CHAPTER 11

Transport in Plants

11.1 Means of Transport

1. Which of the following is not a feature of active transport of solutes in plants ?
   (a) Occurs against concentration gradient
   (b) Non-selective
   (c) Occurs through membranes
   (d) Requires ATP *(Odisha NEET 2019)*

2. Which of the following criteria does not pertain to facilitated transport?
   (a) Transport saturation
   (b) Uphill transport
   (c) Requirement of special membrane proteins
   (d) High selectivity *(NEET 2013)*

3. The movement of ions against the concentration gradient will be
   (a) active transport (b) osmosis
   (c) diffusion (d) all of the above. *(2000)*

11.2 Plant-Water Relations

4. What will be the direction of flow of water when a plant cell is placed in a hypotonic solution ?
   (a) Water will flow in both directions.
   (b) Water will flow out of the cell.
   (c) Water will flow into the cell.
   (d) No flow of water in any direction. *(Odisha NEET 2019)*

5. The water potential of pure water is
   (a) less than zero
   (b) more than zero but less than one
   (c) more than one
   (d) zero. *(NEET 2017)*

6. Two cells A and B are contiguous. Cell A has osmotic pressure 10 atm, turgor pressure 7 atm and diffusion pressure deficit 3 atm. Cell B has osmotic pressure 8 atm, turgor pressure 3 atm and diffusion pressure deficit 5 atm. The result will be
   (a) no movement of water
   (b) equilibrium between the two
   (c) movement of water from cell A to B
   (d) movement of water from cell B to A. *(2007)*

7. The water potential and osmotic potential of pure water are
   (a) 100 and 200 (b) zero and 100
   (c) 100 and zero (d) zero and zero. *(1998)*

8. When a cell is fully turgid, which of the following will be zero?
   (a) Turgor pressure (b) Water potential
   (c) Wall pressure (d) Osmotic pressure *(1997)*

9. With an increase in the turgidity of a cell, the wall pressure will
   (a) fluctuate (b) remain unchanged
   (c) increase (d) decrease. *(1997)*

10. Water movement between cells is due to
    (a) T.P.
    (b) W.P.
    (c) D.P.D.
    (d) incipient plasmolysis. *(1992)*

11. A bottle filled with previously moistened mustard seeds and water was screw capped tightly and kept in a corner. It blew up suddenly after about half an hour. The phenomenon involved is
    (a) diffusion (b) imbibition
    (c) osmosis (d) DPD. *(1990)*

12. Water potential is equal to
    (a) Ψ_s + O.P (b) Ψ_s = T.P
    (c) $\Psi_p + \Psi_w$ (d) $\Psi_s + \Psi_p$. *(1988)*

11.3 Long Distance Transport of Water

13. The process responsible for facilitating loss of water in liquid form from the tip of grass blades at night and in early morning is
    (a) transpiration (b) root pressure
    (c) imbibition (d) plasmolysis. *(NEET 2020)*

14. Xylem translocates
(a) water, mineral salts, some organic nitrogen and hormones
(b) water only
(c) water and mineral salts only
(d) water, mineral salts and some organic nitrogen only. *(NEET 2019)*

15. Root pressure develops due to
(a) passive absorption
(b) active absorption
(c) increase in transpiration
(d) low osmotic potential in soil. *(2015)*

16. In soil, water available for plants is
(a) gravitational water
(b) chemically bound water
(c) capillary water
(d) hygroscopic water. *(1999)*

17. The movement of water, from one cell of cortex to adjacent one in roots, is due to
(a) accumulation of inorganic salts in the cells
(b) accumulation of organic compounds in the cells
(c) water potential gradient
(d) chemical potential gradient. *(1995)*

18. Guttation is mainly due to
(a) root pressure (b) osmosis
(c) transpiration (d) imbibition. *(1992)*

19. In soil, the water available for root absorption is
(a) gravitational water (b) capillary water
(c) hygroscopic water (d) combined water *(1991)*

20. The principal pathway of water translocation in angiosperms is
(a) sieve cells (b) sieve tube elements
(c) xylem vessel system (d) xylem and phloem. *(1990)*

