organs) like leaves and flowers for example holding the leaf in flat and horizontal position enabling it to trap maximum sunlight.
5. Brings about opening and closure of petals of flowers through changes in turgidity of cells
6. Brings about opening and closure of stomata in plant leaves when due to changes in turgidity of guard cells facilitating gaseous exchange in plants.

Exercise 3

1. Explain why an animal cell placed in pure water bursts while a plant cell placed in pure water does not.
2. What type of replacement drink should a heavily perspiring athlete take: hypertonic, isotonic or hypotonic? Give reasons for your answer.

3. ACTIVE TRANSPORT

It is the movement of molecules or ions across a cell membrane against their concentration gradient aided by the protein pump with specific binding sites, involving the expenditure of energy.

Cells and tissues which carry out active transport are characterized by

- A high respiratory rate
- The presence of a large number of mitochondria
- Ahigh concentration of Adenosine Tri Phosphate (ATP).

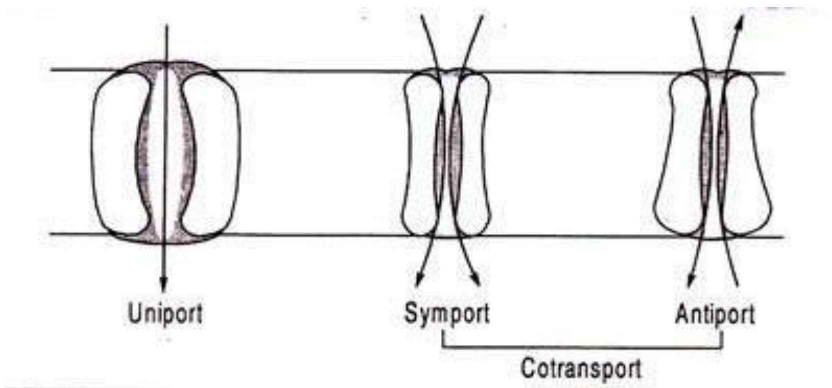
The energy from ATP can be directly or indirectly used in active transport. Active transport can be slowed or inhibited by respiratory poisons (inhibitors) e.g. cyanide or lack of oxygen.

Types of membrane proteins involved in active transport

Three main types of membrane proteins exist;

- **Uniport carriers:** they carry (transport) a single ion or molecule in a single direction
- **Symport carriers:** they carry (transport) two substances in a single direction
- **Antiport carriers:** they carry (transport) two substances opposite directions

Summary



MECHANISM OF ACTIVE TRANSPORT

This can be direct active transport if the energy from ATP is used directly to transport the substances, ions or molecules, or it can be indirect active transport if the energy is not directly used to transport a substance across a membrane.

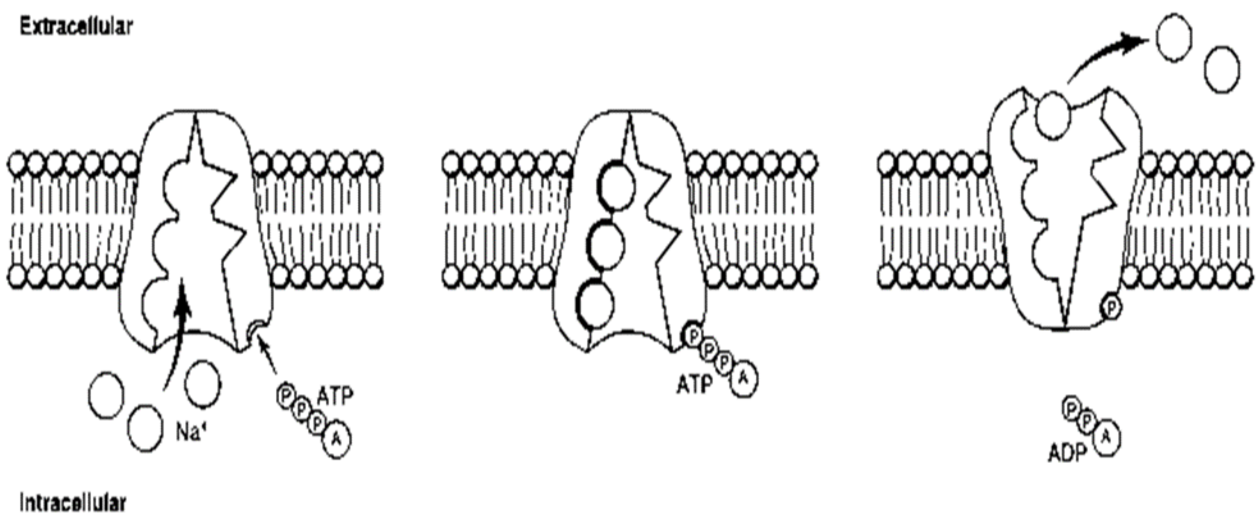
(a) Direct active transport for example: The Sodium-Potassium Pump

