

Unit 8: Plant Physiology

Long Questions

DESCRIPTIVE QUESTIONS

NUTRITION IN PLANTS

Q1. Define nutrient. Give detail of macronutrients regarding their role in plants. Also mention the effect of their deficiencies.

Ans. All autotrophic organisms need carbon dioxide and water, which supply carbon, oxygen and hydrogen. These are predominant elements which serve as nutrients and are required by plants for the synthesis of organic molecules. There are many other nutrients that plants get from environment.

★ **Fertilizers** are added to the soil to provide macro and micronutrients to the crops.

Macronutrients

The type of nutrients which are needed in relatively larger amounts for growth and development. There are **nine** macronutrients i.e., carbon, hydrogen, oxygen, nitrogen, potassium, calcium, phosphorus, magnesium and sulphur.

Explanation

- **Carbon, oxygen and hydrogen** are required for making organic compounds.
- **Nitrogen** is necessary for plant growth as it plays an essential role in energy metabolism and the production of proteins.
- **Deficiency of nitrogen:** A deficiency of nitrogen results in leaf loss and **stunted growth** (remain small in size).
- **Phosphorus:** Phosphorus is a part of ATP. It also plays a role in promoting root growth and favours flowering in the aerial zone.
- **Deficiency of Phosphorus:** A deficiency of phosphorus leads to **delayed flowering**, as well as the browning and **wrinkling of the leaves**.
- **Potassium** is involved in water regulation and the transportation of the plant's photosynthesis, reinforces cellular tissue and stimulates the uptake of nitrates.
- **Deficiency of potassium:** Dark patches are formed on the leaves when there is shortage of potassium.
- **Calcium** provides stability to the cell wall and promotes the development of the cell wall. It also plays a role in cellular proliferation and maturation and aiding in the development of seeds.
- **Insufficient calcium** leads to the development of **yellow and brown patches** on the leaves.

★ **Note:** All questions and paragraphs marked with a star ★ are explanations of the Box Information provided in the textbook.

- **Magnesium** constitutes the core of the chlorophyll molecule and is therefore essential for photosynthesis. It promotes the absorption and transportation of phosphorus and also contributes to the storage of sugars within the plant.
- **Magnesium deficiencies** result in **weak stalks, loss of greenness** in the oldest leaves and the appearance of **yellow and brown spots**.
- **Sulfur** is a fundamental element in the metabolism of nitrogen.
- **Deficiency of sulfur:** If there is a shortage of sulfur, the plant becomes **lighter in colour**.

Q2. Define micronutrients. Illustrate the role of elements crucial for the growth of plants.

Ans. “The nutrient which are needed in relatively very smaller amounts to meet the needs of growth processes are called **micronutrients**”. There are **seven** micronutrients i.e., iron, manganese, zinc, molybdenum, copper, chlorine and boron.

- **Iron** is essential for the synthesis of chlorophyll. It acts as a cofactor for several enzymes which are involved in energy transfer and nitrogen metabolism.
- **Deficiency:** Its deficiency results in interveinal **chlorosis** (yellowing).
- **Manganese** is involved in the processes of photosynthesis, nitrogen metabolism, carbohydrate metabolism and activation of enzymes.
- **Deficiency:** Its deficiency results in the **premature falling of the leaf** and **delayed maturity**.
- ★ Manganese is important of the activity of antioxidant enzymes, such as superoxide dismutase (SOD), which help mitigate oxidative stress in plants under adverse environmental conditions.
- **Zinc** facilitates chlorophyll synthesis, root development and uptake of nutrients.
- **Deficiency of zinc** can lead to **stunted growth**.
- **Molybdenum** is critical of nitrogen fixation, nitrogen reduction, sulfur metabolism, phosphorus metabolism and iron utilization.
- **Deficiency:** Its deficiency can result in **chlorosis** of older leaves and **stunted growth**.
- **Copper** is necessary for lignin synthesis providing strength and rigidity to cell wall. It is involved in nitrogen metabolism, reproductive development and also acts as a cofactor for enzymes.
- **Deficiency:** Its deficiency can result in **chlorosis, twisted leaves** and **stunted growth**.
- **Chlorine** is involved in stomatal regulation, osmotic adjustment and transport of nutrients.
- **Deficiency:** Its deficiency can affect the **health** and **growth** of plants.

Q3. How does nutrient absorption from insects benefit insectivorous plants in nutrient-poor soils?

Ans. Nutrition in Insectivorous Plants

Some plants supplement organic molecule into their food in addition to inorganic nutrients. These organic chemicals are acquired by capturing and breaking down insects and tiny animals such plants are called insectivorous plants. All insectivorous plants are true autotrophs. However, their development accelerates when they capture prey. Apparently,

nitrogenous compounds of animal body are of benefit to these plants. The captured insects are broken down by enzymes that are released by the leaves. Pitcher plant, venus fly trap and sundew are some of the known insectivorous plants.

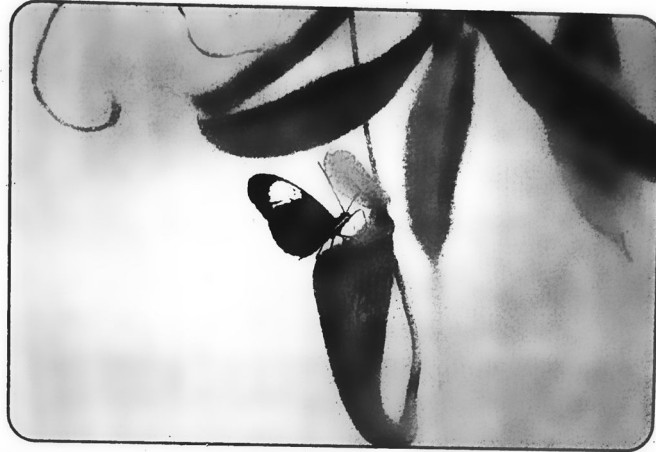


Fig: Pitcher plant, insects are entrapped within the leaf

Pitcher plant (*Sarracenia purpurea*): Pitcher plant has leaves modified into a sac or a pitcher, partly filled with water. The leaf's terminal portion is altered to create a hood, which partially covers the exposed opening of the pitcher. It has numerous stiff hairs that prevent little insects from crawling out once they fall inside it.

Venus-fly trap (*Dionaea muscipula*): Venus-fly trap has a "trap" consisting of two lobes that are hinged at the end of each leaf. The inner surfaces of the lobes contain trichomes which are hair-like projections that trigger the lobes to close rapidly upon contact with prey. The hinged traps are lined with fine bristles that interlock upon closure, preventing the prey from escaping. The trapped insect is then digested by the enzymes secreted from the glands on the leaf surface and the products are then absorbed.



Fig: Venus-fly trap, prey is trapped between the lobes of a leaf

Sundew (*Drosera intermedia*) catches its prey with shiny drops of "dew", where the plant's common name comes from. The leaves are covered with tiny hairs that look like tentacles. Each leaf has gland and has a single drop of dew at the tip. The insects, attracted by plant's odour are trapped by tentacles. The trapped insects are digested by enzymes and products are absorbed.

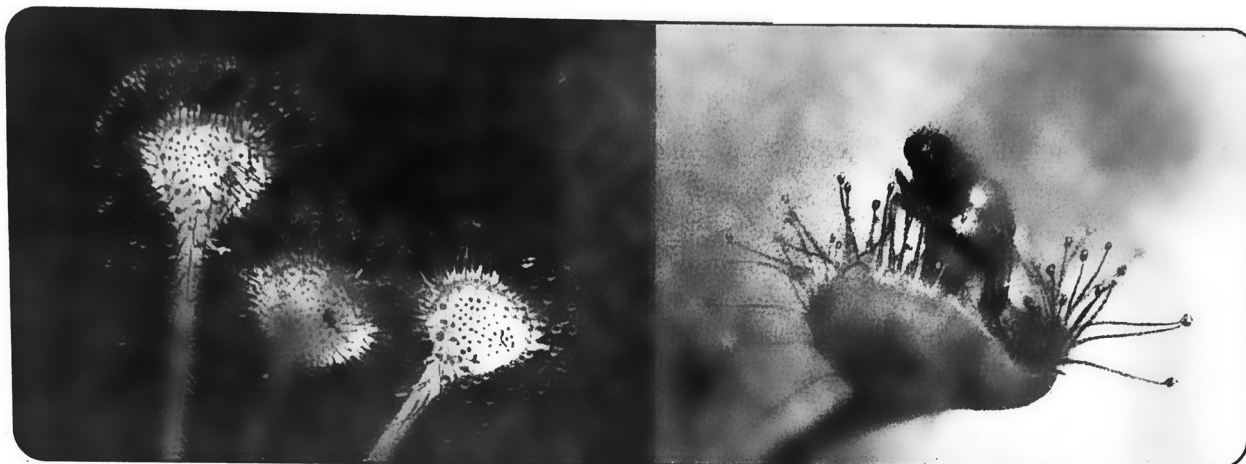


Fig: Sundew, insects are entangled by the tentacles

GAS EXCHANGE IN PLANTS

Q4. Describe opening and closing of stomata as per starch-sugar hypothesis.

