Chapter 08 PLANT PHYSIOLOGY

Student Learning Outcomes (SLOs)

After studying this chapter, the students will be able to:

- List the macro and micronutrients of plants highlighting the role of each nutrient.
- State the examples of carnivorous plants.
- Explain the role of stomata and palisade tissue in the exchange of gases in plants.
- Relate transpiration with gas exchange in plants.
- Describe the structure of xylem vessel elements, sieve tube elements, companion cells, tracheids and relate their structures with functions.
- Describe the movement of water between plant cells, and between the cells and their environment in terms of water potential.
- Describe the movement of water through roots in terms of symplast, apoplast and vacuolar pathways.
- Explain the movement of water in xylem through TACT mechanism.
- Describe the mechanisms involved in the opening and closing of stomata.
- Explain the movement of sugars within plants.
- State movement of water into or out of the cell in isotonic, hypotonic, and hypertonic conditions.
- Explain the osmotic adjustments in hydrophytic (marine and freshwater), xerophytic and mesophytic plants and plants in saline soil.
- List the adaptations in plants to cope with low and high temperatures.
- Explain the turgor pressure and its significance in providing support to herbaceous plants.
- Describe the structure of supporting tissues in plants.
- Explain primary and secondary growth in plants.
- Justify the formation of annual rings.
- Explain influence of apical meristem on the growth of lateral shoots.
- Outline the role of important plant growth regulators.
- Explain the types of movement in plants in response to light, force of gravity, touch and chemicals.
- Define photoperiodism.
- Classify plants with examples on the basis of photoperiodism.
- Describe the mechanism of photoperiodism with reference to the mode of action of phytochrome.
- Explain the role of low temperature treatment on flower production especially to biennials and perennials.

NUTRITION IN PLANTS

- **Nutrition:** The collective processes involved in the intake and utilization of nutrients for growth, repair, and maintenance of activities in an organism is called nutrition.
- Organisms require nutrition for their **survival and maintenance.**
- A nutrient is a **substance** that provides the body with essential ingredients required for metabolism.
- Specific nutrients, such as **carbohydrates**, lipids, and proteins, serve as sources of energy. Other nutrients, including water, electrolytes, minerals, and vitamins, are necessary for the metabolic process.

Macronutrients and Micronutrients:

- **Need of Autotrophs:** All autotrophic organisms need carbon dioxide and water, which supply carbon, oxygen and hydrogen. These are the 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.

Check Understanding!
1. Which macronutrient is a key component of ATP and nucleic acids in plants?
A. Nitrogen B. Phosphorus
C. Potassium D. Calcium

- **Division of Plant Nutrients:** The nutrients of plants can be divided into two groups.

(1) Macronutrients:
- The nutrients which are needed in relatively larger amounts are called macronutrients.
- There are nine macronutrients:

(i) Carbon (ii) Hydrogen (iii) Oxygen (iv) Nitrogen
(v) Potassium (vi) Calcium (vii) Phosphorus (viii) Magnesium
(ix) Sulphur

- Carbon, oxygen and hydrogen are required for making organic compounds.

(i) Nitrogen:
- It is necessary for plant growth as it plays an essential role in energy metabolism and the production of proteins.
- A deficiency of nitrogen results in leaf loss and stunted growth.

(ii) Phosphorus:
- It is a part of ATP. It also plays a role in promoting root growth and favours flowering in the aerial zone.
- **Deficiency:** A deficiency of phosphorus leads to delayed flowering, as well as the browning and wrinkling of the leaves.

(iii) Potassium:
- It is involved in water regulation and the transportation of the plant's reserve substances.
- It enhances the ability of plants to carry out photosynthesis, reinforces cellular tissue, and stimulates the uptake of nitrates. Dark patches are formed on the leaves when there is shortage of potassium.

(iv) Calcium:
- It 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.
- **Deficiency Symptoms:** Insufficient calcium leads to the development of yellow and brown patches on the leaves.

(v) Magnesium:
- It 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.
- **Deficiency:** Magnesium deficiencies result in weak stalks, loss of greenness in the oldest leaves, and the appearance of yellow and brown spots.

(vi) Sulfur:
- It is a fundamental element in the metabolism of nitrogen. If there is a shortage of sulfur, the plant becomes lighter in colour.

(2) Micronutrients:
The nutrients which are needed in very smaller amounts are called micronutrients.
- There are **seven micronutrients:**

(i) Iron (ii) Manganese (iii) Zinc (iv) Molybdenum
(v) Copper (vi) Chlorine (vii) Boron

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

(i) Iron:
- It is essential for the synthesis of chlorophyll.
- It acts as a cofactor for several enzymes which are involved in energy oxidative stress in plants under adverse environmental conditions.

(ii) Manganese:
- It is involved in the processes of photosynthesis, nitrogen metabolism, carbohydrate metabolism and activation of enzymes.
- **Deficiency Symptoms:** Its **deficiency** results in the premature falling of the leaf and delayed maturity.

(iii) Zinc:
- It facilitates chlorophyll synthesis, root development and uptake of nutrients.
- **Deficiency Symptoms:** Deficiency of zinc can lead to stunted growth.

(iv) Molybdenum:
- It is critical for nitrogen fixation, nitrogen reduction, sulfur metabolism, phosphorus metabolism and iron utilization.
- **Deficiency Symptoms:** Its **deficiency** can result in chlorosis of older leaves and stunted growth.

- Manganese is important for the activity of antioxidant **enzymes**, such as superoxide dismutase (SOD), which help mitigate **transfer and** nitrogen metabolism. Its deficiency results in interveinal chlorosis.

(v) Copper:
- It 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 Symptoms:** Its **deficiency** can result in chlorosis, twisted leaves and stunted growth.

(vi) Chlorine:
- It is involved in stomatal regulation, osmotic adjustment and transport of nutrients.
- **Deficiency Symptoms:** Its deficiency can affect the health and growth of plants.

Check Understanding!
2. Why is zinc important for plant hormone regulation?