11.4 Transpiration

21. Stomatal movement is not affected by
(a) temperature
(b) light
(c) O_2 concentration
(d) CO_2 concentration. *(NEET 2018)*

22. Which of the following facilitates opening of stomatal aperture?
(a) Decrease in turgidity of guard cells
(b) Radial orientation of cellulose microfibrils in the cell wall of guard cells
(c) Longitudinal orientation of cellulose microfibrils in the cell wall of guard cells
(d) Contraction of outer wall of guard cells *(NEET 2017)*

23. Water vapour comes out from the plant leaf through the stomatal opening. Through the same stomatal opening carbon dioxide diffuses into the plant during photosynthesis. Reason out the above statements using one of following options.
(a) The above processes happen only during night time.
(b) One process occurs during day time and the other at night.
(c) Both processes cannot happen simultaneously.
(d) Both processes can happen together because the diffusion coefficient of water and CO_2 is different. *(NEET-I 2016)*

24. A column of water within xylem vessels of tall trees does not break under its weight because of
(a) lignification of xylem vessels
(b) positive root pressure
(c) dissolved sugars in water
(d) tensile strength of water. (2015)

25. Transpiration and root pressure cause water to rise in plants by
(a) pushing it upward
(b) pushing and pulling it, respectively
(c) pulling it upward
(d) pulling and pushing it, respectively. *(2015 Cancelled)*

26. Which one gives the most valid and recent explanation for stomatal movement?
(a) Starch hydrolysis
(b) Guard cell photosynthesis
(c) Transpiration
(d) Potassium influx and efflux *(2015 Cancelled)*

27. In land plants, the guard cells differ from other epidermal cells in having
(a) cytoskeleton
(b) mitochondria
(c) endoplasmic reticulum
(d) chloroplasts. *(2011)*

28. Guttation is the result of
(a) diffusion (b) transpiration
(c) osmosis (d) root pressure. *(Mains 2011)*

29. Guard cells help in
(a) transpiration
(b) guttation
(c) fighting against infection
(d) protection against grazing. *(2009)*

30. The rupture and fractionation do not usually occur in the water column in vessel/tracheids during the ascent of sap because of
(a) weak gravitational pull
(b) transpiration pull
(c) lignified thick walls
(d) cohesion and adhesion. *(2008)*

31. Potometer works on the principle of
(a) osmotic pressure
(b) amount of water absorbed equals the amount transpired
(c) root pressure
(d) potential difference between the tip of the tube and that of the plant. *(2005)*

32. Stomata of a plant open due to
(a) influx of potassium ions
(b) efflux of potassium ions
(c) influx of hydrogen ions
(d) influx of calcium ions. *(2003)*

33. Main function of lenticel is
(a) transpiration (b) guttation
(c) gaseous exchange (d) bleeding. *(2002)*

34. Opening and closing of stomata is due to the
(a) hormonal change in guard cells
(b) change in turgor pressure of guard cells
(c) gaseous exchange
(d) respiration. *(2002)*

35. Glycolate induces opening of stomata in
(a) presence of oxygen
(b) low CO_2 concentration
(c) high CO_2
(d) CO_2 absent. *(2001)*

36. In guard cells when sugar is converted into starch, the stomatal pore
(a) closes completely (b) opens partially
(c) opens fully (d) remains unchanged. *(1992)*

37. At constant temperature, the rate of transpiration will be higher at
(a) sea level
(b) 1 km below sea level
(c) 1 km above sea level
(d) 1.5 km above sea level. *(1992)*

38. Conversion of starch to organic acids is required for
(a) stomatal opening
(b) stomatal closing
(c) stomatal formation
(d) stomatal activity. *(1992)*

39. In terrestrial habitats, temperature and rainfall conditions are influenced by
(a) water transformations
(b) transpiration
(c) thermoperiodism
(d) translocation. *(1992)*

40. Which of the following is used to determine the rate of transpiration in plants?
(a) Porometer/Hygrometer
(b) Potometer
(c) Auxanometer
(d) Tensiometer/Barometer *(1992)*