Ans. The opening of stomata is primarily regulated by guard cells. At night, when photosynthesis ceases due to lack of light, stomata typically close to conserve water. However, plants still respire taking in O_2 and releasing CO_2 . The closure of stomata at night helps minimize water loss through transpiration.

Multisensory Hydraulic valves

The guard cells function as multisensory hydraulic valves. Guard cells function as multisensory hydraulic valves as they open and close in response of certain environmental factors like light, CO_2 and humidity. The two hypotheses which may explain the opening and closing of stomata are **starch sugar hypothesis** and **influx of K^+ ion**.

Starch sugar hypothesis

In 1856, German botanist H. Van Mohl proposed that guard cells in leaf epidermis are solely responsible for photosynthesis, producing sugars during the day. As sugar concentration increases in guard cells, the water potential drops. Water moves into guard cells causing them to become turgid and open the stomata. At night, photosynthesis ceases and sugars are converted to insoluble starch or used for respiration, leading to a decline in free sugars. Consequently, water moves out of guard cells and they lose turgor pressure. So, they become flaccid and close the stomata. However, this mechanism does not fully explain the rapid turgor changes in guard cells during stomatal movements.

Q5. Explain influx of K^+ ion in regulation of opening and closing of stomata. How does abscisic acid override the effect of light and CO_2 in stomatal movement?

Ans. Influx of K^+ ion

According to this hypothesis the opening of stomata in plants is facilitated by the active transport of potassium ions (K^+) into guard cells, which reduces their osmotic potential. This influx of K^+ leads to water entering the guard cells through osmosis, causing them to become turgid and open the stomata.

Role of blue light: Blue light enhances this process by acidifying the surrounding environment, promoting K^+ uptake and subsequent water absorption. At night, K^+ passively

diffuses out of the guard cells, resulting in water loss and causing the guard cells to become flaccid, thereby closing the stomata.

★ Hormonal Involvement

Hormones are involved in stomatal movement in plants. At high temperature when leaf cells start wilting, a hormone called abscisic acid, is released by mesophyll cells. This hormone stops the active transport of K^+ into guard cells, overriding the effect of light and CO_2 concentration. So, K^+ pumping stops and stomata close.

SUPPORT IN PLANTS

Q6. What is palisade tissue? Give its structure and role in photosynthesis.

Ans. Palisade tissue is primarily located just beneath the upper epidermis of the leaf. It consists of elongated, tightly packed cells that are rich in. The arrangement of these cells is organized to maximize light absorption and allowing plants to efficiently convert light energy into chemical energy.

Carbon dioxide from the atmosphere diffuses into the leaf through the stomata. Once inside, the gas travels through air spaces within the spongy mesophyll and then into the palisade mesophyll cells, where it is used in photosynthesis. Oxygen produced during photosynthesis diffuses out of the palisade cells back through the spongy mesophyll and exists the leaf through the stomata.

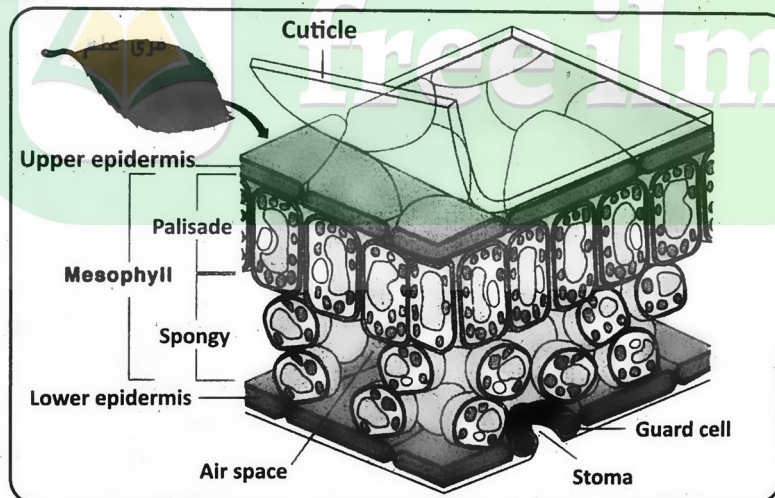


Fig: Structure of a leaf showing cuticle, epidermis, palisade mesophyll, spongy mesophyll, guard cells and stomata.

Q7. Elaborate the role of different types of supporting tissues in plants.

Ans. Supporting tissues in Plants

Supporting tissues play an important role in maintaining the **structural integrity, support and flexibility** of plants. These tissues consist of **parenchyma, collenchyma, sclerenchyma, xylem and phloem**.

1. Parenchyma: The parenchyma tissue provides support to **herbaceous plants** and parts of larger plants. The parenchyma cells of the epidermis, cortex and pith absorb water. This water creates an internal hydrostatic pressure known as turgor pressure that maintains the rigidity of cells.

Role of Turgor Pressure: Turgor pressure arises from the elevated osmotic pressure within the cell vacuole. The membrane that surrounds the vacuole is called the **tonoplast**. It has many active transport mechanisms that move ions into the vacuole, even the elevated ionic concentration, water is drawn into the vacuole, resulting in turgidity and providing mechanical support to the plant's soft tissues.

2. Collenchyma: Collenchyma cells are specialized cells that are **grouped in the form of strands or cylinders**. They are found beneath the epidermis of young stems, leaf stalks and along veins in leaves. Collenchyma cells **lack secondary walls**. Their primary walls are thickened at the corners, due to extra deposition of cellulose. They elongate when stem or leaf grown lengthwise. They provide support to the young parts of plant in which secondary growth has not taken place.

3. Sclerenchyma: This tissue provides structural support to the plants. Typically, the cells of sclerenchyma tissue possess thick secondary cell walls. These walls are **saturated with lignin**, an organic compound that gives strength and rigidity to the walls. The majority of sclerenchyma cells are non-living. The main function of this tissue is to provide support to the various components of the plant.