Q. What mechanisms enable carnivorous plants to supplement their nutrient uptake despite being autotrophs? **(Exercise Inquisitive Questions 2)**

Nutrition in Insectivorous Plants:

- Some plants use organic molecules into their food in addition to **inorganic nutrients**. These organic chemicals are acquired through the process of **capturing and breaking down** insects and tiny animals.
- **Characteristics of 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.
- **Examples:** Pitcher plant, Venus fly trap and sundew are some of the known insectivorous plants.

(i) Pitcher Plant: It has leaves modified into a sac or a pitcher, partly filled with water (Fig).
- 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.

Figure: Pitcher plant, insects are entrapped within the leaf.

(ii) Venus-fly Trap:

- It 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 (Fig.).
- 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.

> **Check Understanding!**
> 3. What type of trap is used by the Venus flytrap to capture its prey?
> A. Sticky trap B. Snap trap
> C. Pitfall trap D. Bladder trap

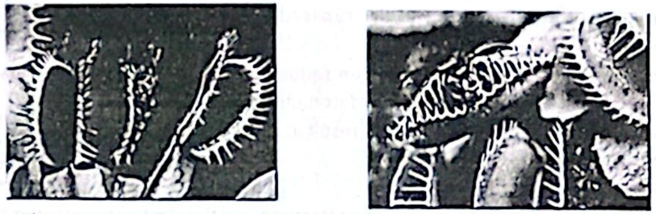


Figure: Venus-fly trap, prey is trapped between the lobes of a leaf.

(iii) Sundew:

- It catches its prey with shiny **drops of "dew,"** where the plant's common name comes from (Fig.) 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.

Figure: Sundew, insects are entangled by the tentacles.

GAS EXCHANGELN PLANTS

- **Stomata (Singular = Stoma):** The tiny openings or **pores** present within the plant tissues which are necessary for gaseous exchange.
- **Location of Stomata:** These are typically found in **leaves** but can even be present in some stems.
- **Structure of Stomata:** The stomata are surrounded by **specialized cells or the guard cells** that facilitate the opening and closing of the stomatal pores. Guard cells are bean-shaped and contain chloroplasts.
- Guard cells can open and close depending on environmental conditions use the opening and closing of stomata control the transpiration rate in plants.

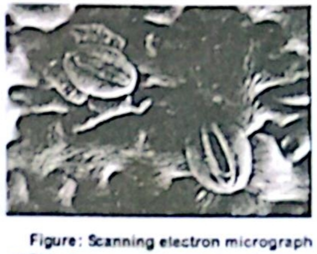


Figure: Scanning electron micrograph (SEM) of open and closed stomata on a lavender leaf

- **During Daylight:** During daylight, stomata open to allow CO_2 to enter the plant for photosynthesis. The opening of stomata is primarily regulated by guard cells.
- **During Night:** 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.

> **Check Understanding!**
> 4. How does gas exchange occur in plants during the daytime?

Q. Describe the mechanism of opening and closing of stomata? (Exercise L.Q.4)

Q. Can you explain the hypothesis regarding the opening and closing of stomata? (Exercise Inquisitive Questions 1)

Opening and Closing of Stomata:

- The guard cells which surround the stomata function as multisensory hydraulic valves (Fig.).
- **Hypotheses Explain Opening and Closing of Stomata:**
- The two hypotheses which may explain the opening and closing of stomata:
  (I) Starch Sugar Hypothesis (ii) Influx of K^+ ion

(I) 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.

(ii) Influx of K^+ ion:

- 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. **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.

- **Palisade Tissue:** It 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.
- **Diffusion of CO² into Leaves:** 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 exits the leaf through the stomata.

- 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.

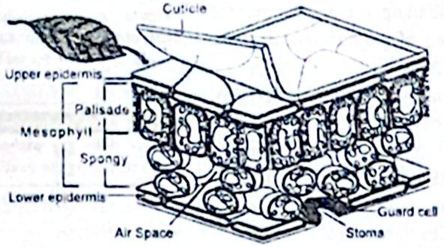


Figure:Structure of a leaf showing cuticle, epidermis, palisade mesophyll, spongy mesophyll, guard cells and stoma.

Check Understanding!

5. Which supportive tissue consists of dead cells with thick, lignified walls?
A. Parenchyma B. Collenchyma
C. Sclerenchyma D. Phloem

SUPPORT IN PLANTS

Q. How can you say that parenchyma and schlerenchyma provide support to plants?
(Exercise Inquisitive Question)

- Supporting tissues play an important role in maintaining the structural integrity, support and flexibility of plants. These tissues consist:
  (i) Parenchyma (ii) Collenchyma (iii) Sclerenchyma (v) 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.
- 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 when the concentration within is higher than that of the surrounding fluid. Due to 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 grows lengthwise.
- They provide support to the young parts of plant in which secondary growth has not taken place.

(3) Sclerenchyma:

- This tissue also 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 confers 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.
- **Types of Cells Present in Sclerenchyma:** There are three types of sclerenchyma cells which are:
  (i) Fibres (ii) Sclereids (iii) Vessels

(i) **Fibers (Tracheids):** These are elongated and cylindrical in shape. They can be found either **as compact** bundles inside the xylem or as bundle caps.

(ii) **Sclereids:** These 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):** They are long tubular structures that are joined end to end to form a long water conducting pipe in xylem.

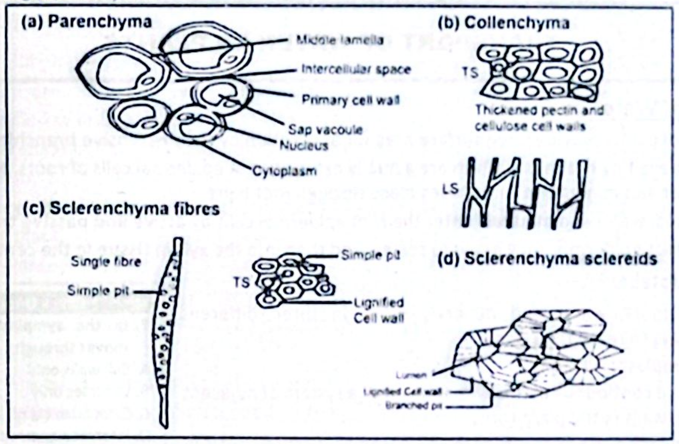


Figure:Specialized plant cells; (a) Parenchyma (b) Collenchyma (c) Sclerenchyma

WATER POTENTIAL

- **Kinetic Energy in Water Molecules:**
- 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).