Most animal cells have a low internal concentration of Na^+, relative to their surroundings, and a high internal concentration of K^+. They maintain these concentration differences by actively pumping Na^+ out of the cell and K^+ in. The remarkable protein that transports these two ions across the cell membrane is known as the **sodium-potassium pump**.

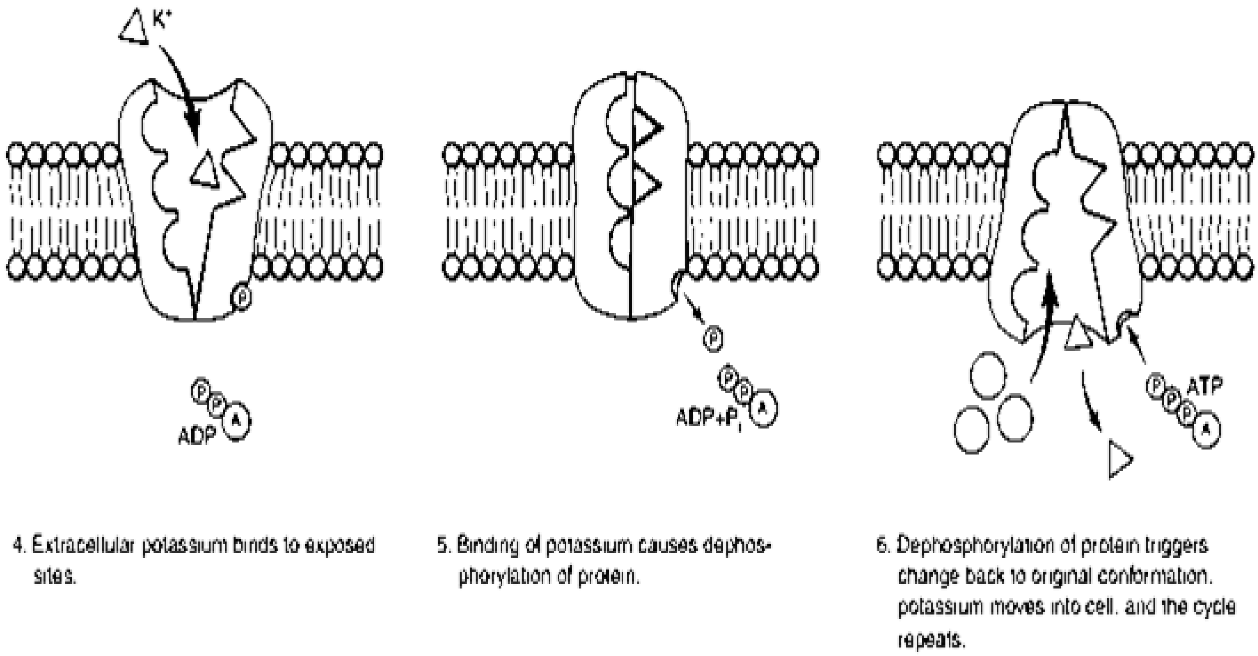
The cell obtains the energy it needs to operate the pump from adenosine triphosphate (ATP). The sodium-potassium pump works through a series of conformational changes in the transmembrane protein.

- Three sodium ions bind to the cytoplasmic side of the protein, causing the protein to change its conformation.