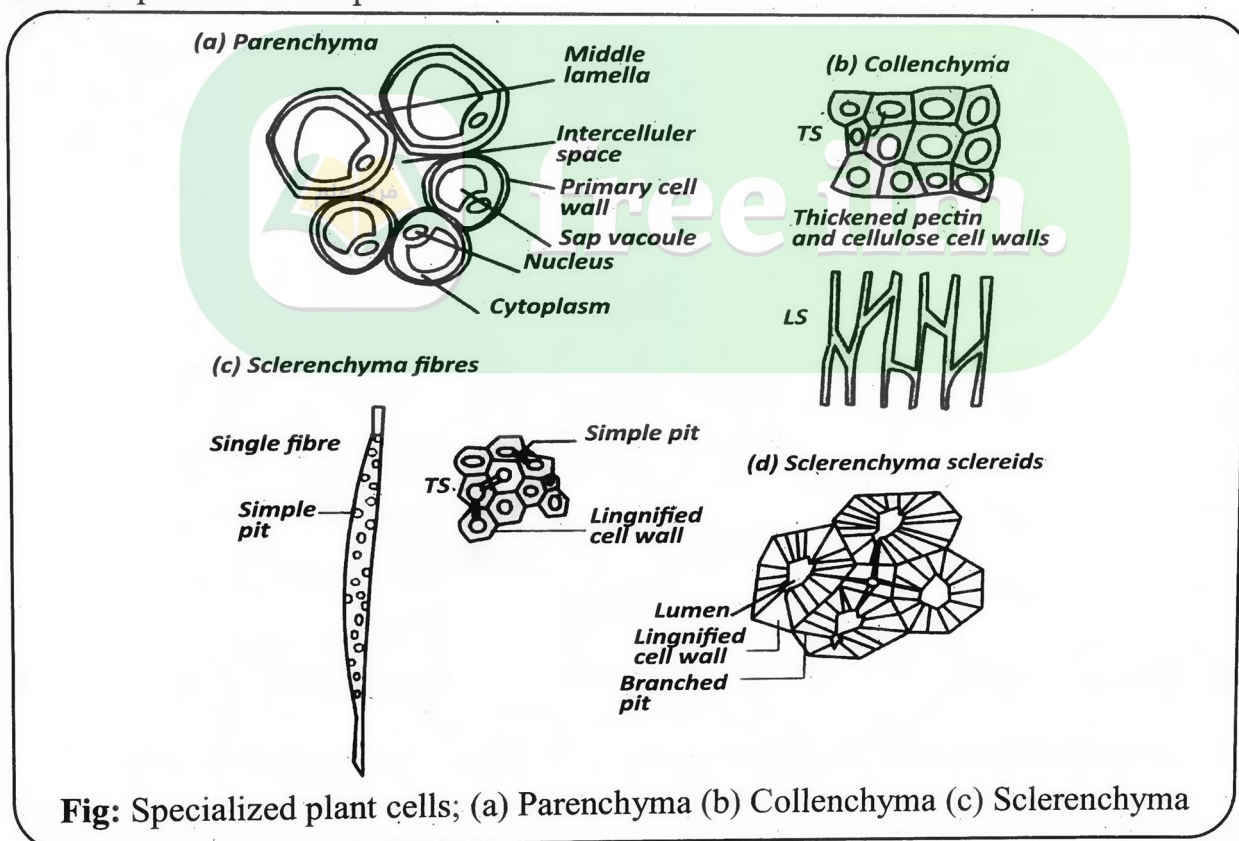


Fig: Specialized plant cells; (a) Parenchyma (b) Collenchyma (c) Sclerenchyma

Types: There are three types of sclerenchyma cells which are fibres, sclereids and vessels.

- (i) **Fiber (Tracheids)** are elongated and cylindrical in shape. They can be found either as compact bundles inside the xylem or as bundle caps.
- (ii) **Sclereids** are smaller in size as compared to fibers and are present in the seed coats and shells of nuts. Their function is to offer protection.
- (iii) **Vessels (Tracheae)** are long tubular structures that are joined end to end to form a long water conducting pipe in xylem.

WATER POTENTIAL

Q8. What is water potential? Describe the effects of solute and atmospheric pressure on water potential?

Ans. Water Potential (ψ_w)

Water molecules possess **kinetic energy** which means that in liquid or gaseous form they move about rapidly and randomly from one place to another. So, greater the concentration of the water molecules in a system the greater is the total kinetic energy of water molecules. This is called water potential (symbolized by Greek letter **Psi** = ψ_w).

Pure water has maximum water potential which by definition is zero. Water moves from a region of higher ψ_w to lower ψ_w . All solutions have lower ψ_w than pure water and so have negative value of ψ_w (at atmospheric pressure and at a defined temperature). So the osmosis can be defined as the movement of water molecules from a region of higher water potential to a region of lower water potential through a partially permeable membrane.

Factors that determine water potential

In plant cells, two factors determine water potential i.e., **Solute potential (ψ_s)** and **Pressure potential (ψ_p)**.

1. Solute Potential (ψ_s)

The solute potential or osmotic potential is a measure off the change in water potential (ψ_w) of a system due to the presence of solute molecules. ψ_s is always a negative value, so if more solute molecules are present, lower (more negative) is the ψ_s .

2. Pressure Potential (ψ_p)

It is the part of water potential which is due to the pressure exerted by water. If pressure greater than atmospheric pressure is applied to pure water or a solution, its water potential increases. When water enters plant cells by osmosis, pressure may be build up inside the cell making the cell turgid and increasing the pressure potential.

Thus, the total water potential (ψ_w) is sum of solute potential (ψ_s) and pressure potential (ψ_p):

$$\psi_w = \psi_s + \psi_p$$

If we use the term water potential, the tendency for water to move between any two systems can be measured; not just from cell to cell in a plant but also from soil to root, from leaf to air and from soil to air. The steeper the potential gradient the faster is the flow of water along it.

TRANSPORT OF WATER IN PLANTS

Q9. Which pathways are followed by water to reach xylem from soil?

Ans. Uptake of Water by Roots

Roots of plants provide large surface area for absorption by their extensive branching systems. Roots have tiny **root hairs**, which are actually **extensions of epidermal cells** of roots. Most of the uptake of water and minerals in roots takes place through root hairs.

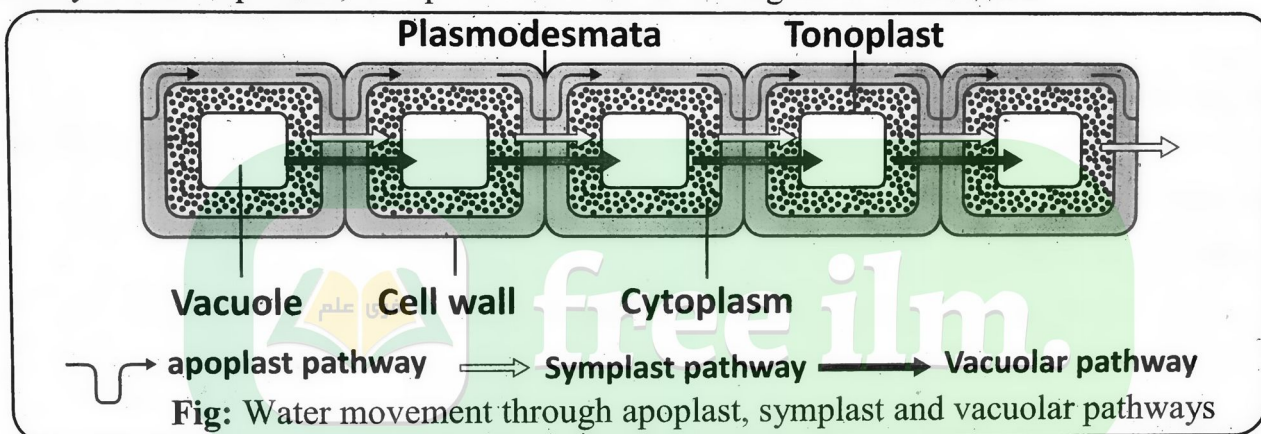
From soil, water and minerals enter the root epidermal cells by active and passive transport. From root epidermis, they move to cortex and then into the xylem tissue in the centre of root.
Pathways: Inside roots, water and minerals move in three different pathways to reach the xylem.

1. The Apoplast Pathway

It is a continuous pathway that involves a system of **adjacent cell walls** in the plant roots. The apoplast pathway becomes discontinuous in the endodermis in the roots due to the presence of Casparian segments.

2. The Symplast Pathway

In symplast pathway, water and minerals move through interconnected protoplasts of root cells. The protoplasts of neighbouring cells are **interconnected through plasmodesmata** which are cytoplasmic strands that extend through pores in adjacent cell walls. The symplast pathway is less important, except for minerals in the region of endodermis.



3. The Vacuolar Pathway

In Vacuolar pathway, water and minerals move through cell membranes, cytoplasm and tonoplast (membranes of vacuoles) and vacuoles. They move from vacuole to vacuole and bypass the symplast and apoplast pathways. Movement in vacuolar pathway is negligible.

Q10. Explain the key structural components of xylem tissue.