41. The most widely accepted theory for ascent of sap in trees is
(a) capillarity
(b) role of atmospheric pressure
(c) pulsating action of living cell
(d) transpiration pull and cohesion theory of Dixon and Jolly. *(1991)*

42. Stomata open and close due to
(a) circadian rhythm
(b) genetic clock
(c) pressure of gases inside the leaves
(d) turgor pressure of guard cells. *(1988)*

43. Phenyl mercuric acetate (PMA) results in
(a) reduced photosynthesis
(b) reduced transpiration
(c) reduced respiration
(d) killing of plants. *(1988)*

44. Transpiration is least in
(a) good soil moisture
(b) high wind velocity
(c) dry environment
(d) high atmospheric humidity. *(1988)*

11.5 Uptake and Transport of Mineral Nutrients

45. When water enters in roots due to diffusion, is termed as
(a) osmosis (b) passive absorption
(c) endocytosis (d) active absorption. *(1996)*

46. Poisons like cyanide inhibit Na^+ efflux and K^+ influx during cellular transport. This inhibitory effect is reversed by an injection of ATP. This demonstrates that
(a) ATP is the carrier protein in the transport system
(b) energy for Na^+-K^+ exchange pump comes from ATP
(c) ATP is hydrolysed by ATPase to release energy
(d) Na^+-K^+ exchange pump operates in the cell. *(1994)*

47. Minerals absorbed by root move to the leaf through
(a) xylem (b) phloem
(c) sieve tubes (d) none of the above. *(1989)*

11.6 Phloem Transport: Flow from Source to Sink

48. What is the direction of movement of sugars in phloem?
(a) Bi-directional
(b) Non-multidirectional
(c) Upward
(d) Downward *(NEET 2019)*

49. A few drops of sap were collected by cutting across a plant stem by a suitable method. The sap was tested chemically. Which one of the following test results indicates that it is phloem sap?
(a) Acidic
(b) Alkaline
(c) Low refractive index
(d) Absence of sugar *(NEET-II 2016)*

50. In a ring girdled plant
(a) the shoot and root die together
(b) neither root nor shoot will die
(c) the shoot dies first
(d) the root dies first. *(2015 Cancelled)*

51. The translocation of organic solutes in sieve tube members is supported by
(a) cytoplasmic streaming
(b) root pressure and transpiration pull
(c) P-proteins
(d) mass flow involving a carrier and ATP. *(2006)*

52. Loading of phloem is related to
(a) increase of sugar in phloem
(b) elongation of phloem cell
(c) separation of phloem parenchyma
(d) strengthening of phloem fiber. *(2001)*

53. Bidirectional translocation of solutes takes place in
(a) parenchyma (b) cambium
(c) xylem (d) phloem. *(1997)*

54. Translocation of carbohydrate nutrients usually occurs in the form of
(a) glucose (b) maltose
(c) starch (d) sucrose. *(1993)*

55. Which is correct about transport of conduction of substances?
(a) Organic food moves up through phloem
(b) Organic food moves up through xylem
(c) Inorganic food moves upwardly and downwardly through xylem
(d) Organic food moves upwardly and downwardly through phloem *(1991)*

56. Death of protoplasm is a pre-requisite for a vital function like
(a) transport of sap (b) transport of food
(c) absorption of water (d) gaseous exchange. *(1989)*

ANSWER KEY

1.	(b)	**2.**	(b)	**3.**	(a)	**4.**	(c)	**5.**	(d)	**6.**	(c)	**7.**	(d)	**8.**	(b)	**9.**	(c)	**10.**	(c)
11.	(b)	**12.**	(d)	**13.**	(b)	**14.**	(a)	**15.**	(b)	**16.**	(c)	**17.**	(c)	**18.**	(a)	**19.**	(b)	**20.**	(c)
21.	(c)	**22.**	(b)	**23.**	(d)	**24.**	(d)	**25.**	(d)	**26.**	(d)	**27.**	(d)	**28.**	(d)	**29.**	(a)	**30.**	(d)
31.	(b)	**32.**	(a)	**33.**	(c)	**34.**	(b)	**35.**	(b)	**36.**	(a)	**37.**	(d)	**38.**	(a)	**39.**	(b)	**40.**	(b)
41.	(d)	**42.**	(d)	**43.**	(b)	**44.**	(d)	**45.**	(b)	**46.**	(b)	**47.**	(a)	**48.**	(a)	**49.**	(b)	**50.**	(d)
51.	(a)	**52.**	(a)	**53.**	(d)	**54.**	(d)	**55.**	(d)	**56.**	(a)								

Hints & Explanations

1. (b) : Active transport is highly selective process.