Check Understanding!

6. How does solute potential affect water movement?

- **In plant cells,** two factors **determine** water potential:
  (i) Solute potential (Ψ_s) (ii) Pressure potential (ΨP)

➤ **Factors Determine Water Potential in Plants:**

- 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 osmosiscan 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.

(i) Solute Potential (Ψs):

- A measure of the change in water potential (Ψ_W) of a system due to the presence of solute molecules is called solute potential.
- Ψ_s is always a **negative value,** so if more solute molecules are present, lower **(more negative)** is the Ψ.

(ii) Pressure Potential (Ψ):

- A part of water potential due to the **pressure exerted** by water is called pressure potential.
- 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 built up inside the cell making the cell turgid and increasing the pressure potential.

- **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 LN PLANTS

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.

Steps of Uptake:

- Inside roots, water and minerals move in three different pathways to reach the xylem.

Check Understanding!

7. In the symplast pathway, water moves through:
A. Cell walls only
B. Vacuoles only
C. Cytoplasm via plasmodesmata
D. Intercellular air spaces

(i) The Apoplast Pathway:

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

(ii) 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.
- Limitations the symplast pathway is less important, except for minerals in the region of endodermis

(iii) 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.
- Limitation movement in vacuolar pathway is **negligible.**

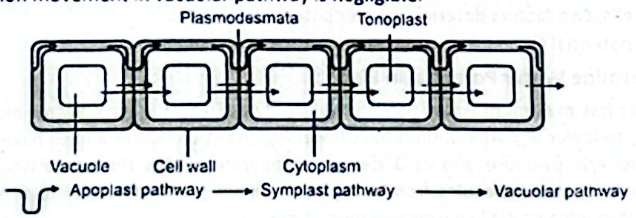


Figure: Water movement through apoplast, symplast and vacoular pathways.

Structure of Xylem Tissue:

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

Check Understanding!

8. What is the function of xylem fibers?

Types of Cells Present in Xylem:

Xylem comprises of tracheids, vessels, xylem fibres and xylem parenchyma (Fig.).

(i) Tracheids:

- They 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.

(ii) Vessels:

- They 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.

(iii) Xylem Fibres:

- They 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.

(iv) Xylem Parenchyma:

- These 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.

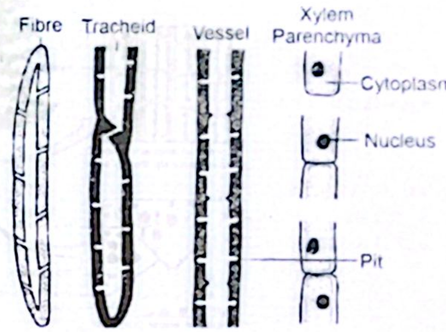


Figure: Different components of xylem tissue

The Movement of Water through Xylem:

- **The movement of water within plants,** from roots to leaves, occurs **primarily** through specialized vascular tissue known as xylem.
- The **TACT (Transpiration, Adhesion, Cohesion, Tension)** mechanism 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.
- **Transpiration:** It 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 toward the leaves.
- Transpiration, therefore, act as the primary driving force behind water transport in the xylem.
- **Adhesion:** It 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 play a crucial role in maintaining the continuity of the water column, especially in tall plants where gravity exerts a significant downward force on the water column.

- **Cohesion:** It 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.

Check Understanding!

9. What is the role of companion cells in phloem tissue?
A. Conducting water
B. Supporting sieve tubes with metabolic activities
C. Providing structural support
D. Storing food

- **Tension:** It 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.

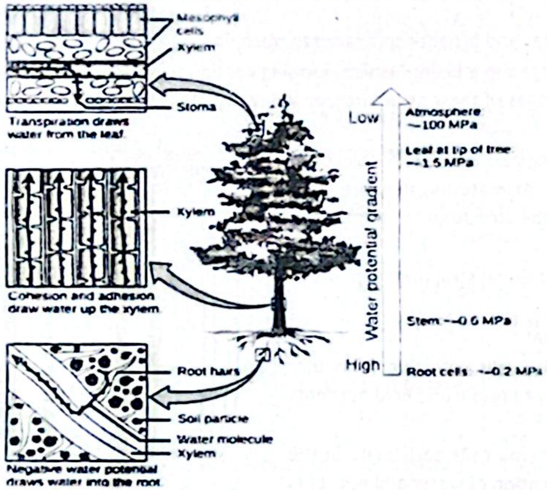


Figure:The TACT mechanism of water flow from root to leaf.

TRANSLOCATION OF FOOD IN PLANTS

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.
- **Location of Phloem:** 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**.

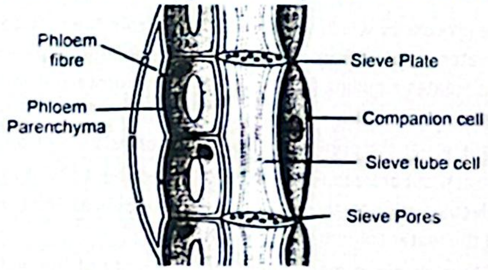


Figure:Different components of phloem tissue.

Types of Cells of Phloem:

- Phloem comprises of:
  (i) Sieve Elements (ii) Companion Cells
  (iii) Phloem Fibres (iv) Phloem parenchyma

Check Understanding!

10. What is the Pressure Flow Theory?

- 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** wall where pores interconnect the sieve tube elements. 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 tubes.
- 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.
- **Phloem parenchyma** stores substances, such as sugars, resins, latex, and mucilage, which are important for plant defence and moisture retention.