- In its new conformation, the protein binds a molecule of ATP and breaking ATP into adenosine diphosphate and phosphate (ADP + Pi). ADP is released, but the phosphate group remains bound to the protein. The protein is now phosphorylated.
- The phosphorylation of the protein induces a second conformational change in the protein. This change translocates (moves) the three Na^+ across the membrane, so they now face the exterior. In this new conformation, the protein has a low affinity for Na^+, and the three bound Na^+ dissociate from the protein and diffuse into the extracellular fluid.
- The new conformation has a high affinity for K^+, two of which bind to the extracellular side of the protein as soon as it is free of the Na^+.
- The binding of the K^+ causes another conformational change in the protein, this time resulting in the dissociation of the bound phosphate group.
- Upon releasing the phosphate group, the protein regains its original conformation, exposing the two K^+ to the cytoplasm. This conformation has a low affinity for K^+, so the two bound K^+ dissociate from the protein and diffuse into the interior of the cell. The original conformation has a high affinity for Na^+; when these ions bind, they initiate another cycle.



1. Protein in membrane binds intracellular sodium.
2. ATP phosphorylates protein with bound sodium.
3. Phosphorylation causes conformational change in protein, allowing sodium to leave.



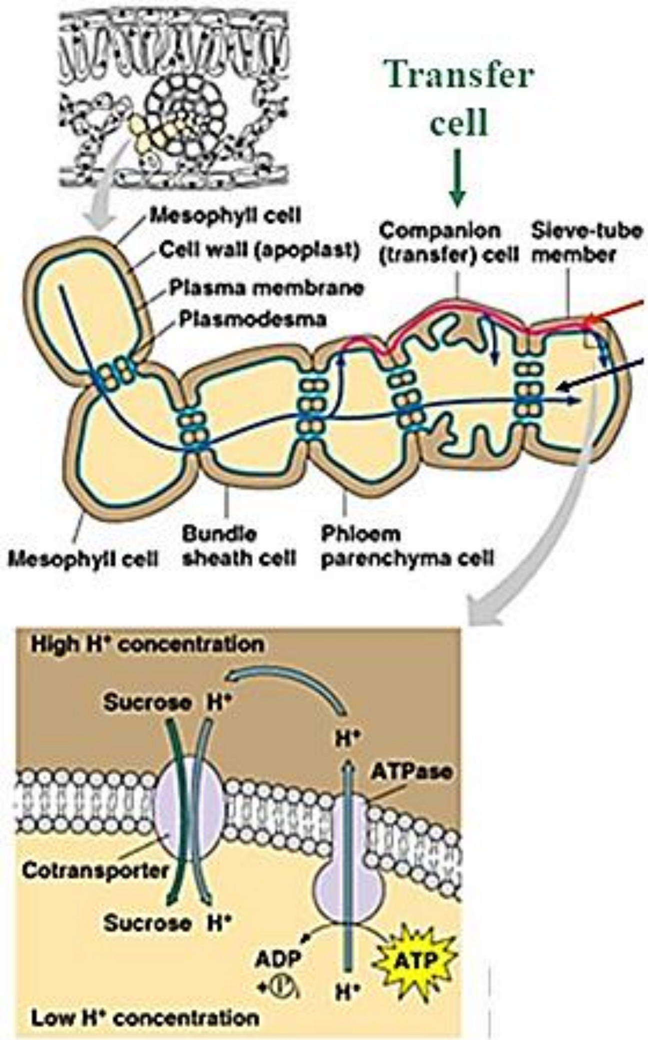
Note:

Three Na^+ leave the cell and two K^+ enter in every cycle. The changes in protein conformation that occur during the cycle are rapid, enabling each carrier to transport as many as 300 Na^+ per second.

(b) Indirect active transport mechanism/secondary active transport

The molecules move hand-in-hand with sodium ions or protons that are moving *down* their concentration gradients. This type of active transport, called **cotransport,**

Example 1: transport of glucose from transfer cells to phloem sieve tube cells



Sucrose made in the leaf mesophyll cells is transported into sieve tubes by special **transfer cell**s, these have highly convoluted cells which increases the surface area of the cell membrane availed for exchange of substances

The ATP driven **proton pump** pumps protons (H^+ ions) from the sieve tube into the cytosol of transfer cell. This creates a proton gradient, in which the concentration of protons is higher inside the transfer cell than the sieve tube. Membranes are impermeable to protons, so protons diffuse back down their concentration gradient is through a second cotransport protein. The re-entry of protons is coupled with transport of glucose molecules against their concentration gradient into the sieve tube cells.

