EXTENSIVE QUESTIONS

20. Write the role each macro and micronutrients of plants in a tabular form.
Ans. Mineral nutrition in plants:

Macronutrients	Major Functions
Carbon, Hydrogen, Oxygen	Component of carbohydrates, liquid, protein and nucleic acid molecules.
Nitrogen	Component of proteins, nucleic acids, chlorophyll and enzymes.
Phosphorus	Component of nucleic acids, phospholipids, ATP and NADP
Calcium	Component of cell wall, involved in membrane permeability, enzyme activator.
Magnesium	Component of chlorophyll, acts as enzyme activator.
Sulphur	Component of certain amino acids and vitamins.
Potassium	Osmosis and ionic balance opening and closing of stomata, enzyme activator.
Micronutrients	**Major Functions**
Chlorine	Activator of enzymes, involved in photosynthesis

Iron	Activator of enzymes, component of cytochromes ferixdoxin, plastoquinone, assists in the manufacture of chlorophyll and other biochemical processes.
Manganese	Activator of enzymes, needed for chlorophyll production.
Copper	Activator of enzymes, component of plastocyanin, helps plants to metabolize nitrogen.
Zinc	Activator of enzymes, used in development of enzymes and hormones. It is used by the leaves and needed by legumes to form seeds.
Molybdenum	Activator of enzymes, helps plants to use nitrogen.
Boron	Activator of enzymes, helps in cell development and helps to regulate plant metabolism.

21. What is the role played by the palisade and spongy mesophyll in exchange of gases in plants?

Ans: Role of Palisade and Spongy Mesophyll in Exchange of Gases:

Mesophylls are special types of parenchymatous cells (thin walled living cells) which are present between the two epidermal layers of leaves. These cells are modified to carry out photosynthesis.

Types of mesophyll in dicot and monocot leaves:

In dicots, there are two distinct layers of mesophyll, the **palisade mesophyll** are the **spongy mesophyll.** The palisade mesophyll is elongated and compactly packed cells with no intercellular spaces between them.

Upper Epidermis:

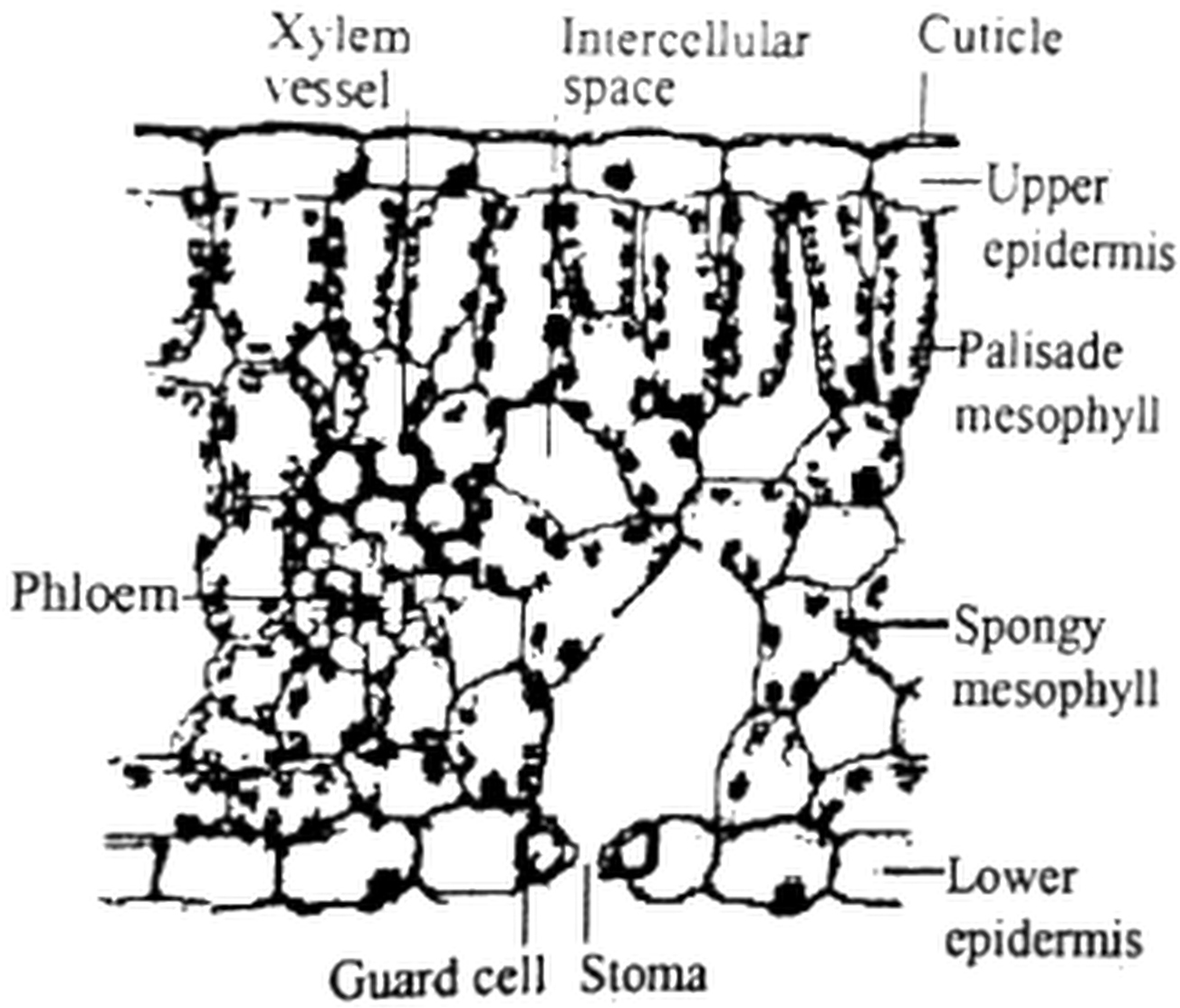
The epidemics beside mesophyll is called **upper epidermis.**

Lower Epidermis:

On the other hand, spongy mesophylls are loosely packed cell with large intercellular spaces. The epidermis beside spongy mesophyll is called **lower epidermis.**

Bifacial or Dorsiventral Leaves:

Suh leaves, in which upper and lower epidermises can be differentiated because of the presence of two types of mesophyll cells, are called **bifacial** or **dorsiventral leaves.** In monocots, the leaves are **monofacial** or **isobilateral as** only spongy mesophyll cells are present between both epidermises. The mesophyll cells are metabolically active cells of the plant therefore, they are rapidly involved in exchange of gases. The passage for this exchange of gases through mesophyll tissue is provided by the stomata.



T.S of Bifacial leaf

Relationship of Stomata and Transpiration with Exchange of Gases:

Stomata:

Stomata are small biconvex shaped openings present in leaf epidermis. A stomatal aperture or stoma (singular) is formed by two, kidney or bean shaped guard cells, which are specialized epidermal cells of leaf, in bifacial leaves, more stomata are distributed in lower epidermis as intercellular species are present along this epidermis. Whereas, isobilateral leaves have equal number of stomata in both epidermises.

Transpiration:

The **transpiration** is the loss of water in the form of vapours through aerial (above the ground) parts of the plants mainly through the stomata. It is not only responsible for transportation of water and minerals but also plays a vital role in the exchange of gases. During day light, the stomata are widely open and provide a wide passage for the exchange of gases.

22. Describe the exchange of gases between plants and environment.

Ans: Pattern of Exchange of Gases between plat and environment:

In daytime plants are involved in both photosynthesis and respiration but at night only respiration does occur. Therefore, pattern of gaseous exchange is different in day and night.

Exchange of gases in daytime:

In daytime, since the rate of photosynthesis is much faster than the rate of respiration so the carbon dioxide released from respiration does not fulfill the photosynthetic need Hence, plants import carbon dioxide from the environment. Similarly, the oxygen released from photosynthesis is much more than the need of respiration; hence, it is exported out of the plant body.

Exchange of gases at night:

Plants begin to perform exchange of gases just like animals at night I e, they absorb oxygen and release carbon dioxide to the environment because photosynthesis is stopped. Now oxygen required for respiration is absorbed from environment and the carbon dioxide produced from respiration is released outside.

Compensation point of photosynthesis:

At the time of dawn (sunrise) and (sunset) the rate of photosynthesis becomes equal to the rate of respiration due to low intensity. In this situation, the carbon dioxide from respiration is sufficient to the carry-on photosynthesis and the oxygen released from photosynthesis is consumed in respiration. Therefore, the net gaseous exchange between plant and its environment is completely stopped. This is known as **compensation point** of photosynthesis.

23. Explain the movement of water between plant cells and their environment.

Ans: Movement of Water between Plant Cells and their Environment:

The uptake or loss of water by cells takes place by osmosis. The term osmosis is specifically applied to the movement of water from the region of its higher concentration to the region of its lower concentration though semipermeable membrane. The movement of water into the cell is called endosmosis while the movement of water out of the cell is called exosmosis. The movement of water into or out of the cell exhibits three kinds of water relations such as water potential, solute potential and pressure potential.

Water potential (Ψ_w):

Water potential is a measure of the potential energy in water that enables it to move from one place to another. Potential or pressure is denoted by the Greek letter **Ψ** (psi) and is expressed in units of pressure (pressure is a form of energy) called Mega **Pascal (MPa).** In this way, water potential is represented by Ψ_w. Water potential of a medium is directly proportional to the concentration of water in that medium; therefore, pure water has highest water potential. Water potential of pure water is designated a value of zero (even though pure water contains plenty of potential energy, that energy is ground) and it is taken as a reference because Ψ_w of all other solutions are compared with pure water. Water potential of all the solutions or the cells must be less than zero i.e. in negative range.

The water potential in plant solutions is mainly influenced by solute concentration and pressure greater than atmospheric pressure. Water potential can be broken down into its individual components using the following equation:

$$\Psi_w = \Psi_s + \Psi_p$$

Where

Ψ_w = solution potential

Ψ_p = pressure potential

As the individual components change, they cause or lower the total water potential of a system. 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. Therefore, for water to move through the plant from the soil to the air (a process called transpiration), the conditions must exist as such:

Ψ_w of soil > Ψ_w of root > Ψ_w of stem > Ψ_w of leaf > Ψ_w of atmosphere.

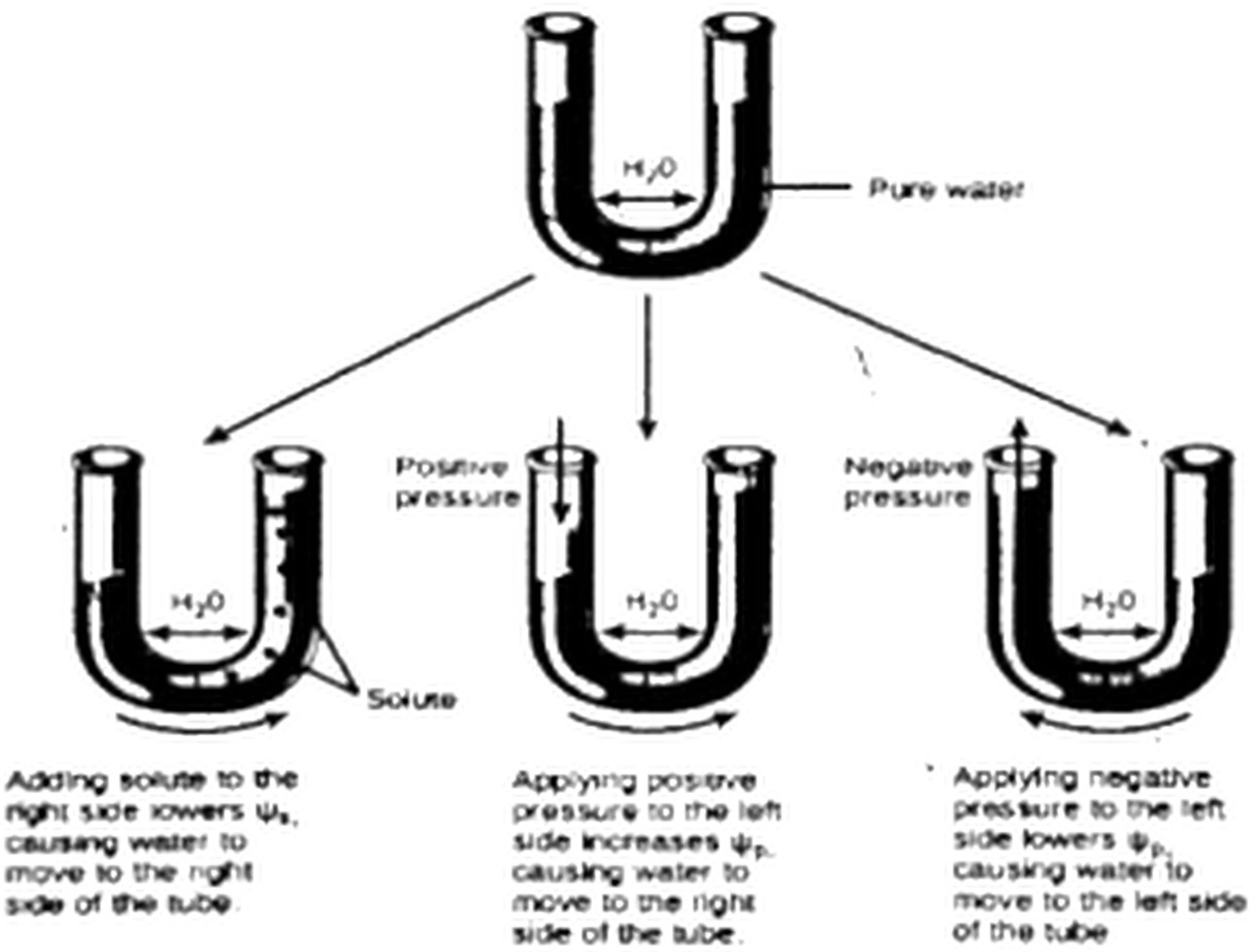


Fig changes in Ψ_w of the two adjacent systems and their effects. In this example semipermeable membrane is placed between two aqueous systems in a U shape tube, water will move from region of higher to lower water potential until equilibrium is reached. Solutes concentration and pressure greater than atmospheric pressure (positive pressure) influence total water potential for each side. Water moves in response to the difference in water potential between two systems (the left and right sides of tube).