2. (b) : Facilitated transport or facilitated diffusion is the spontaneous passage of molecules or ions across a biological membrane passing through specific transmembrane integral proteins. Facilitated diffusion is mediated by protein channels and carrier proteins. Most transport proteins that mediate facilitated diffusion are very selective and only transport certain molecules. The major classes of proteins involved in facilitated diffusion are aquaporins, ion channels and carrier proteins. Importantly, neither channels nor carrier proteins require energy to facilitate the transport of molecules; they enable molecules to move down their concentration gradients (downhill transport).

3. (a) : Active transport involves movement of materials across the membrane against the concentration gradient of the solute particles. It requires energy in the form of ATP and carrier molecules.

4. (c) **5. (d)**

6. (c) : Diffusion pressure deficit is the reduction in the diffusion pressure of water in a system over its pure state. It is given by DPD = O.P – W.P (T.P). DPD determines the direction of net movement of water. It is always from an area or cell of lower DPD to the area or cell of higher DPD. So, cell A having lower DPD, water will move from cell A to B.

7. (d) : Water potential or chemical potential in pure water is zero. Osmotic potential or solute potential

represents the effect of dissolved solutes on water potential solutes reduce the free energy of water by diluting the water. The osmotic potential of pure water is zero. If solutes are added to water its potential becomes less than that of pure water and is expressed as a negative value.

8. (b) : In a fully turgid cell, DPD = 0 because it has T.P. = O.P. It means that the cell has no further capacity to absorb any water. Water potential is equal but opposite in sign to DPD. So in a fully turgid cell the water potential is zero.

9. (c) : The entry of water in cell develops turgor pressure, which exerts pressure on the cell wall. Cell wall counteracts the turgor pressure. As the turgor pressure increases, wall pressure also increases to prevent the cell from bursting.

10. (c) : Water movement between cells is due to DPD. If a cell is placed in pure water it shows endosmosis and as a result water enters into the cell. Thus, the osmotic entry of water is due to high osmotic pressure of the cell sap. The inward movement of water is, therefore due to the fact that it's OP > TP. The net force with which water is drawn into a cell is equal to the difference of OP and TP, known as diffusion pressure deficit. DPD = OP – TP.

11. (b) : A bottle filled with previously moistened mustard seeds and water was screw capped tightly and kept in a corner. It blews up suddenly after about half an hour due to phenomenon of imbibition. The absorption of water by the solid particles of an adsorbent causing it to enormously increase in volume without forming a solution is called imbibition.

12. (d) : Water potential is the difference in the free energy or chemical potential per unit molal volume of water in a system and that of pure water at the same temperature and pressure.

Water potential is represented by Greek letter ψ (psi) or ψ_w. Water potential is the sum total of ψ_s and ψ_p. Therefore, $\psi_w = \psi_s + \psi_p$.

13. (b) : Transportation of ions from the soil into the vascular tissues of the roots, increases the pressure inside the xylem, known as root pressure. Effects of root pressure is observable at night and early morning when evaportation is low and excess water collects in the form of droplets around special openings of veins near the tip of grass blades and leaves of many herbaceous parts.

14. (a)

15. (b) : Root pressure is positive pressure that develops in the xylem sap of the root of some plants. It is a manifestation of active water absorption.

