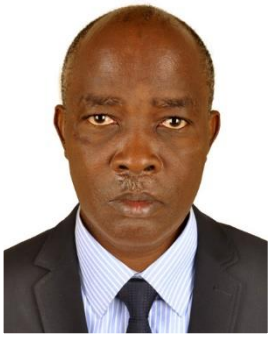


Dr. Bbosa Science

Cell Physiology

Overview

Materials move in and out of the cell by the following processes: osmosis, diffusion, active transport, phagocytosis and pinocytosis. Some of these processes require energy while others do not. The materials include water, gases, enzymes, hormones, antibodies and solutes

General objectives
By the end of the topic, the learner should be able to

(i) Explain the physiological process by which materials move in and out of cells
(ii) Explain the role of these processes in the life of organism

Specific objectives
The learner should be able to

a. Describe osmosis, diffusion, active transport, phagocytosis and pinocytosis
b. State the factors that affect the process of diffusion
c. Describe the process of osmosis
d. Explain the significance of diffusion and osmosis in organisms
e. Explain how solvents and solutes are exchanged in animal and plant tissue or cell across the cell membrane in relation to tis structure.
f. Describe how unicellular organisms obtain water and food.
g. Explain the relationship between structure and function of cell membranes

Practical

a. Identify habitats with suitable media for organism's survival.
b. Demonstrate use of salt in food preservation.
c. Demonstrate use of visking tubing, glass column, and microscope in diffusion and osmosis experiments.
d. Demonstrate conditions affecting the rate of diffusion
e. Demonstrate effects of osmosis on the cell or tissue

This refers to the processes by which material get in and out of the cell. These processes include:-

1. Diffusion
2. Osmosis
3. Phagocytosis
4. Pinocytosis
5. Active transport

Diffusion

It is the movement of particles (molecules or ions) from a region where they are comparatively concentrated to a region where they are at lower concentration. The difference in the concentration between two regions is called concentration gradient or diffusion gradient. Diffusion will always take place whenever such a gradient exist; and it will continue until eventually the particles are uniformly distributed throughout the system.

It is a passive process which takes place by random thermal motion.

Functions of diffusion

1. Gaseous exchange at the lungs
2. Absorption of glucose and amino acids from intestine
3. Absorption of water from colon
4. Uptake of glucose by cells from blood: Glucose does not diffuse freely through the cell membrane because it is insoluble in lipids. It passes through the cell membrane is facilitated by proteins. Therefore, diffusion of glucose through the cell membrane is called facilitated diffusion.
5. Gaseous exchange for photosynthesis
6. Loss of water during transpiration
7. Diffusion of flower scent to attract insect pollinators.
8. Absorption of ions from the soil

Factors that affect the rate of diffusion

1. Distance over which diffusion occurs: the bigger the distance the lower the rate of diffusion
2. Temperature: the higher the temperature the faster the rate of diffusion because particles have nigh kinetic energy.
3. Extent of the concentration gradient: The greater the difference in concentration, the more rapid the diffusion. The closer the distribution of the material gets to equilibrium, the slower the rate of diffusion becomes.
4. Mass of the molecules diffusing: Heavier molecules move more slowly; therefore, they diffuse more slowly. The reverse is true for lighter molecules.
5. Solvent density: As the density of a solvent increases, the rate of diffusion decreases. The molecules slow down because they have a more difficult time getting through the denser medium. If the medium is less dense, diffusion increases. Because cells primarily use diffusion to move materials within the cytoplasm, any increase in the cytoplasm's density will inhibit the movement of the materials. An example of this is a person experiencing dehydration. As the body's cells lose water, the rate of diffusion decreases in the cytoplasm,

and the cells' functions deteriorate. Neurons tend to be very sensitive to this effect. Dehydration frequently leads to unconsciousness and possibly coma because of the decrease in diffusion rate within the cells.

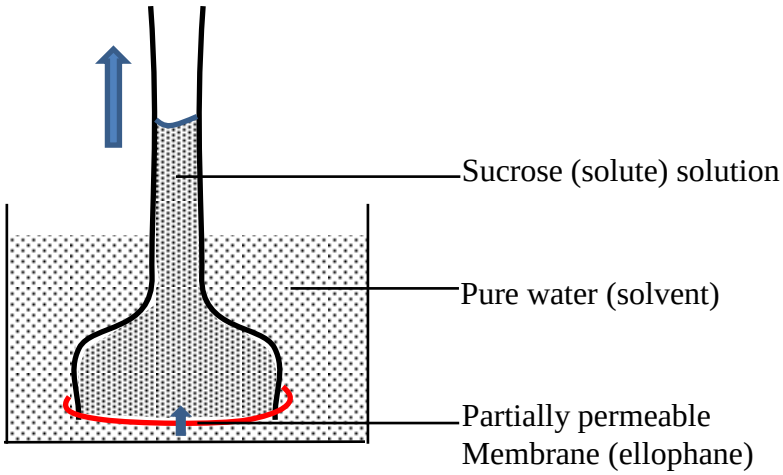
6. Solubility: As discussed earlier, nonpolar or lipid-soluble materials pass through plasma membranes more easily than polar materials, allowing a faster rate of diffusion.
7. Surface area and thickness of the plasma membrane: Increased surface area increases the rate of diffusion, whereas a thicker membrane reduces it.

Osmosis

This is the passage of solvent molecules from a region of their high concentration to a region of their low concentration through a partially permeable membrane. The solvent in biological system is water.

Simple demonstration of osmosis

Osmometer



The solid arrows indicate the net flow of water (solvent) into the solution. The membrane being partially permeable, allows water molecules to pass into the thistle funnel from the beaker. As a result of net flow of water into the funnel, the solution rises up the tube as indicated by the arrow.

Water potential, Ψ (Psi)

This is the capacity of the system to lose water. At standard temperature and pressure pure water is given a water potential of Zero. Adding a solute to water lowers the water potential, making it negative. This is because, the presence of solute molecules lowers the concentration of the of water molecules, thus, reducing the number of water molecules that can diffuse out of it. Further adding of a solute lowers the water potential, making it more negative.

When this happens, water moves to equilibrate, moving from the system or compartment with a higher water potential to the system or compartment with a lower water potential.

Osmotic pressure

This is the pressure which is required to prevent the net movement of pure water into an aqueous solution through the differentially permeable membrane. The osmotic pressure increases as the concentration of the solute increases. In other words, osmotic pressure is inversely proportional to water potential.

Osmosis and cells

Cell membranes are differentially permeable. If a cell is surrounded by pure water or a solution whose solute concentration is lower than that of a cell content, the water molecules will pass into the cell by osmosis. The volume of the cell increases and the cell swell up; in this case the water potential of the external solution is higher and the osmotic potential lower than that inside the cell. The external solution is said to be **hypotonic**.

