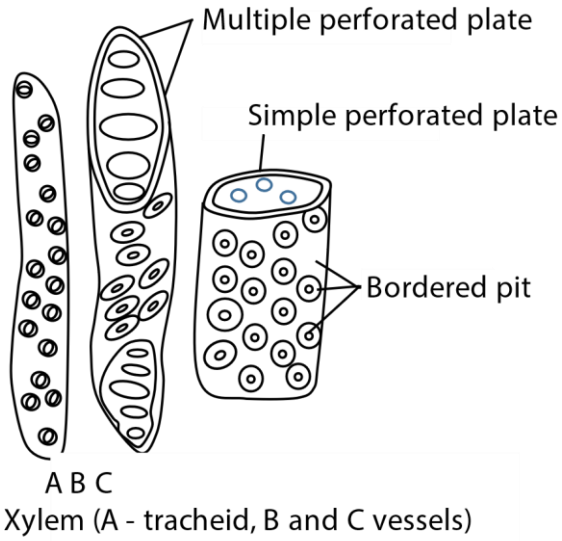
Advanced Level biology

Transport on flowering plants

Water and mineral salts are transported xylem while the manufactured food is transported in the phloem

Xylem

Consist of parenchyma cells and fibers together with vessels and tracheid.



Xylem (A - tracheid, B and C vessels)

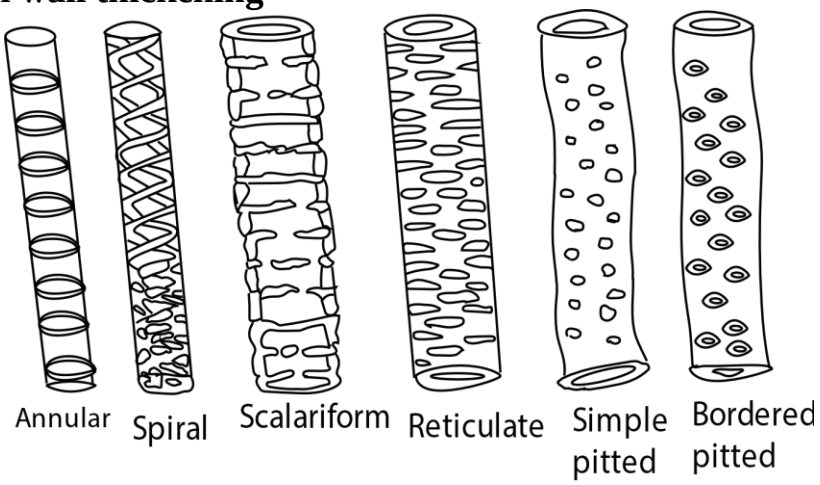
Vessels are made of cylindrical dead cells, one on top of another with the cross wall broken down to form a long continuous tube from the roots to the leaves.
The type of vessel found depend on the degree and nature of cell thickening. In the **protoxylem** the lignin is deposited in rings or spirals to the cells is still capable of expansion. In metaxylem there is more extensive lignification arranged in patterns known as reticulate, scalariform or pitted.

Role/Importance of endodermis

- Contains impermeable thickening of suberin called Casparian strip which forces water and solutes to cross the plasma membranes of endodermal cells instead of slipping between the cells, i.e. from apoplast pathway to symplast pathway enabling water to move n one direction
- It ensures that only materials required by the root pass through the endodermis, while toxic substances and pathogens are generally excluded.
- Builds up root pressure in the xylem by actively pumping mineral salts into the xylem which enable water to enter the xylem by osmosis

Importance of plasmodesmata
- to allow the movement of molecules and substances (water mineral salts, photosynthetic substance) between cells
- allow entry of water into the symplast pathways

Types of cell wall thickening



Tracheid are spindle-shaped cell arranged in rows with ends of the cells overlapping. The cells have heavily lignified cell wall with no cell contents.

Functions of xylem
1. Transport water and mineral salts
2. They provide mechanical support.

Adaptations of the xylem
1. Cross walls are perforated or completely removed to form continuous tubes from roots to stems and leaves
2. Xylem vessels have no living contents to allow water to flow freely
3. Contain bordered pits to allow water cross to living cells