Q. **How does Pressure Flow Theory explain the movement of sugars through a plant?** (Exercise Inquisitive Question 5)

Mechanism of Translocation:

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

(i) **Diffusion:** It 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** so it is not practically justified.

(ii) **Pressure flow theory:** This theory was proposed by Ernst Munch in 1930.

- 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 relies on the principle of osmotic pressure differences between source and sink regions.

Steps Explain Pressure Flow Theory:

Following steps explain the pressure-flow theory.

(I) **Glucose Converted into Sucrose:** 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.

(II) 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.

(III) **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.

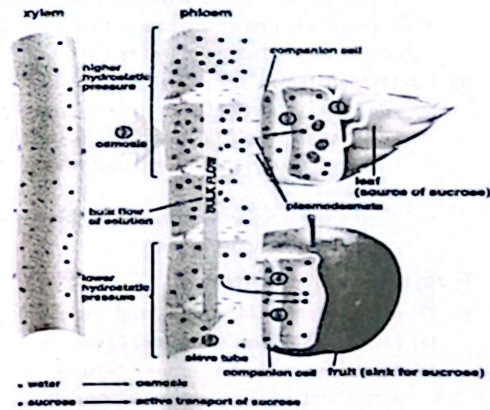


Figure: The pressure-flow theory

(iv) **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.

(v) 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

Q. What is the role of meristem in the growth of plants? (Exercise LQ)

- The **permanent increase** in cell size, which can occur in various dimensions such as height, width, and mass is called growth.
- 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.
- **In Lower Plants:** The entire plant body is capable of growing in **higher plants**.
- Growth is limited to certain regions known as growing points.
- **Meristems:** The growing points consist of groups of cells, called meristems, that are capable of **continuous cell division.**

> **Check Understanding!**
> **11. Which meristem is responsible for primary growth in plants?**
> A. Lateral meristem
> B. Apical meristem
> C. Intercalary meristem
> D. Cork cambium

Types of Meristems:

- There are **three types of meristems** in plants:
  (a) Apical Meristems (b) Intercalary Meristems (c) Lateral meristems

(a) Apical meristems: They are found at the tips of roots **and shoots**.
- They are primarily responsible for the extension of the plant body.
- These are perpetual 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.

(b) Intercalary Meristems:
- They 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.

(c) Lateral Meristems:
- They 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.

Types of Lateral Meristem:

- There are two main forms **of lateral meristems:**
  (a) Vascular Cambium (b) Cork Cambium
  (a) Vascular cambium is located between the **xylem** and **phloem** and is responsible for production of secondary xylem and secondary **phloem.**
  (b) 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.

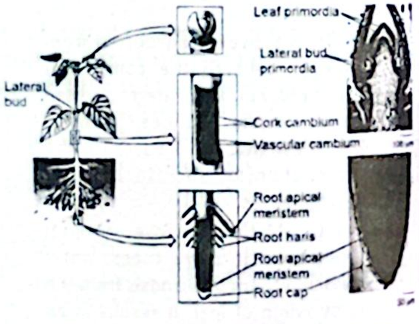


Figure: Apical meristem produces the primary plant body and lateral meristem produces the secondary plant body.

Types of Growth:

- In plants, there are two types of growth i.e., primary growth and secondary growth (Fig.).

(a) 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.

> **Check Understanding!**
> **12. What is cell differentiation and why is it important?**

Phases of Primary Growth:

- The process of **primary growth** in plants occurs in **three phases.**

(i) Cell Division:
- The cells of apical meristems **undergo divisions** 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.

(ii) 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.

(iii) 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. This area is called zone of cell differentiation. In this zone, cells are fully differentiated and each type of cell performs specific function.

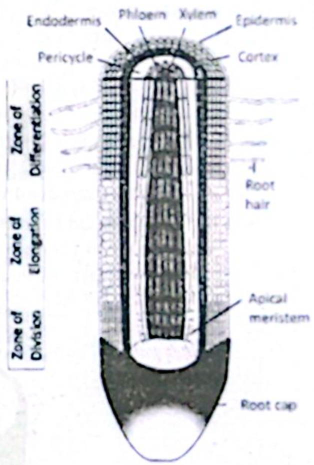


Figure: Primary growth in a root

(b) Secondary Growth:
- The **increase** in thickness or girth of **stems and roots** of plants is called secondary growth.
- 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.**
- 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 cork. The region of mature stem outside of the vascular cambium, which contains secondary phloem, cork cambium and cork, is collectively called bark.

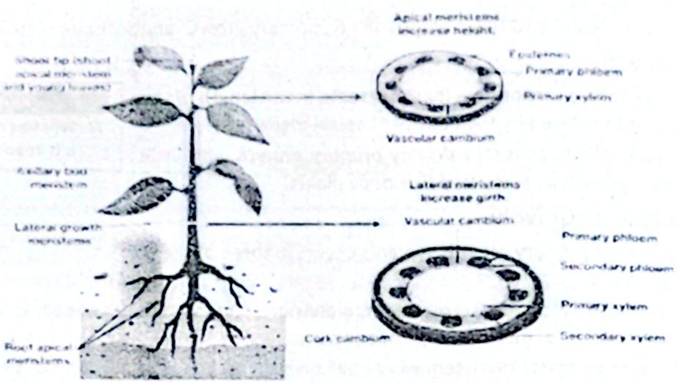


Figure: Primary and secondary growth in a plant.

Q. How do the annual rings depict climatic variability? **[Exercise Inquisitive Question]**

- **Annual Ring Formation:** 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:
  (a) Spring wood (early wood) (b) Autumn wood (late wood)
- These rings provide valuable information about the age of the tree and the environmental conditions experienced during each growing season.
- The cambium is a **meristematic tissue** that generates new vascular tissues i.e., xylem and phloem. 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. 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.

> **Check Understanding!**
> 13. Annual rings in a tree trunk are formed as a result of:
> A. Apical meristem activity
> B. Intercalary meristem activity
> C. Seasonal variations in secondary growth
> D. Cell elongation

> - **Dendrochronology** is the scientific method of dating and studying tree rings to analyse past climate conditions and events.