Assignment: Describe the mechanism of transport of glucose across the epithelium of the villus

THE FACTORS AFFECTING ACTIVE TRANSPORT OF MATERIALS

(i) Temperature

Increase in temperature increases the rate of transport of substances by active transport, so long as the increase in not above the optimum. The increase in temperature makes respiratory enzymes more active, having kinetic energy of both enzymes and substrate molecules increased which results into collisions of molecules at a faster rate thus forming enzyme substrate complexes that form products. In this case, ATP is required to power active transport.

At very high temperatures, above the optimum, respiratory enzymes are denatured in the carrier proteins in the membrane. This reduces the rate of active transport.

At very low temperatures, below the optimum, the respiratory enzymes together with the carrier proteins are inactive and this reduces the rate of active transport

(ii) Availability of oxygen

Oxygen is required for aerobic respiration to generate ATP. Increase in oxygen concentration results into increased rates of active transport as more ATP molecules are available for the process. In circumstances of very little or no oxygen, the rate of active transport is reduced since in the case of anaerobic respiration, there's very little or no ATP molecules available for active transport

(iii) Concentration of respiratory substrates e.g. glucose

If the concentration of respiratory substrate is increased, the rate of active transport also increases and if it is lowered, the rate of active transport lowers. This is because increase in the amount of the substrate increases the rate of ATP generation during respiration. If the amount of substrate is reduced, the rate of ATP generation is also lowered.

Importance of active transport

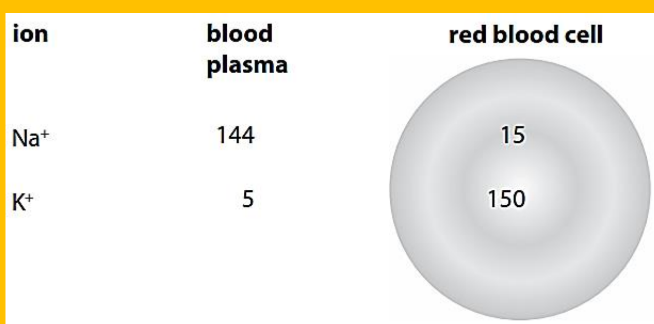
- It is a means of absorption of food materials in the mammalian gut
- It is the means of absorption of mineral salts by plant root hairs and the root epidermal cells of the peliferous layer
- It facilitates the excretion of waste materials from the cells to the extracellular fluids against a concentration gradient e.g. excretion of urea
- It is important in muscle contractions and relaxations where there's active pumping in and out of calcium ions inside the cytoplasm (sarcoplasm) of the muscle.
- It is responsible for the loading and unloading of materials in the plant's phloem tissue, this creates pressure differences in the phloem tissue that maintain mass flow of materials.
- Active transport is vital in transmission of nerve impulses along nerve cells where it creates a membrane action potential using the potassium-sodium pumps.

- It plays a part in the opening and closure of stomata where differential pumping of potassium ions between the guard cells and neighboring subsidiary cells lead to turgidity changes hence causing stomatal movements (opening/closure).

Note: metabolic poisons (inhibitors), inhibit the enzymes and carrier proteins required to bring about active transport by either changing the active sites/binding sites for the enzymes/carrier proteins for the molecules to be transported. The poisons also inhibit ATP synthesis hence cutting off the source of energy needed to affect the active transport.

***Exercise* 4**

1. In the production of urine, glucose is initially lost from the blood but is then reabsorbed into the blood by cell s in the kidneys. Explain why it is important that this reabsorption occurs by active transport rather than by diffusion.
2. Suggest why active transport is affected by changes in oxygen concentration but diffusion is not.
3. The diagram shows the concentration in mmol dm–3 of two different ions inside a human red blood cell and in the plasma outside the cell.



(a) Explain why these concentrations could not have occurred as a result of diffusion.

(b) Explain how these concentrations could have been achieved.

(c) If respiration of red blood cells is inhibited, the concentrations of potassium ions and sodium ions inside the cells gradually change until they come into equilibrium with the plasma. Explain this observation.

4. In an experiment, carrot discs were first washed thoroughly in pure water. The discs were then immersed in aerated potassium chloride solution of known molarity at varying temperatures. The results are given in the table below.

After four hours of the experiment, the carrot discs at 25^{o}C were treated with potassium cyanide. The absorption of potassium ions in μgg^{-1} of fresh carrot tissue was obtained as shown below.