Solute potential (Ψ_w):

Solutes reduce water potential (resulting in a more negative Ψ_w) by consuming some water of the potential energy available in the water. This measure of decrease in water potential of a medium due to addition of solutes is called **solute potential.**

Solute potential is negative in a plant cell and zero in distilled water. Typical values for cell cytoplasm are -0.5 to10 MPa Solute molecules can dissolve in water because water molecules can bind to them bia hydrogen bonds; a hydrophobic molecule like oil, which cannot bind to water, cannot go into solution. The energy in the hydrogen bonds between solute molecules and water is no longer available to do work in the system because it is tied up in the bond. In other words, the mounts of available potential energy are reduced when solutes are added to an aqueous system. Thus Ψ_s decreases with increasing solute concentration. Because Ψ_s is one of the two main components of total Ψ_w of a system are decreased in Ψ_s will cause a decrease in total Ψ_w the internal water potential of a plant cell is more negative than pure water because of the cytoplasm's high solute content. Because of these differences in water potential, water will move from the soil into a plant's root cells-via the processes of osmosis. This is why solute potential is sometimes called osmotic potential.

Pressure potential (Ψ_p):

If pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential increases. It is equivalent to pumping water from one place to another such a situation may arise in living system. When water enter the plant cells by osmosis pressure may be built by inside the cell making the cell turgid and increasing the water potential. This measure of increase in water potential of a medium due to the addition of water or due to pressure greater than atmospheric pressure is called **pressure potential.** Following example would help understand the concept of water potential. To adjacent vacuolated cells are shown with Ψ_w, Ψ_s and Ψ_p.

Cell A	Cell B
Ψ_w = -1400 KPa	Ψ_w = -600 KPa
Ψ_s = -600 KPa	Ψ_s = 800 KPa
Ψ_p = -2000 KPa	Ψ_p = -1400 KPa

i. Which cell has higher water potential?

Ans: Cell B

ii. In which direction will water move by osmosis?

Ans: From Cell B to Cell A.

iii. What will be the water potential of the cells at equilibrium?

Ans: Cells will have the water potential -1400 + -600 = -2000/2 = -1000 KPa at equilibrium.

iv. What will be the solute potential and pressure potential of the cells at equilibrium?

Ans: The solute potential of the cells will be 700 KPa and the pressure potential will be – 1700 KPa at equilibrium

24. Describe the movement of water though roots.

Ans: Uptake of water by roots and pathways:

The cell wall of epidermal cells of roots is freely permeable to water and other minerals. The cell membrane is differentially permeable. From root hairs water enters the epidermal cells by osmosis. The water moves along the concentration gradient. It passes through cortex, endodermis, and pericycle and reach the xylem vessels.

There are three pathways taken by water to reach the xylem tissues.

(a) The apoplast pathway

(b) The symplast pathway

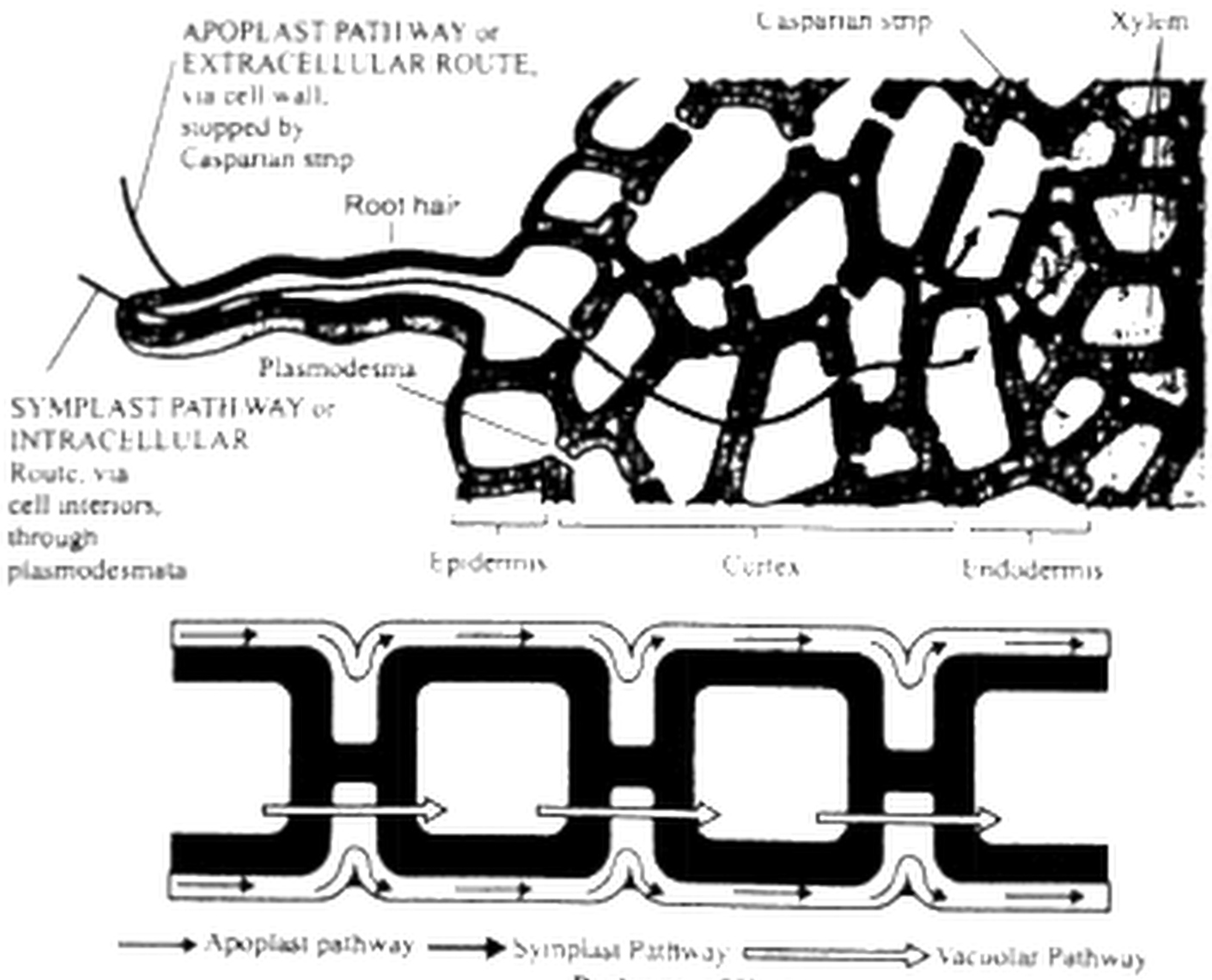
(c) The vacuolar pathway

(a) Apoplast Pathway:

The apoplast is the system of adjacent cell walls, which continues throughout the plant. When water moving through spaces in the cell walls reaches the endodermis, its progress is stopped by **casparian strips,**(a band of suberin and lignin bordering four sides of root endodermal cells).Therefore water and solutes particularly salt in the form of ions must pass through the cell surface and into the cytoplasm of the cell of the endodermis. In this way the cell of the endodermis can control and regulate the movement of solutes through the xylem. This is called **apoplast pathway.**

(b) Symplest pathway:

Movement of cell sap that involves cytoplasmic of adjacent cells is termed as **symplest pathway.** The **simplest** is the system of interconnected protoplast in the plant the **cytoplasm** of neighboring **protoplast** is linked by the **plasmodesmata.** Once water and any solutes it contains is taken into the cytoplasm of one cell it can move through the simplest without having to cross further membranes Movement might be aided by cytoplasmic streaming. The simplest is an important pathway of water movement.



Pathway of Water

(C) Vacuolar pathway:

In the vacuolar pathway water moves from vacuole to vacuole through neighboring cells, crossing the simplest and apoplast in the process and moving through membranes and tonoplast by osmosis. It moves down a water potential gradient.

25. Describe the components and functions of xylem.

Ans: Components of xylem and their functions:

Xylem is a complex (made up of different kind of cells), permanent (lacks power of cell division) tissue that consists of four, cell types:

- **i.** Tracheids
- **ii.** Vessel Elements
- **iii.** Xylem Fibre
- **iv.** Xylem Parenchyma

i. Tracheids:

Tracheids are dead, elongated cells with tapering ends and lignified walls. They have mechanical strength, give support, and also involve in conduction of water and minerals. These cells are universally present in xylem tissue of all vascular plants, which are therefore, called **tracheophytes.**

ii. Vessel Elements:

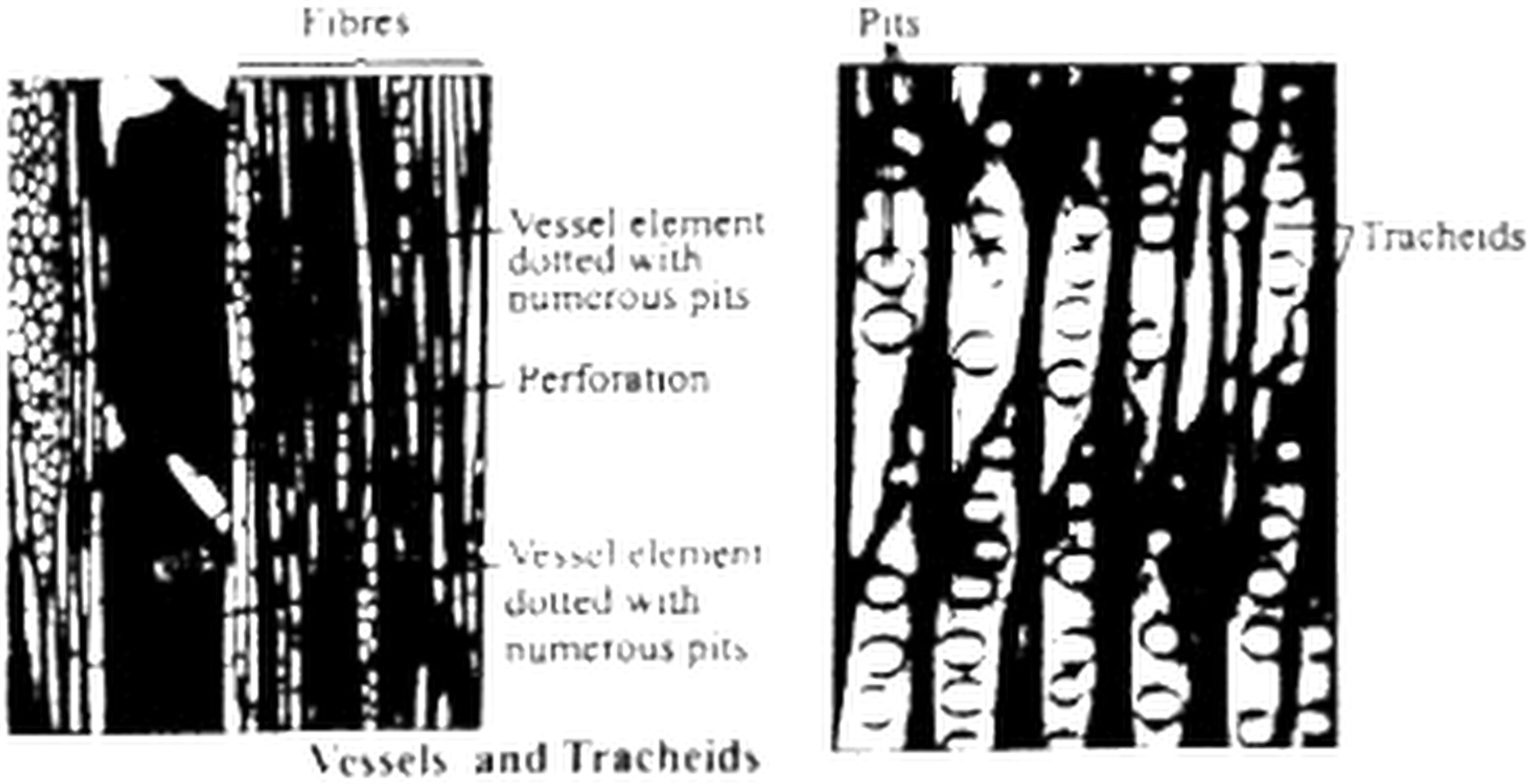
Xylem Elements are dead, very long, highly thick-walled tubular structures formed by the fusion of several vessel cells (vessel elements) end to end in a row. **Vessel elements** are shorter than tracheids but they form pipeline in plant body as they are placed one above the other Xylem, vessels are only found in angiosperms where they are involved in conduction of water and minerals and also provide mechanical support to the body.

iii. Xylem Fibres:

Xylem Fibres are also dead but narrow, highly elongated, highly thick walled cells with tapering ends. They are mainly responsible for mechanical support to the plant body.

iv. Xylem Parenchyma:

The only living cells of xylem are **xylem parenchyma,** which are thin walled, broad cells and are involved in the storage of water and minerals temporarily during conduction.



Vessels and Tracheids

26. Describe the components and functions of phloem.

Ans: Components of phloem and their functions:

Phloem tissues are also complex permanent tissues that are composed of three living cells (sieve tube elements, companion cells and the phloem parenchyma) and one dead cell (phloem fibre).

Sieve Tube Elements:

Sieve tubes are the long tube-like structures, which translocate solutions of organic solutes (sucrose) throughout the pant body. These are formed by the end-to-end fusion of cells called sieve tube elements. **Sieve tube elements** are thin walled living cell but do not have nuclei, actually, their nuclei are lost as they mature. These cells are narrow from the centre and wide from the ends. A transverse or oblique pore bearing partition, the **sieve plate,** separates two successive sieve tube elements.