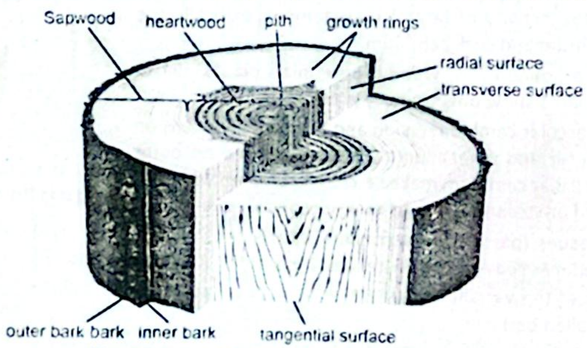


Figure: Anatomy of a tree trunk showing annual rings

Plant Growth Regulators:

- The chemicals in plants which regulate the rates of growth and the rate of metabolism in their cells are called growth regulators. Special chemical messengers, called plant growth regulators or plant hormones regulate their growth.

Types of Plant Growth Regulators:

- There are five major groups of plant growth regulators.
  (i) Growth Promoters: (a) Auxins (b) Cytokinins (c) Gibberellins
  (ii) Growth Inhibitors: (a) Abscisic Acid (b) Ethylene

> **Check Understanding!**
> 14. How do gibberellins affect seed germination?

(a) Auxins:

- These are indole acetie acid (IAA) or its variants.
- These regulate following activities:
  - 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.

(b) Gibberellin:

- Gibberellins are produced in the apical portions of roots and shots, and transported to other parts. Gibberellins contain Gibberellic acid and there are more than **110** different gibberellins.
- They preform following activities:
  - 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 **longday plants**, while inhibit in short-day plants.
  - Cause delay in leaf senescence in a few species.

(c) 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.
- 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.

> **Check Understanding!**
> 15. Which of the following acts as a growth inhibitor and promotes seed dormancy?
> A. Gibberellin B. Ethylene
> C. Cytokinin D. Abscisic acid

Growth Inhibitors:

(a) Abscisic Acid (b) Ethylene

(a) Abscisic acid:

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

(b) Ethylene:

- It is a natural product of the metabolism of plants. Inhibits stem growth, notably during physiological stress.
  - Inhibits root growth.
  - Breaks dormancy of bud.
  - Promotes flowering in pineapple.
  - Promotes fruit ripening.

OSMOREGULATION IN PLANTS

- 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:

(i) **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.**

(ii) **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.**

(iii) **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.

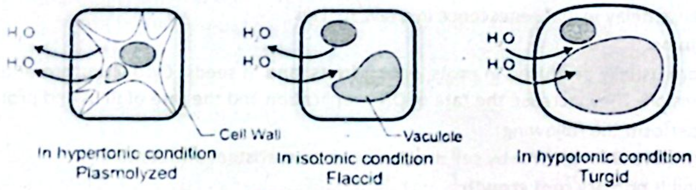


Figure : Effect of Hypertonic, Hypotonic and Isotonic solution to plant cell.

Q. Describe osmoregulation in Hydrophytes and Halophytes? **(Exercise LQ1)**

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.

(i) **Hydrophytes:**

- They are adapted to aquatic environments, including marine and freshwater ecosystems, through specialized osmotic adjustment mechanisms.

(ii) **Marine Hydrophytes:**

- They thrive in saline (hypertonic) conditions, where water tends to leave their cells.
- They excrete excess salts using specialized salt glands and synthesize organic 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.

> **Check Understanding!**
> 16. Describe the process of plasmolysis in plant cells.

(iii) **Freshwater Hydrophytes:**

- They grow in hypotonic environments, where water continuously enters their cells. These plants expel excess water through structures like hydathodes or vacuoles to avoid overhydration.
- 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:** Water lilies, lotus, seaweeds and tape grass (Fig).

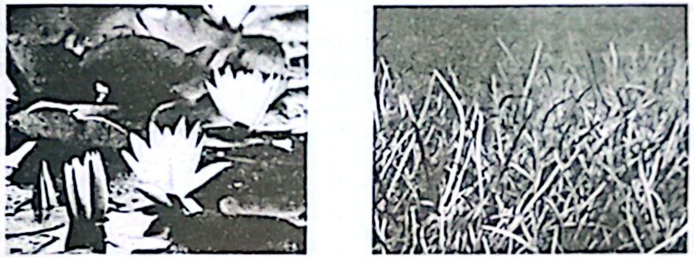


Figure: (a) Waterlily floating in freshwater. (b) Tape grass in freshwater lake.

(i) **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 (Fig.).

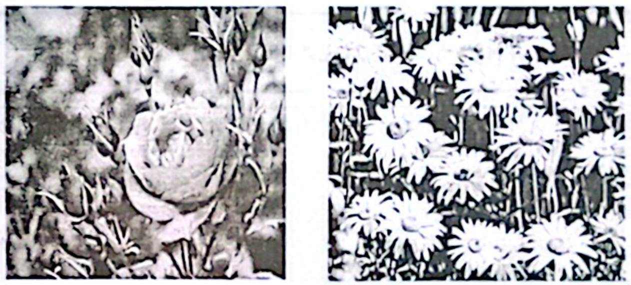


Figure: Examples of mesophytes, left (rose) and right (daisy).

(ii) **Xerophytes:**

- These are plants that are adapted to survive in dry conditions. 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.

- Other adaptations in 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:** Thorn trees, desert marigold, and blue agave (Fig.).

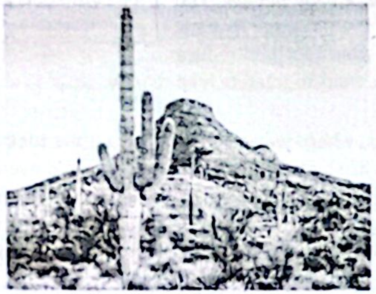


Figure: A xerophytic plant

Check Understanding!