4. Lignified to prevent water loss

5. Lignified to prevent them from collapsing under negative pressure of transpiration pull.

6. Small tube to enable high capillarity

7. Xylem walls have high adhesive forces.

8. Torus in bordered pits act as a plug for controlling passage of water in some plants

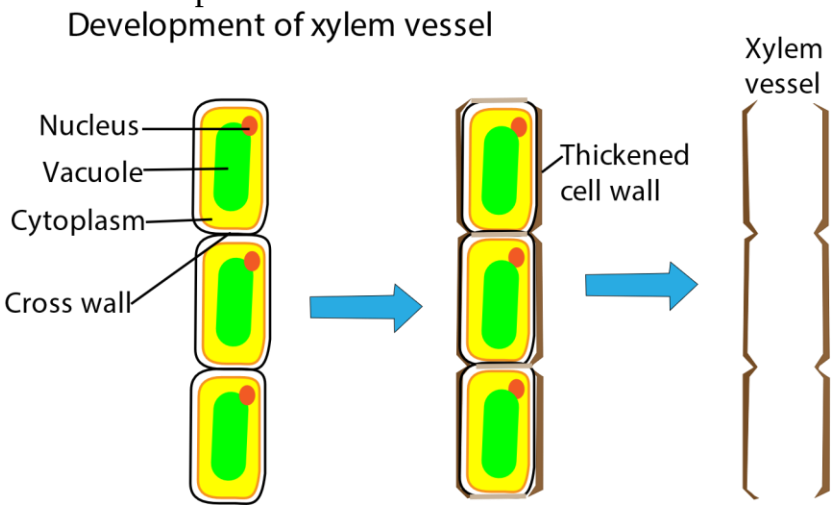
Adaptation of xylem to provide support

1. Walls are lignified

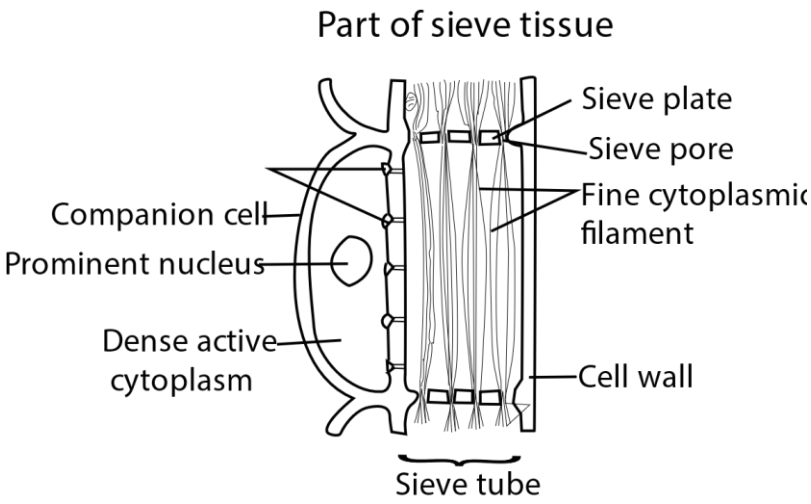
2. Vessels are circular for additional support.

Development of xylem

Cells destined to form xylem vessel elongate and develop thickened secondary wall. The walls are later lignified. The cell content die and cross section walls degenerate to form continuous open tube.



Phloem



The phloem consists of sieve tubes and companion cells.
Sieve tubes consist of columns of elongated, thin walled living cells called sieve tubes/elements. They have cross walls with many holes or pores called sieve plates. Each sieve tube has a companion cell.

Function
Transport of manufactured food (sucrose and amino acid) from leaves to other parts of the plant.

Sucrose is the choice of food transport probably because
1. it is soluble in water
2. less reactive than glucose
3. has high energy content than glucose

Adaptations phloem for its functions
1. Lack a nucleus and most cell organelles to leave room for transportation of food

2. The sieve plates are perforated to allow rapid flow through from one cell to another.

3. Has filament for quick transport by streaming

4. Intimate association with companion cells to obtain energy and materials

Differences between xylem and phloem

	Xylem	Phloem
1	Vessels are made of dead	Elements are made from living cells

	cells	
2	Vessels have lignified cell walls	Phloem do not have lignified cell walls
3.	The end wall disappears completely	The end wall form sieve plates. They do not disappear completely
4.	Have pits	Have plasmodesmata
5.	Thick walls	Thin walls
6	Transport water and mineral salts	Transport food (sucrose and amino acids)

Development of phloem

Cells destined to become sieve elements elongate, most cell organelles degenerate leaving cytoplasmic filament. The plasmodesmata of the end wall widen forming sieve pores.

Absorption of water

Water is absorbed by root hair by osmosis whereas mineral salts are absorbed by active transport.

Adaptations of root hair for absorption of water

1. They are numerous to provide large surface area
2. They have thin epithelium to reduce diffusion distance
3. Have vacuole with salt to facilitate osmosis

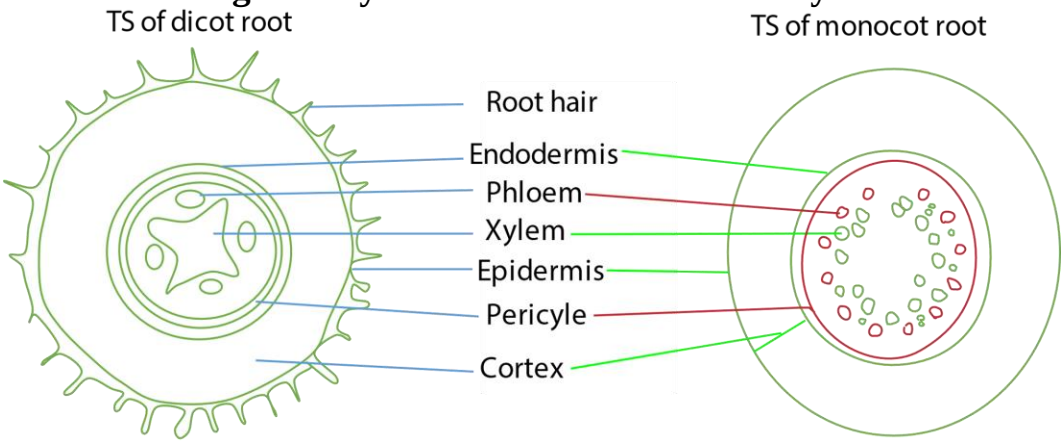
Absorption of mineral salts

By active transport when the concentration of the mineral is lower in the soil. Minerals cannot be passively absorbed by roots. There are two main reasons for this.

(i) Minerals are present as charged particles in soil. They cannot move across cell membranes.

(ii) Concentration of minerals in the soil is usually lower than the concentration of minerals in the root

Sections through dicotyledonous root and monocotyledonous



Functions of parts of the root
Root hair - absorb water and mineral salts
Xylem – transport water from root to other parts of the body
Phloem - transport food to all parts of the
Cortex – is made up of parenchyma cells for support and storage

Pericycle – become lignified in older roots to provide support and is where lateral roots develop

Special methods of obtaining nutrients

1. some plants have mycorrhiza, an association of room and fungi; the fungi decompose humus into soluble nutrients (nitrogen and phosphorus) and also increases the surface area for their absorption by the roots. Plants that lack chlorophyll also obtain, carbohydrates and proteins from the fungi.
2. Legumes such as peas, beans and soya bean have nitrogen fixing bacteria in their root nodules for fixation of nitrogen.
3. Plants in nitrogen deficient are feed on insects to obtain nitrogen.