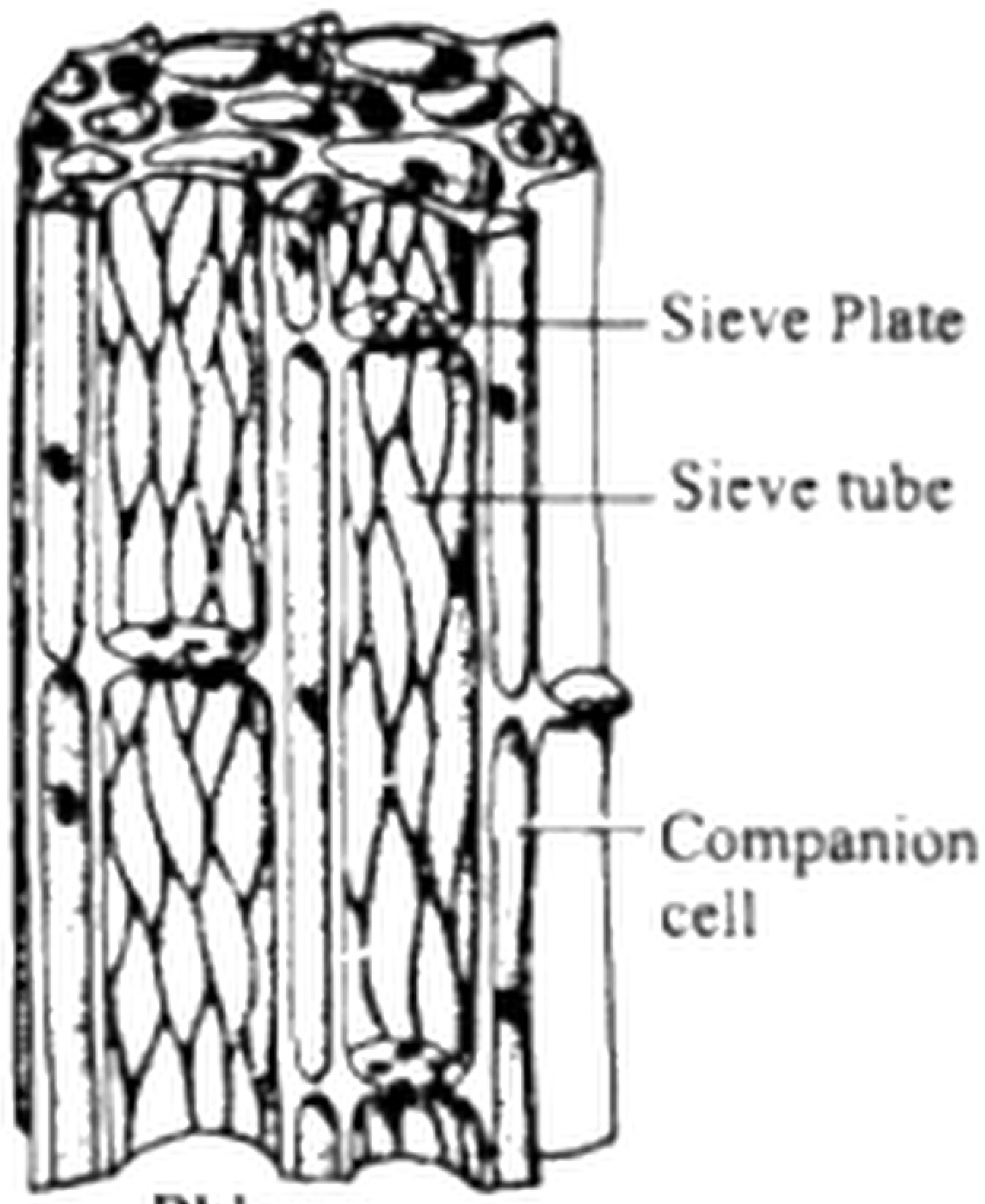
Companion Cells:

Due to the absence of nuclei, the functions of sieve tube elements are controlled by adjacent **companion cells.**

The sieve elements and companion cells, together from a functional unit that act as conducting channels and are involved in transport of organic solutes. Companion cells provide energy to sieve tube elements for their activities. Like xylem tissue phloem also possesses parenchyma and fibre cells.

Phloem Parenchyma:

Phloem parenchymal are storage cells and phloem fibres are very much thick walled supporting cells.



Phloem

27. Describe the ascent of sap in xylem through TACT mechanism.

Ans: Ascent of Sap:

Water and minerals are absorbed by the root epidermal cells of soil from where these substances are first moved to the root xylem cells and then to the leaves. These upward movements of water and dissolved mineral from root to the leaves through xylem tissue is called **ascent of sap.** Since this movement occurs against the gravity therefore, a considerable force is required to conduct water and minerals in tall heighted plants. The most acceptable theory that explain these movement is generally called TACT theory.

TACT theory:

According to this theory, four factors such as transpiration pull, Adhesion, Cohesion and Tension (TACT) are combined to form a collective force that is mainly responsible for ascent of sap.

Components of TACT force:

TACT force consist of four components i.e. transpiration pull, Adhesion, Cohesion and Tension.

1. Transpiration Pull:

When stomata are open, the water molecules move from the region of high-water potential (intercellular spaces of leave) to a region of low potential (in the air). These evaporations of water are called transpiration. In the same way the dry intercellular spaces pull water from surrounding cells which in turn pull the water from the xylem tissue. Thus, the phenomenon of transpiration develops a pulling force, the **transpiration pull** that compels the water and minerals to move upward the xylem. In xylem water and dissolved minerals are present in the form of a continues column which is maintained by forces such as Adhesion, Cohesion and Tension.

2. Adhesion:

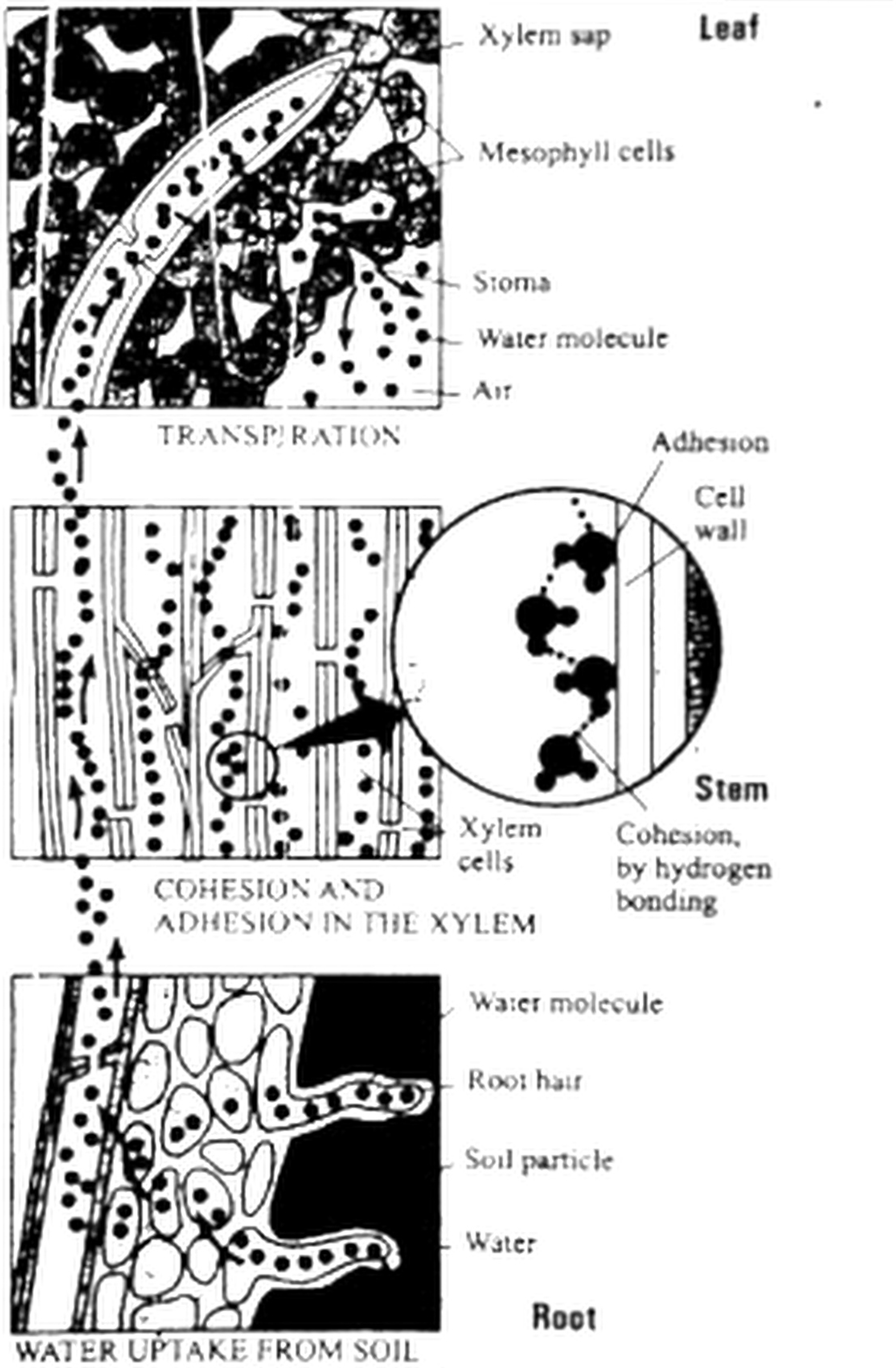
Adhesion is the attractive force between water molecules and other substances. Because both water and cellulose are polar molecules so there is a strong attraction for water within the hollow capillaries of the xylem. Adhesion of the string of water molecules to the walls of xylem cells assists upward movement of in the xylem when transpiration is not occurring.

3. Cohesion and Tension:

Water is polar molecule with the oxygen carrying a slight negative charge while the hydrogen carries a slight positive charge. As a result, nearby water molecules attract one another forming weak hydrogen bonds. These attractions among water molecules are called cohesion and the hydrogen bonds formed between them are termed as tension.

Mechanism of TACT force:

The column of water molecule within the xylem is at least as strong and as unbreakable as a steel wire of the same diameter. Hydrogen bonds among water molecules provide the cohesion that hold together the string of water extending the entire height of the plant within the xylem. As long as transpiration continues, the string is kept **Tense** and is pulled upward as one molecule. The bulk flow of water to the topo of a plant is driven by solar energy since evaporation from leaves is responsible for transpiration pull.



Movement of water in xylem through TACT Mechanism

28. Explain the mechanism of opening and closing of stomata.

Ans: Opening and Closing of stomata:

Stomata are generally open in day and close (incompletely) at night. The opening and closing of stomata depend upon the changes in the turgidity of guard cells when guard cells are turgid, the stomata are fully opened but when they become flaccid, the stomata are closed.

There are two theories, which may explain the opening and closing of stomata.

- **(a)** Starch sugar inter conversion theory
- (b) K^+ ions. Influx/efflux theory

(a) Starch sugar interconversion theory:

According to this theory, the guard cells are the only photosynthesizing cells of leaf epidermis because they have high chlorophyll content then the surrounding epidermal cells.

In the morning:

In the morning when plant is exposed to light, the process of photosynthesis is started. As the concentration of glucose (sugar) is increased (the product of photosynthesis) the solute potential and water potential of guard cells become low (more negative). Since the surrounding epidermal cells have high water content at that time so water begins to move from surrounding epidermal cells to the guard cells. The entry of water into the guard cells makes them turgid and thus, stromata are opened.

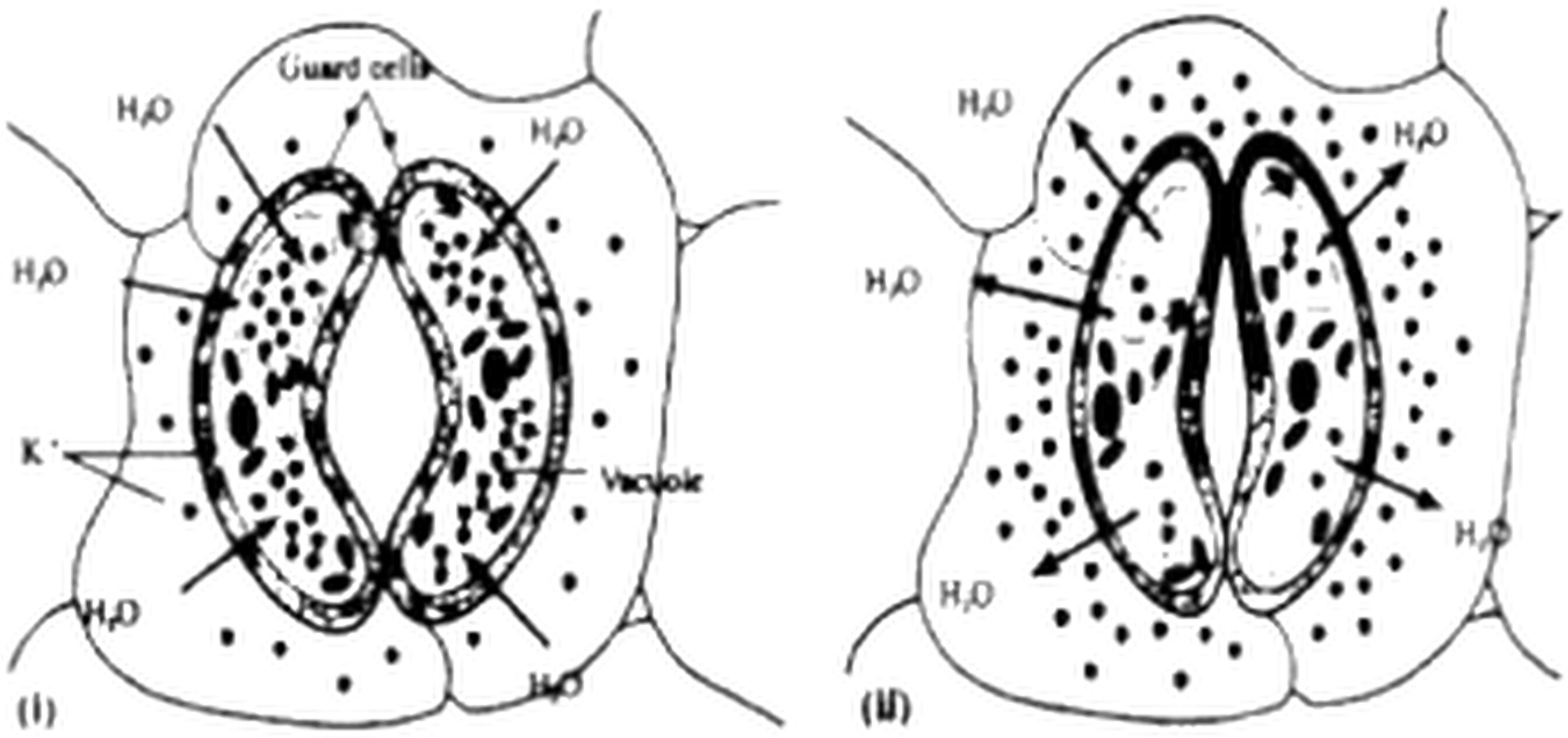
In the evening:

In the evening when the process of photosynthesis is stopped, the concentration of glucose is decreased because some glucose has been consumed in respiratory activities of guard cells, some of it is transformed into sucrose so that it can be transported to other parts, and the remaining glucose is converted into insoluble starch and is stored for later use. The decrease in glucose concentration caused an increase in solute potential and obviously water potential of the guard cells. In this way, water begins to move from guard cells to surrounding epidermal cells. Due to loss of water guard cells become flaccid, thus stomata are closed.

K^+ ionc influx/efflux theory:

According to this theory, the start of photosynthetic activities in the morning when plant is exposed to light, causes are decrease in level of CO_2 in the guard cells. Low level of CO_2 favors of stimulates the influx (inward movement) of K^+ ionic (shown in red dots in the figure) into the guard cells from surrounding epidermal cells by active transport. At the same time, malic acid is ionized into malate ions and H^+ ions due to the exposure of blue light (a part of visible light). The accumulation of H^+ ions causes decrease in pH of guard cells, which are then pumped to surrounding epidermal cells in order to maintain the pH of guard cells. The incoming K^+ ions are combined with malate ions to form potassium malate that is highly soluble in water thus decreases the sulate potential and the water potential of the guard cells. In these ways water begins to move from surrounding epidermal cells to guard cells. The entries of water into the guard cells make them turgid and thus, stomata are opened.