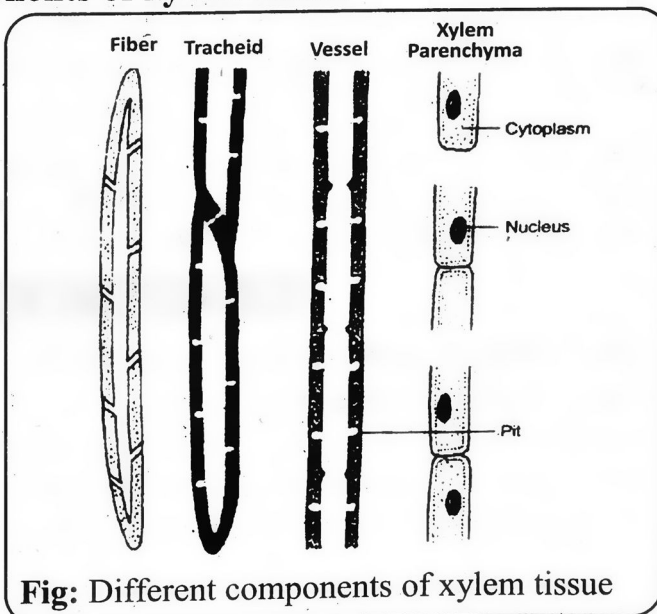
Ans. Structure of Xylem Tissue

Xylem is the vascular tissue in plants that carries water and dissolved minerals (sap) from the roots to the stem and leaves. It is also a key structural component which provides mechanical support to the plant body.

Composition

Xylem comprises of tracheids, vessels, xylem fibres and xylem parenchyma.

- Tracheids** are elongate and thin cells that have thick walls made of **lignin**. The ends of the cells are tapered and they are linked to each other by bordered pits,



which enable the lateral movement of water between cells.

- b. **Vessels** are shorter and broader compared to tracheids. They are arranged in a linear fashion, forming continuous channels. **Perforation plates** are present at the outer edges of these structures, enabling efficient movement of water.
- c. **Xylem fibres** are elongated cells with thickened lignified walls. At maturity, they are dead and enhance the structural integrity of the xylem. They offer **additional structural support** to the plant.
- d. **Xylem parenchyma** are living cells with thin walls that have the ability to retain and hold nutrients and water. Xylem parenchyma cells participate in the **lateral translocation** of water and nutrients and can also contribute to the healing and regeneration of xylem tissue.

Q11. Explain the TACT mechanism of water flow from root to leaf?

Ans.

The movement of water within plants, from roots to leaves, occurs primarily through specialized vascular tissue known as xylem.

TACT: The TACT (Transpiration, Adhesion, Cohesion, Tension) also called **cohesion – tension theory** is a widely accepted model explaining how water moves against gravity through the xylem to reach all parts of the plant. This mechanism depends on both physical and chemical properties of water and the plant's interaction with its environment.

Components of TACT mechanism

1. Transpiration

Transpiration is the process by which water evaporates from the surface of plant leaves, specifically through stomata. As water vapour exits the leaf, **a negative pressure is generated** within the leaf tissue. This negative pressure creates a pulling force, drawing water upward from the roots through the stem and towards the leaves. Transpiration, therefore, acts as the **primary driving force** behind water transport in the xylem.

2. Adhesion: Adhesion is the attraction **between water molecules** and the walls of the **xylem vessels**. Due to this attraction, water

molecules stick to the walls of xylem vessels as they move upward. This property prevents any break in the water column within xylem. Adhesion thus plays a crucial role in maintaining

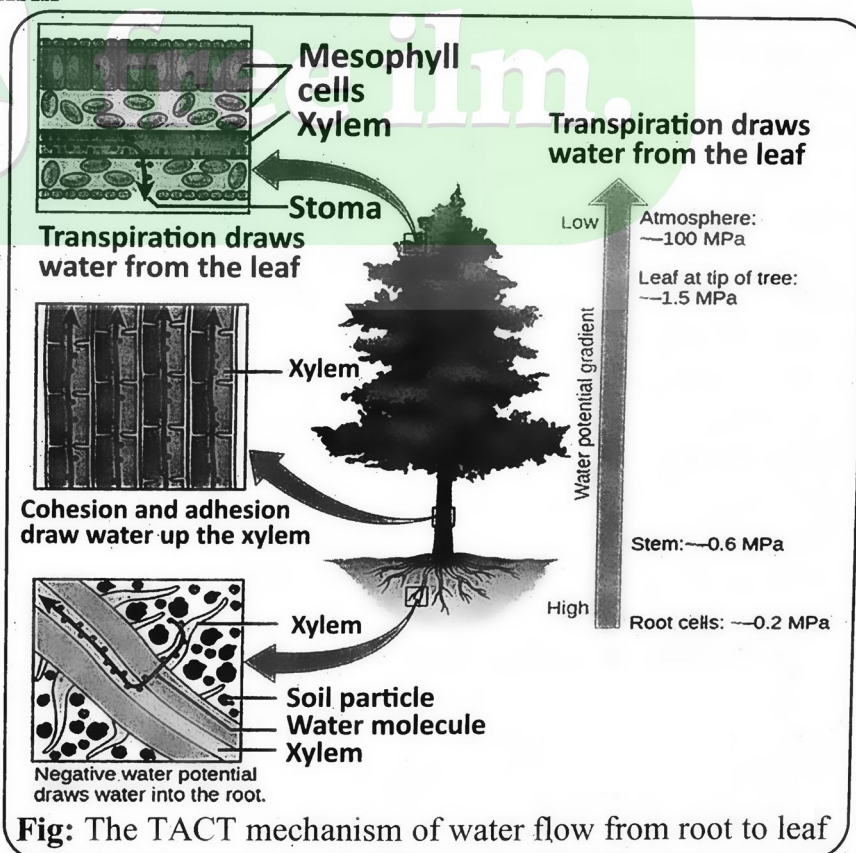


Fig: The TACT mechanism of water flow from root to leaf

the **continuity of the water column**, especially in tall plants where gravity exerts a significant downward force on the water column.

3. Cohesion: Cohesion refers to the attractive force between water molecules themselves, caused by hydrogen bonding. Water molecules within the xylem stick together, forming an unbroken column from the roots to the leaves. This cohesive property of water ensures that the “pull” initiated by transpiration at the leaf level extends down through the entire water column.

4. Tension: Tension is the negative pressure created by the pulling force of the transpiration at the leaf level. As water evaporates from the leaf surface, it creates a low-pressure area that extends through the xylem. This tension pulls the cohesive water column upwards. Tension is therefore vital for the continuous ascent of water within the xylem.

TRANSLOCATION OF FOOD IN PLANTS

Q12. Describe the structural composition of phloem.

Ans. Structure of Phloem

Phloem is a vascular tissue in plants responsible for the transport of organic nutrients, particularly the products of photosynthesis, from the leaves to other parts of the plant where they are needed or stored. The phloem is generally found on the outer side of both primary and secondary vascular tissue in plants with secondary growth. The phloem constitutes the inner bark.

Components: Phloem comprises of **sieve elements, companion cells, phloem fibres** and **phloem parenchyma**.

1. Sieve Tube Elements or Cells: The cells of phloem that transport sugars and other organic material throughout the plant are called **sieve tube elements or cells**. Sieve tube elements have ‘sieve areas’, which are the portions of the cell where pores interconnect the sieve tube elements.

Sieve Tube: Some of the sieve areas are generally formed in end walls of sieve tube elements where the individual cells are joined together to form a longitudinal series called a sieve tube.

2. Companion cells: Each sieve tube element is associated with one or more companion cells. Sieve tube elements and companion cells are in communication with each other by plasmodesmata. Companion cells **supply ATP and proteins** to sieve tube elements as they **lack nucleus**.

3. Phloem parenchyma: Phloem parenchyma **stores** substances, such as sugars, resins, latex and mucilage which are important for plant defence and moisture retention.

4. Phloem fibers: Phloem fibres are specialized sclerenchyma cell, which are elongated, spindle shaped have thick walls. These are crucial in providing **mechanical support** and strength to plant.