If the cell is surrounded by a solution whose solute concentration exceeds that of the cell, water passes out of the cell and the volume reduces and consequently shrinks. The external solution is hypertonic.

If the solute concentration of the solution and the concentration of the cell constituent are equal, osmosis does not occur, the solution is **isotonic.**

Effects of osmosis on animal cell e.g. Red blood cell

A solution of 0.9% sodium chloride is **isotonic** with human cells, and if red blood cells are immersed in isotonic solution, they will neither swell nor shrink. When placed in hypotonic solution, red blood cells swell and burst or hemolyze or undergo **hemolysis**.

On the other hand, a red blood cell immersed in a hypertonic solution will shrink and plasma membrane crinkles. This is known as **crenation**.

It follows that if a cell is to maintain its normal size and shape, it must exist permanently in an isotonic solution or failing that, it must have special mechanism enabling it to survive in a hypertonic or isotonic solution. This special mechanism is called **osmoregulation**. For example, fresh water Amoeba would undoubtedly swell up and burst, just like a red blood cell in water were it not for a contractile vacuole that expels excess water from the body.

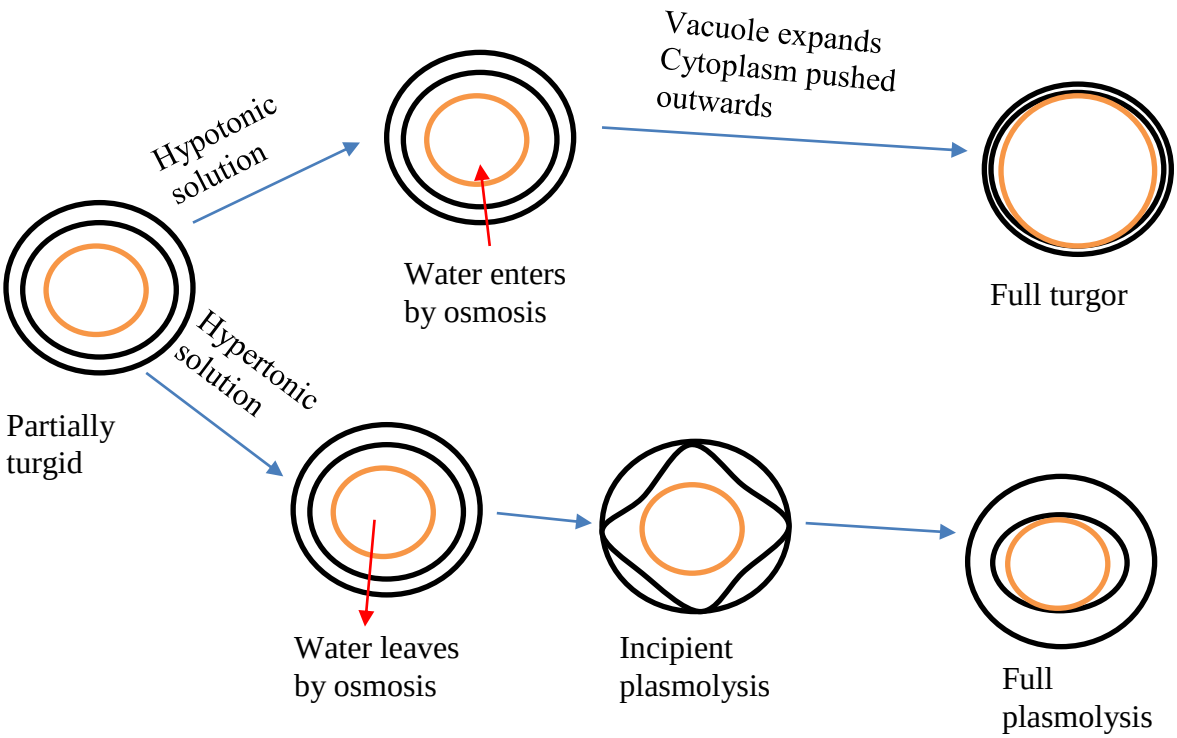
Effects of osmosis on plant cell

When the plant cell is surrounded by a hypotonic solution, water enters the vacuole by osmosis, the cell swells as the volume increases. However, it does not burst. This is because the cellulose cell wall stretches and develops tension, resisting further expansion of the cell.

As water flow into the vacuole by osmosis, the tension developed by the cell wall causes an internal hydrostatic pressure to develop. This is called pressure potential and it opposed the continued uptake of water into the cell by osmosis. The pressure potential reaches a maximum when the cell wall is stretched as much as possible and can stretch no more. At this point the cell is said to be **fully turgid** or maximum turgor is reached.

Turgidity in the cell provides support and maintain shape and form of plant parts.

Summary of the events that ensure if a partially turgid cell is placed in (A) a solution of eak solute concentration (B) a solution of strong concentration.



When plant cells are immersed in a hypertonic solution, water is drawn out of the cell. This leads to a decrease in the volume of the cell. In a few minutes, the protoplast shrinks to such an extent that it pulls away from the cell wall leaving a gap between the cell wall and plasma membrane. The shrinkage of protoplast from the cell wall is called **plasmolysis**. Plasmolysis sometimes happen to the plants exposed to extreme salty water but otherwise it rarely occurs in nature.

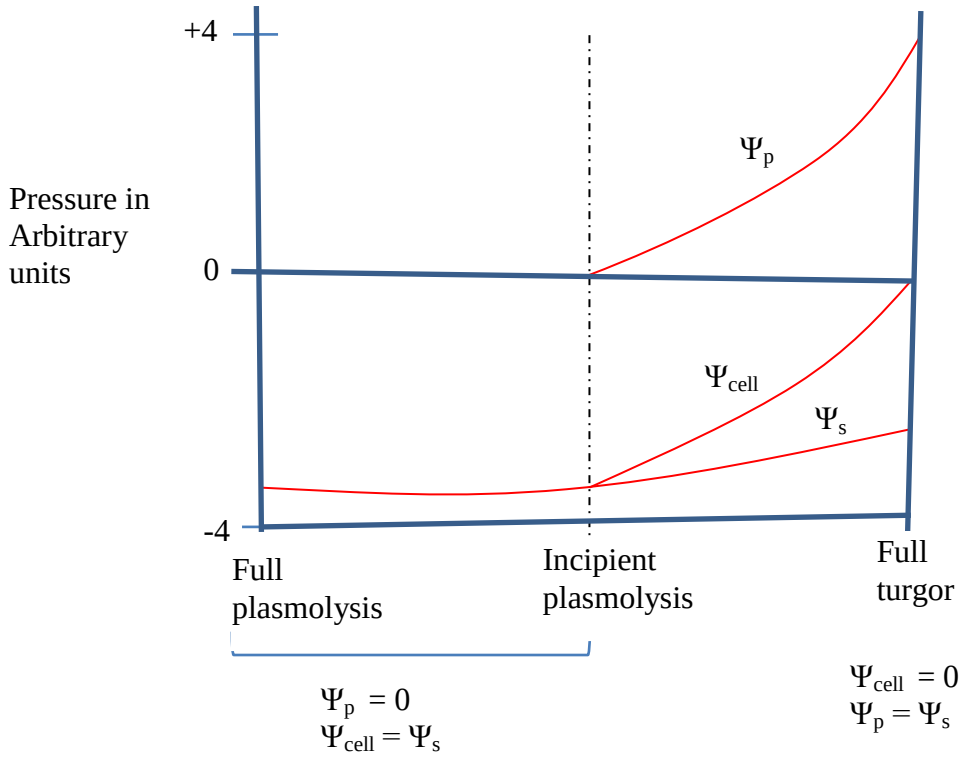
The water relations of plant cell
In considering the water relation of a plant cell we need to take into account the following three pressures.