In the evening the photosynthetic activity is stopped and level of CO_2 rises in guard cell. High level of CO_2 favors or stimulate the efflux (outwards movement) of K^+ ion (shown in red dots in figure) from guard cell in to the surrounding epidermal cell by active transport. At the same time, malic acid is reformed by the combination of malata, ions andH$^+$ ions as there is no exposure of blue light now. Due to absence of potassium malate. Solute potential and the water potential of the guard cells are increased. In this way, water begins to move to surrounding epidermal cells from guard cells. The loose water from the guard cells makes them flaccid and thus, stomata are closed.



(i) Stomata opening (ii) Stomata closing

29. Describe the translocation of organic solutes in plants.

Ans: Translocation of organic solutes:

The movement of prepared food (organic solutes) to different parts of the plant body through phloem tissue is called translocation of organic solutes.

Pattern or direction of translocation:

Like ascent of sap, this movement cannot be characterized as upward or downward movements, because prepared food is to move to different directions. Therefore, in order to define the direction of this movement, it is usually said that translocation always occurs for a source towards a sink. The term source is applied to the area of supply of food such as food manufacturing organ or storage organ (when it supplies the food). The term sink is used for the area of utilization of food such as metabolizing organ or storage organ (when it stores the food). Leaf is purely a source while fruit is particularly a sink on the other hand root and stem act as both source, and sink.

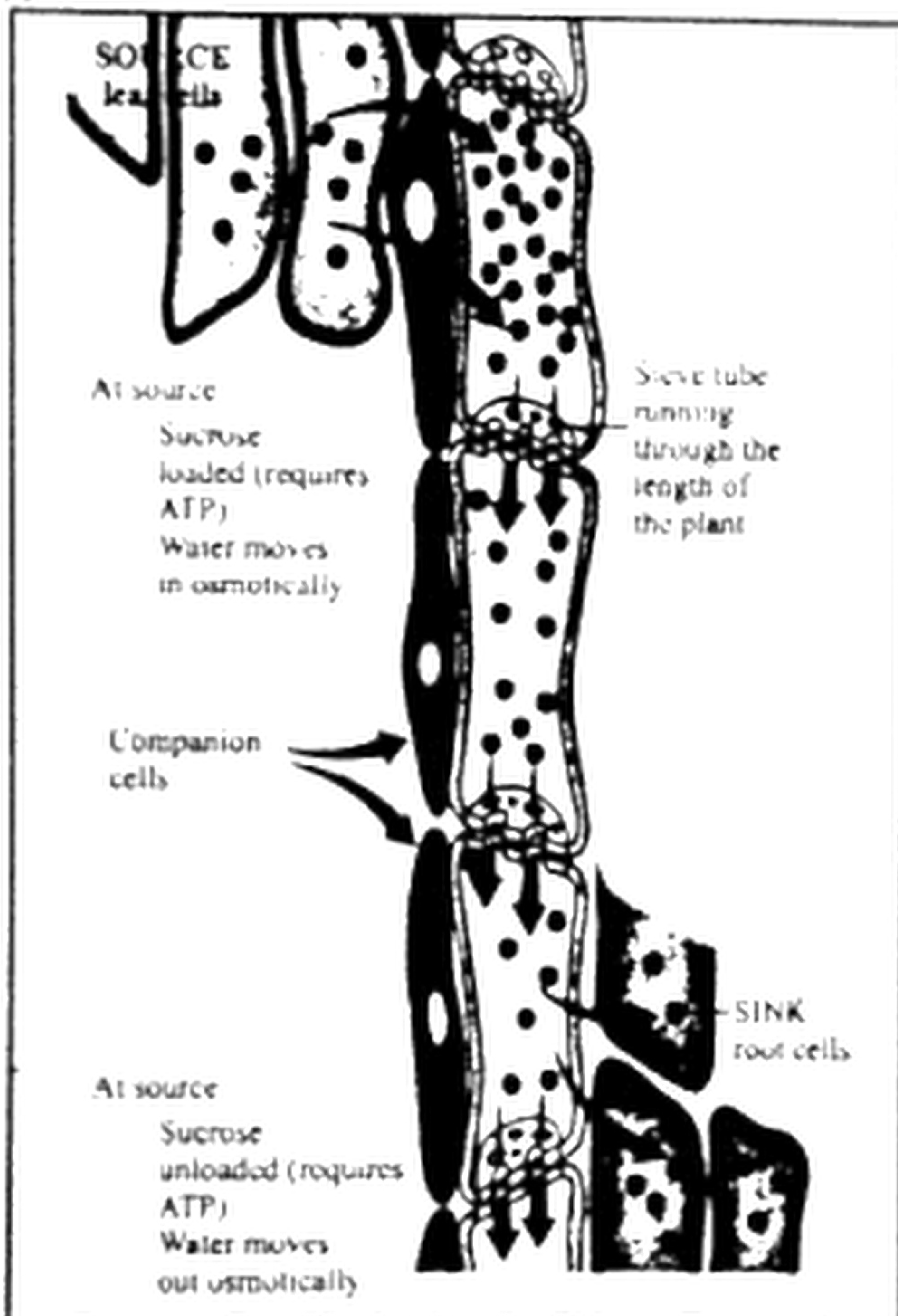
Composition of Translocating Fluid (Phloem sap):

The studies of composition of phloem sap have revealed that it consists of

10-25% dry matter. The 90% of this dry matter is sucrose (cane sugar), while remaining are other organic compounds.

Mechanism of translocation:

The most acceptable theory that explains the mechanism of translocation of organic solutes is the pressure flow or mass flow theory. According to this theory, the sugar produced in source regions, such as photosynthesizing leaves or storage places are loaded into the phloem's sieve tube elements by the companion cells. The active transport increases the concentrations of sugars in the phloem, thus solute potential and water potential are decreased. As a result, water moves to phloem by osmosis from the nearby xylem cells and increases hydrostatic pressure (any pressure by the presence of water) in the phloem cells, which pushes forcibly the sugary solution away from the leaf (source). The pressure gradient from source to sink causes translocation from the area of higher hydrostatic pressure (the source) to the area of lower hydrostatic pressure (the sink). When this solution is reached the sink such as roots, the root cells actively absorb the organic solutes from this solution. The loss of solutes in phloem sap causes an increase in solute potential water potential so the water from the phloem flows back to the xylem tubes.



Pressure flow Mechanism for Phloem Transport

Pressure flow Mechanism for Phloem Transport: Sugar is actively loaded into the sieve tube at the source. As a result, water moves into the sieve tubes by osmosis. At the sink, the sugar is actively unloaded and water leaves the sieve tube by osmosis.

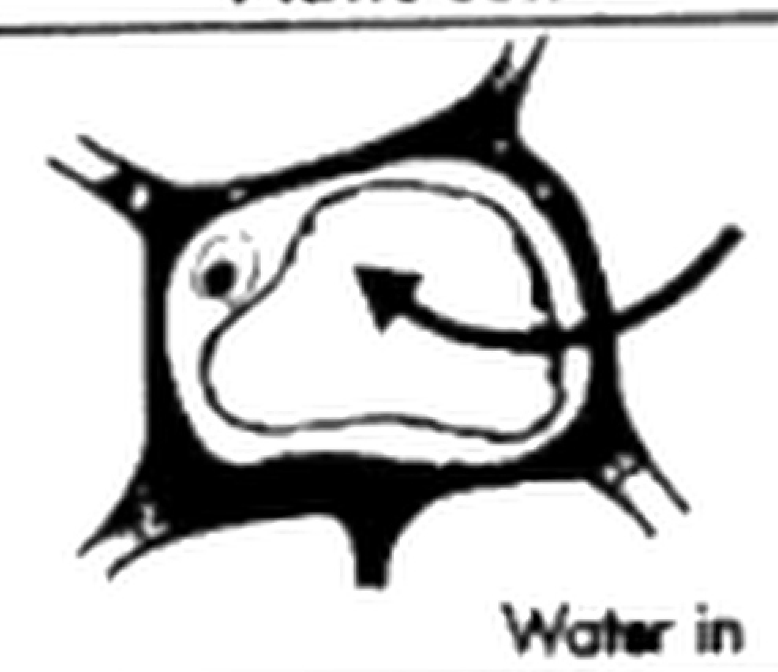
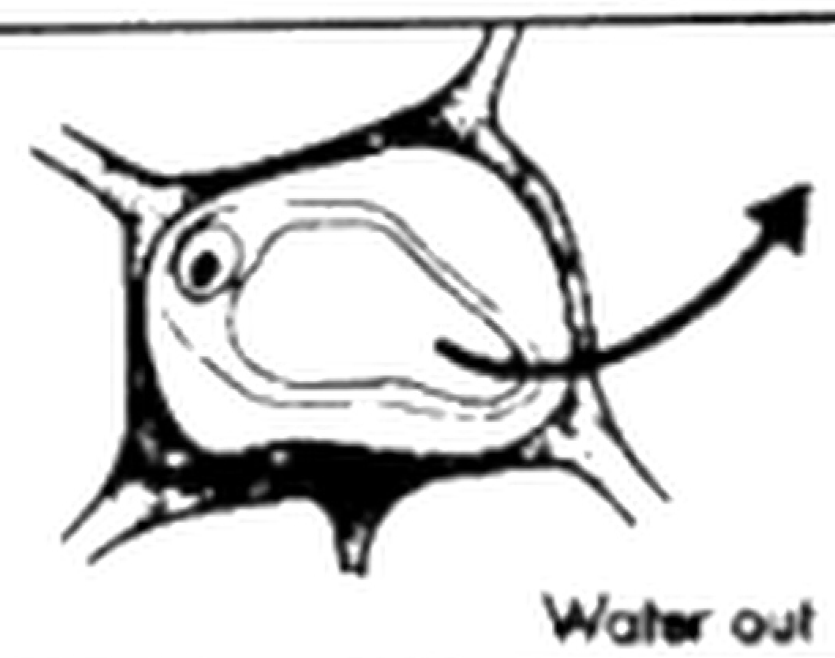
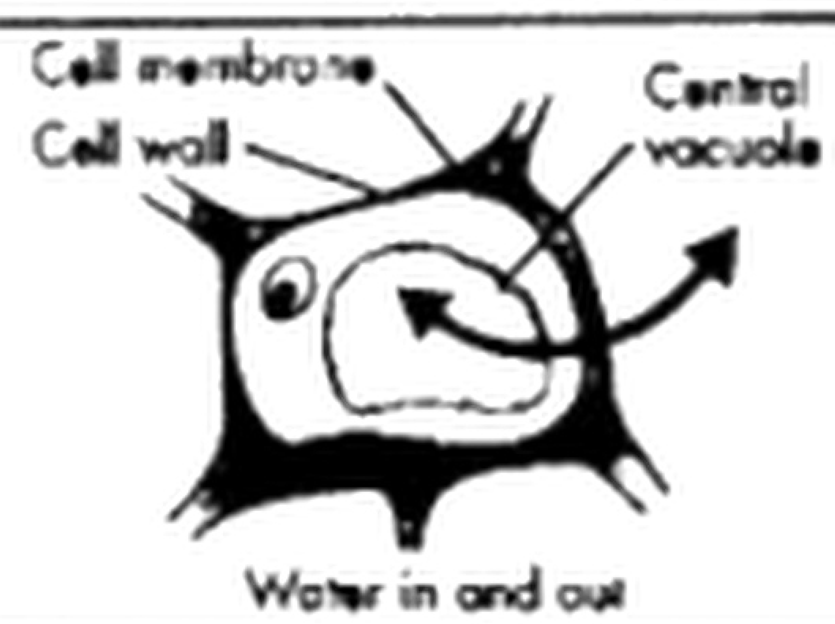
30. Describe movement of water in and out of the cell in different osmotic conditions.

Ans: Homeostasis in Plants:

Homeostasis is the ability to maintain a steady state within a constantly changing environment that contributes towards the success of living systems. The outer environment conditions such as water availability, nutrients and temperature often show fluctuations that also effect these components within plant body. Plants have several adaptations to cope with these challenges.

Osmotic adjustment (Osmoregulation):

The maintenance of water and solute level in the body is called osmotic adjustment or osmoregulation. Water and solute relations establish three kinds of osmotic situations such as hypotonic, and isotonic.

Medium and its effect	Plant cell
Hypotonic • Water potential is higher than cell sap • Solute concentration is lower than cell sap • Endosmosis i.e. movement of water inward	
Hypertonic • Water potential is lower than cell sap • Solute concentration is higher than cell sap • Exosmosis i.e. movement of water outward	
Isotonic • Water potential is same as in cell sap • Solute concentration is same as in cell sap • No net movement of water	

Movement of water in different osmotic conditions:

Different osmotic conditions cause different effects upon net movement of water in and out of cells. If a cell is kept in a medium which has higher water potential and lower solute concentration than cell sap, the water begins to move from cell to the medium (**exosmosis)** and cell become flaccid. Such medium is called **hypertonic medium.** Both hypotonic and hypertonic type of osmotic conditions compete for osmotic adjustment. The idea situation for a cell is i**sotonic** in which water potential of both cell and outer environment is equal, therefore, there is no net movement of water in and out of the cell. However, this situation is rarely available to the plants in natural environment.

31. Describe osmotic adjustment in plants of different environment.

Ans: Osmotic adjustment in plants of different environment:

Based upon availability of water, plants are classified into hydrophytes, mesophytes and xerophytes. Each group exposed in different osmotic conditions therefore, show different osmotic adjustments.

Hydrophytes:

The plants that are found in the area where abundant water is available are called **hydrophytes.** Aquatic plants of freshwater habitats are example of such plants. These plants are exposed in hypotonic conditions so face problem of flooding (excess of water). Such plants show highest rate of transpiration due to broad leaves with large surface area and distribution of stomata on upper epidermis, which are kept open day and night. These plants do not store water and either have very thin cuticle or almost none, on their surface.

Mesophytes:

The plants that are found in the area where moderate supply of water is available are called **mesophytes.** Common crop plants such as wheat, rice corn are example of such plants. These plants are exposed in nearly isotonic conditions so face no drastic problem of flooding (excess of water) or dehydration (deficiency of water). Such plants show moderate rate of transpiration due to medium sized leaves with distribution of stomata on lower epidermis, which are generally open in day and close at night. However, these plants can close their stomata even in day. These plans store a very small amount of water, have very thin cuticle on their surface.