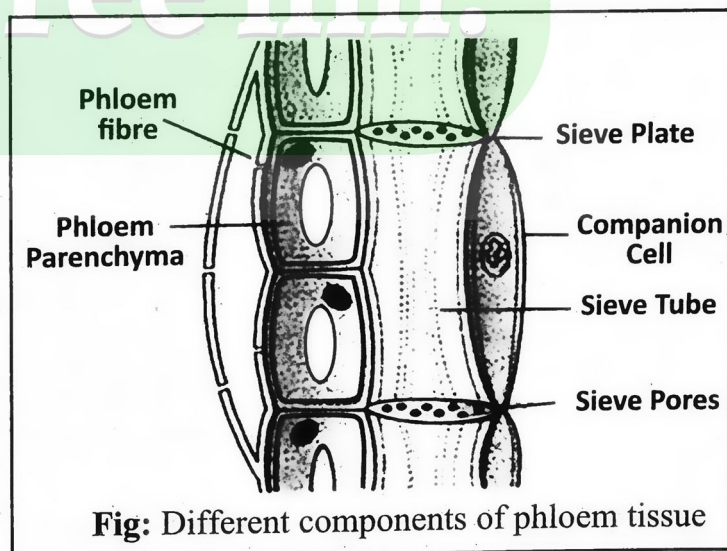


Fig: Different components of phloem tissue

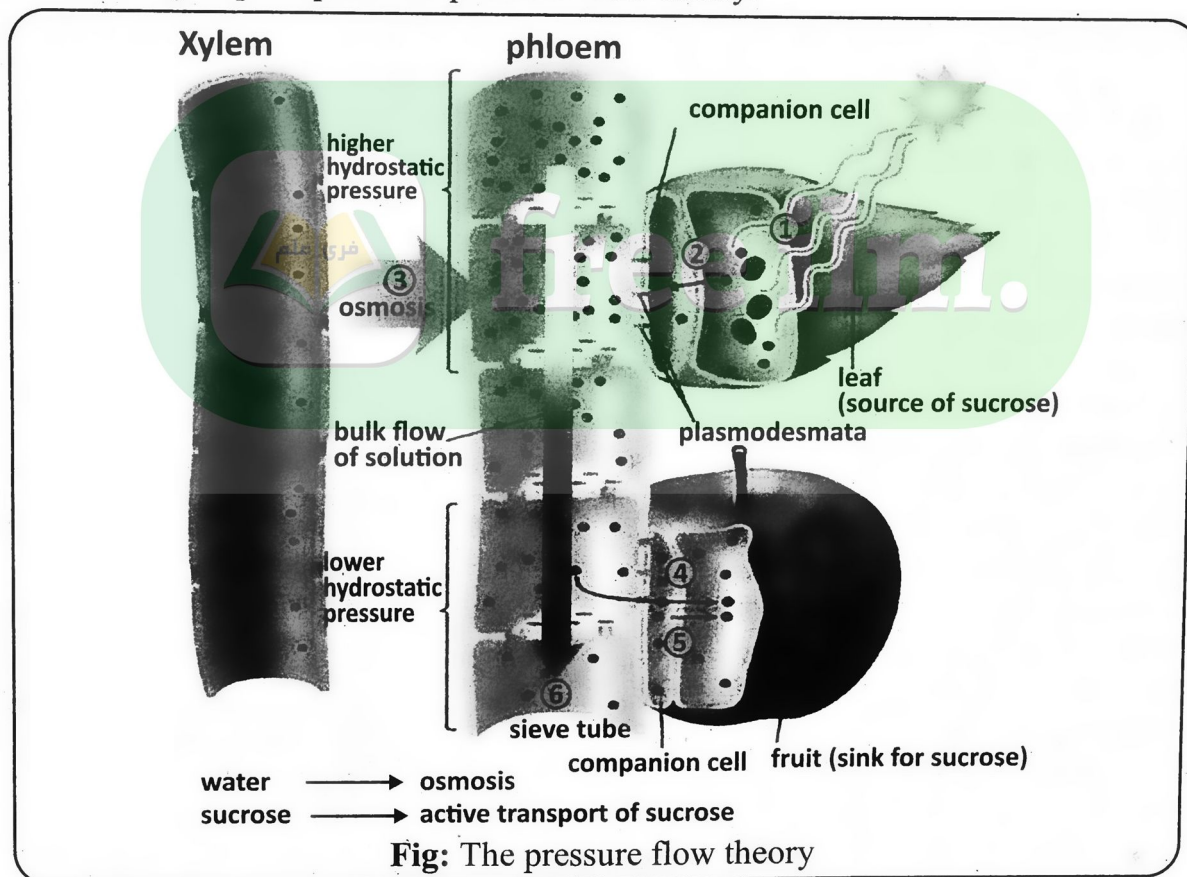
Q13. Explain mass flow hypothesis for the transport of sugars?

Ans. Mechanism of Translocation of sugars

The transport of sugars in plants takes place through phloem tissue. Passive theories of phloem transport include:

1. **Diffusion** is far too slow, to account for the **velocities** of sugar movement in phloem, which on the average is **1 meter per hour**, while the rate of diffusion is **1 meter per eight years**.
2. **Pressure flow theory:** The pressure-flow theory, also known as the **mass-flow hypothesis**, is the most widely accepted explanation for the transport of sugars in plants through the phloem. This process of translocation moves sugar **from the source** (where they are synthesized) **to the sink** (where they are consumed or stored). This theory was proposed by **Ernst Munch in 1930**. This theory relies on the principle of osmotic pressure differences between source and sink regions.

Steps: Following steps explain the pressure-flow theory:



1. The **glucose** formed during photosynthesis in **mesophyll cells**, is used in **respiration**. The excess of glucose is converted into non-reducing sugar i.e., **sucrose**.
2. **Sucrose** is actively transported from mesophyll cells to the **companion cells** of phloem. From here, sucrose diffuses to **sieve tubes**, through **plasmodesmata**. So, the concentration of sucrose in sieve tubes increases.
3. Due to **higher sucrose** (solute) concentration in sieve tubes, water moves into them by osmosis from the nearby xylem of leaf. It results in an **increase** in the **water potential** at the source end of sieve tubes.

4. At the **sink** end, sugar is actively **unloaded** from sieve tubes and water also follows by osmosis. The exit of water lowers the water potential at the sink end. So, there is a higher water potential at the source end while a lower water potential at the sink end.
5. The difference in water potential causes water to flow from source to sink. Since sucrose is dissolved in water, it is carried along from source to sink along with water.

GROWTH IN PLANTS

Q14. What are growing points in plants? Explain the types of meristem and their role in growth. / What is the role of meristem in growth of plants?

Ans. Growth in Plants

Growth in plants refers to a **permanent increase in size**, which can occur in various dimensions such as height, width and mass. Throughout life, the plant adds organs such as branches, leaves and roots. Its organs increase in size from the tips but the rate of growth is not uniform throughout the body.

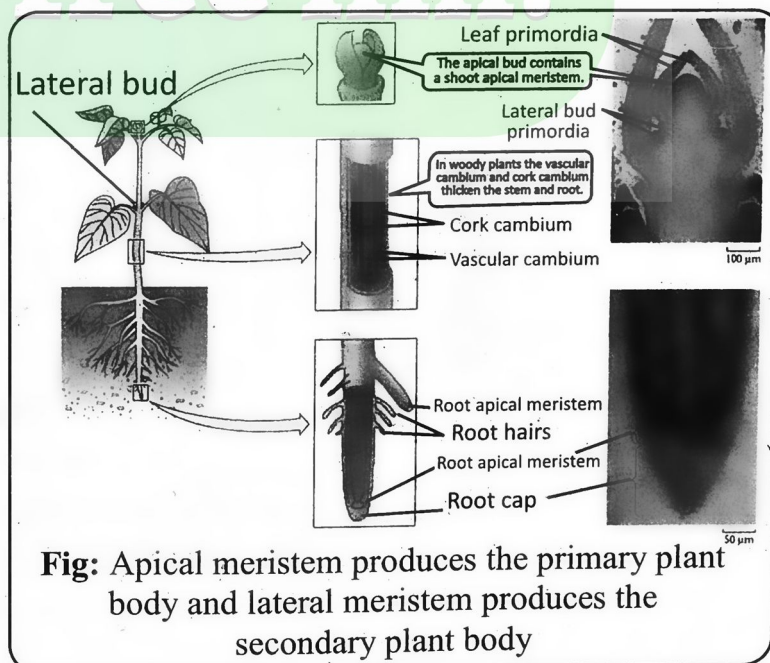
Growing points: In lower plants, the entire plant body is capable of growing, but in higher plants, growth is limited to certain regions known as **growing points**.