17. In freshwater hydrophytes, osmotic pressure inside cells is regulated by:

A. Stomatal closure
B. Active absorption of salts
C. Removal of excess water by vacuoles
D. Constant water influx balanced by excretion

(iii) Halophytes:

- They inhabit saline soil with high concentrations of salts like NaCl, $MgCl_2$, $MgSO_4$, or saline water.
- On such a substratum, only such plants can grow which can tolerate a relatively high concentration of these salts.
- These plants have succulent leaves and sometimes the stem is also succulent. In certain cases, leaves are modified into spines.
- **Examples:** Sea arrow grass and sea lavender.

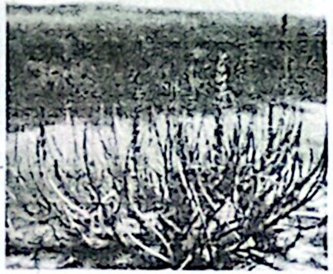


Figure: Sea Arrowgrass

- Halophytes growing in marshy places near seashore form a special vegetation known as the mangrove or tidal woodland. These are also called Helophilous halophytes.

THERMOREGULATION IN PLANTS

Q. 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? (Exercise LQ)

- Thermoregulation is a **homeostasis in which organisms maintain their body temperature** despite variations in environmental temperature.
- **Effect of High Temperature: It denatures the enzymes and damages the metabolism.**

➢ **Adaptation to Cope High Temperature:**

- 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.

- **Effect of Low Temperature:** It 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 of Coe Low Temperature:**

- 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.
- 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.
- 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

- Organisms react to both external and internal stimuli. Animals may exhibit locomotion in reaction to stimuli but the plants are fixed, hence they can only alter their growth pattern.

➢ **Tropic Movements:**

- The growth movements in plants that are triggered by a 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.**
- Following are the major types of tropic movements in plants:

Check Understanding!

18. What are the effects of high temperature on plant cells?

(i) 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.

(ii) Geotropism:

- It is the movement of plant parts in response to gravity.
- Roots display positive geotropism and shoots negative geotropism.

(iii) 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.

(iv) Chemotropism:

- The movement in response to some chemicals is called chemotropism. The hyphae of fungi are chemotropic.

PHOTOPERIODISM

Q. Explain the concept of photoperiodism and its influence on plant flowering. How do short-day, long-day and day-neutral plants differ in their flowering responses, and what role does phytochrome plays in this process? (Exercise LQ 5)

➲ **Photoperiodism**

- The response of plants to **relative length of day and night** is called photoperiodism.
- Apart from photosynthesis and phototropic responses, another very important way in which light shows its effect on plants is through variations in day length called **photoperiod.**

(i) Effect of Photoperiod And Temperature on Plants on Plants:

- In plants, photoperiod and temperature affect:
  (a) Flowering
  (b) Fruit and seed production
  (c) Bud and seed dormancy
  (d) Leaf fall and germination, Photoperiod affects flowering, when shoot meristems starts producing floral buds instead of leaves and lateral buds.

> **Check Understanding!**
> **19. Photoperiodism is the response of plants to:**
> A. Light intensity
> B. Duration of light and dark
> C. Temperature fluctuations
> D. Humidity levels

(ii) Work of Garner And Allard on Photoperiodism:

- The phenomenon of photoperiodism was first of all **observed** in **1920 by Garner and Allard**.
- They studied that **tobacco plant produces** flowers only after exposure to a **series of short days**.
- Tobacco plant naturally produces flowers under **same conditions, in autumn**, but flowering could be induced artificially to **short days exposing**.
- With further studies they are able to classify flowering plants in two main groups:
  (i) Long-Day Plants: Which **require long** days for flowering.
  (ii) Day-Neutral Plants: That flower without being Influenced by **photoperiod.**

(iii) Effect of Quantity of light on Flowering:

- 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.**

> **Critical Length**
> - The minimum length of day or light to induce flowering.

(iv) Effect of Quality of Light on Flowering:

- Further experimentation also revealed that **quantity of light** is also influenced by the **quality of light.**
- **Cocklebur** a short day plant, will not flower if its **long night** is interrupted but experiments showed that **red light** was **effective in preventing** flowering but **far-red light** reversed (Stimulate Flowering) the effect of red light.

Last Light Exposure is Important:

- It was also demonstrated that the last light treatment always determines the response. This response to light intensity and **quality leads** to the discovery of a blue light sensitive protein pigments, **the phytochromes.**

> **Check Understanding!**
> **20. How does phytochrome control photoperiodism?**

➤ **Classification of Plants According to Photoperiodic Requirements for Flowering.**

(i) Short day plants (SDP's)	• Flowering induced by **dark periods longer than a critical length,** e.g., cockelbur 8.5 h; tobacco 10-11h. (under natural conditions equivalent to days **shorter than a critical length** e.g., cocklebur 15.5 h; tobacco 13-14h)	• **Examples:** cocklebur (Xanthium), chrysanthemum, soyabean, tobacco, strawberry
(ii) Long day plants (LDP's)	• Flowering induced by dark periods **shorter than a critical length,** e.g., henbane 13h. (Under natural conditions equivalent to days **longer than a critical** length, e.g. henbane 11h).	• **Examples:** henbane (Hyoscyamus niger), snapdragon cabbage, spring wheat spring barley.
(iii) Day-neutral plants (DNP's)	• Flowering independent of photoperiod.	• **Examples:** cucumber, tomato, garden pea maize, cotton

➤ **Some Phytochrome-Controlled Responses in Plants**

General purpose effected	Red light promotes
(i) Germination	• Germination of some seeds, e.g. some lettuce varieties. • Germination of **fern spores.**
(ii) Photomorphogenesis (light-controlled development of form and structure)	• Leaf **expansion** in dicotyledons • Leaf **unrolling** in grasses (monocotyledons) • **Chloroplast development** • **Greening** (protochlorophyll converted to chlorophyl) • Inhibition of **internode growth** (including epicotyl, hypocotyls, mesocotyl), i.e. preventing of etiolation. • **Unhooking** of plumule in dicotyledons.
(iii) Photoperiodism	• Stimulates **flowering** in long day plants • **Inhibits** flowering in short day plants

➤ **Role of Phytochromes in Flowering:**

- A blue light snsitive system of plants is a **protein pigment** found in leaves known as **phytochrome.**
- Phytochrome exists in two forms i.e. P_{660} **and** P_{730}.