Table: Comparison of osmotic adjustment in different groups of plant:

Features	Hydrophytes	Mesophytes	Xerophytes
Habitat	Aquatic	Terrestrial (moderate)	Terrestrial (severely dry)
Osmotic conditions of medium	Hypotonic	Nearly isotonic	Strong hypertonic
Problems faced by pant	Flooding	No drastic Problem	Severe Dehydration
Rate of transpiration	Very high rate	Medium rate	Very low rate
Stomatal distribution	On upper epidermis	On lower epidermis	Sunken stomata
Stomatal opening	Stomata remain open all the time	Open in day and close at night	Close in day and open at night
Thickness of cuticle	Very thin or none	Less thick	Very thick
Storage of water	None	Little storage	Succulent

Xerophytes:

The plant that are found in the area where very little amount of water is available are called **xerophytes.** Desert plants such as cactus, opuntia are example of such plants. These plants are exposed to severely hypertonic conditions so face extreme degree of dehydration. Such plants show very reduced rate of transpiration due to narrow needle like leaves or due to complete modification of leaves into spines. They have stomata in depressions (**sunken stomata),** which are generally close in day and open at night. These plants store a very high amount of water, therefore; they are called **succulent plants.** They have very thought cuticle on their surface.

32. Describe osmotic adjustment of halophytes in saline soil.

Ans: Osmotic Adjustments of plants (halophytes) in Saline Soils:

A saline soils is characterized by the presence of excessive salt concentration. High saline soils are characteristics of salt marshes. Saline soil due to very low solute potential and water potential create a physiological drought i.e. plants are unable to absorb water even water is available in the soil. Therefore, plants living in saline environment (**halophytes)** have adapted mechanisms to deal with this problem.

Halophytes respond to salinity by taking up sodium and chloride at high rates and then accumulating these ions in the vacuoles of the leaf cells, keeping the salt concentration in the cytoplasm and organelles at a low level that does not interfere with the functions of their enzymes and metabolic machinery of their leaves. These plants use the accumulated salt for osmotic adjustment to the low water potential in the soil form soil.

On the other hand, some halophytes do not uptake salts from soil; instead, they make osmotic adjustment by accumulating their own dissolved substances compatible with enzymes and metabolism. These **"compatible solutes"** are mostly organic compounds such as the nitrogenous compounds glycine and, in some plants, sugar alcohols, such sorbitol.

33. Describe adaptations in plants to cope with low temperature and high temperature stress.

Ans: Thermoregulation plants:

All organisms for optimum activity of their enzymes require a suitable temperature. Thermoregulation is a type of homeostasis by which an organism is able to perform necessary adjustment in response to low and high temperature stress. Plants also have certain adaptations that enable them to tolerate against low and high temperature changes.

Adaptations in plants to cope with the low temperature stress:

Low temperature affects the fluidity of cell membrane because lipids of the membranes become locked into crystal structures, thus membranes become porous which affect the transport of solutes. The structure of membrane protein is also affected. In addition, freezing temperature also causes ice crystal formation with in cytoplasm that interferes with the metabolic activities of cell.

In order to prevent crystallization in cell membrane, plants increase the **proportion of unsaturated fatty acids** (which have low freezing point), which help membrane to maintain structure at low temperature and the crystal formation is inhibited. In order to **prevent** crystallization within cytoplasm, the plants native to cold regions such as oaks, mapes, roses and other have adapted to bring **changes in solute compositions** of the cells which causes cytosol to super cool without ice formation, although ice crystals may form in the cell **wall**. These adaptations of plants to low temperature stress require time because of this reason rapid chilling to plants is more stressful than gradual drop in air temperature.

Adaptations in pants to cope with the high temperature stress:

High temperature stress causes excessive evaporative loss of water by transpiration that may leads to dehydration and ultimately wilting (loss to turgor). It also causes denaturation of enzymes and damages the metabolism therefore, harms or kills the plants. In hot areas, the plant develops a shiny cuticle, which reflects much of the incident light. Thus preventing the heat absorption and overheating by the plant. The leaves contain numerous stomatal openings, which allow the loss of water (transpiration) and remove the heat from the plant. However, very high temperature i.e. above 45°C, plants closed their stomata to prevent the water loss. Therefore, most plants have adapted to survive in such high temperature stress situations by synthesizing large quantities of special proteins called **heat shock proteins.** Since these proteins are heat tolerant, so they embrace enzymes and other proteins thus help prevent denaturation.

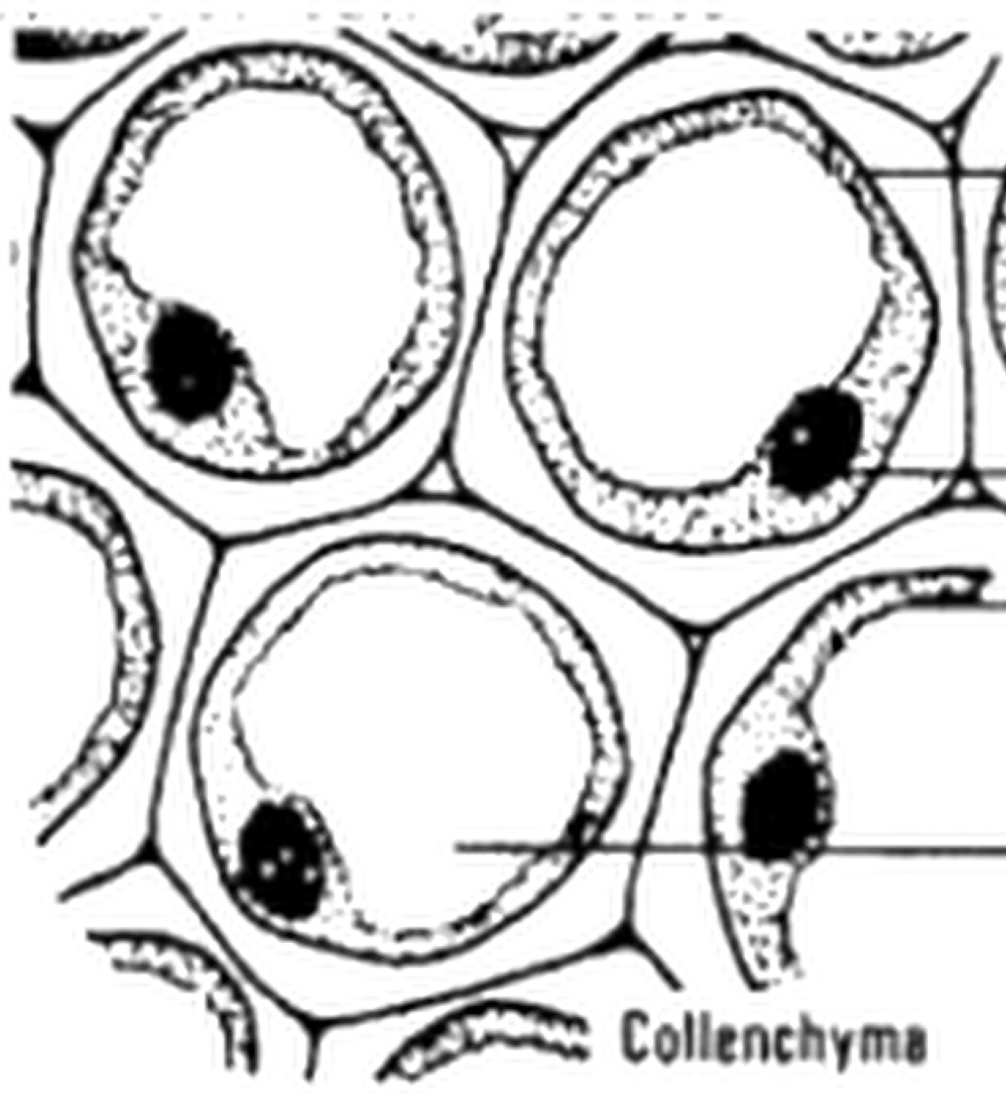
34. What is the role of mechanical tissue to support in plants?

Ans: Support in plants:

When the life started on land from water, one of very important needs for the organisms was to gain some sort of support and strength for keeping their bodies in shapes. Plants also have variety of mechanism for support. Such as turgor mechanism in parenchyma cells, mechanical tissues (thick walled e.g. collenchyma and sclerenchyma) arrangement of vascular bundles and secondary growth.

Role of turgor mechanism in support:

In plants the **parenchyma** cells have large central vacuoles, which are filled with water. The water causes pressure on the surrounding walls when the cells are turgid. These pressures on the walls keeps the cells, stiff and hard and is called **turgor pressure.** In herbaceous plants where the specialized supporting tissues are not common, the turgidity of the cells provide support and strength and it grows uprightly. In these causes the plant may wilt or collapse due to decrease in turgidity (decrease in the internal hydrostatic pressure). Besides the hydrostatic pressure the plants specially shrubs and trees have some supporting tissues, like collenchyma's, sclerenchyma, and conducting tissues.



Role of mechanical tissues in support:

The term mechanical tissue is used for the tissues of thick-walled cells i.e. collenchymas and sclerenchyma.

Collenchymas:

The **collenchyma is** characterized by the extra cellulose deposition at the corners of these cells. It is a mechanical tissue, providing support particularly in young plants, herbs and leaves etc, (where secondary growth does not occur) collenchymas is living so it can grow and stretch freely. In stems and petioles, it plays more important role in support because of its location in peripheral regions near epidermis.

Sclerenchyma:

Sclerenchyma tissues are solely meaning for giving support and mechanical strength for the plants. The mature cells are dead due to the formation of very thick secondary lignified wall (lignin is a macromolecule that provide rigidness to the wall).

Types of Sclerenchyma:

The sclerenchyma is of two types, i.e. fibres and sclereids.

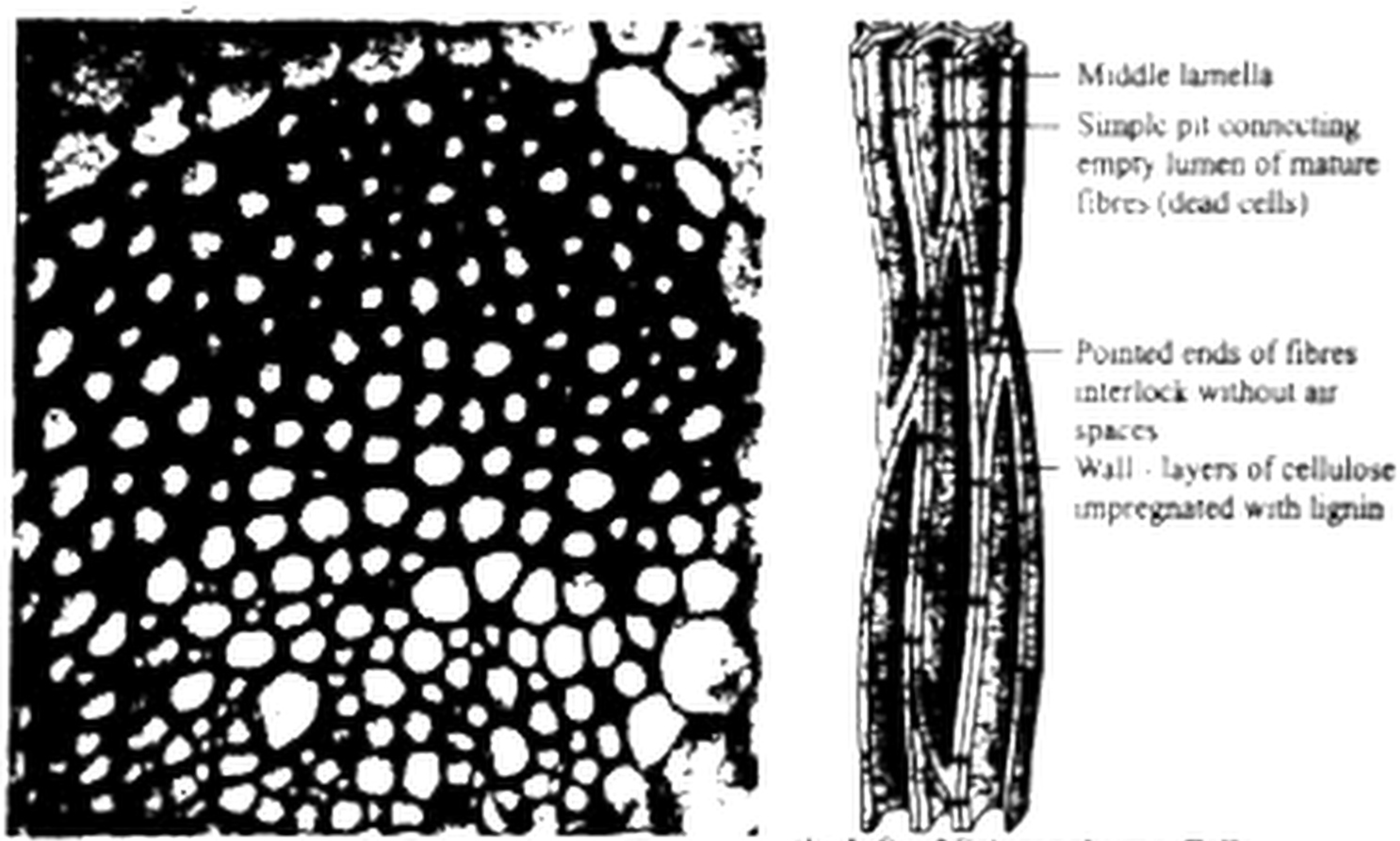
i. **Fibres:**

Fibres are found in the pericycle of stems forming a solid rod of tissue. Fibres also found in xylem and phloem tissue.