These growing points consist of groups of cells, called **meristems** that are capable of continuous cell division.

Types of Meristems

There are **three types of meristems** in plants that accounts for growth in plants. i.e., **apical meristem, intercalary meristem** and **lateral meristem**.

1. **Apical meristems** are found at the tips of roots and shoots. They are primarily responsible for the **extension of the plant body**. These are perpetual growth (continuous growth) zones found and are responsible for the increase in the number of cells at the tips of roots and stems. They play an important **role in primary growth**.
2. **Intercalary meristems** are separated from the apex by permanent tissues. They are situated at the **bases of internodes** in many plants such as grasses and play an important role in the production of **leaves and flower**. These are temporary.
3. **Lateral meristems** are cylinders of dividing cells present along the peripheral regions. They are responsible for growth in **thickness of stems and roots**. They are found in woody plants and are crucial for secondary growth. There are two main forms of lateral meristems; **vascular cambium** and **cork cambium**.



- **Vascular cambium** is located between the xylem and phloem and is responsible for the production of secondary xylem and secondary phloem.
- **Cork cambium** is formed in the outer layer of stems and roots. This tissue produces cork cells which replace the epidermis and forms the outer protective bark.

Q15. Define primary growth in plants? Describe the phases of primary growth in plants?

Ans. Primary Growth

Primary growth is responsible for an **increase in the length of the plants**. It is facilitated by the activity of apical meristems. Herbaceous plants generally display primary growth with little secondary growth as compared to woody plants.

Phases: The process of primary growth in plants occurs in three phases.

1. **Cell Division:** The cells of apical meristems undergo mitotic division and the number of cells is increased. It happens at the tips of apical meristems of root and shoot. The area of apical meristem where cell division occurs, is called **zone of cell division**. In this zone, cells are non-vacuolated and small. These cells have spherical nuclei in the centre of cytoplasm.
2. **Cell Elongation:** After the formation of new cells, their volume increases due to uptake of water. Plasticity of cell wall increases and wall pressure is reduced. It happens at a little distance from the tips of apical meristems. The area where cell elongation occurs, is called **zone of cell elongation**. In this zone, cells are vacuolated and large. They have nuclei in the peripheries of cytoplasm. During this phase, different cells elongate in different dimensions and the final size of cells is attained. For example, the cells which are determined to develop into pith, cortex etc. do not elongate much length-wise while the cells which are determined to develop into xylem tissue elongate more length-wise.
3. **Cell Differentiation:** After the cells have got their final size and shape, elongation stops and cells are specialized to perform specific functions. Their cell walls become thicker and many new structural features develop. It happens in the area next to the zone of elongation. In this zone, cells are fully differentiated and each type of cell performs specific function.

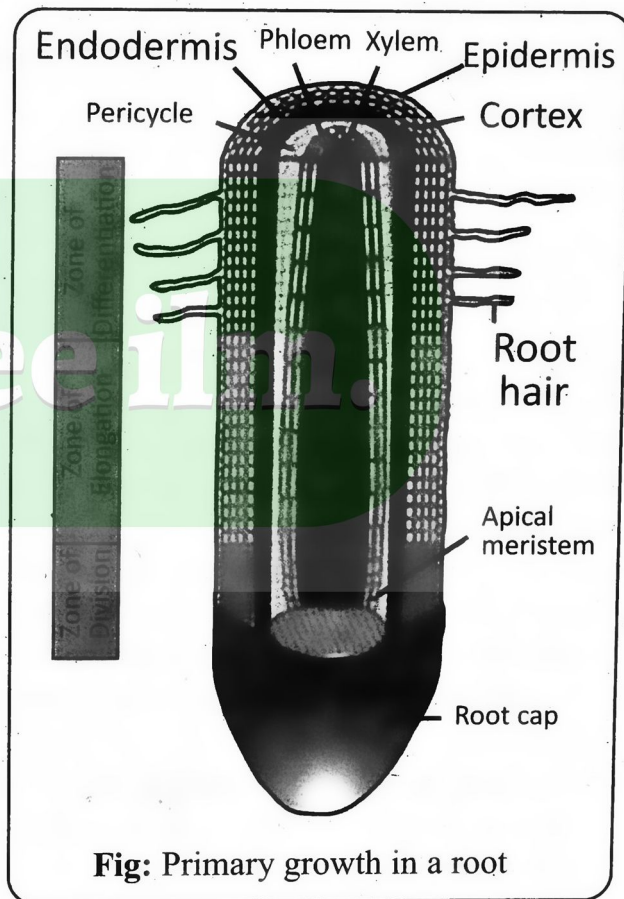


Fig: Primary growth in a root

Q16. Define secondary growth in plants. Describe the significance of secondary growth in plants? / Describe the changes associated with change in season from spring to autumn in cambium?

Ans. Secondary Growth

Secondary growth refers to the increase in thickness or girth of stems and roots. It is due to the activity of lateral meristems, specifically the vascular cambium and cork cambium. It is more prominent in woody perennial plants, while herbaceous plants show only primary growth.

Explanation

The cells of vascular cambium divide and produce new cells on both of its outer and inner margins. Cells produced on outer margins of vascular cambium make secondary phloem while the cells produced on its inner margins make secondary xylem. Secondary tissues (particularly secondary xylem) cause increase in plant's thickness. Division in cork cambium produces cells on both outer and inner sides. These cells make new bark. The region of mature stem outside of the vascular cambium, which contains secondary phloem, cork cambium and cork, is collectively called **bark**.

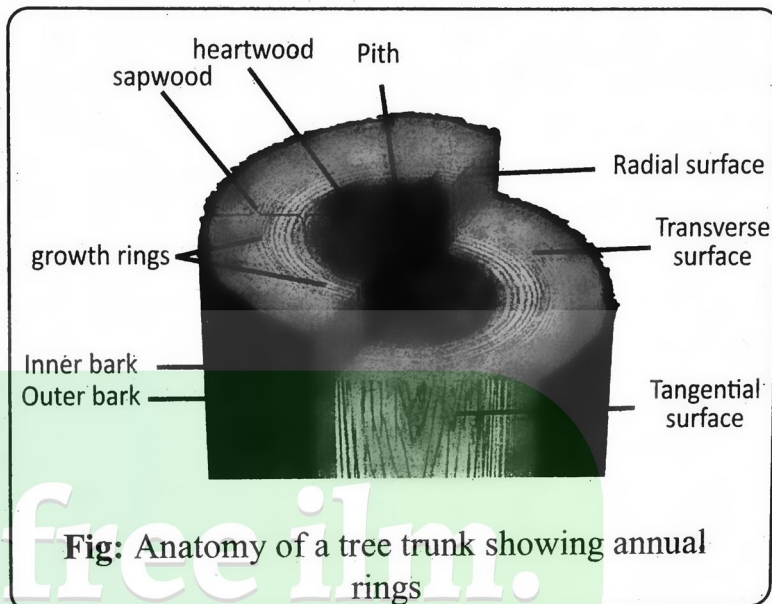


Fig: Anatomy of a tree trunk showing annual rings

Annual Rings: Annual rings are formed due to the **seasonal activity** of the cambium layer in trees. This process is influenced by environmental factors and results in the production of two distinct types of wood each year: **spring wood** (early wood) and **autumn wood** (late wood). These rings provide valuable information about the **age** of the tree and the **environmental conditions** experienced during each growing season.

- **Cambium:** The **cambium** is a meristematic tissue that generates new vascular tissues i.e., xylem and phloem.
- **Growth in spring:** In **spring**, when conditions are favourable, the cambium is **highly active**, producing a large volume of xylem with wider vessels, resulting in lighter-coloured spring wood.
- **Growth in autumn:** As the season changes to **autumn**, the cambium's **activity decreases**. It produces fewer xylem elements, which are narrower and denser, leading to the formation of **darker autumn wood**. The combination of spring wood and autumn wood forms a complete annual ring. Each year, a new ring is added, allowing for the determination of a tree's age through **dendrochronology**.