16. (c) : Water occurs in the soil in the different forms as: free water, gravitational water, hygroscopic water, chemically combined water and capillary water. Free water is that water which runs away and is not held by the soil. Obviously it is not available to the plants. Gravitational water goes down into the deeper strata of earth and it is also, not available to the plants. Hygroscopic water is present in the form of thin films around the soil particles and it is also not available to the plants under normal conditions but it may be available under adverse conditions. Chemically combined water is not available to the plants at all. The only water which is available to the plants is capillary water. Capillary water makes up about 75% of the total water available to plants. The rest of soil water (hygroscopic, combined, free, gravitational and 25% capillary water) are not available to plants. These are called echard or unavailable water.

17. (c) : Movement of water always occurs from low DPD to high DPD. During water absorption by roots, water as well as solutes enter through root hair. After absorption of water by root hair, its TP is increased and thus DPD or SP is decreased. Then water from root hair moves to the cells of the cortex along the concentration gradient and finally reaches the xylem.

18. (a) : The loss of water through water stomata (hydathodes) is called as guttation. Guttation occurs when transpiration rate is very low as compared to rate of water absorption, due to this, root pressure is developed and water is pushed out through specialised pores at vein endings called hydathodes. Therefore guttation is not due to the activity of hydathodes but due to root pressure.

19. (b) : *Refer to answer 16.*

20. (c) : The principal pathway of water translocation in angiosperms is xylem vessel system. The sap (*i.e.*, water with dissolved minerals) is absorbed mainly by roots and is moved upward to all the parts of plants *via* stem. It occurs mainly through xylem.

21. (c) : High temperature, light and CO_2 concentration affect opening and closing of stomata while O_2 concentration has negligible effect on stomatal opening and closing.

22. (b) : When turgidity increases within the two guard cells flanking each stomatal aperture or pore, the thin outer wall bulge out and force the inner walls into a crescent shape. This results in the opening of stomata. The opening of stomata is also aided by the radial orientation of cellulose microfibrils in the cell wall of guard cells rather than longitudinal orientation.

23. (d)

24. (d) : Cohesion, adhesion and surface tension are the forces responsible for movement of water up the tracheary elements. Water molecules remain attached to one another by a strong mutual force of attraction

called cohesion force. On account of cohesion force, the water column can bear a tension or pull of upto 100 atm. Therefore, the cohesion force is also called tensile strength. Its theoretical value is about 15,000 atm but the measured value inside the tracheary elements ranges between 45 atm to 207 atm. Water column does not further break its connection from the tracheary elements because of another force called adhesion force between their walls and water molecules. Another force called surface tension accounts for high capillarity through tracheids and vessels.

25. (d) : The transpiration process, pulls water upwards with the help of cohesion and adhesion properties of water molecules. According to transpiration pull theory, due to transpiration, the water column inside the plant comes under tension. This is called 'transpiration pull'. On account of this tension, the water column is pulled up passively from below to top of the plant (almost like a rope). Root pressure is the pressure that forces water, absorbed from the soil, to move through the roots and up (*i.e.*, pushes it up) the stem of a plant. It may be due to both the osmosis of water from the soil into the root cells, and the active pumping of salts into xylem tissue which maintains a concentration gradient along which the water moves.

26. (d) : According to this theory, K^+ ion enter and accumulate in guard cells during daytime, causing opening of stomata and during night, K^+ ions move out of stomata and stomata closes.

Malic acid is formed in guard cells
↓ Dissociates into
H^+ + malate ions
↓ K^+ ion exchange from subsidiary cells
K^+ + malate ions in guard cells
↓
Osmotic pressure of guard cells increased
↓
Endosmosis into guard cells
↓
Guard cells turgid
↓
Stomata open

27. (d) : The leaf and stem epidermis is covered with pores called stomata (sing., stoma), part of a stoma complex consisting of a pore surrounded on each side by chloroplast-containing guard cells and two to four subsidiary cells that lack chloroplasts. The guard cells differ from the epidermal cells in the following aspects:
The guard cells are bean-shaped in surface view, while the epidermal cells are irregular in shape.
The guard cells contain chloroplasts, so they can manufacture food by photosynthesis (The epidermal cells do not contain chloroplasts).
Guard cells are the only epidermal cells that can synthesise sugar.