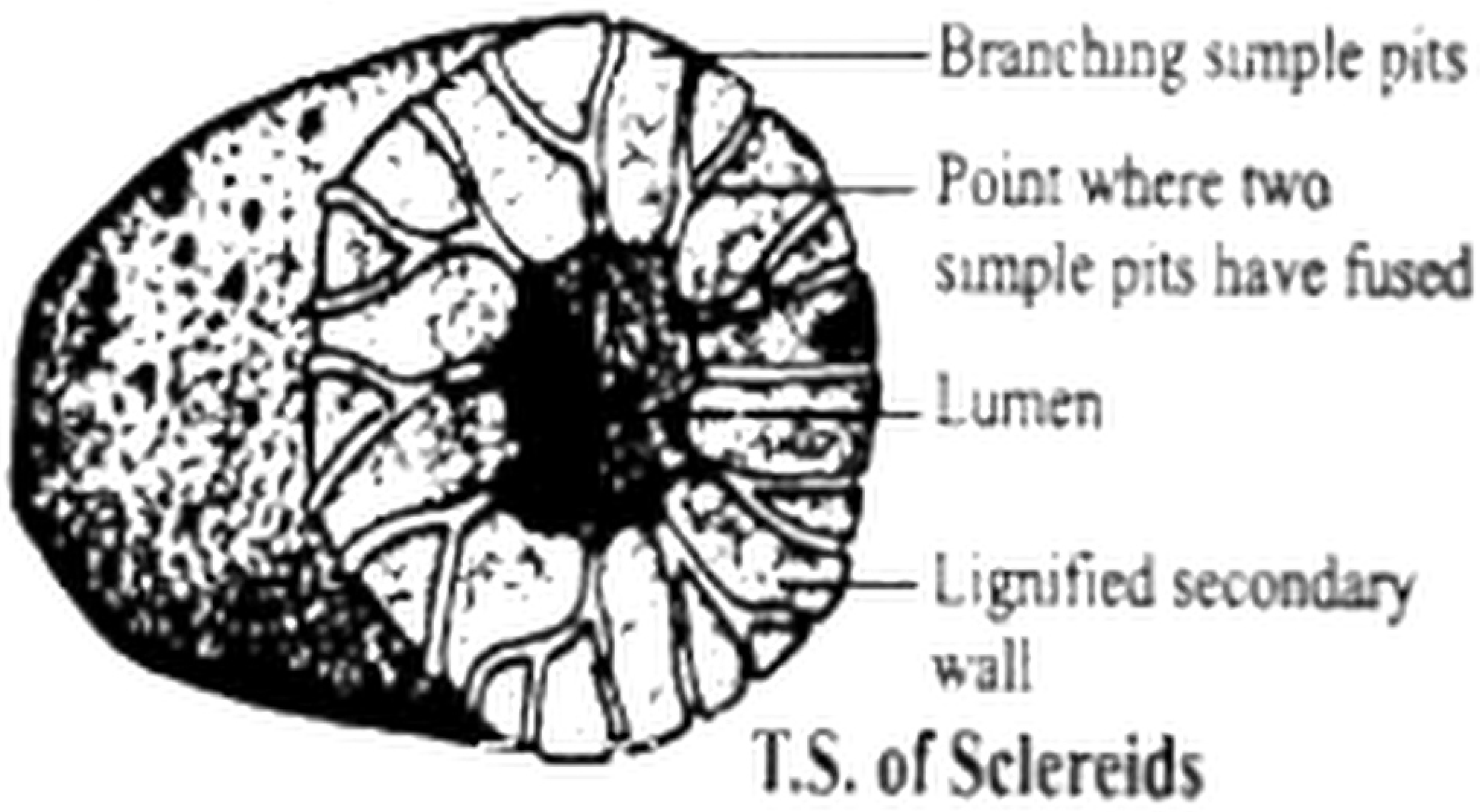
ii. **Sclereids:**

Sclereids are common in fruit wall and seed coats.

Fibres are elongated cells and sclereids are roughly spherical or variously shaped cells otherwise both have heavily thickened walls with lignin and with great tensile strength.



(a) T.S. of Sclerenchyma Cells (b) L.S. of Sclerenchyma Cells



T.S. of Sclereids

Arrangement of vascular bundles:

In dicot plants, vascular bundles are arranged in the form of ring in stem. As compared to monocot plants in which vascular bundles are scattered in the stem, the ring arrangement of vascular bundle in dicot plants also provide support to the plant body.

35. Describe meristematic tissue in plants.

Ans: Growth and Development in Plants:

Development is a programmed series of changes by which an organism is converted from simpler to form that is more complex. The growth is part of development process, which is characterized by an irreversible increase in the size and mass of an organism. In plants growth and development involve four phases; cell division (production of new cells), cell elongation (enlargement of cell size), cell maturation and differentiation (cell structurally and functionally become specialized to perform particular functions). Plants add new organs like, branches, leaves, roots etc throughout life. This unique pattern is called **open growth**.

Meristematic tissues (Meristems):

In lower plants, the entire plant body is capable of growing, but in higher plants, growth limited to certain regions known as growing points that possess specialized tissues for growth, the **meristematic tissues or meristems.** The cells remain forever young and divide actively throughout the plant in these tissues. When a meristematic cell divides in two, the new cell that remains in the meristem is called an **initial**, and the other is called the **derivative.** As repeated mitotic divisions of the initial cells add new cells, the derivatives are pushed farther away from the zone of active division. They stretch, enlarge and differentiate into other types of tissues as they mature. Meristematic cells are generally small and cuboidal with large nuclei, small vacuoles, and thin walls.

Types of Meristems:

A plant has two major kinds of meristems:

i. Apical Meristem **ii.** Lateral Meristem

i. Apical Meristems (Primary Meristems):

Lateral meristems are cylinders of diving cells on lateral sides in stems and roots of dicots and gymnosperms and increase their thickness and diameter. These meristems are derived from apical meristem after embryonic life therefore, they are also called **secondary meristem.**

ii. Lateral Meristems (Secondary Meristem):

Lateral Meristems are cylinders of dividing cells on lateral sides in stems and roots of dicots and gymnosperms and increase their thickness and diameter. These meristems are derived from apical meristem after embryonic life therefore; they are also called **secondary meristem.**

Types of Lateral Meristems:

Vascular cambium, cork cambium, and intercalary meristem are the types of lateral meristems.

i. Vascular Cambium:

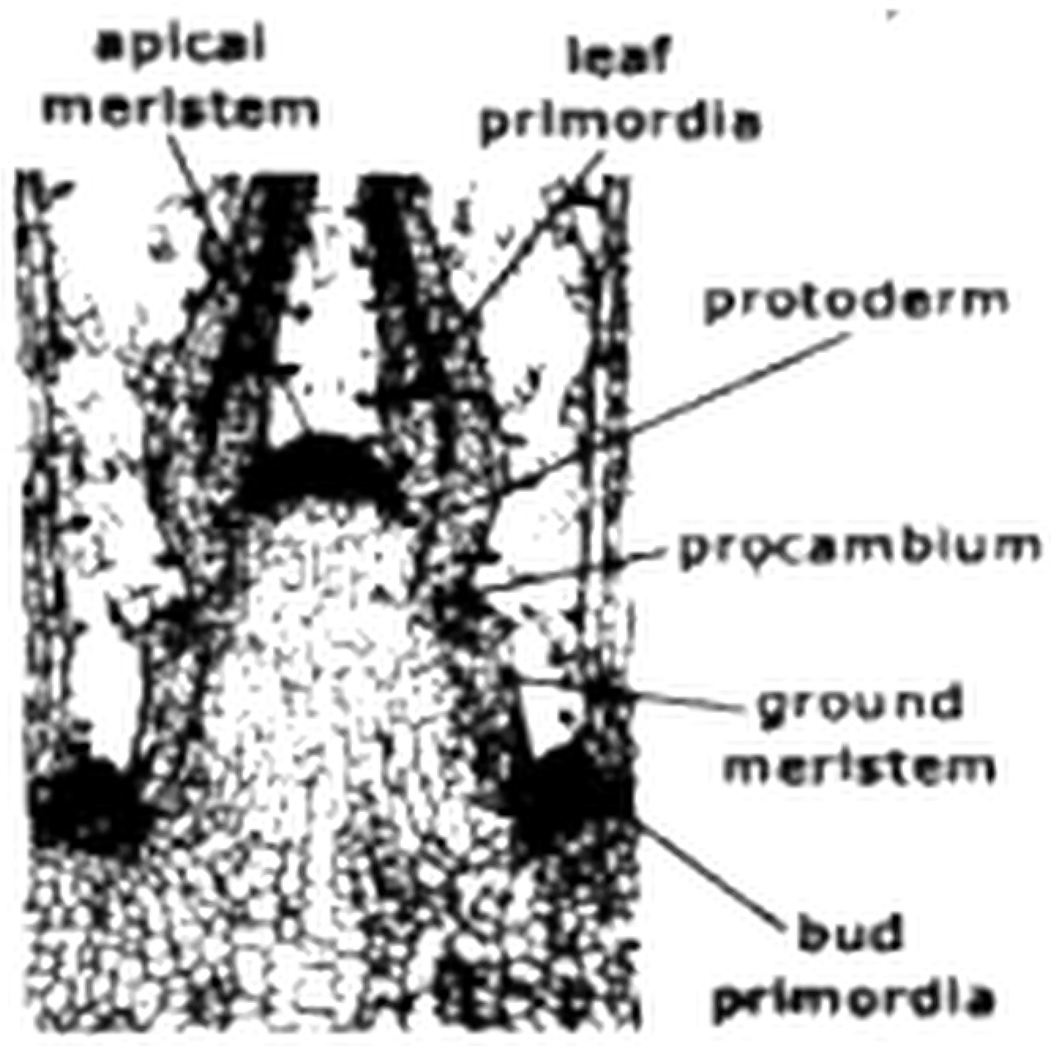
Some plants grow in diameter by producing new tissues laterally from a cylinder of tissue called the **vascular cambium,** which extends throughout the length of the plant from the tips of the shoots to the tips of the roots.

ii. Cork cambium:

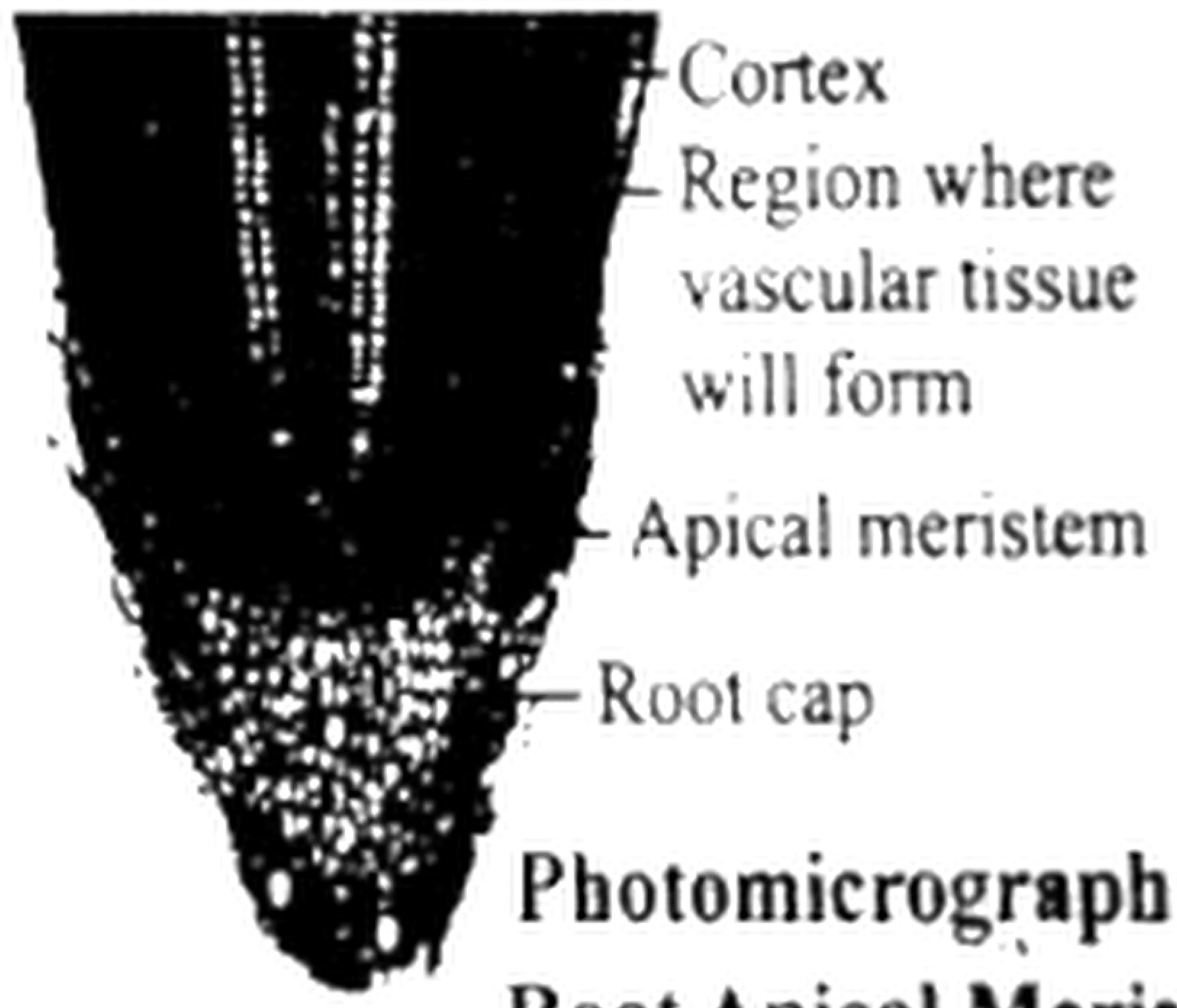
Cork cambium also called **phellogen**, are found in the bark of roots and stems of woody plants where they contribute in width of plant body.

iii. Intercalary Meristems:

Intercalary Meristems originate from apical meristems but they are separated from them and are located along the stems near the nodes. Growth in these tissues give rise side branches, leaves and lateral buds that grow up to a certain size (determinate growth). Tissues produced by cell divisions of the any lateral meristem are secondary tissues.