- The net water potential of the whole cell or **water potential**.
- The water potential of the solution in the vacuole or **solute potential**.
- Th hydrostatic pressure caused by the cell wall pressing inwards against the cytoplasm or **pressure potential**

When a plasmolyzed plant cell is transferred in pure water, the water will immediately enter the cell sap in the vacuole by osmosis. The protoplasm will begin to expand against the cytoplasm, so the pressure potential is zero and the water potential equals the osmotic potential of sap. As the influx of

water continues, the protoplast goes on expanding until cell membrane comes in contact with the cellulose wall. When this occurs, the influx of water starts to be opposed by inward pressure of the cell wall, i.e. the pressure potential. The water potential of the cell now become less negative than the osmotic potential of the cell sap by the amount of the pressure potential. As the cell continues to expand, the pressure potential gets steadily greater and 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 water potential of the sap is exactly counterbalanced by the pressure potential.

A graph illustrating the relationship between the water potential of the cell (Ψ_{cell}), Osmotic potential of the cell sap (Ψ_s) and pressure potential (Ψ_p) of a plant cell at different states of turgor and plasmolysis.



The water relationship of a plant cell can be summarized by the following equation

Water potential	=	Osmotic potential of cell sap	+	pressure potential
Ψ_{cell}	=	Ψs	+	Ψp

Measuring water potential

1. cut living tissue of equal mass or volume and measure them.
2. Place the tissues in a series of solutions of different solute concentration
3. Allow the tissues to stay in the solution for a certain period of time
4. Remove the tissues from the solution and measure the second time

The solution which produces no change is the solution with the same water potential as the tissue. Therefore, the osmotic potential is equal to the water potential

When a plant cell is placed in a hypotonic solution, water enters its vacuole by osmosis. This makes the volume of the protoplast to increase, so causing it to press against the cell wall. This outward pressure, called **turgor pressure**, stretches the cell wall and opposed by an inward pressure (pressure potential) exerted by the cell wall against the cell's contents.

Turgor pressure reaches its maximum valves called **full turgor pressure** when the cell wall cannot be stretched anymore. At full turgidity, the pressure potential (Ψp) is equal and opposite to the osmotic potential (Ψs) of the cell, i.e. $\Psi p = \Psi s = \Psi s$ (since Ψs is always negative)

Note: when a plant cell placed in a hypertonic solution, water leaves the cell vacuole by osmosis. As a result, the protoplast shrinks and eventually pulls away from the cell wall, a process called **plasmolysis**. The point at which plasmolysis is just about to happen, i.e. when the protoplast (cell membrane) is just about to lose contact with the cell wall is referred to as **incipient plasmolysis**

Wilting

When the cell in the stem and leaves of a plant lose more water by evaporation than they can absorb, turgor is reduced and the plant visibly droops. This phenomenon is called wilting.it can often be observed on hot, dry and windy days. The plant recovers at night as evaporation is reduced and stomata closed; but if the water supply to the root is inadequate, the plant dies.

Functions of osmosis

1. Absorption of water by the root hair
2. Absorption of water in the loop of Henle
3.

Active transport

It energy-consuming transport of molecules or ions across a membrane against a concentration gradient. Substances usually transported across cell membrane by active transport include Na^+, K+, ureate ion and amino acids

The following observation suggest evidence to the use of energy in active transport.

(i) It is only found in living system which are continuously producing energy by respiration.

(ii) Increase in temperature and oxygen concentration increases the rate of active transport

(iii) When formation or use of ATP is inhibited by such agents as cyanide, active transport will not take place
(iv) Cells that take part in active transport contain large number of mitochondria.

Functions of active transport

(i) Absorption of minerals in the stomach
(ii) Absorption of minerals in ascending loop of Henle
(iii) Absorption of mineral in the root hair from the soil
(iv) Entry of water into the guard cell leads to their opening

Endocytosis and exocytosis

These are process by which larger objects are taken into or expelled from the cells

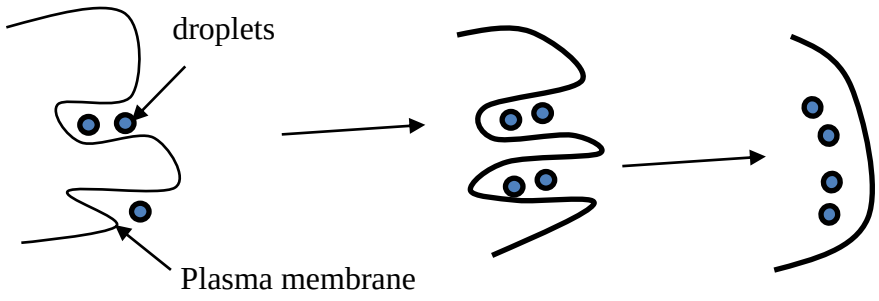
Exocytosis

This provide a means by which enzymes, hormones, antibodies and cell wall precursors are released from the cells. Here a vesicle containing the material moves towards the surface of the cell and fuse with the plasma membrane. The vesicle the opens to the exterior and its contents leave the cells

Endocytosis

This provide a means by which big objects are taken by the cell. First the plasma membrane invaginates to form a flask-shaped depression which envelops the material. The neck of the flask then closes, and the invagination becomes sealed off to form a vesicle which moves into the cell. When a liquid like substance is taken in by the cell the process is referred to as **pinocytosis**. And solid particles are taken in by **phagocytosis**.