Time in minutes	**Potassium ion uptake in μgg^{-1} fresh mass of carrot**	
	At temperature 2^{o}C	**At temperature 25^{o}C**
0	0	0
60	90	170
120	105	300
240	130	480
300	130	500
360	130	500

(a) Represent the data graphically (05 marks)

(b) Describe the changes in the rate of potassium ion uptake within the first hour at 25^{o}C. (03 marks)

(c) During the first hour of the experiment, some potassium ions enter the carrot disc cells passively. Suggest any two-passive means of their movement. In each case, state a condition needed for their movement. (04 marks)

(d) Calculate the mean rate of absorption of potassium ions at 2^{o}C between the second and 6th hour of the experiment. (02 marks)

(e) Explain the effects of treating the effects of treating the carrot cells with potassium cyanide on the rate of potassium ion uptake. (03 marks)

(f) Suggest;

(i) the aim of the experiment (01 mark)

(ii) Why the carrot discs were first washed in pure water. (02 marks)

(iii) Why the potassium chloride solution was aerated (01 mark)

4. CYTOSIS

This is a form of active transport involving infoldings or out folding of secretions of the cell surface membrane. involves movement with vesicles or vacuoles. Cytosis involves the contractile proteins in cellular microfilaments and microtubules, therefore, it is an **active process**. Cytosis results in bulk transport of materials into the cell or outside the cell. cytosis is divided into two main types

(i) Endocytosis
(ii) Exocytosis

ENDOCYTOSIS

This is bulk transport of materials inside the cell. It involves a small area of plasma membrane folding inwards to surround a material to be taken in and moves deeper inside the cell. There are two main forms of endocytosis;

(i) Phagocytosis
(ii) Pinocytosis

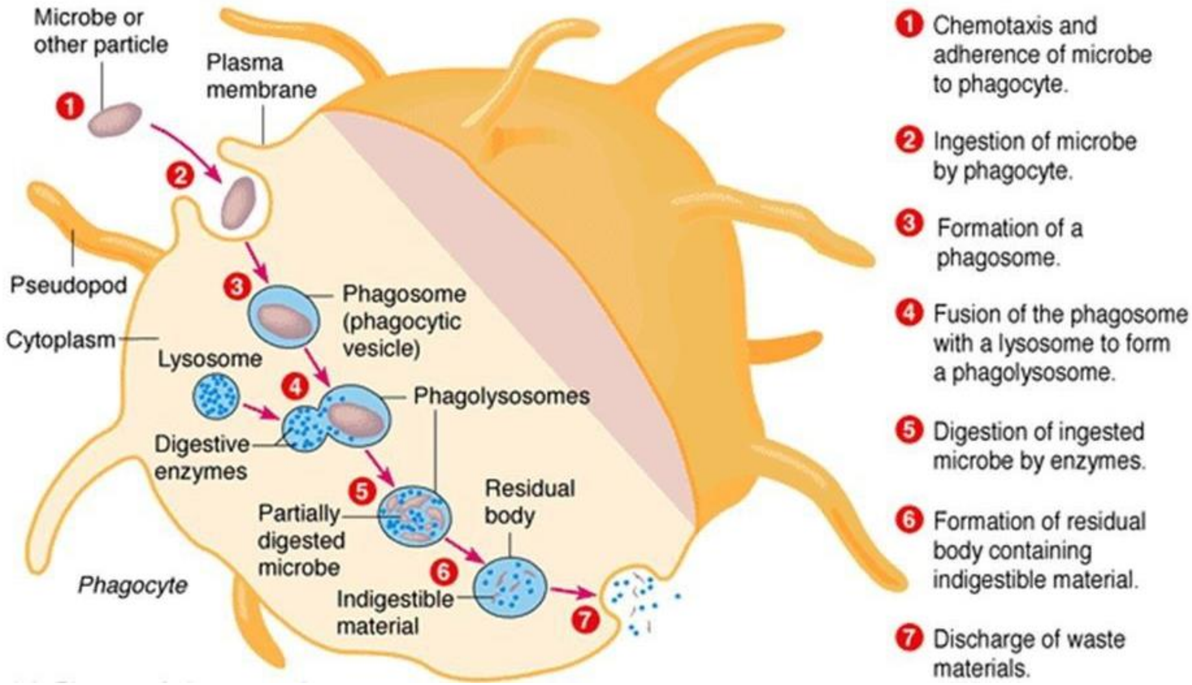
PHAGOCTOSIS (cellular eating)

This is called cellular eating and it involves the cell taking in large solid substances. Phagocytosis involves invagination of cell membrane surrounding of the organism or particle forming a phagocytotic vesicle or vacuole which pinches off the cell membrane and moves into the cytoplasm.