➤ **Inactive or Quiscent Form of Phytochromes:**

- P_{660} **a quiscent** form absorbs **red light** at a **wave length** of 660 nm and is converted to active P_{730}.

> **Check Understanding!**
> **21. The optimal temperature for vernalization in many plants is around:**
> A. 25°C B. 0°C
> C. 4°C D. 10°C

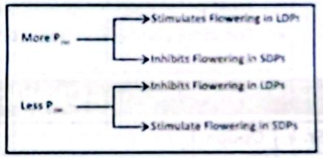
➤ **Active Form of Phytochromes:**

- P_{730} 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.
- **Day Light: (Red Light)** Day light contains more red-light.
- Thus during the day a plant has P_{730} **phytochromes.**
- Night: (Far- Red Light) Night contains more far-red light.
- While during the night it contains more phytochromes in the form of P_{660}.

> P_{730} کا دن کے وقت بننا: لمبے دنوں میں P_{730} زیادہ بنیں گے
> کیونکہ دن کے وقت P_{660} والے فائٹو کروم 660nm کی ریڈ
> لائٹ جذب کرتے ہیں اور P_{730} میں تبدیل ہوتے جائیں گے۔
> اس لیے دن جتنا لمبا ہو گا P_{730} اتنے ہی زیادہ بنیں گے۔ اور دن
> جتنا چھوٹا ہو گا P_{730} اتنے کم بنیں گے۔

➤ **Inter Conversion of P_{660} And P_{730} Acts As Internal Clock of Plants:**

- The presence of P_{660} **and** P_{730} form of phytochrome helps the plants with a means of detecting whether it is light or dark environment. The rate at which P_{730} is converted to P_{660} provides the plant with a "clock" for measuring the duration of darkness.

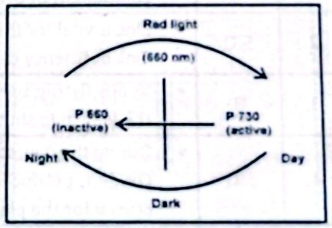


➤ **Role of Red Light in Flowering:**

- Red light inhibits flowering in the short day plants (SDPs) but promotes flowering in long day plants (LDPs), under suitable conditions.

➤ **Hypothesis of Interconversion of $P_{730} - P_{660}$:**

- This observation (role of red light in flowering) led to hypothesize that the P_{730}-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 (more during day light),** would inhibit **flowering in short** day plants but **promote flowering** in long day plant.



- **Reason:** Because P_{730} **accumulates** in the day and diminishes **at night**, thus short day plants could flower only if the night were **long enough**. Because of short days there will be **less no. of** P_{730} so no flowering is **produced in SDPs.**
- **During short night** a great amount of P_{730} **would not** be completely **inactivated** so the **enough** P_{730} **remain** at the **end of the night** to promote flowering in **long day plants**. (See box to relate the concept)

➢ **Actual Time Measuring Phenomenon in Plant:**

- 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}.
- Other factors like presence or **absence of light** and **length of dark** or **light period** also play an important role in **flowering**.
- Phytochromes seem to be **responsible** for the detection of **either light or darkness**.
- **Florigen:** The biological clock once **stimulated** causes production of florigen hormone in leaves, which travel through phloem to the floral buds, **initiating flowering.**

VERNALISATION

- **Biennial** and **perennial** plants are stimulated to produce flower by exposure to low temperature. This phenomenon is known as **Vernalisation.**

➢ **Mechanism:**

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

➢ **Low Temperature Requirement:**

- The duration of low temperature (chilling) treatment required **varies from four days to three** months. **(4 Days to 3 Months)**
- **Temperature around 4°C** is found to be **very effective**. It stimulates the production of **"Vernalin"** hormone. This hormone induces **Vernalisation.** It is now believed that vernalin is nothing special but actually it is **Gibberellin.**

> **Check Understanding!**
> **22. Why is 4°C significant in vernalization?**

➢ **Advantage of Vernalisation:**

- Photoperiodism and vernalisation serve to synchronise (working in combination) the reproductive behaviour of plants with their environment, ensuring reproduction at favourable times of years.
- They also ensure that members of the **same species produce flower at the same time,** encouraging cross pollination for genetic-variability.
- For some plants, **Vernalization** is an **absolute requirement** but in some plants it simply helps in inducing flowering.

Check Understanding (Solutions)