Stages in endocytosis are shown in the diagram below



Questions

1. Which of the following process do not involve osmosis?
   A. movement of water into the guard cell
   B. movement of water through the xylem
   C. entry of water into the vacuole
   D. passage of water across the endodermis
2. A cell is said to have full turgor pressure when
   A. The cell membrane is just touching the cell wall
   B. Water enters the vacuole by osmosis
   C. Water leaves the vacuole by osmosis
   D. The cell wall cannot be stretched any more
3. Which one of the following changes in a cell would increase its water potential?
   A. Decrease in turgor pressure
   B. Increase in osmotic potential
   C. Decrease in osmotic potential
   D. Increase in pressure potential
4. The following are adaptations for survival among animals during period of water shortage.
   (i) Tolerance of water loss
   (ii) Biochemical production of water
   (iii) Reduction in water loss
   (iv) Evasion of hot environment

   Which one of the following is correct set used by the camel?

   A. (i) and (ii) only
   B. (i) , (ii) and (iii)
   C. (i)m (ii) and (iv)
   D. (iii) and (iv)
5. The passage of glucose molecules from maternal circulation to the fetal circulation across the placenta is by
   A. facilitated diffusion
   B. osmosis
   C. active transport
   D. simple diffusion

6. What would be the water potential of a cell if its pressure potential is 500kPa and solute potential is -4900kPa
   A. -4400kPa
   B. 4400kPa
   C. 5400kPa
   D. -5400kP
7. Which one of the following is true about active transport?
   A. Requires a semi-permeable membrane
   B. Occurs in both living and non-living cells
   C. Uses oxygen
   D. Involves movement of molecules along a concentration gradient
8. Cells are limited in size in order to
   A. Keep their volume down
   B. Allow movement of materials in and out of the cell
   C. Cut down energy requirement
   D. Enable nucleus control the cell efficiently
9. Large steroid diffuse quickly through cell surface membrane suggesting that the membranes
   A. Consist of non-polar molecules
   B. Are semi-permeable
   C. Are freely permeable
   D. Are made of polysaccharide
10. The figure below shows a system of two cells separated by a semipermeable membrane.

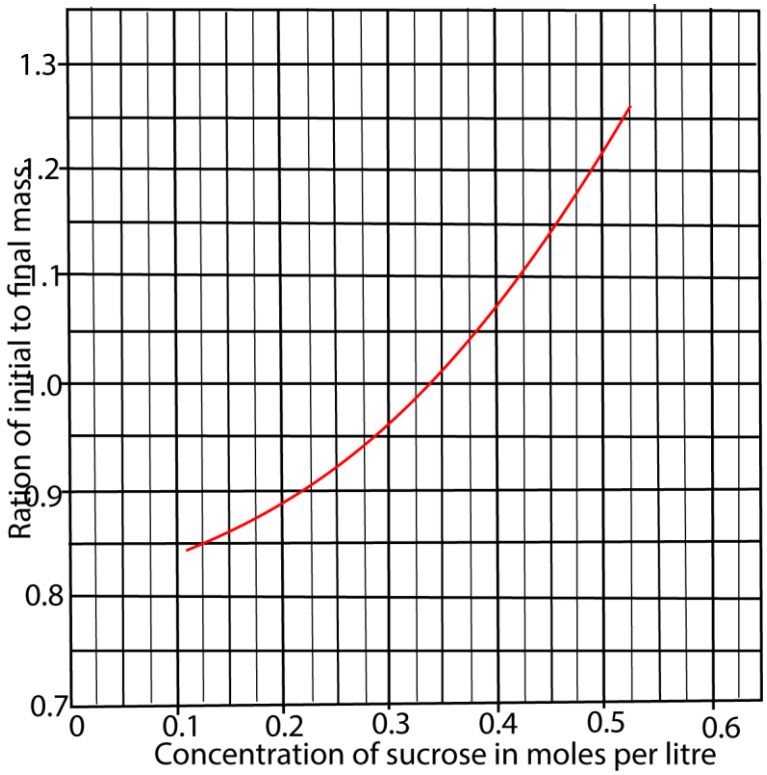
Cell A	Cell B
Ψs = -600kPa Ψp = 400kP	Ψs = -800kPa Ψp = 400kP

Which of the following statement is correct about the movement of water in the system?

   A. water moves out of both cells A and B
   B. water moves from cell B to A
   C. there is no movement of water between the cells
   D. water moves from cell A to cell B
11. Higher concentration of some of the ions in the cell sap of some fresh water algae compared to external water is due to
   A. Diffusion
   B. Active transport
   C. Pinocytosis
   D. Osmosis

12. If the solute potential of the external solution is higher than that of the cell, the external solution is said to be
    A. Hypotonic to the cell solution
    B. Hypertonic to the cell solution
    C. Isotonic to the cell solution
    D. Of lower osmotic pressure than the cell solution
13. Which of the following is correct about a natural semipermeable membrane?
    A. Does not allow of solute molecules
    B. Always allows equal movement of water molecules to either side of the membrane
    C. Allow passage of solvent molecules more than solute molecules
    D. Allow passage of solvent and solute molecules equally.
14. Which of the following would speed up the process of diffusion?
    A. Reducing the concentration gradient
    B. Increasing the distance across which diffusion occurs
    C. Increasing the area over which diffusion occurs
    D. Lowering the temperature of the medium
15. Which part of an amoeba is concerned with active uptake of water?
    A. Ectoplasm
    B. Contractile vacuole
    C. Pseudopodia
    D. Cell membrane

16. Weighed pieces of potatoes tissues were placed in sucrose solutions of difference concentrations. After 6 hours the potatoes pieces were weighed. The graph below was plotted from the result of the experiment from the graph we can conclude that



A. the concentration of sucrose causing no change in mass is 0.34M
B. 0.42M sucrose solution causes increase in mass of the potato tissue
C. 0.22M sucrose solution causes a decrease in the mass of the potato tissues
D. The potato tissue in molar 0.34 is at full turgor.

17. The cell wall pressure equals the osmotic pressure of the cell at
A. partial turgor
B. full turgor
C. incipient plasmolysis
D. complete plasmolysis

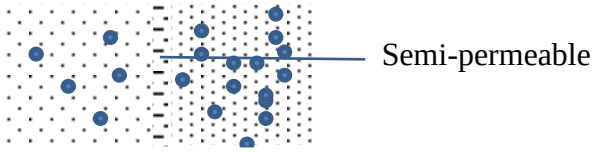
18. Water moves across the cortex to the endoderm by means of
A. osmotic gradient
B. cohesion
C. capillarity
D. Active transport

19. A young plant stem maintains an erect position mainly due to
A. lignified tissue in the stem
B. water pressure in the xylem vessels.
C. high turgor pressure in the parenchyma cells
D. high osmotic pressure in the parenchyma cell

20. For diffusion to occur

A. the diffusing particles should be of uniform size
B. the diffusion medium should be of uniform density.
C. there must be uniform distribution of the diffusing particles
D. a free energy gradient must exist.

21. The figure below shows a condition on two sides of a semi-permeable membrane



Which one of the following would occur if the water potential was the same on both sides of the membrane?