Differences between dicotyledonous and monocotyledonous root

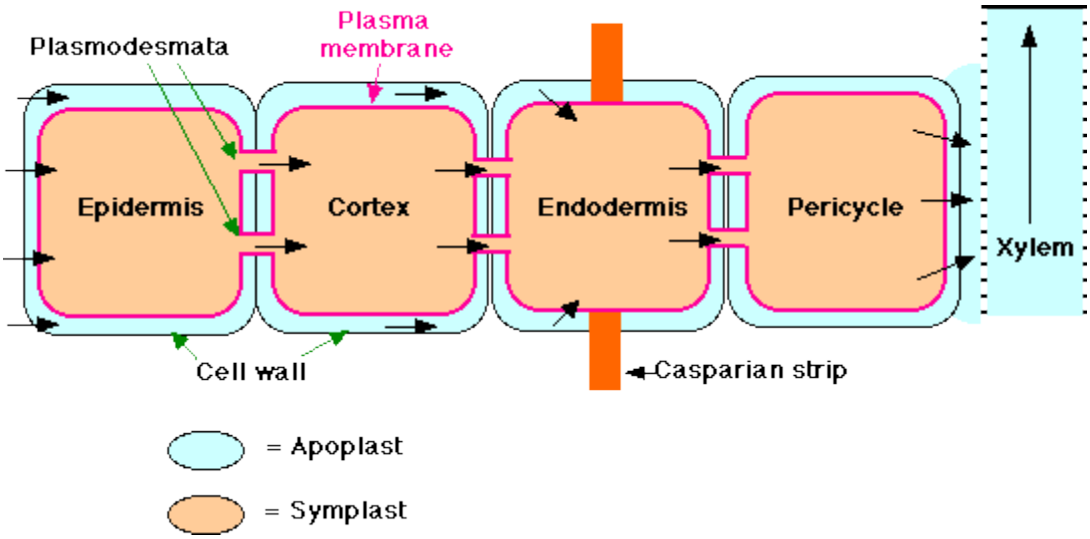
Dicot Root	Monocot root
Pericycle gives rise to cork cambium, parts of the vascular cambium, and lateral roots	Pericycle gives rise to lateral roots only
Has a limited number of Xylem and Phloem	Has a higher number of Xylem and Phloem
Angular or Polygonal xylem	Round or Oval round
Has no pith	Larger and well developed pith
Secondary growth occur	Secondary growth does not occur
Has cambium	Has no cambium
E.g. Pea, beans, peanuts, etc	E.g. Maize, banana, palm, etc.

The route taken by water

1. **The apoplast pathway**: this consists of the interconnected cell walls of adjacent cell which are in contact with each other and therefore form continuous system. The water flows in the spaces between the cellulose microfibrils.

2. **The Symplast pathway**: this consists of the cytoplasm which is continuous from cell to cell via the plasmodesmata. To get into the Symplast pathway water has to cross the partially permeable plasma membrane by osmosis.

3. **The vacuolar pathways** through the vacuoles.



Both pathways are used, but most water follow the apoplast pathways as this is the fasted of the two. Once the water reaches the endoderm, water is diverted from apoplast pathway to Symplast pathway by an impermeable thickening of suberin called **Casparian strip**.

Role of endodermis in water and mineral transport

- Contains impermeable thickening of suberin called Casparian strip which forces water and solutes to cross the plasma membranes of endodermal cells instead of slipping between the cells, i.e. from apoplast pathway to symplast pathway enabling water to move n one direction
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Importance of plasmodesmata

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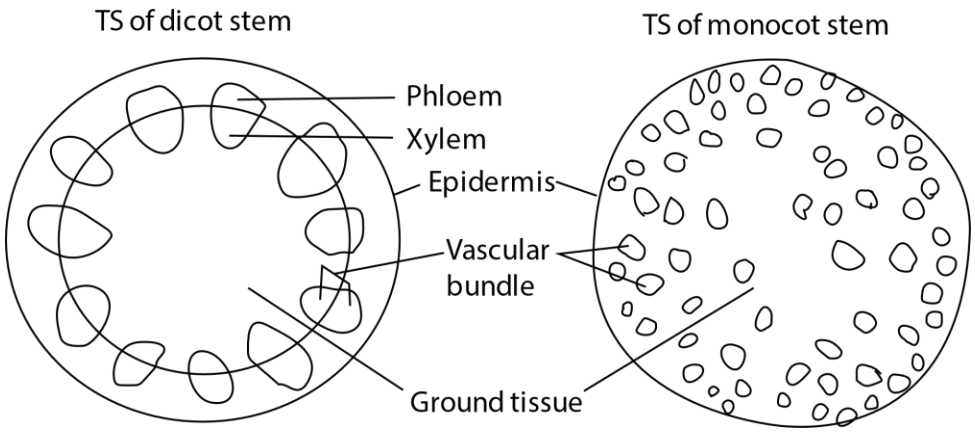
Internal structure of the dicot stem and monocot stem



Differences between dicotyledonous and monocotyledonous team

Dicot root	**Moncot stem**
Vascular bundles in a ring	Vascular bundle scattered
4 to 8 vascular bundle	Numerous vascular bundles
Has pith	Has no pith
Xylem elements polygonal	Circular xylem elements
Has pericycle	Has no pericycle
Has medullary rays	Has no medullary rays
Undergo secondary thickening	No secondary thickening

The forces that contribute to the movement of water up the stem

1. **Root pressure:** this is a hydrostatic force that pushes water from the root to the stem.
   a. Mineral ions enter the roots through active transport.

   b. This maintains a gradient for water to move into the cells by osmosis.

   c. this creates a hydrostatic force moving water through the roots and up the stem of a plant.

   d. Root pressure can only provide a modest push and does not significantly play a major role in water movement in tall plants. Root pressure serves to reestablishment of continuous chains of water molecules in the xylem; which often break under enormous tensions created by transpiration pull

2. Transpiration pull: this a suction pull created by loss of water through the stomata. Constant water loss via transpiration from the leaves causes a negative water pressure in the leaves. The negative pressure in the leaves works like a 'suction' force, pulling the water up the stem.

3. Capillary Action: water moves up the stem in response to the 'suction' caused by transpiration because of two forces: adhesion and cohesion. Cohesion is the tendency for water molecules to stick together and adhesion is the tendency for water molecules to stick to other surfaces, such as the inside of the xylem vessels. Stem xylem is structurally adapted to take advantage of capillarity, because they are very long with a narrow diameter.

Transport of organic substances

These are transported /translocated in the phloem.