Process of phagocytosis by a neutrophil

- The engulfing cell detect chemo-attractive molecules released by target matter, and respond by moving towards it.
- The material to be engulfed becomes attached to the phagocytic cells by means of some lock and key mechanisms involving receptor proteins on the cell surface membrane.
- Local contractile processes of each cell’s cytoskeleton become active in the cytoplasm. Theses consist of proteins actin and myosin; these proteins react with ATP, and help to form pseudopodia that result in a new food vacuole around the foreign material.

- The engulfed particles are digested by enzymes delivered to the vacuole by lysosomes, protein substances are absorbed into the surrounding cytoplasm across the lining of the vacuole. Any undigested material may be got rid of by the vesicles of vacuoles moving into the cell surface membrane and fusing with it.



Importance of phagocytosis

- It is the main feeding mechanism of amoeba and other members of the protozoan phylum rhizopoda
- Recognition and destruction of invading foreign bacteria by white blood cells
- Disposal in mammals of senescent or damaged cells and cell debris

PINOCYTOSIS (cellular drinking)

This is cellular drinking; it is similar to phagocytosis only that the infoldings forming the vesicles are much smaller. Liquid and large macro molecules such as proteins are taken in via small pinocytotic vesicles. The process is highly specific involving the binding of the molecules with corresponding receptor molecules in the plasma membrane.

Importance

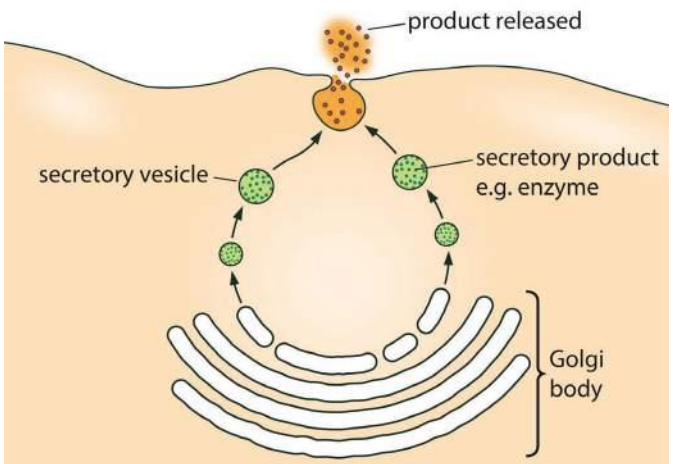
- Uptake of nutrients from the surrounding follicle cells by human egg cell
- Uptake of liquids and large macromolecules such as proteins, lipids across the walls of ileum.

EXOCYTOSIS

This involves the vesicles or vacuoles moving to the cell membrane, fusing with it releasing their contents to the outside of the cell.

Exocytosis provides a means by which enzymes, hormones, antibodies and cell wall precursors are released from the cell.

The vesicles are often derived from the Golgi apparatus which move along microtubules of the cytoskeleton of the plasma membrane. When the vesicles get into contact with the plasma membrane, the lipid molecules of the two bilayers rearrange and diffuse. The content of the vesicles spill to the outside of the cell and the vesicle membrane becomes part of the plasma membrane.



Summary of exocytosis in a secretory cell

Importance of exocytosis

- Release of excretory products by secretory cells outside themselves e.g. pancreatic cells manufacture insulin and secrete it into blood by exocytosis and many other hormones are secreted in this form by the gland cells
- Facilitates synaptic transmission during which neuro-transmitter substances like acetylcholine secreted into the synaptic vesicles of synaptic knobs fuse with the pre-synaptic membrane to release neuro transmitter substances into the synaptic cleft of the synapse.

- Delivers cell wall materials to the outside of the cell from the Golgi apparatus/body through vesicles which contain proteins and certain carbohydrates.
- Replenishes the plasma membrane as the vesicle membrane become part of the plasma membrane become part of the plasma membrane after discharging their contents to the outside.

Exercise 5

1. Distinguish between pinocytosis and phagocytosis
2. (a) Explain the occurrence of various transport mechanisms across a cell membrane. (10 marks)

   (b) Describe how endocytosis occurs. (06 marks)

End.