The transition between these two types of wood is gradual from spring to autumn, but the shift from autumn back to spring in the following year is abrupt, marking a clear distinction between the growth periods. This data is valuable for studying long-term climate variability and changes.

PLANT GROWTH REGULATORS

Q17. What are plant growth regulators? Compare and contrast the roles of auxins and gibberellins in plant growth.

Ans. Plant Growth Regulators

Plants regulate the rates of growth and the rate of metabolism in their cells. Special chemical messengers, called plant growth regulators or **plant hormones** regulate their growth. There are five major groups of plant **growth regulators** i.e., **auxins**, **cytokinins**, **gibberellins**, **abscisic acid** and **ethylene**.

Auxins	Gibberellin
• These are indole acetic acid (IAA) or its variants. • In stem, promote cell enlargement in region behind apex. • Promote cell division in cambium. • In root, promote growth at very low concentrations. Inhibit growth at higher concentrations, e.g., geotropism. Promote growth of roots from cuttings and calluses. • Promote bud initiation in shoots but sometimes antagonistic to cytokinins and is inhibitory. • Promote apical dominance and fruit growth. They can sometimes induce parthenocarpy. • Cause delay in leaf senescence (aging) in a few species. • Inhibit abscission.	• Gibberellins are produced in the apical portions of roots and shoots, and transported to other parts. Gibberellins contain Gibberellic acid and there are more than 110 different gibberellins. • Promote cell enlargement in the presence of auxins. Also promote cell division in apical meristem and cambium. • Promote 'bolting' of some rosette plants. • Promote bud initiation in shoots of chrysanthemum callus. • Promote leaf growth and fruit growth. May induce parthenocarpy. • In apical dominance, enhance action of auxins. • Break bud and seed dormancy. • Sometimes may substitute for red light. Therefore, promote flowering in long-day plants, while inhibit in short day plants. • Cause delay in leaf senescence in a few species.

Q18. Cytokinins are one of the most important plant growth regulators, comment.

Ans. Cytokinins

They are usually produced in roots, young fruits and in seeds. Cytokinins promote **cytokinesis** during cell division. They increase the rate of **DNA replication** and the **rate of RNA** and **protein synthesis**.

Functions: They perform the following:

- Promote stem growth by cell division in **apical meristem** and **cambium**.
- Inhibit **primary root growth**.
- Promote **lateral root growth**.

- Promote **bud initiation** and leaf growth.
- Promote **fruit growth** but can rarely induce **parthenocarpy**.
- Promote lateral bud growth, also break **bud dormancy**.
- Cause delay in leaf senescence.
- Promote **stomatal opening**.

Q19. What are the domains of actions of Absciscic acid and ethylene as growth regulators in plants? / How Absciscic acid and ethylene effect plant growth during physiological stress?

Ans. Absciscic acid

Absciscic acid (**ABA**) is synthesized mainly in mature green leaves, fruits and root caps.

Functions: It performs the following functions:

- **Inhibits** stem and root growth notably during physiological stress, e.g., drought and waterlogging.
- Promotes bud and **seed dormancy**.
- Promotes **flowering** in short day plants and inhibits in long day plants (antagonistic to gibberellins).
- Sometimes promotes **leaf senescence**.
- Promotes **abscission**.
- Promotes closing of stomata under conditions of **water stress** (wilting).

Ethylene

It is a natural product of the metabolism of plants. Inhibits stem growth, notably during physiological stress.

Functions: It performs the following functions:

- Inhibits **root growth**.
- **Breaks dormancy** of bud.
- Promotes **flowering** in **pineapple**.
- Promotes **fruit ripening**.

OSMOREGULATION IN PLANTS

Q20. Define osmoregulation. Write the effects of various types of solutions on cells.

Ans. Osmoregulation in Plants

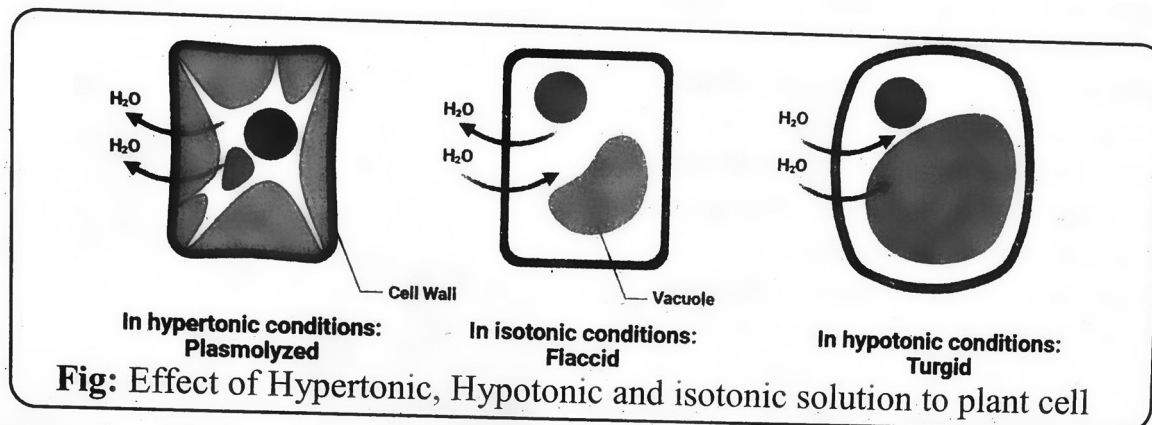
Osmoregulation refers to the process by which an organism maintains a stable internal equilibrium of water and dissolved substances, irrespective of the surrounding environmental conditions.

Many marine organisms undergo osmosis without the requirement for regulatory systems since their cells have the same osmotic pressure as that of the sea.

However, some organisms must actively acquire, retain or eliminate water or salts in order to regulate their internal water and mineral balance.

Types of Solutions and their effect on living cells

1. **Hypotonic solution:** A solution having reduced solute concentration relative to the intracellular environment of a cell. As a result, water enters the cell by osmosis resulting in the **swelling**.



2. **Hypertonic solution:** A solution having high solute concentration relative to the intracellular environment of a cell. As a result, water moves out of the cell which causes the cell to **shrink** due to loss of water, a condition called **plasmolysis**.
3. **Isotonic solution:** A solution whose solute concentration resembles to the intracellular environment of the cell. Net movement of water between the cell and its environment is zero in this case leaving no effect on size or shape of the cell.

Q21. Describe osmoregulation in hydrophytes and mesophytes?

Ans. Osmotic Adjustments in Plants

Plants are distributed in different habitats of **aquatic, moderate, severely dry terrestrial and saline nature**, thus termed as **hydrophytes, mesophytes, xerophytes** and **halophytes**, respectively.

1. **Hydrophytes** are adapted to aquatic environments, including marine and freshwater ecosystems, though specialized osmotic adjustment mechanism, these are of two types.
 - **Marine hydrophytes** thrive in **saline** (hypertonic) conditions, where water tends to leave their solutes like proline, glycine, betaine and sugars to retain water by increasing their internal osmotic potential. They have **thick cuticles** which further reduce water loss, and they exhibit halophytic traits to tolerate high salinity e.g., seaweeds, seagrass, mangroves.
 - **Freshwater hydrophytes** grow in hypotonic environments, where water continuously enters their cells. These plants expel excess water through structures like **hydathodes** or vacuoles to avoid overhydration (over flooding). They actively absorb essential ions, such as **potassium** and **calcium** to maintain osmotic balance and compensate for the dilute surroundings. With thin or absent **cuticles**, these plants facilitate water exchange and often have reduced root systems relying on direct nutrient and water absorption from their environment. Examples of hydrophytes are water **lilies, lotus** and **tape grass**.
2. **Mesophytes** live in moderate environments that are neither too dry nor too wet.
 - They prefer soil that is not waterlogged and has a moderate salt content and humidity.
 - Mesophytes have well-developed roots and shoots with a fully formed vascular system.
 - They do not require any special adaptations to survive.
 - Their leaves are flat, broad and green with stomata on the surface.
 - Examples of mesophytes include **rose, tomatoes** and **daisies**.

Q22. How does xerophytes and halophytes are adapted to live in dry conditions and high salt concentrations respectively?