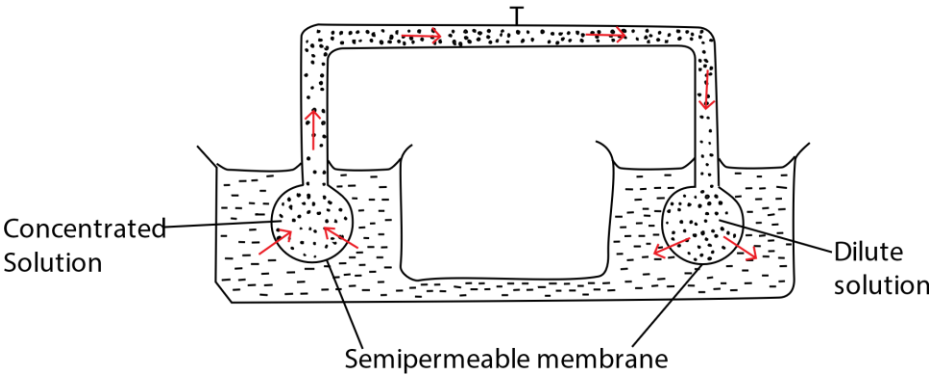
Evidences for transportation of organic materials in the phloem

a. When phloem is cut, the sap exudes is rich in organic material such as carbohydrate. The fact that sap is exuded suggests that the content of the poem is under pressure.
b. The sugar content of the phloem varies with environment conditions i.e., where condition favor photosynthesis, the concentration of sugar in phloem increases indicating that phloem transport photosynthetic products.
c. Removal of a complete ring of phloem from around a stem causes an accumulation of sugars above the ring, indicating that their down progress has been interrupted.
d. If radioactive $^{14}CO_2$ is given to the plants as photosynthetic substrate, the sugar later found in phloem contain ^{14}C. when phloem and xylem are separated by waxed paper, the ^{14}C is almost entirely found in the phloem.
e. Aphids need-like mouthparts with which they penetrate phloem in order to obtain sugars. Fluids obtained from cut mouth of anaesthetized aphid are analyzed to contain sugars.

Mechanism of translocation

1. Mass flow: this is a process where particles move in the same direction at the same speed.

The mass flow is believed to occur in the sieve tubes may be illustrated by the Munch model below:



When set up correctly, water enter through the left-hand funnel by osmosis creating hydrostatic pressure that pushes water out of the right hand until the concentration of solute on either side is equal.

Continuous flow in the phloem is caused by continuous loading of sugars by active transport in the leaves and their continuous removal in the root.

Strength of mass flow theorem

(i) Sucrose concentration is higher at the source than at sink
(ii) sap oozes out suggesting it is under pressure
(iii) viruses are only transported from source to sink.

Weaken of mass flow theorem
(i) Solute move around in different direction
(ii) Different solutes move at different rates.

Transpiration

This is the loss of water by the plant by evaporation

Functions of transpiration

1. absorption of water
2. absorption of mineral salts
3. cooling of the plants.

Factors that affect the rate of transpiration

(a) Environmental factors

1. Temperature: the higher the temperature, the higher the rate of transpiration due to availability of vaporization energy.
2. **Humidity:** high humidity lows the rate of evaporation. Increase in the rate of humidity reduce water potential gradient between the leaf and environment reducing the rate of evaporation.
3. **Air movement/wind:** blows away saturated air around the stomata facilitating evaporation. Strong wind lower the rate of transpiration due to closure of the stomata.
4. **Atmospheric pressure**: the lower the atmospheric pressure, the greater the rate of evaporation.
5. **Light increases** transpiration by opening the stomata and increasing temperature.
6. **Availability of water:** Transpiration is high when there is continuous water supply in the soil to replace the lost water.

This is the loss of water from a plant through the stomata because of evaporation. The following factors all affect the rate of transpiration:

(b) Internal factors that

1. **Surface area of the leaf**. The bigger the leaf surface area, the higher the rate of transpiration.
2. **Thickness of the leaf cuticle;** thin cuticle leads high rate if transpiration due to reduced diffusion gradient
3. **Stomata sizes and density**: numerous big stomata allow fast rate of water loss.
4. **Distribution of the stomata**: leaves with a big number of stomata on the upper cuticle loss water faster than those with the stomata on the lower cuticle.

Adaptations of plants to live in arid area

Xerophytes are plants adapted to survive in arid area.

1. Extremely long **vertical roots** absorb water deep in the soil e.g. Acacia.
2. **Superficial** roots have an advantage of absorbing water quickly before it has a chance of evaporation e.g. cacti.
3. Some plants have got succulent leaves and/or stem to store water e.g. giant saguaro cactus of North America.
4. some plants have reduced number of stomata on their leaves e.g. in prickly pear
5. Some plants have sunken stomata which holds humid air against the leaf surface reducing the rate of evaporation

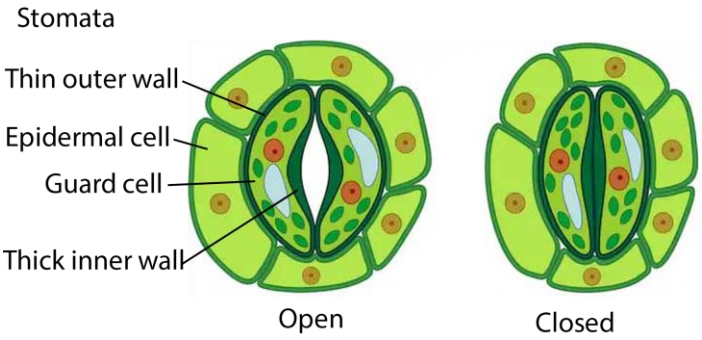
6. Some plants fold their leaves to reduce evaporating surface e.g. marram grass which thrives on dry coastal sand dunes.
7. Cuticlar transpiration in xerophytes is reduced by having **small leaves** with low surface area and by having a **thick cuticle** which is impermeable to water. In some plant leaves have been modified into thorns.
8. Some plants may suffer from water shortage in winter because freezing of soil which decrease water availability from the soil, causing **physiological drought.**
9. One way of circumventing this problem is to **shed the leaves** by deciduous trees before winter sets in, thereby reducing the leaf surface area.

Stomata

These are pores perforating the epidermis of the leaves and non-woody stems. They are usually numerous on the lower epidermis of the leaf and fewer on the upper epidermis.

The stomata allow gaseous exchange of CO_2 and O_2 and permit escape of water from the leaves.