A. Movement of water molecules would stop
B. Solute molecules would move at the same rate to both sides of cell membrane
C. Solute molecules would move to side A
D. Water molecules would move at same rate to both sides of the membrane

22. Initial absorption of water by the seed during germination is caused by

A. osmotically active substance in the seed
B. imbibition pressure due to colloidal particles present in seed coat
C. Active absorption involving expenditure of energy
D. mass flow through micropyle

23. Which of the following best describes a plant cell which is fully turgid?

A. pressure potential of the cell sap is zero
B. water potential of the cell sap is equal to the osmotic potential of the sap
C. Pressure potential is equal to the osmotic potential of the sap
D. osmotic potential of the cell is zero

24. Which of the following process is exclusively physical?

A. transpiration
B. capillarity
C. root pressure
D. Guttation

25. The cell pressure equals the osmotic potential of a cell

A. when the diffusion gradient is zero
B. at incipient plasmolysis
C. at complete plasmolysis
D. at partial turgor

26. The pressure which tend to force water out of a cell is called
    A. Osmotic potential
    B. turgor pressure
    C. water potential
    D. Pressure potential

27. Nutrients are transported across cell membrane by
    A. osmosis
    B. Active transport
    C. mass flow
    D. diffusion

28. Which statement is true for a fully turgid cell?
    A. osmotic potential equals water potential of the cell
    B. wall pressure is zero
    C. Wall pressure equals turgor pressure of the cell
    D. Wall pressure is equal to osmotic potential plus turgor pressure

29. Direct exchange of metabolite can take place among cell via plasmodesmata except in the
    A. mesophyll
    B. cortex
    C. phloem
    D. xylem

30. Large steroid molecules diffuse easily through surface membranes because
    A. Consist of non-polar molecule.
    B. Are semi permeable
    C. Are freely permeable
    D. Are made of polysaccharides
31. Which one of the following water relation is not true about a plasmolyzed plant cell?
    A. Tugor pressure is zero
    B. Pressure potential is equal to osmotic potential of sap
    C. Pressure potential is zero
    D. Water potential of the cell is equal to osmotic potential of cell sap
32. Which of the following best describes a plant cell which is fully turgid?
    A. Pressure potential of the cell is zero
    B. Water potential of the cell sap is equal to osmotic potential of the sap
    C. Pressure potential is equal to osmotic potential of the sap
    D. Osmotic potential is zero
33. Which one of the following changes in cell would increase its water potential?
    A. Decrease in turgor pressure
    B. Increase in solute potential
    C. Decrease in osmotic potential
    D. Increase in pressure potential

34. The type of feeding mechanism shown in figure 4 is

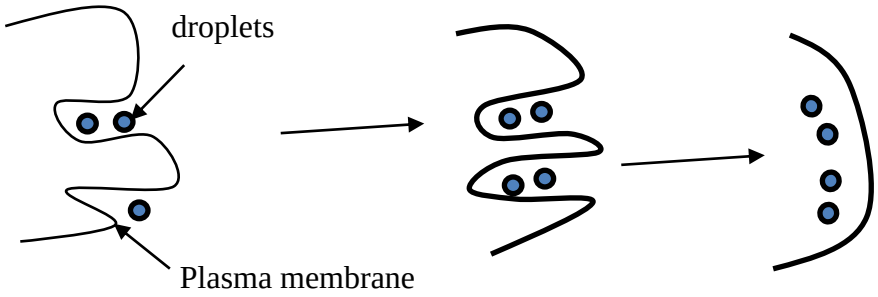


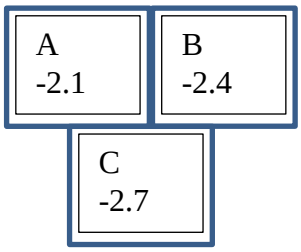
Fig 4

A. pinocytosis. B. phagocytosis.

B. phagocytosis. D. predation.

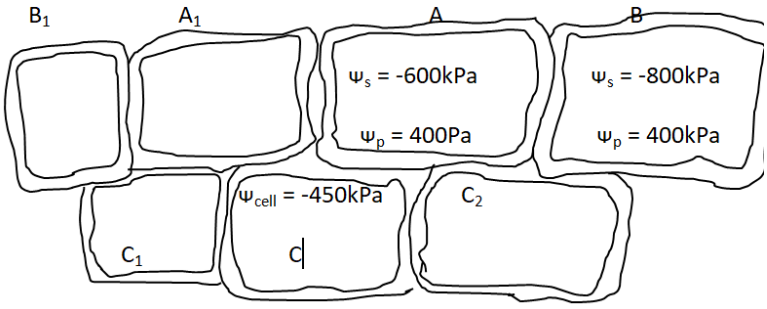
35. Two cell A and B have water potential of -2000kPa and 1000kPa respectively. Which one of the following statement is true about the cells?
A. cell A has high concentration of water molecules than cell B
B. Cell A has a higher solute potential than cell B
C. there is net movement of water from cell A to cell B
D. cell A has a less solute potential than cell B

36. The figure below represents plant cell A, B, and C with their respective water potential in (kPa) indicated.



Which of the following is correct direction of water movement between the cells
A. C to A
B. A to B
C. C to B
D. B to A

37. Figure below shows two guard cell A and A_1, with adjacent cells B, B_1, C, C_1 and C_2. The values of the solute potential and pressure potential shown in cell A and B are exactly the same as those for cell A_1 and B_1 respectively. Similarly, the water potential indicated in cell C is the same as in cell C1 and C2. Use the figure to answer the questions that follow.



(a) (i) calculate the water potential of cell A and B (02marks)

(ii) Show by means of arrows the movement of water in the seven cells (03marks)

(b) Explain why the net movement of water in the cell is as you have indicated in (a)(ii) (03marks)

(c) What would be the effect of the net movement of water indicated in (a)(ii) to guard cells a and A1?