Ans.

1. Xerophytes are plants that are adapted to survive in dry conditions.

Adaptations: They have special adaptations to minimize water loss and store water. Plants that store water are known as **succulents**.

- They possess **fleshy stems** that can store water and used when needed.
- Xerophytes include **waxy coatings** on leaves to reduce water loss, leaf dropping during dry periods and leaf folding or repositioning to absorb sunlight efficiently. Examples of xerophytes include **thorn trees, desert marigold, cacti and blue agave**.



Fig: A xerophytic plant (cactus)

2. Halophytes: Halophytes are the plants which inhabit **saline soil** with high concentration of salts like **NaCl, MgCl₂, MgSO₄** or **saline water**. On such a substratum, only those plants can grow which can tolerate a relatively high concentration of these salts.

Adaptations

- These plants have succulent leaves and sometimes the stem is also succulent.
- In certain cases, leaves are modified into spines.
- Examples of halophytes are sea **arrowgrass** and sea **lavender**.

THERMOREGULATION IN PLANTS

Q23. Describe the Physiological adaptation of plants to extreme conditions. How do plants adjust their cell membrane composition and protein structures to survive high and low temperatures?

Ans. Thermoregulation in Plants

Thermoregulation is a homeostatic mechanism in which organisms maintain their internal body temperature despite variations in environmental temperature.

1. High Temperature

High temperature denatures the enzymes and damages the metabolism. Plants use **evaporative cooling** to cope with high temperature.

- Hot and dry weather, however, causes water deficiency resulting in closing of stomata, thus plants suffer in such conditions.
- Most plants have adapted to survive in heat stress as the plants of temperate regions face the stress of **40°C** and higher temperature. The cells of these plants synthesize large quantities of special proteins called **heat-shock proteins**. These proteins **embrace** enzymes and other proteins thus help to prevent their denaturation.

2. Low Temperature

i. Non – Freezing Temperature: Low temperature, alters the **fluidity** of the **cell membrane**, because **lipids** of the membrane become **locked into crystalline structures**, which affects the transport of the solutes. The structure of the membrane proteins is also affected.

- **Adaptations:** Plants respond to cold stress by **increasing** proportion of **unsaturated fatty acids**, which help membrane to maintain structure at low temperature by preventing crystal formation. This adaptation requires time. Because of this reason, rapid chilling of **plants is more stressful** than gradual drop in air temperature.

ii. Freezing temperature

Freezing temperature causes **ice crystal formation**. The confinement of ice formation around cell wall does not affect as badly and plants survive. However, formation of ice crystals within protoplasm perforates membranes and organelles hence killing the cells.

- **Adaptations:** The plants native to cold region such as **oaks, maples, roses** and other plants have adapted to bring changes in **solutes composition** of the cells, which causes cytosol to super cool without ice formation, although ice crystals may form in the cell walls.

MOVEMENTS IN PLANTS

Q24. What are tropic movements in plants? Explain major types of movements in plants?

Ans. Tropic movements

The growth movements in plants that are triggered due to an **external stimulus**, are collectively called **tropic movements** or **tropisms**. Such movements occur as a curvature of whole organ towards or away from stimuli such as light, touch, chemical, water and gravity.

Types: Following are the major types of tropic movements in plants:

1. **Phototropism:** It is the movement of part of plant, in **response to stimulus of light** and is caused by the differential growth of part of a plant like stem or root. The tips of shoots usually show positive phototropism while roots show negative phototropism.
2. **Geotropism:** It is the movement of plant parts in **response to gravity**. Roots display positive geotropism and shoots negative geotropism.
3. **Thigmotropism:** It is the movement in **response to stimulus of touch**, for example climbing vines. When they come in contact with some solid object, the growth on the opposite side of contact increases and the tendril coils around the support.
4. **Chemotropism:** The movement in plants in **response to some chemicals** is called chemotropism. For example, the sugary environment on the stigma of a flower induces pollen tube to grow inside the pistil/carpel to reach the ovule.

PHOTOPERIODISM

Q25. Define photoperiodism. Classify flowering plants according to photoperiodism.

Ans. Photoperiodism

The response to changes in day length that enables plants to adapt to seasonal changes in their environment is termed as **photoperiodism**. Simply, it is response of plants to the length of day and night.

Contribution of Garner and Allard

Effect of photoperiodism was first studied in **1920 by Garner and Allard**. They studied that tobacco plant flowers only after exposure to a series of short days. Tobacco plant naturally flowers under same conditions, in autumn, but flowering could be induced by artificially exposing to short days.

Classification on basis of effect of light period

With further studies they were able to classify flowering plants into **long-day plants**, which require long days for flowering, **short-day plants**, which require short days for flowering and **day-neutral plants** which flower without being influenced by photoperiod.

Effect of Dark Period

Later on, further studies indicated that it is really the **length of the dark period** which is critical. Thus, short-day plants are really long-night plants. If they are grown in short days, but the long night is interrupted by a short light period, flowering is prevented. Long-day plants will flower in short days if the long night period is interrupted.

Classification of plants according to photoperiodic requirements for flowering with examples.

Short-day plants (SDPs)	Long-day plants (LDPs)	Day-neutral plants (DNPs)
Flowering induced by dark periods longer than a critical length, e.g., cocklebur 8.5h; tobacco 10-11h.	Flowering induced by dark periods shorter than a critical length, e.g., henbane 13h.	Flowering independent of photoperiod.
Examples include cocklebur (<i>Xanthium</i>), chrysanthemum, soyabeans, tobacco, strawberry.	Examples include henbane (<i>Hyoscyamus niger</i>), snapdragon, cabbage, spring wheat, spring barley	Examples include cucumber, tomato, garden pea, maize, cotton.

Q26. Explain the role of Phytochrome in flowering.

Ans. Role of Phytochrome in flowering: Phytochrome a photoreceptor protein exists in two forms i.e., P_{660} and P_{730} , P_{660} is a quiescent form. It absorbs red light at a wavelength of 660 nm and is converted to active P_{730} which absorbs **far red light at 730 nm** and is converted to P_{660} .

In nature, the P_{660} to P_{730} conversion takes place in day light and P_{730} to P_{660} conversion occurs in the dark.

The rate at which P_{730} is converted to P_{660} provides the plant with a “clock” for measuring the duration of darkness.

It has been found that red light inhibits flowering in short-day plants but promotes flowering in long-day plants, under conditions during which flowering normally takes place.

This observation led to the hypothesis that the P_{730} to P_{660} interconversion might be the **plant time-regulator** for flowering.

According to this hypothesis, P_{730} , converted from P_{660} by the absorption of red light would inhibit flowering in short day plants but promote flowering in long day plants.

Because P_{730} accumulates in the day and diminishes at night, short day plants could flower only if the night were long enough, during which a great amount of P_{730} would not be completely inactivated, so that enough P_{730} would remain at the end of night to promote flowering.

But now it is generally agreed that the time measuring phenomenon of flowering is not totally controlled by the interconversion of P_{660} to P_{730} .

Role of Florigen in flowering

Other factors, like presence or absence of light and length of dark or light period also play an important role in flowering. The biological clock once stimulated causes production of

florigen hormone in leaves, which travels through phloem to the floral buds, initiating flowering.

VERNALISATION

Q27. What is vernalisation? Describe its significance?

Ans. Vernalisation

The process of induction of flowering in plants by exposing them to certain low (chilling) temperature is called **vernalisation**. It is usually effective in biennial and perennial plants.

Low Temperature

The low temperature stimulus is received by the **shoot apex** of a mature stem or embryo of the seed but not by the leaves as in photoperiodism.

For some plants, vernalisation is an **absolute requirement** while in some cases it simply assists in inducing flowering.

Duration: The duration of low temperature (chilling) treatment required varies from **four days to three months**.

Temperature around **4°C** is found to be very effective in this regard.

Significance

- It stimulates the production of a hormone "**vernalin**" which induces vernalisation.
- Photoperiodism and vernalisation serve to synchronise the reproductive behaviour of plants with their environment, ensuring reproduction at favourable times of year.
- They also ensure that members of the same species flower at the same time, encouraging cross pollination for genetic variability.