Each stomata is bound by two cells called **guard cells**. These are sausage (banana) shaped and contain chloroplasts, a sap vacuole and cellulose sell wall. The inner wall is thick and less elastic while the outer wall is thinner and more elastic.



Difference between Guard cells and epidermal cell

Guard cells	Epidermal cells
Has chloroplast	Lacks chloroplast
Prominent nucleus	Less prominent mixture
Kidney shaped	Irregularly shaped
Uneven thick walls	Uniform cell wall
Dense cytoplasm	Less dense cytoplasm

The opening and closing

Stomata opening and closure depends on changes in turgor of the guard cells if water flows into the guard cells by osmosis, their turgor increases and they expand. But they do not expand uniformly in all directions. The relatively inelastic inner wall makes them bend and draw away and the pore opens. If the guard cells lose water the reverse happens: their turgor decrease and they straighten, thus the pore closes.

Mechanism of opening and closure of the stomata

a. Sugar hypothesis

Guard cells contain chloroplast; these photosynthesize when exposed to light. Accumulation of sugar in the guard cell lead to osmotic uptake of water. When the guard cells become turgid, the thinner cell wall stretch while the thicker wall resist expansion and draw from each other creating a pore.

Limitation of this mechanism

(a) The stomata response is too rapid to be explained accumulation of sugars in the guard cells.
(b) Some stomata open at night and close during the day
(c) Some guard cells lack plasmodesmata

b. Enzymatic conversion of starch to glucose

At high pH or low carbon dioxide concentration, enzymes convert starch to sugars. This lead to osmotic uptake of water and opening of stomata in light or during day. At night, there is no photosynthesis, carbon dioxide accumulates, and the pH falls, enzyme convert sugar or glucose to starch. This lowers the osmotic potential of the guard cell, and lose water by osmosis which leads to closure of the stomata.

Limitation of enzymatic hypothesis theory

(a) Some guard cells contain no starch
(b) Some guard cells do not contain chloroplast
(c) Some stomata open during the night and close during the day.

c. Active uptake of ions

This hypothesis suggest that stomata open due to active uptake of potassium ions. This increase the osmotic potential of the guard cells leading to osmotic uptake of water and opening of the stomata.

Alternatively, loss of potassium ions by diffusion lower osmotic potential of the cell, loss of water by osmosis and closure of the stomata.

Adaptations of the guard cells to their functions

(i) they are kidney – shaped to enable them form a pore between them when they become turgid.
(ii) Have chloroplast which carries out photosynthesis thus forming sugar.
(iii) Have large vacuoles which regulate the osmotic pressure of the cell.
(iv) Thicker inner walls & thin outer walls; enables them to bulge outwards when turgid.

Halophytes

These are plants that survive in saline water e.g. mangrove.

Adaptations of halophytes to their habitat

- Possess succulent leaves and/or stem for storage of water

- Have salt glands to secrete excess salts
- Have thick cuticle to reduce water loss
- Have sunken stomata to reduce transpiration.
- Some have aerial roots for gaseous exchange
- Some have organic solutes like sorbitol for gaseous exchange.
- Some exhibit vivipary i.e. seeds germinate while still attached to the parent plant and grow into self-sustaining seedling before they fall off.

Exercise

1. Which one of the following types of plant is likely to have the most thin leaf cuticle?
   A. Mesophytes
   B. halophytes
   C. hydrophytes
   D. xerophytes
2. Sucrose is the major transport solute in plants because is
   A. is highly soluble so can be transported in high concentration in the sap
   B. can easily convert into glucose and fructose
   C. insoluble so it cannot be used in chemical reaction
   D. can be oxidized by the living parts of the phloem
3. Which of the following sets of conditions in the guard cells would lead to the opening of the stomata?
   A. High carbon dioxide concentration and low sugar concentration
   B. low carbon dioxide concentration and high sugar concentration
   C. High sugar concentration and high carbon dioxide concentration
   D. Low pH and high starch concentration
4. Which one of the following structures are characteristic of a floating plant?
   A. Light, thin leaves with hairy surface.
   B. broad, thick leaves with thin cuticle
   C. Light, thin leaves with thick cuticle
   D. broad, thin leaves with aerenchyma

5. Which one of the following parts would show a distinct blue color if a section of a root of dicotyledonous plant was stained with iodine
   A. Pericycle
   B. Piliferous layer
   C. Endodermis
   D. Pith
6. A companion cell has a large nucleus because
   A. it supports the sieve tube element which lacks a nucleus
   B. it controls a large volume of cytoplasm
   C. movement of materials in sieve tubes is an active process.
   D. of its high metabolic rate
7. If a metabolic poison was taken up by a plant, which one of the following processes would be affected immediately?

   A. Evaporation of water from leaf surfaces.
   B. Movement of food from leaves to roots.
   C. Movement of water within the stem.
   D. Movement of water within leaves.

8. Stomatal closure occurs when

A. The turgor in guard cells rises
B. The pH in the guard cells decreases
C. The osmotic potential in the guard cells is more than that in surrounding cells
D. Starch in the guard cells is converted to sugars

9. Which one of the following parts would show a distinct blue color if a cross section of a dicotyledonous plant was stained with iodine solution?
A. Pericycle
B. Poriferous layer
C. Endodermis
D. pith

10. The path way which allows water to move form cell to cell through the cytoplasm is the
A. apoplast
B. vacuolar
C. Symplast
D. cuticular

11. Which of the following does not contribute to the movement of water from the root system to the leaves in a flowering plant?
A. Root pressure
B. Cohesion forces
C. Transpiration pull
D. Atmospheric pressure

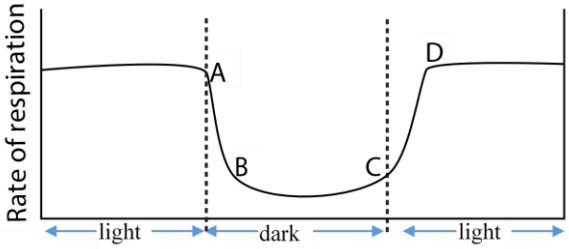
12. Which one of the following is the main form of photosynthetic product transported by the phloem?
A. Starch
B. Amino acid
C. Sucrose
D. Glucose

13. During the heat of the day, control of stomatal movements to reduce excessive water loss is due to
A. Active accumulation of mineral ions in the guard cells
B. Synthesis of abscisic acid
C. Inter-conversion of glucose and starch in the guard cell
D. Synthesis of glucose during photosynthesis.