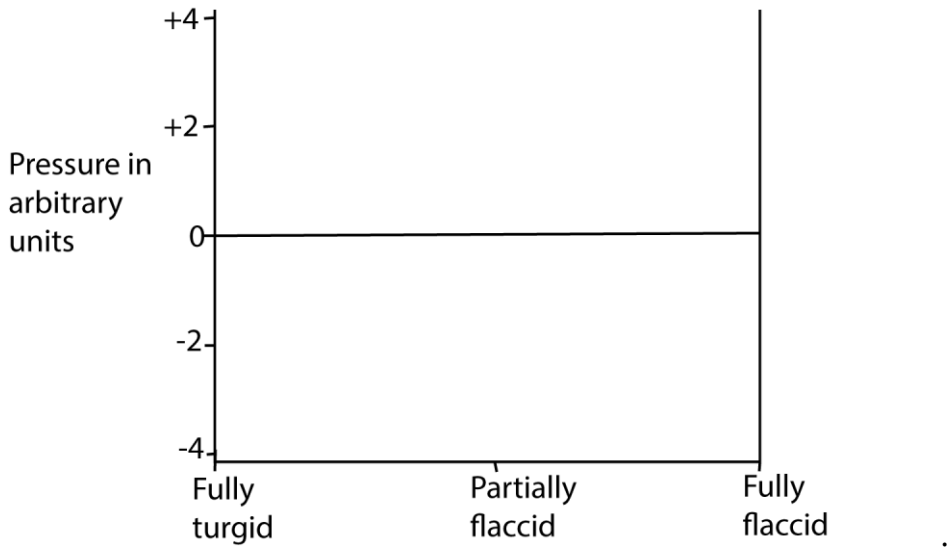
38. (a) What is water potential of a plant cell? (01marks)

(b) A fully turgid cell was placed in a hypertonic sugar solution and left until it was fully flaccid. Sketch on figure, curves to show the following pressure changes within the cell during the time of experiment.

(i) Curve A – changes in water potential of the cells (01 marks)

(ii) Curve B – changes in osmotic potential of the cell sap (01 marks)

(iii) Curve C – changes in pressure potential (01 marks)



(c) Outline three ways of verifying that active uptake of a particular ion is occurring in a plant growing in a culture solution (03 marks)

(d) State the importance of active transport in guard cell (03 marks)

39. (a) (i) What is active transport? (1 mark)

(ii) How is the occurrence of active transport in cell related with the structure of the plasma membrane? (02 marks)

(iii) What evidence is there to account for the fact that active transport requires energy and it is selective? (02 mark)

(b) Summarize the events that occur in the plant cells when it achieves full turgor (2 marks)

(c) Figure 6 represents the apparatus demonstrating the mass flow hypothesis.

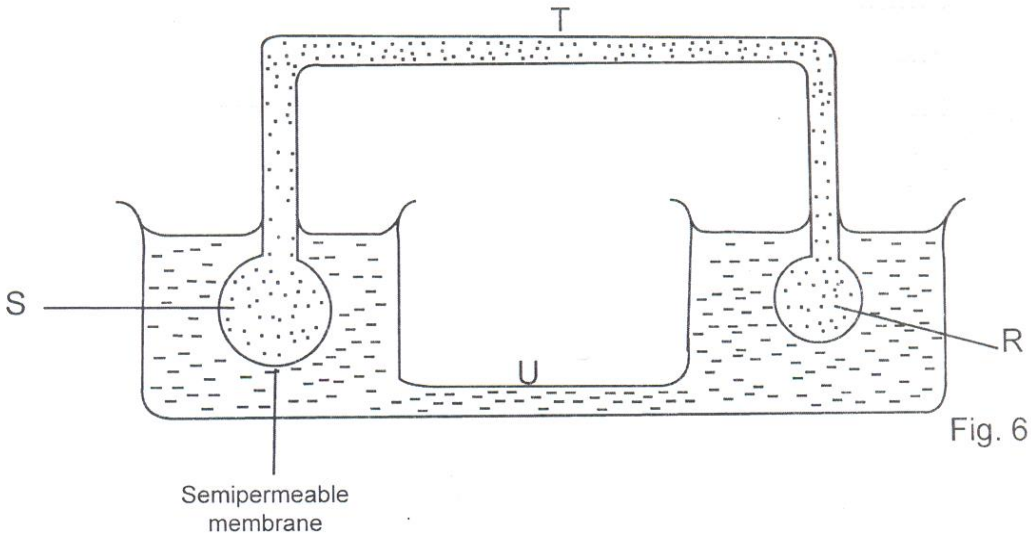


Fig. 6

S is a concentrated solution
R is a dilute solution

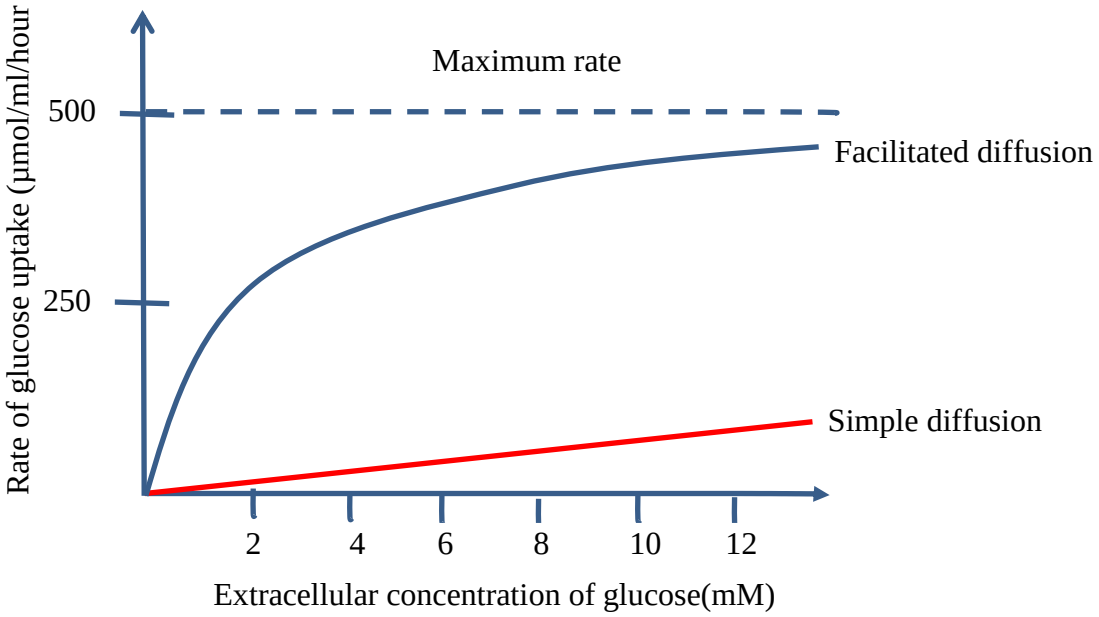
(i) Referring to figure 6, suggest which vessels are represented; T and U in plants (1mark)

Vessel T ……

Vessel U ……

(ii) List two weakness of the above hypothesis (2 marks)

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



(a) Describe the rate of glucose uptake with increasing extracellular concentration when glucose is facilitated. (9marks)

(b) Compare the rate of glucose uptake when diffusion is facilitated and when it is not. (8mark)

(c) Explain the effect of increasing extracellular concentration of glucose on the uptake of glucose, when diffusion is facilitated. (8marks)

(d) Suggest what would happen to the rate of glucose if a respiratory poison was introduced into the cell membrane. Give an explanation for your answer. (06marks)

(e) Explain why

(i) Facilitated diffusion occurs (06marks)

(ii) The membrane is able to carry out facilitated diffusion (3marks)

41. (a) Distinguish between plasmolysis and wilting. (4marks)

(b) How are xerophytes adapted to survive water shortage? (16marks)

42. (a) Differentiate between osmosis and active transport.