Photomicrograph of
shoot, apical meristem



**Photomicrograph of
Root Apical Meristem**

36. Describe the role lateral meristems in secondary growth.

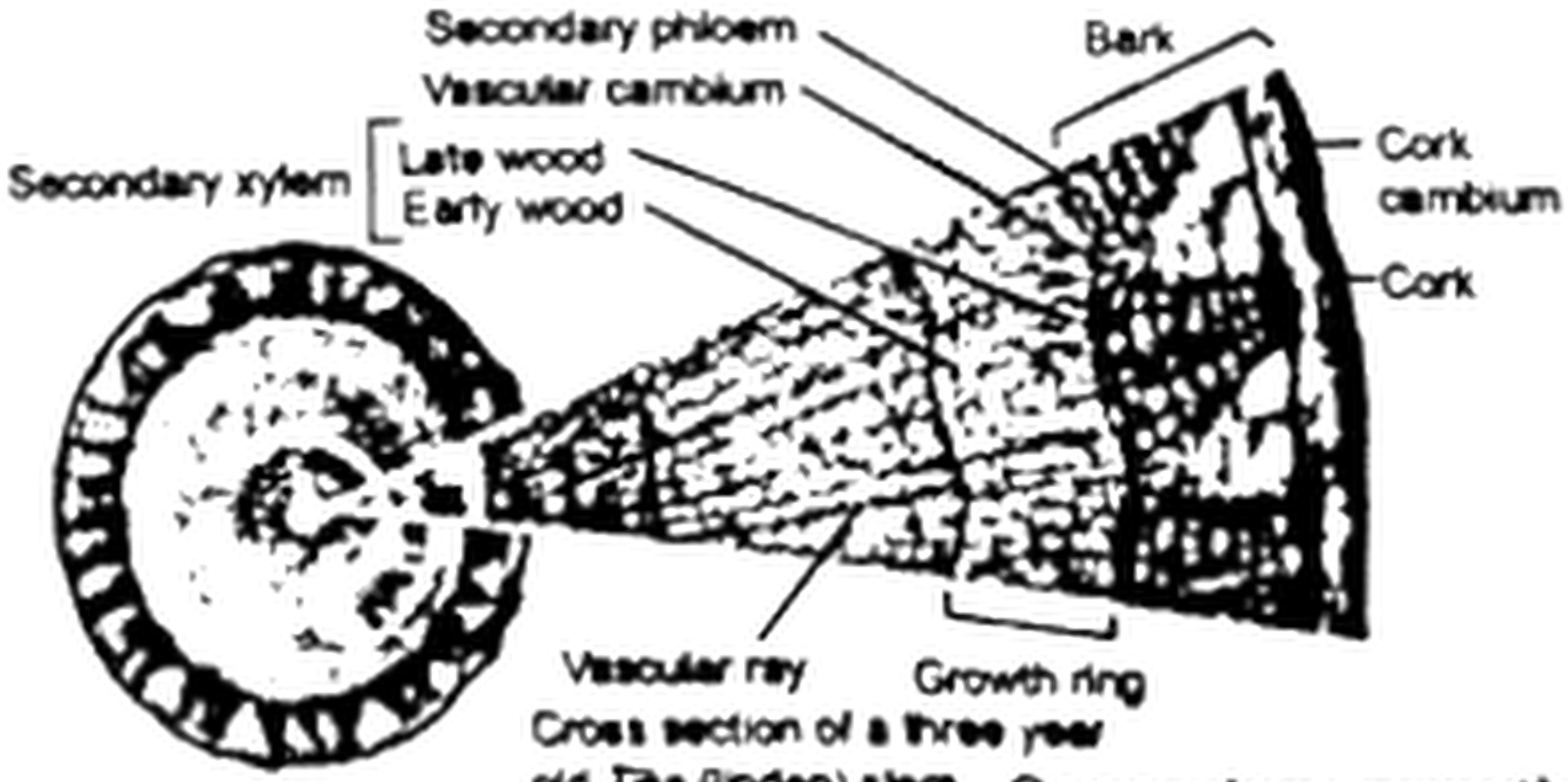
Ans: Role of lateral meristems in secondary growth:

Two lateral meristems i.e. cork cambium and vascular cambium mainly participates in secondary growth.

Role of vascular cambium:

As the plant grows lengthwise by the activity of apical meristem, vascular cambium is also produced. It is present in vascular bundle between primary xylem and primary phloem. Its rate of cell division is faster than cork cambium therefore, it contributes ore tissues in secondary growth.

It adds two new tissues in plant body: **secondary xylem** (towards its inner side) and **secondary phloem** (towards its outer side).



Secondary growth

The rate of production of secondary xylem is faster than secondary phloem and it is produced in two different ways during the whole year growth. In autumn and winter seasons, comparatively smaller sized cells are produced due to deficiency of water while in spring and summer seasons, larger sized cells are produced probably due to availability of water. Because of this differential growth pattern distinct rings of smaller and larger cells are formed, which represent the growth of one whole year, therefore, these rings are called **growth rings** or **annual rings.** We can determine the age of plant by counting the number of these growth ring as each ring is form in one year.

Role of cork cambium (Phellogen):

The cork cambium or phellogen generally originates from outer most layer of primary cortex. It adds two new tissues in plant body during secondary growth secondary cortex (towards its outer side beneath the epidermis). The cork cells become dead after sometimes due to which epidermis also becomes dead. Therefore, the outer surface of mature trees looks rough.

37. Describe growth correlation in plant.

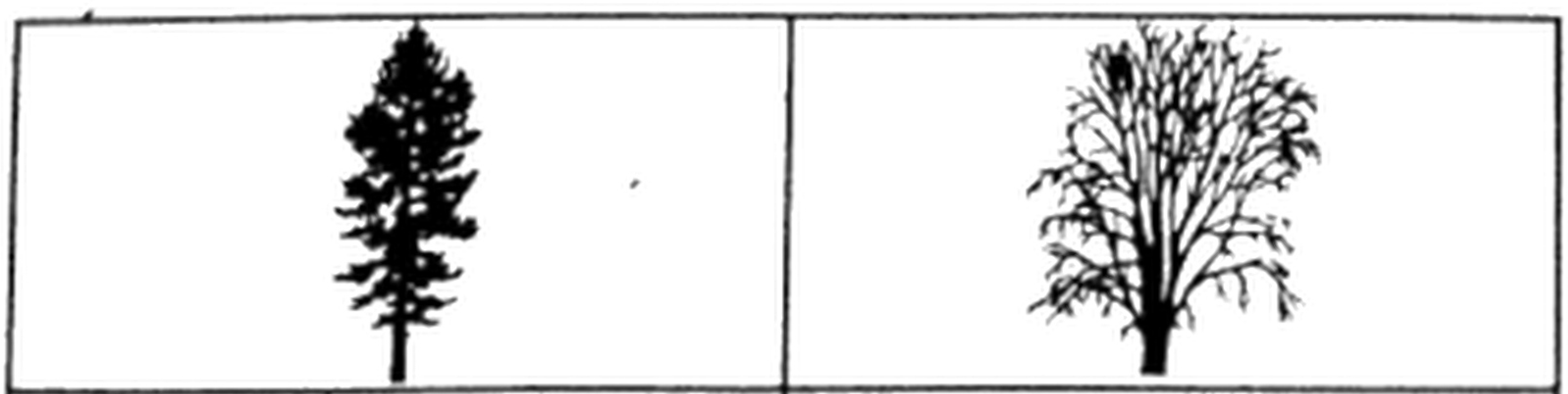
Ans: Growth correlation:

During the development of a plant, the rate of growth at different growing points is not constant, for example, growth of different meristem sometime influence upon each other. Such interactions among different growing points are called **growth correlations.** These growth correlations may be **positive** (if growth of one part promotes the growth of other part) or **negative** (if growth of one part inhibits the growth of other part).

Apical Dominance:

Apical dominance is a kind of negative growth correlation in which the presence of a growing apical bud inhibits growth of lateral buds. It is also found in roots where lateral root growth is inhibited by growth of the main root. The plants showing tall height with short side branches have very strong apical dominance and the plants showing short height and very dense growth of lateral branches have very little apical dominance.

Botanists have performed several experiments to study the cause of apical dominance and finally concluded that it is the auxin (a plant growth regulator) which is released from apical bud and inhibits the growth of lateral buds. It is also revealed that **cytokinin** produced by lateral buds (another plant growth regulator) works antagonistically to the **auxins** in apical dominance, thus neutralizes the influence of apical bud on lateral buds. It means that plants having strong apical dominance produce more auxins from apical bud and less cytokinin from lateral buds. Similarly, the plants having weak apical dominance produce less auxins from apical bud and more cytokinin from lateral buds.



(a) A plant showing strong apical dominance (b) A plant showing weak apical dominance

38. Describes the roll of growth regulators in plants.

Ans: Growth Responses in plant:

Plants generally adjust themselves to changing environment by growth. The changes in plant shape of functions are often regulated by **plant hormones** (growth substances) produced in response to environmental factors. The plant hormones act at the level of cells to induce cell division, enlargement or cell maturation.

Plant Growth Regulators:

Plants are coordinated by chemicals, commonly known as **plant hormones,** which necessarily move from their sites of synthesis to the sites of action and because their effects are usually on some aspect of growth, they are called **growth regulators.**

Types of Growth Regulators:

Five major types of growth regulators are recognized (a) auxins (b) gibberellins (c) cytokinins (d) abscisic (e) ethane

Growth promoters and Growth Inhibitors:

Auxins gibberellins and cytokinins are called **growth promoters** because of their general role in promotion of growth while abscisic acid and ethane are called **growth inhibitors.**

(a) Anxins:

An auxin or **indoie-3-acetic acid** (IAA), was the first plant hormone identified. It is manufactured primarily in the shoot tips (in leaf primordial and young leaves), in embryos, and in parts of developing flowers and seeds. They are mainly responsible for cell elongation.

(b) Gibberellins:

The gibberellins are wide spread throughout the plant kingdom, and more than 75 have been isolated to date. Rather than giving each a specific name, the compounds are numbered, for example, GA1, GA2 and so on **Gibberellic acid 3 (GA3)** is the most widespread and most thoroughly studied. The gibberellins are especially abundant in seeds and young shoots where they control stem elongation by stimulating both cell division and elongation.

(c) Cytokinins:

These are named because of their role in cell division (cytokinesis), the cytokinins have a molecular structure similar to adenine. Naturally occurring **zeatin**, isolated first from com *(Zea mays)*, is the most active of the cytokinins. Cytokinins are found in sites of active cell division in plants for example, in root tips, seeds, fruits, and leaves.

(d) Abscisic Acid:

Abscisic acid (ABA) is synthesized in plastids from carotenoids during stress situations and diffuses in all directions through vascular tissues and parenchyma. Its principal effect is inhibition of cell growth. ABA increase in developing seeds and promotes dormancy. If leaves experience water stress, ABA amounts increase immediately, causing the stomata to close.

(e) Ethylene or ethane:

Ethylene or ethane is a simple gaseous hydrocarbon produced from an amino acid and appears in most plant tissues in large amounts when they are stressed. It diffuses from its site of origin into the air and affects surrounding plants as well. Ethylene stimulates the ripening of fruit and initiates abscission of fruit and leaves.

Table: A comparison of effects of plants growth regulators on different plant parts:

Part Affected	Auxins	Gibberellin	Cytokinins	Abscisic Acid	Ethene
Stem	˚Promote cell enlargement behind apex. ˚Promote cell division in cambium	˚Promote cell enlargement in the present of apex. ˚Promote leave growth	˚Promote division in apical meristem and cambium ˚Promote cell leave growth	Inhibit growth during stress, e.g. drought, salinity and water logging	Inhibit growth during stress, e.g. drought, salinity and water logging
Root	˚In low cone, promote growth ˚In high cone, inhibit growth ˚Promote growth from cutting and calluses	Nil	˚Inhibit primary root growth	Nil	Inhibit root growth

Floral buds	Promote bud initiation	Promote bud initiation	˚Promote lateral root growth ˚Promote lateral bud growth ˚Break bud dormancy	Nil	Promote bud initiation
Flowering	Nil	˚Promote in long day plants ˚inhibit in short day plants ˚Acts as substitute for red light ˚Antagonistic to Abscisic acid	Nil	˚Promote in short day plants ˚inhibit in short day plants ˚Acts as substitute for far red light ˚Antagonistic to gibberellin	Promote in pineapple
Apical dominance	Promote	Enhance the action of auxin	Inhibit	Nil	Nil

Fruit growth	Promote ripening	Promote ripening	Promote ripening	Nil	Promote ripening
Parthenocarpy	Rarely Promote	Promote	Rarely Promote	Nil	Nil
Leaf senescence	Delay	Delay	Delay	Promote	Nil
Seed dormancy	Nil	Break	Break	Promote	Nil
Abscission	Inhibit	Inhibit	Inhibit	Promote	Nil
Stomatal opening	Nil	Nil	Promote	Inhibit	Nil

39. Describe growth movement in plants.

Ans: Growth movement in plants (Tropic Movements):

The plants as their characteristics do not show locomotion, but the individual plant organs may show movements by change in differential growth in response of various stimuli (internal or external). In this section, you are going to learn about **tropic movements or tropisms** that are either towards or away from certain external stimuli such as light, force of gravity, touch and chemical.

Phototropism:

Phototropism is the movement of plants parts, either towards (positive) or away (negative) from light scurce. Such movements are found in shoots and roots. Shoots show positive phototropism (grow upward above the ground) and roots show negative geotropism (grow downward under the ground).

Geotropism:

Geotropism (gravitropism) is the movement of plants parts, either towards (positive) or away (negative) from force of gravity. Such movements are also found in shoots ad roots. Shoots show negative geotropism (grow upward above the ground) and roots show positive (grow downward under the ground).

Thigmotropism:

Thigmotropism is the movement due to the touch stimulus. Such movements are shown by climbing pants that require any supportive structure such as a wall, a wooden stick or rod or even a rope to climb over.

Chemotropism:

In Chemotropism the stimulus is a chemical (nutrients). Such movement is shown by fungal mycelium in which hyphae show more growth towards the nutrients.

40. What is photoperiodism? Explain the mechanism of photoperiodism with reference to the mode of action of phytochromes.

Ans: Photoperiodism:

Light exerts its influence on living organism through variation in intensity, quality and day length. Total duration of light in the whole dy is called **photoperiod** and its effect on the development of flowers in some plants is called photoperiodism. This behavior is found in some plants in which due to the exposure of appropriate photoperiod their vegetative buds are transformed into floral buds and the flowers are begin to produce. If such plants do not get required, photoperiods their vegetative growth remains continue but flowers are not produced.

Classification of plants based upon photoperiodism:

Plants are classified into three main groups on the basis of how photoperiodism affects their flowering.

Short-day plants: These plants flower when the photoperiod is less than a certain critical length, e.g. aryland mammoth, cocklebur, chrysanthemum, tobacco etc.

Long-day Plants:

These plants flower when the photoperiod exceeds from the critical length e.g. spinach, sugar beet, Henbane snapdragon, cabbage, spring wheat etc.

Day-neutral plants:

These plants can flower in any photoperiod after a considerable vegetative growth. The flowering is not affected by variation in day length or darkness in these plants, e.g. tomato, pansy, bean, sweet pea, rose, etc.

Concept of critical photoperiods:

The concept of critical lengths of photoperiod for both long day and short-day plan, is different and its duration is also variable for every plant even they belong to the same group. For example, for **tobacco, 14 hours** photoperiod is seemed to be critical and for **cocklebur 15.5 hours** photoperiod is critical, however both are short day plants Actually, length of critical photoperiod depends upon the level and relative proportion of two forms of phytochromes in plant body. Critical photoperiod for short day plant can be defined as the maximum length of day, which is required to stimulate/induce flowering in a short-day plant.

Similarly, "critical photoperiod for long day plant can be defined as the minimum length of day, which is required to stimulate/induce flowering in a long day plant". For example, for henbane 11 hours photoperiod is critical.