28. (d) : Various ions from the soil are actively transported into the vascular tissues of roots, water follows its potential gradient and increase the pressure inside the xylem. This positive pressure is called root pressure. Effect of root pressure is observable at night and early morning when evaporation is low and excess water collects in the form of droplets near the tip of leaves of many herbaceous plants. Such water loss in its liquid phase is known as guttation.

29. (a) : Stomata are the main organs for transpiration. The stem and leaf epidermis are provided with numerous stomata. Diffusion of water vapour through the stomatal pores is known as stomatal transpiration. Transpiration occurs while the stomata are open for the passage of carbon dioxide and oxygen during photosynthesis. Stomatal opening and closing is regulated by the movement of guard cells.

30. (d) : *Refer to answer 24.*

31. (b) : Potometer is an instrument or apparatus with the help of which, rate of transpiration can be measured. Main types of potometers are as under:
Simple potometer, Farmer's potometer and Ganong's potometer. The whole instrument is made of glass and consists of a long tube, having a side tube, bent at right angles. A fresh plant shoot is cut under water and is inserted into the side tube through a cork, fitted into the mouth of this tube. The whole apparatus is filled with water and the joints are made air tight. The apparatus is placed in the sunlight. Air bubble enters the tube and after this lower end of the tube is placed in the beaker, containing water. Water is absorbed by the shoot and is transpired through the leaves. Transpiration pull is created and the air bubble begins to move alongwith the transpiration pull. Readings are taken for the air bubble and thus amount of water absorbed and transpired is calculated.

32. (a) : *Refer to answer 26.*

33. (c) : Lenticels generally appear under stomata. The lenticel of phellogen itself also has intercellular spaces. Because of this relatively open arangement of cells, the lenticels are regarded as structures permitting the entry of air through the periderm. Lenticels are characterstics of woody stem but they are also found in roots of trees and other perennials for entry of oxygen through them.

34. (b)

35. (b) : Zelitch (1963) suggested that glycolic acid is formed in the guard cells. This acid is formed under low concentration of CO_2. Glycolate formed gives rise to carbohydrates. Under this condition, osmotically active

material is produced and ATP synthesis also takes place. ATP is produced during glyoxylate- glycolate shuttle. This ATP helps in the active pumping of water in the guard cells and stomata open. Stomata close when this process is reversed.

36. (a) : In guard cells when sugar is converted into starch, the stomatal pore closes completely. At night time, the CO_2 released during respiration accumulates. As a result, the acidity of the guard cells increases and pH decreases. The decreased pH favours conversion of sugar to starch. Pressure of the guard cells fall and hence they become flaccid. As a result, stomatal aperture closes.

37. (d) : At constant temperature, the rate of transpiration will be higher at 1.5 km above the sea level. At lower atmospheric pressure there is increase in the rate of evaporation.

38. (a) : There is evidence to believe that besides organic acids the turgidity of guard cells is usually controlled by K^+, Cl^- and H^+. The opening of stomata is initiated by exertion of H^+ by guard cells, intake of K^+ and Cl^-, disappearance of starch and appearance of organic acids like malic acid.

39. (b) : In terrestrial habitats, temperature and rainfall conditions are influenced by transpiration. The rate of transpiration is directly proportional to the saturation deficit of atmosphere. Plants growing in region where transpiration is meagre, do not show over heating. So transpiration prevents overheating.

40. (b) : *Refer to answer 31.*

41. (d) : Transpiration pull cohesion theory for ascent of sap in trees is most widely accepted. This concept was proposed by Dixon and Jolly, 1884. It is based upon three basic assumptions which are cohesion in between water molecules, continuity of water column and transpiration pull.

42. (d) : The pressure that develops in a cell due to osmotic diffusion of water inside it, is called turgor pressure. Stomata open and close due to turgor pressure of guard cells. When turgid, they swell and bend outward. As a result, the stomatal aperture opens. When they are flaccid, the tension from the wall is released and the stomatal aperture closes.

43. (b) : Phenyl mercuric acetate (PMA) results in reduced transpiration. PMA is an antitranspirant. These are some chemicals whose limited application on the leaf surface reduces or checks transpiration.