(b) What is meant by water potential of a plant cell? (1marks)

4. (a) Explain the terms water potential, osmotic potential and pressure potential

(b) discuss the water relation of

(i) a turgid cell

(ii) a plasmolyzed cell

(c) Discuss the various way in which various forms of entry of materials in the cell operate.

SECTION A

1. Figure 1 shows changes in the different potentials of a fully plasmolysed plant cell placed in a hypotonic solution.
Figure 2 shows the rate of movement of two different substances across a phospholipid membrane; glucose by facilitated diffusion and water by simple diffusion, at varying extracellular concentration.

Figure 1

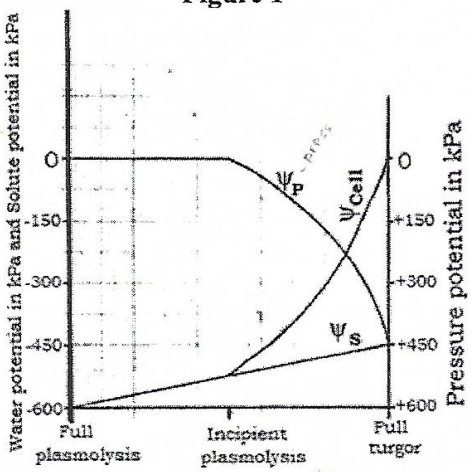
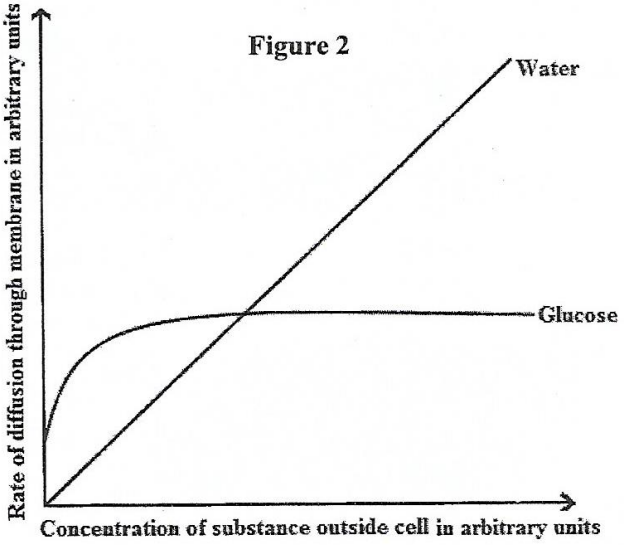


Figure 2



(a) From **figure 1,** compare the changes in pressure potential and water potential from full plasmolysis to full turgor. (05 marks)

(b) As indicated in **figure 1**, explain the change in water potential from full plasmolysis to full turgor. (15 marks)

(c) From **figure 2,** explain the effect of increasing extracellular concentration:

(i) on glucose uptake. (07 marks)

(ii) on water uptake (05 marks)

(d) Explain the observed rates of uptake of glucose and water, from figure 2 above. (08 marks)

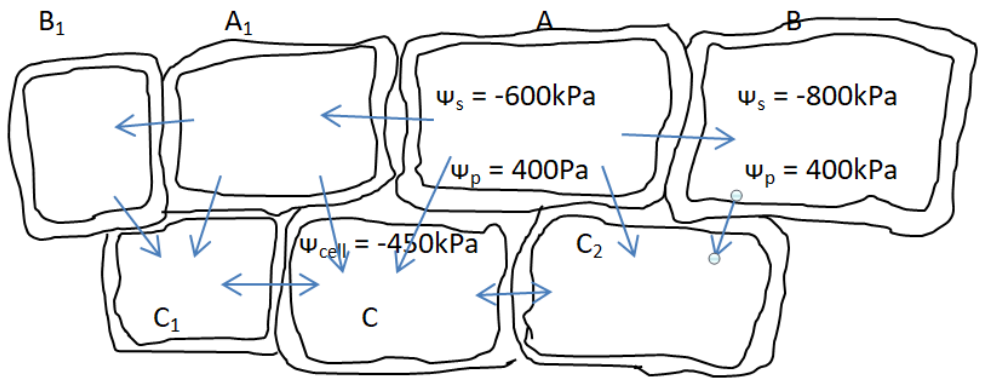
Answers to objective type questions

1	B	11	B	21	D	31	B		
2	D	12	B	22	B	32	C		
3	C	13	C	23	C	33	C		
4	C	14	C	24	D	34	A		
5	D	15	B	25	A	35	B		
6	A	16	A	26	D	36	B		
7	C	17	B	27	D				
8	D	18	A	28	D				
9	C	19	C	29	D				
10	D	20	D	30	A				

37. (a) (i) Water potential of cell A = -600 + 400 = -200kPa

Water potential of cell B = -800+400 = -400kPa

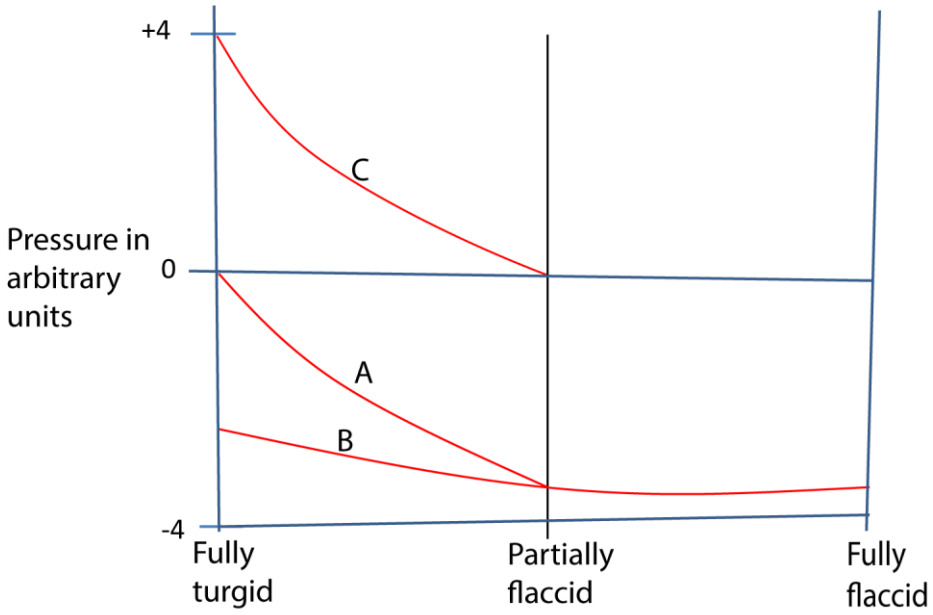
(ii)



(b) Water moves from a region of high (less negative) water potential to a region of low (more negative) water potential

(c) The guard cells lose turgidity and the stomata close

38. (a) Water potential is the capacity of the system to lose water



(c) To show that active transport is occurring of a particular ion

- Then the concentration of the ion is higher in cells than in culture solution
- When metabolic poison reduce uptake of ions
- When increase in oxygen concentration increase the rate of uptake of the ion

(d) Uptake ions into the guard cells by active transport increase their osmotic potential. This leads to uptake of water by osmosis and expansion of the guard cells. Expansion of the guard cell causes opening of the stomata.