14. If the rate of transpiration lags behind that of absorption, movement of water up the plant is mainly by
A. Root pressure
B. Capillarity
C. Mass flow
D. Transpiration

15 . A column of water in the xylem vessel of a tall tree ascends without breaking mainly due to
A. Root pressure
B. Cohesive forces
C. Transpiration pull
D. Adhesive force

16. Under which of the following conditions would transpiration be most rapid?
    A. Dark and windy
    B. Light and windy
    C. Dark and still
    D. Light and still
17. The figure shows the rate of transpiration of hibiscus shoot under different light conditions

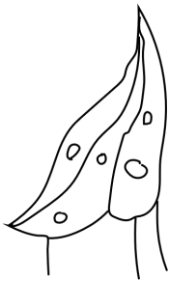


From the graph at which of the stages indicated did the stomata begin to open?

18. Which one of the following occurs as a result of low pH in the guard cells?
    A. Conversion of sugar to starch, reducing osmotic pressure
    B. Conversion of starch to sugar, reducing osmotic pressure
    C. Conversion of sugar to starch, increasing osmotic pressure
    D. Conversion of starch to sugar, increasing osmotic pressure
19. Which one of the following adaptation helps a desert succulent plant to reduce water loss?
    A. Possess deep roots
    B. Has reduced number of stomata
    C. Possess extensive roots
    D. Sheds its leaves during dry season
20. Which of the following does not involve mass flow?
    A. Blood flow in the arteries
    B. Uptake of food by the tapeworm
    C. Movement of food and water in the gut
    D. Transport of water and mineral salts by the xylem
21. Which of the following qualities of the guard cells least contribute to their opening?
    A. Uneven thickened walls
    B. Inner walls being less elastic than outer walls
    C. Presence of chloroplast
    D. Presence of vacuoles
22. Failure to synthesize abscisic acid in plants may lead to
    A. Leaves turning yellow
    B. Plant drying up
    C. Leaves becoming salty
    D. Poor development of leaves
23. Which one of the following best describes the transport of photosynthetic products in a plant?
    A. Active transport
    B. Osmotic movement
    C. Mass flow
    D. Cytoplasmic streaming

24. Which one of the following pairs of animals have incomplete double circulatory system?
    A. Rabbit and toad
    B. Toad and lizard
    C. Pigeon and monkey
    D. Snake and whale
25. Which one of the following changes bring about the opening of stomata in plant leaves?
    A. Fall in the pH of the intercellular spaces
    B. Synthesis of starch
    C. Rise in levels of carbon dioxide in intercellular spaces
    D. Conversion of starch to sugar
26. Plants growing in humid habitat lose water by
    A. Transpiration
    B. Cuticular transpiration
    C. Guttation
    D. evaporation
27. Stomatal closure occurs when
    A. turgor in the guard cells rises.
    B. the pH in the guard cells decreases.
    C. the osmotic potential in the guard is more than that in surrounding cells.
    D. starch in the guard cells is converted to sugar.

22. Figure 2 shows a section of a structure a plant tissue.



The tissue with such a structure is the
A. collenchyma.
B. parenchyma.
C. phloem.
D. xylem.

Structured questions

28 (a) Describe two forces that enable water move up the xylem vessels in continuous column. (12marks)

(b) Explain how light influences stomatal opening in a plant that has been previously in the dark. (8marks)

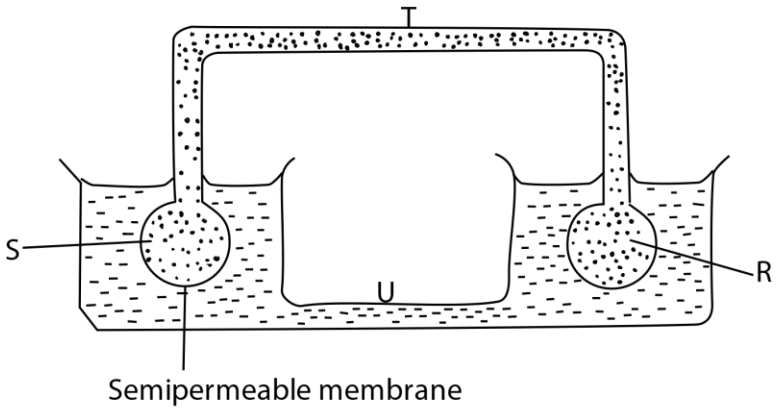
29. (a) (i) What is active transport? (1 mark)

(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.



S is a concentrated solution
R is dilute solution

(i) Referring to figure above, 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)

30. Differentiate between the following:

(a)Diffusion and Osmosis

(b)Transpiration and Evaporation

(c) Osmotic Pressure and Osmotic Potential

(d) Imbibition and Diffusion

(e)Apoplast and Symplast pathways of movement of water in plants.

(f)Guttation and Transpiration.

Assay questions

31. (a) How does each of the following explain the movement of water and mineral salts up the xylem?
    (i) Cohesion and tension theory (06marks)
    (ii) Root pressure (05marks)

23 (2008/2/5)

32(a)Explain how light may affect the activities of organism (13 marks)

(b) Why do transpiration occur mainly through the leaves other than other parts of the plants?

24 2007/1/4)

33 (a) Describe the structure of guard cells in plant leaf (6marks)
(b) (i) Explain how stomatal opening occurs according to
Starch ↔ glucose interconversion (8marks)
(ii) Photo synthetic theory (6marks)

34. (a) How is the structure of the phloem suited for its function? (10marks)

(b) Describe mass flow of materials through the phloem. (10marks)

35. The distribution of the stomata and other leaf modification in plants are indicative of their habitats. Discuss. (20marks)

27. (a)With the aid of a labelled diagrams differentiate between the structure of a transverse section of a dicotyledonous and a dicotyledonous root. (6marks)

(b) Describe the adaptations of the structure responsible for transport of materials in plants. (14marks)

Marking guide

1	C	6	D	11	D	16	B	21	D	26	C
2	A	7	B	12	C	17	C	22	B	27	B
3	B	8	B	13	C	18	A	23	C		
4	D	9	C	14	A	19	B	24	B		
5	C	10	C	15	B	20	B	25	D		

Structured Question

28. (a) **Root pressure:** this is a hydrostatic force that pushes water from the root to the stem because is constantly absorbed by the roots by osmosis into the xylem and partially due to active process.