44. (d) : Transpiration is least in high atmospheric humidity. The rate of transpiration is directly proportional to the saturation deficit. In other words, transpiration rate depends upon the gradient of vapour pressure. Hence, at high atmospheric humidity transpiration rate is low.

45. (b) : Water is absorbed from soil by root system and mainly by root tips. There are two independent mechanisms of water absorption in plants-active water absorption and passive water absorption. In active water aborption, water is absorbed by the activity of the root itself. In passive water absorption, transpiration pull is responsible for absorption of water. According to this theory loss of water from mesophyll cells of leaves in transpiration decreases their TP and hence increases their DPD. As a result of their increased DPD, they absorb water from adjacent xylem vessels of leaves. This xylem of the leaves is in continuation with xylem of stem and roots and hence this pull is transmitted downwards. The pull or tension is removed only when water is absorbed through root hair and this is passive water absorption. Thus transpiration pull is responsible for passive water absorption.

46. (b) : Active transport is uphill movement of materials across the membrane where the solute particles move against their chemical concentration or electrochemical gradient. Hence, the transport requires energy in the form of ATP. Metabolic inhibitors like cyanide inhibit absorption of solutes by lowering the rate of respiration. Consequently less ATP are formed. However, by adding ATP, active transport is facilitated. It occurs in plants as in climacteric fruits and under cold, stress, ATP synthesis does not occur. Reducing power present in reduced coenzymes is oxidised to produce heat energy. Therefore, the heat liberation pathway of terminal oxidation is cyanide resistant. In normal aerobic respiration, the effect of cyanide poisoning can be minimised by immediate supply of ATP.

47. (a) : Minerals absorbed by roots move to the leaf through xylem. Xylem plays an important role in conduction of water. Hence, when water moves upward through xylem, minerals are also absorbed by the roots and move towards leaves through xylem only. This is known as ascent of sap.

48. (a) : Food is transported by vascular tissue phloem from a source to sink. Source is a part that synthesises food and sink is a part that stores or needs the food. Since source and sink can be reversed depending on plant's need, therefore direction of movement of sugar in phloem can be bidirectional, *i.e.*, both upwards or downwards.

49. (b)

50. (d) : In girdling or ringing experiments, a ring of bark is cut from the stem. It also removes phloem. Nutrients collect above the ring, where the bark also swells up and may give rise to adventitious roots. Growth is also vigorous above the ring. The tissues below the ring not only show stoppage of growth but also begin

to shrivel. Roots can be starved and killed, if the ring is not healed after some time. Killing of roots shall kill the whole plant, clearly showing that bark or phloem is involved in the movement of organic solutes towards root.

51. (a)

52. (a) : When the phloem cells, just near the source, for example green leaves attain higher concentration of sugars, it is called the process of phloem loading. Sucrose is photosynthesised in the chloroplasts of mesophyll cells of leaves. Mesophyll cells are connected with each other through plasmodesmata. Similarly plasmodesmata are also present between the mesophyll cells and companion cells and also between mesophyll cells and sieve tubes. There plasmodesmata are the "channels" meant for the passage of sucrose.

53. (d) : The movement of organic food or solute in soluble form from one part to another part is called translocation of solutes, *e.g.*, from leaves to stem and roots for consumption. The movement of organic material is bidirectional. Because xylem is responsible for upward movement of water and minerals, so it cannot account for downward translocation of solute at the same time. Cortex and pith are not structurally suitable for this purpose. Thus only phloem is left where there is end to end arrangement of sieve tubes united by sieve pores which is responsible for translocation of solutes in both directions.

54. (d) : Translocation of carbohydrates, nutrients usually occurs in the form of sucrose through sieve tube of phloem.

55. (d) : Phloem is the food conducting tissue of plants. The sieve tubes are food conducting elements of the plants. It is proposed that food is translocated by mass flow or by streaming currents of protoplasm.

56. (a) : Death of protoplasm is a pre-requisite for a vital functions like transport of sap. Xylem is a dead tissue and do not have protoplasm, xylem performs the function of transport of water or sap inside the plant from roots to leaves.