38.(a)(i) **Active transport is** energy-consuming transport of molecules or ions across a membrane against a concentration gradient. Substances usually transported across cell membrane by active transport include Na^+, K+, ureate ion and amino acids

(ii) The membrane contains carrier proteins through which ions are moved against concentration gradient using energy in form of ATP

(b) The following observation suggest evidence to the use of energy in active transport.

(i) It is only found in living system which are continuously producing energy by respiration.

(ii) Increase in temperature and oxygen concentration increases the rate of active transport

(iii) When formation or use of ATP is inhibited by such agents as cyanide, active transport will not take place

(iv) Cells that take part in active transport contain large number of mitochondria.

(b) At full turgor; osmotic potential = wall potential, water potential = zero

(c) (i) T- phloem; U = xylem

(ii) weakness of mass flow hypothesis

- It has been observed that osmotic pressure of sieve tubes is actually greater than osmotic pressure of the mesophyll cells
- In some plants translocation is simultaneously bi-directional.
- The pressure gradient in plant is not high enough to explain the speed of translocation.
- the composition of phloem exudates in Cucurbita shows fundamental discrepancy as contrasted with the composition of its fruit.

40.Solution

(a)

- Initially, the rate of glucose uptake is low at low extracellular glucose concentrations
- The rate of glucose uptake then increased rapidly from 0-200 µmol/ml/hr when extracellular glucose concentration increased from 0-1mm.
- The rate of glucose uptake then increased gradually at a decelerating rate from 200 - 460µml/ml/hr when extracellular glucose concentration increased from 1-11mM.
- The rate of glucose uptake then remained more or less constant when extracellular glucose concentration increased from 11-15mm.

(b) similarities

In both, the rate of glucose uptake is low extracellular glucose concentration

In both, the rate of glucose uptake increases with the extracellular glucose concentration.

In both, the rate of glucose uptake increases gradually the extracellular glucose concentration increases from 1to 11mm

In both, the rate of glucose never reaches the maximum rate

Differences:

Rate of glucose uptake in facilitated diffusion.	Rate of glucose uptake in simple diffusion.
Is higher at all extracellular glucose concentrations. Increases rapidly when extracellular glucose concentration increases from 0 to 1mM. Increase non-linearly. Remains almost constant for or extracellular glucose concentration beyond 11mm.	Is lower at all extracellular glucose concentrations. Increases gradually when extracellular glucose concentration increases from 0 to 1mm. Increase linearly. Continues to increase gradually and linearly for or extracellular glucose concentration beyond 11mm.

(c) - initially, an increase in extracellular glucose concentration caused rapid increase in glucose uptake. This is because more glucose molecules were coming into contact with the carrier channel protein, hence increasing the rate of binding and transportation across the plasma membrane.

The rate of glucose uptake the increased gradually with further increase in extracellular glucose concentration because the rate of binding and transportation of glucose molecules is slow and so became the limiting factor

Thereafter, the rate of glucose uptake remained constant because the carrier/ channel protein become saturated with glucose molecules. At this point, the rate of binding and transportation of glucose remain nearly the same however much the glucose concentration is increased in the extracellular environment.

(d). The rate of glucose uptake would initially be unaffected, but it would later gradually reduce.

Glucose uptake in this experiment is by diffusion (simple and facilitated). Diffusion is a passive process, requiring to no metabolic energy, hence the respiratory poison, which interferes with ATP production, would initially have no effect on the rate of glucoses uptake.

However, diffusion is dependent on concentration gradient. Since glucose is not being metabolized in the cell, due to respiration being inhibited by the poison, the glucose would soon accumulate inside the cell.

This would profoundly reduce the steepness of the glucose concentration gradient, thus reducing the rate of glucose uptake.

Glucose uptake can also occur by active transport; which process requires metabolic energy. Introducing a respiration poison would reduce ATP production and hence the rate of active transportation of glucose uptake.

(e)(i) A concentration gradient exist that would allow ions and large polar molecules such as glucose, amino acids, fatty acids and glycerol to move into the cell by simple diffusion.

However, these ions and polar molecules are repelled by the hydrophobic regions of the cell membrane.

Simple diffusion for such solutes is thus too slow to meet the requirements of the cell.

Therefore, another quicker process, facilitated diffusion, must be employed to transport such solute in and molecules across the cell membrane.

(ii) The cell membrane has special integral proteins (carrier and channel proteins) that facilitate the movement of ions and polar molecules across the hydrophobic parts of the membrane.

The carrier protein can change shape they bind with ions or polar solutes and, in so doing, transport these substance across the membrane

42. Solution

(a) Plasmolysis is the separation of cell's protoplast from the cell wall as a result of water loss by osmosis.

Wilting is the loss of rigidity of non-woody parts of plant. It is characterized by drooped leaves due to excessive transpiration.

Plasmolysis cannot occur naturally while wilting is a natural protective process.

(b) Xerophytes live in dry condition such as the desert. These plants run the risk of drastic dehydration and must avoid this happing in order to survive. They are adapted to surviving draught in the following ways;

- They have shiny leaf surfaces to reflect much of the incident light rays to avoid overheating.
- They have thick cuticle impermeable to water. This reduces water loss from the plant surfaces.
- Some have leaves reduced into spikes to reduce water loss.
- Some have reduced total number of stomata and are succulent to conserve water for the plant.
- In some Xerophytes, the stomata open at night and close during day to reduce water loss during day.
- Some plants produce spore and others seeds, which withstand the dry conditions and help the plant to survive the long dry periods.
- Most xerophytes reproduce by vegetative propagation, reducing the need for favorable conditions from germination.
- They have tissues tolerant to desiccation.
- Some have stomata sunken into a hairy leaf surface to reduce water loss by transpiration.
- They develop a deep extensive root system to exploit as much area as possible for water absorption.
- Some shed their leaves occasionally to reduce water loss.
- Some have short life cycle that avoid draughts.
- Some species of plants roll their leaves with the lower surface inside during dry conditions. This reduces water loss through transpiration.

43.