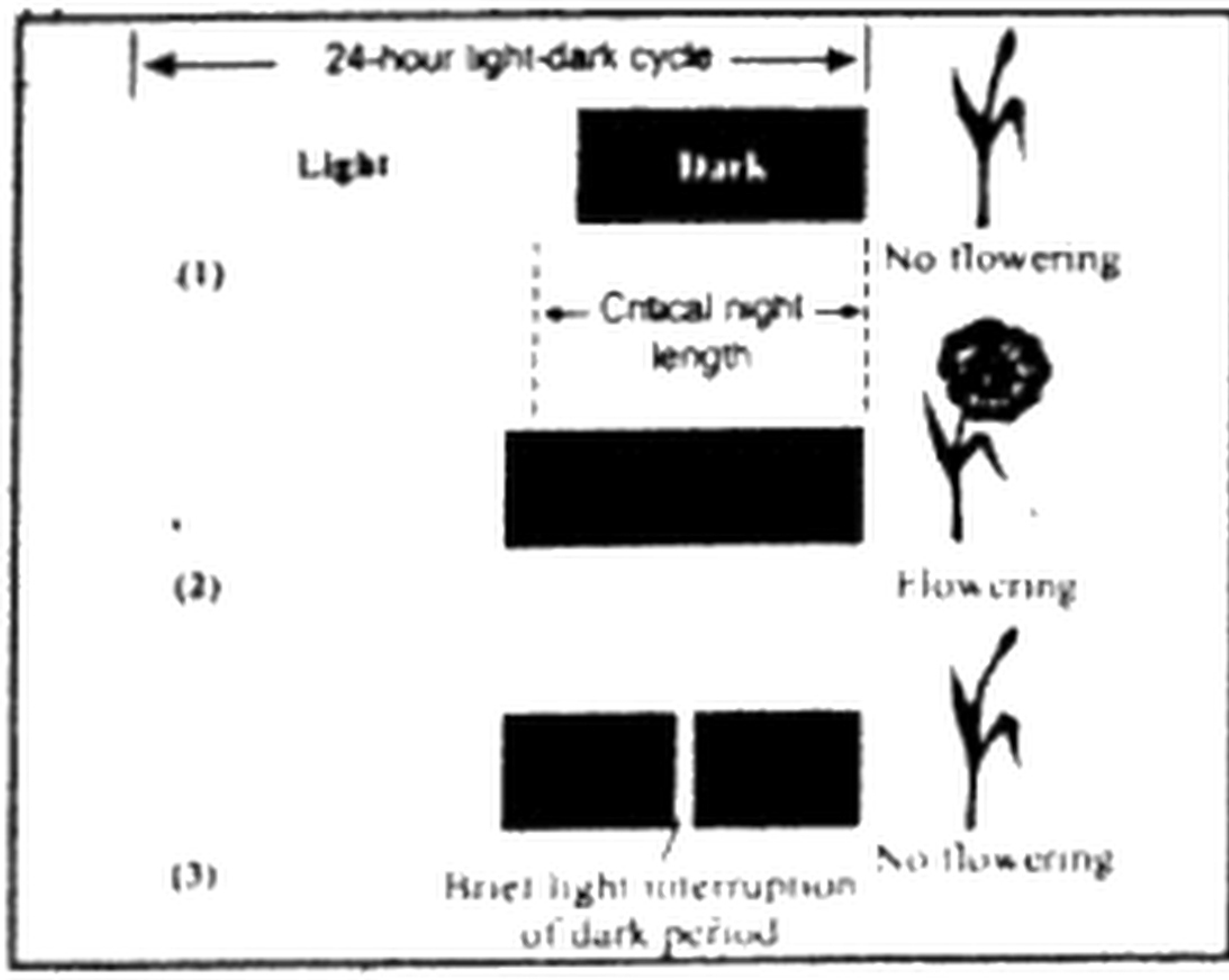
Significance of dark periods over photoperiods:

Now it has been discovered that the actual stimulus for flowering is the uninterrupted dark period rather than the light period. Therefore, it is really the length of dark period, which is critical. For example, if a short day plant (e.g. cocklebur) is grown in appropriate short days (less than 15.5 hours), but its long nights (more than 8.5 hours) are interrupted by short light periods, flowering is prevented. Similarly, a long day plant (e.g. henbane) can flower in inappropriate short days (less than 11 hours), if its long nights or dark periods (ore than 13 hours) are interrupted. Therefore, the short day plants are actually **long night plants** and long-day plants are **short-night plants.**

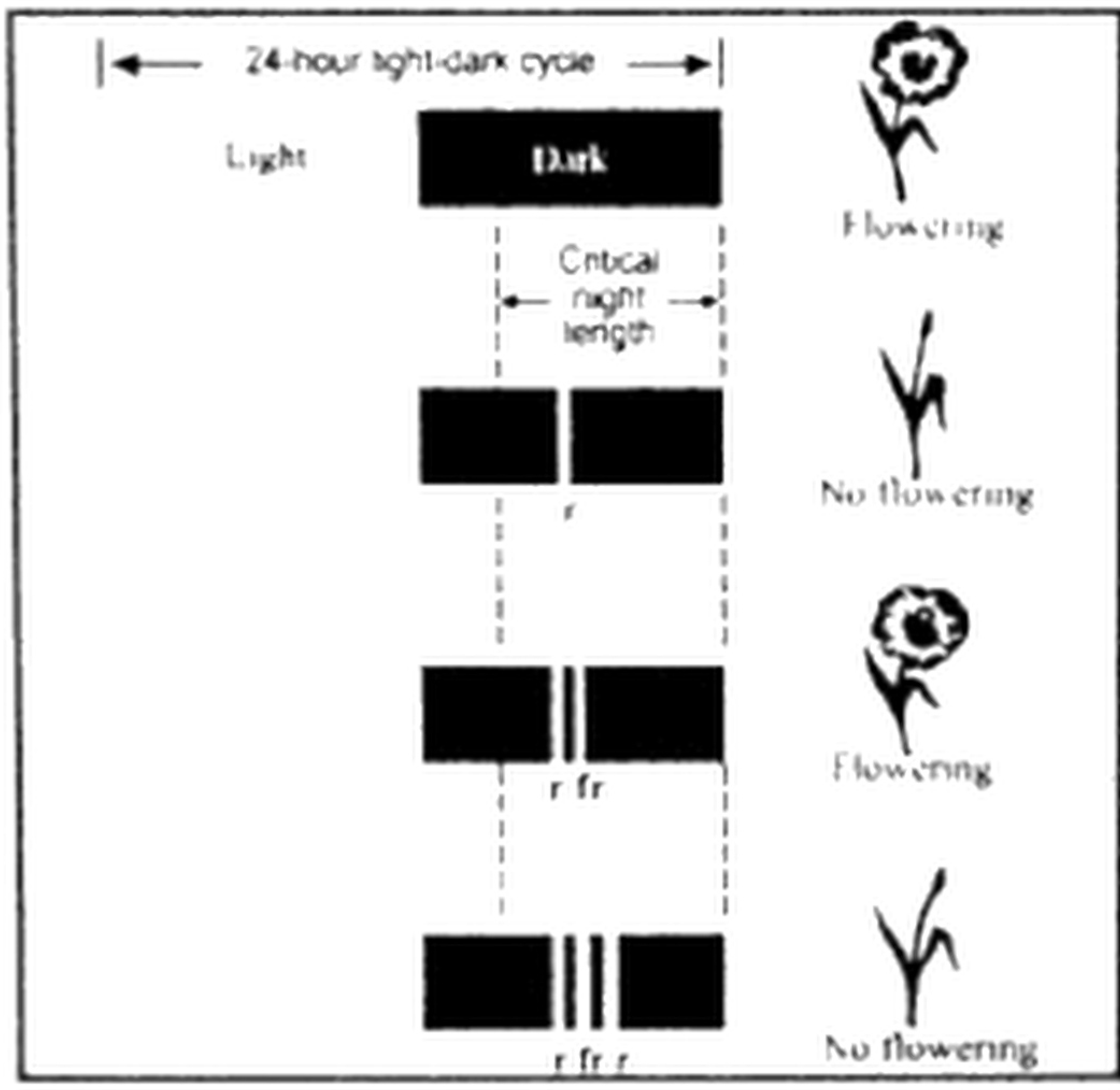
Effect of quality of light and discovery of phytochromes:

Further night interruption experiments on short day and long day plants have revealed that beside dark length the quality (wavelengths) of light is also important in promotion or inhibition of flowering. For example, ocklebur a short day plant, will not flower if its long nights are interrupted but experiments revealed that **red** light (660 nm wavelength) was effective in preventing flowering and the **far red light** (730 nm wavelength) reversed the effect of red light. It was also demonstrated that if more than one type of light exposures were give to interrupt the night, the last light treatment always determines the response. The behavior of long day plants was opposite in these experiments.

Based upon above observation, researchers concluded that there must be some kind of photoreceptors in plants, due to which plants respond differently to these lights. This struggle finally leads to the discovery of these photoreceptor pigments in the form of **phytochromes.**



Phytochrome detects varying periods of day length and darkness.



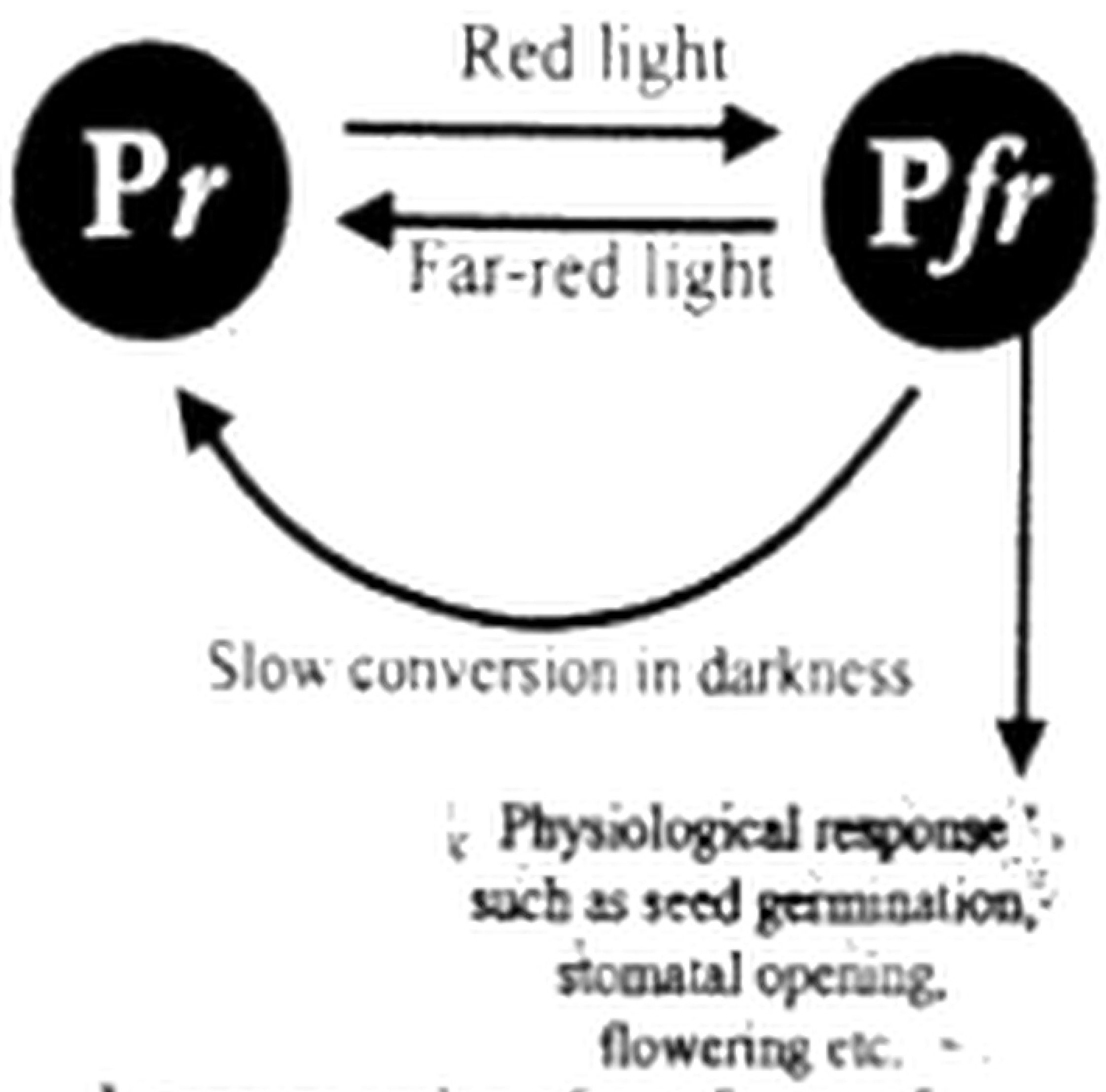
Night interruption experiments on short-day plants using a red light interruption and combinations of red and far-red (fr) light interruptions

Mechanism of Photoperiodism:

The mechanism of photoperiodism depends upon the rate of interconversion and the accumulation of either form of phytochromes. Phytochromes are blue-green pigment, which are involved in photoperiodism as photoreceptor. They are protein in nature but also contain an iron containing non-protein part.

Interconversion of phytochromes:

Phytochromes are found in two interconvertible forms. One form of phytochrome, designated as P_R or P_{660} strongly absorbs red light (at 660 nm) and is converted into the second form of phytochrome i.e. P_{FR} or P_{730}. When P_{FR} or (P_{730}) absorbs far-red light, it reverts to the original form, P_R (P660). Since red light is available in daytime so the conversion of P_R or (P_{660}) to P_{FR} or (P_{730}) occurs in day. Far-red light are invisible heat radiations that are present in both day and night but the conversion of P_{FR} or (P_{730}) to P_R or (P_{660}) occurs at night prominently because P_R or (P_{660}) cannot stay in daytime due to the presence of red light. In this way, the accumulation of either form of phytochrome in day and night enable the plant to determine that weather it is present in day or night. The rate of conversion of P_{FR} (P_{730}) to P_R (P_{660}) that occurs at night also provides a biological clock to the plants to determine the length of their night.



Interconversion of two forms of phytochromes

Stimuli required for induction of flowering:

A short day plant requires low ratio of P_{FR} (P_{730}) to P_R (P_{660}). It (cocklebur) can flower if it is provided with an appropriate dark length (8.5 hours or longer) because this dark length can convert all the accumulated P_{FR} (P_{730}) to P_R (P_{660}), therefore, P_{FR} (P_{730}) to P_R (P_{660}) ratio become low. On the other hand, a long day plant requires a high ratio of P_{FR} (P_{730}) to P_R (P_{660}). It (henbane) can flower if it is provided with an appropriate dark length (13 hours or lesser) because this dark length cannot convert all the accumulated P_{FR} (P_{730}) to P_R (P_{660}), therefore, at the end of night P_{FR} (P_{730}) to P_R (P_{660}) ratio become high. This is the reason why red and far-red lights affect differently in short day and long day plants.

Role of florigen hormone:

The specific ratio of P_{FR} (P_{730}) to P_R (P_{660}) at the end of nights (discussed above) trigger the production of a particular hormone in plants known as **florigen**, which transforms the vegetative buds into floral buds, thus flowers are produced.