Transpiration pull: this a suction pull created by loss of water through the stomata. Constant water loss via transpiration from the leaves causes a negative water pressure in the leaves. The negative pressure in the leaves works like a 'suction' force, pulling the water up the stem.

(b) Guard cells contain chloroplast; these photosynthesize when exposed to light. Accumulation of sugar in the guard cell lead to osmotic uptake of water. When the guard cells become turgid, the thinner cell wall stretch while the thicker wall resist expansion and draw from each other creating a pore.

Secondly, use of carbon dioxide for photosynthesis raises the pH leading to conversion of starch to glucose. Glucose increases the osmotic pressure of the guard cells.

29 (a)(i) **Active transport** is the movement of molecules across a membrane from a region of their lower concentration to a region of their higher concentration—against the concentration gradient. Active transport requires cellular energy to achieve this movement. There are two types of active transport: **primary active transport** that uses adenosine triphosphate (ATP), and **secondary active transport** that uses an electrochemical gradient

(ii) The **active transport** of small **molecules** or **ions across** a cell **membrane** is generally carried out by **transport proteins** that are found **in** the **membrane**. These proteins bind the molecule to be transported, change shape in presence of ATP and spit the substance

in the opposite direction.

(iii) **Evidences that support active transport.**

a. metabolic poisons stop active transport

b. increase in temperature increase the rate of active uptake

c. increase in oxygen concentration increase the rate of active transport

d. cells that carry out active transport have high concentration of mitochondria

(b) At full turgor: $\Psi_p = \Psi_s$ while $\Psi_w = 0$

where Ψ_p = wall pressure

Ψ_s = osmotic pressure

Ψ_w = water potential

(c)(i) T = Phloem

U = xylem

(ii) weakness of mass flow hypothesis

a. solutes move at different rate
b. solutes move in different direction

30. Differentiate between the following:

(a) Diffusion and Osmosis

Diffusion is the passive movement of particles from a region of high concentration to a region of concentration. Osmosis is a type of diffusion in which solvent molecule move across a semi-permeable membrane from a region where they are in high concentration, it is called osmosis. Semi-permeable membrane is not necessary in all cases of diffusion.

(b)Transpiration and Evaporation

Evaporation is conversion of liquid into gas/vapor while transpiration Evaporative loss of water from plants

(c) Osmotic Pressure and Osmotic Potential

Osmotic pressure is the pressure which needs to be applied to prevent the inward flow of water across a semi-permeable membrane or osmotic pressure is the minimum pressure needed to negate the osmosis. whereas osmotic potential is the ability of a solution to suck in water from across a semi-permeable membrane.

(d) Imbibition and Diffusion

Diffusion is random movement of molecules to attain concentration equilibrium. Imbibition is osmotic uptake of water by solids (colloids)

(e)Apoplast and Symplast pathways of movement of water in plants.

Apoplast Pathway	Symplast Pathway
The free diffusional space outside the plasma membrane is called apoplast.	The inner side of plasma membrane is called symplast.
Formed by continuum of cell walls.	Is made continuous because of plasmodesmata.
Water and solutes are usually transported by this.	Smaller molecules are transported through this.

(f) Guttation and Transpiration.

Exudation of water from smaller plants; under low evaporation conditions; is called guttation. Evaporative loss of water from plants is called transpiration. In guttation, water comes out in liquid form; while in transportation, water comes out in gaseous form.

31. (i) Cohesion-adhesion theory

a. Evaporation of water from the cells of the leaves is responsible for raising water from the roots.

b. Evaporation of water from the leaves reduces water potential in the cells next to the xylem in the leaves.

c. Water drawn from the xylem into the leaf cell.

d. Xylem vessels are full of water and, as water leaves them, a tension is set up in the column of water down to the roots.

e. the column of water if high tensile strength is maintained by the cohesive forces that keep water molecules together and the adhesive forces that sticks water molecules to xylem walls

f. The tension in the xylem vessels builds up a force capable of pulling the whole water column upwards by mass flow and water enters the base of the columns in the roots from neighboring root cells.

(ii). Root pressure

The root pressure is a force that pushes up water and salts into xylem.

a. Mineral ions enter the roots through active transport.

b. This maintains a gradient for water to move into the cells by osmosis.

c. this creates a hydrostatic force moving water through the roots and up the stem of a plant.

d. Root pressure can only provide a modest push. Hence root pressure does not play a major role in water movement in tall plants. Root pressure contributes towards reestablishment of continuous chains of water molecules in the xylem; which often break under enormous tensions created by transpiration pull

32 (a) Effects of light on the activity of organism

(i) Light is required to provide energy for photosynthesisant growth.

(ii) Light duration affects plant flowering and animal/insect habits

(iii) Animals use sunlight to manufacture vitamin D, which is important in the formation of strong bones.

(iv) Too much sun can cause skin to tan or burn

(v) light causes opening of flowers and leaves e.g. morning glory

(vi) Phototropism light causes growth towards light

(vii) Phototaxis: some organism move towards light while others move away from light.

(viii) light leads to opening of stomata facilitating gaseous exchange in plants

(ix) light aids vision

(x) migration of bird

(xi) Pigmentation of the skin and season changes of color

(xii) light increases enzymatic and general metabolic activity of animals through raising temperature.

32(b) Transpiration is the process by which plants lose water vapour through their aerial part. It may occur through leaves, green stems and lenticels of woody stems, but 90%occur through the leaves.

Reasons

(i) Leaves are numerous and so offer a larger surface area for escape of water vapor by diffusion from plants.

(ii) Leaves contain numerous pores (stomata) through which a large amount of water vapour can escape

(iii) The spongy mesophyll cells have large intercellular spaces in which water can easily evaporate from neighboring cells to enhance its exit as water vapour from the plants. There are no such intercellular spaces in the other plant parts.

(iv) Leaves are covered with a thinner cuticle which offers less resistance to the escape of water

(v) they are well spread.

33 (a) Guard cells are sausage-shaped cells lying side-by-side in the leaf epidermis. The space between them is called the stoma and is kept closed or open by the orientation of these cells, depending on their turgidity.

- They have a sap vacuole and contain chloroplasts.
- The inner wall is thicker and less elastic than the outer wall.

(b)(i) Rise in pH in the gland cells during day leads to conversion of starch to sugar in the guard cells. This increases the osmotic potential of the cell sap. As a result the guard cells absorb water from the neighboring cells by osmosis and become turgid. The thick, inelastic inner walls make them to bend outwards, leaving the pore open.

(ii)During day, there is formation of sugar by photosynthesis in the guard cells. This increases the osmotic potential of their cell sap. As a result the guard cells absorb water from the neighbouring cells by osmosis and become turgid. The thick, inelastic inner walls make them bend outwards, leaving the pore open.

34. (a) Adaptations of the phloem

Phloem comprises of sieve tubes/sieve elements, phloem parenchyma, phloem fibers and companion cells each specialized to perform specific functions

(i) the Sieve tubes are elongated cylindrical cells connected end to end. Their end walls have sieve plates perforated with pores to allow continuous flow of materials

(ii) the sieve tube have no nuclei to create room for transport

(iii) the sieve tube contain cytoplasmic filaments that facilitate transport by streaming

(iv) companion cells are metabolically active to provide energy for transport in the sieve tube

34 (b) (i) Glucose manufacture in the leaves is converted into sucrose and loaded into the phloem by active transport

(ii) this lowers the water potential causing more to move into the phloem cells causing hydrostatic pressure.

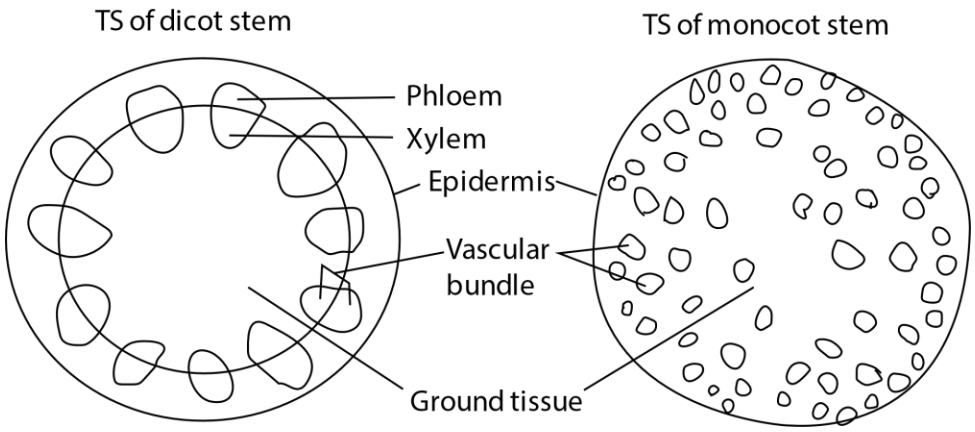
(iii) the increase in hydrostatic pressure causes sugars to move

(iv) Removal of sugar by root and other cell maintains the pressure gradient ensuring continuous movement of sugar from leaves to other parts f the plant.

35 Distribution of stomata and habitats

a. Hydrophytes live in fresh water have numerous stomata on the surface of the leaves and very few on the back of the leaves to get rid of excess water by transpiration.
b. Mesophytes live on land that contains adequate water. To reduce water loss they have more stomata on lower surface than upper surface. The leaves some times are hairy with thick cuticle to reduce water loss
c. Halophytes survive in saline water. Have very few stomata on both side of the leaves reduce water loss. Have thickened leaves and stems to store water.
d. Xerophytes live dry areas such desert: have reduced size and number of leaves with seduce number of stomata to recue water loss. The stomata are sunken stomata and leaves thick waxed cuticles. Leaves are hairy.

36. **Internal structure of the dicot stem and monocot stem**


TS of dicot stem
TS of monocot stem
Phloem
Xylem
Epidermis
Vascular bundle
Ground tissue

Differences between dicotyledonous and monocotyledonous team

	Characteristics	Dicotyledonous stem	Monocotyledonous stem
1.	Vascular bundles	Arranged in ring	Scattered across the stem
2.	Number of vascular bundles	Contains 4 to 8 vascular bundles	Contain numerous vascular bundles
3.	Size of vascular bundles	All vascular bundles have equal sizes	Outer vascular bundles are smaller than inner vascular bundles
4.	Sclerenchymatous bundle cap	present	Absent
5.	Sclerenchymatous bundle sheath	absent	Present
6.	Metaxylem	Many metaxylem are present	Two metaxylem are present per vascular bundle
7.	Protoxylem	absent	Present
8.	Xylem elements	polygonal	Circular
9.	Phloem parenchyma and phloem fibers	present	Absent
10.	Pith	Present	Absent
11.	Medullary rays	Present	Absent
12.	Pericycle	Present	Absent
13.	Ground tissue	Differentiated into steler and extra-steler tissue	Undifferentiated
14.	Hypodermis	sclerenchymatous	Chlorenchymatous
15.	Trichomes	present	Absent
16.	Silica deposition in epidermis	present	Absent
17.	Secondary thickening	occurs	Does not occur

36 (b) (i) **Adaptations of the xylem**

1. Cross walls are perforated or completely removed to form continuous tubes from roots to stems and leaves

2. Xylem vessels have no living contents to allow water to flow freely

3. Contain bordered pits to allow water cross to living cells

4. Lignified to prevent water loss

5. Lignified to prevent them from collapsing under negative pressure of transpiration pull.

6. Small tube to enable high capillarity

7. Xylem walls have high adhesive forces.

8. Torus in bordered pits act as a plug for controlling passage of water in some plants

Adaptation of xylem to provide support

1. Walls are lignified

2. Vessels are circular for additional support.

(ii) **Adaptations phloem for its functions**

1. Lack a nucleus and most cell organelles to leave room for transportation of food

2. The sieve plates are perforated to allow rapid flow through from one cell to another.

3. Has filament for quick transport by streaming

4. Intimate association with companion cells to obtain energy and materials