Sr. #	Option	Explanation
1.	B	• Phosphorus is essential for energy transfer as it forms part of ATP, and it's also a structural component of DNA and RNA.
2.	S.Q	• Zinc is vital for the synthesis of auxins, which regulate growth and development in plants. Zinc deficiency can lead to stunted growth and malformed leaves.
3.	B	• Venus flytrap uses a snap trap mechanism. When trigger hairs are touched, the lobes of the leaf snap shut quickly, trapping the insect inside.
4.	S.Q	• During the day, stomata remain open to allow carbon dioxide to enter for photosynthesis. Oxygen, produced as a by-product, exits through the same openings. This exchange is crucial for the plant's survival.
5.	C	• Sclerenchyma cells are dead at maturity and have very thick, lignin-reinforced walls, making them ideal for rigid support in mature parts of the plant.
6.	S.Q	• Solute potential is always negative and lowers the water potential of a solution. The more solutes present, the more negative the Ψs, causing water to move into the solution by osmosis.
7.	C	• In the symplast pathway, water enters cells and moves from cell to cell through plasmodesmata, which are cytoplasmic connections between plant cells.
8.	S.Q	• Xylem fibers are thick-walled, lignified cells that provide mechanical strength and support to the plant stem but do not participate in water conduction.
9.	B	• Companion cells are living and closely associated with sieve tube elements. They help load and unload sugars and maintain the metabolic functions of sieve tubes, which lack nuclei.
10.	S.Q	• The pressure flow theory explains how food moves from sources (like leaves) to sinks (like roots or fruits) under pressure differences. Sugars are actively loaded into sieve tubes, drawing in water and generating high pressure for flow.
11.	B	• Apical meristem is found at the tips of roots and shoots. It is responsible for primary growth, which results in the elongation of the plant.
12.	S.Q	• Cell differentiation is the process by which unspecialized cells become specialized in structure and function. It allows the formation of different tissues like vascular, ground, and dermal tissues necessary for plant function.
13.	C	• Annual rings form due to alternate production of spring wood and autumn wood by the vascular cambium during different seasons, reflecting yearly growth cycles.
14.	S.Q	• Gibberellins trigger germination by stimulating the production of hydrolytic enzymes, which break down stored food in the seed, especially starch, providing energy for the growing embryo.
15.	D	• ABA (abscisic acid) is a stress hormone that inhibits growth, promotes seed dormancy, and helps plants respond to drought by closing stomata.
16.	S.Q	• Plasmolysis occurs when a plant cell is placed in a hypertonic solution. Water leaves the cell, the cytoplasm shrinks, and the plasma membrane pulls away from the cell wall, often leading to cell death.
17.	D	• Freshwater hydrophytes deal with a hypotonic environment, so they continuously absorb water, which is removed by vacuoles or specialized structures to prevent bursting.
18.	S.Q	• High temperatures can cause protein denaturation, damage to cell membranes, increased respiration, and impaired photosynthesis, ultimately leading to wilting or death if prolonged.
19.	B	• Photoperiodism is a plant's response to the length of day and night, not the light's intensity. It affects flowering, dormancy, and other developmental processes.
20.	S.Q	• Phytochrome exists in two interconvertible forms: Pr (red-absorbing) and Pfr (far-red absorbing). The ratio of these forms helps plants detect night length and regulate flowering accordingly.
21.	C	• Vernalization typically occurs at around 4°C, which is cold enough to trigger flowering responses in cold-requiring plants without causing freezing damage.
22.	S.Q	• 4°C is considered the optimal temperature for vernalization in many plants. At this temperature, the cold stimulus is strong enough to activate physiological changes without causing cold injury.

Exercise

Exercise **MULTIPLE CHOICE QUESTIONS (MCQs)** Section 01

1. **Process by which water evaporates from surface of leaf primarily through stomata:**
   (a) Transpiration (b) Guttation (c) Imbibition (d) Cohesion
2. **Through which structure does most of transpiration occurs?**
   (a) Root hairs (b) Phloem (c) Xylem (d) Stomata
3. **The TACT theory primarily explains**
   (a) The movement of nutrients in the plants (b) The transport of water in plants
   (c) The absorption of minerals (d) The process of photosynthesis
4. **Which of the following is not a function of xylem?**
   (a) Transport of water (b) Transport of minerals (c) Transport of food (d) Mechanical support
5. **Which of the following has a perforated cell wall?**
   (a) Vessel (b) Fibre (c) Tracheid (d) Sclereid
6. **Exposure to low temperature stimulates the process of flowering in biennial or perennial plants:**
   (a) Dormancy (b) Photoperiodism (c) Vernalization (d) All of above
7. **Plants that are adapted to survive in dry conditions:**
   (a) Xerophhytes (b) Hydrophytes (c) Mesophytes (d) Halophytes
8. **When sugar content in a cell increases the concentration of solute increases, what happens to the water potential?**
   (a) Raises (b) Drops (c) Unchanged (d) None of these
9. **In higher plant, transport of food materials occurs through;**
   (a) Companion cells (b) Sieve tubes (c) Vessel elements (d) Tracheids
10. **The plant hormone which inhibits the stem and root growth Is:**
    (a) Auxin (b) Ethylene (c) Cytokinin (d) Gibberellin
11. **The leaves of some hydrophyte float on the surface of water. In such a leaf, stomata are found in:**
    (a) Lower epidermis (b) Upper epidermis (c) Sides of leaf (d) Deep depressions in leaf
12. **Mesophytes are adapted to survive in:**
    (a) Moderate environments (b) Dry conditions
    (c) Water environments (d) All of above

Answer Key with Explanations

Sr.No.	Option	Answer	Explanations
1.	(a)	Transpiration.	• Transpiration is the process by which water is transported through a plant, from the roots to the leaves, and is then released into the air as water vapor. This occurs mainly through the stomata on the surface of the leaves.
2.	(d)	Stomata	• Stomata are small openings on the surface of leaves that allow for gas exchange, including the release of water vapor into the air. Most transpiration occurs through these stomata.
3.	(b)	The transport of water in plants.	• The TACT theory (Tension, Adhesion, Cohesion, Transpiration) explains how water is transported up a plant stem, from the roots to the leaves, against gravity.
4.	(c)	Transport of food	• Xylem is responsible for transporting water and minerals from the roots to the leaves, as well as providing mechanical support to the plant. However, it is not involved in the transport of food, which is carried by the phloem.
5.	(c)	Tracheid	• Tracheids are a type of xylem cell that have perforated cell walls, allowing for the passage of water and minerals.
6.	(c)	Vernalization	• Vernalization is the process by which exposure to low temperatures stimulates flowering in certain plants, such as biennials and perennials.
7.	(c)	Xerophytes	• Xerophytes are plants that have adapted to survive in dry conditions, often with specialized features such as thick cuticles or deep roots.
8.	(b)	Drops	• As the concentration of solutes increases, the water potential decreases, making it more negative. This is because the presence of solutes reduces the amount of free water available
9.	(b)	Sieve tubes	• Sieve tubes are specialized cells in the phloem that are responsible for transporting food materials, such as sugars and amino acids, throughout the plant.
10.	(b)	Ethylene	• Ethylene is a plant hormone that can inhibit stem and root growth, among other effects.
11.	(b)	Upper epidermis	• In floating leaves of hydrophytes, stomata are often found on the upper epidermis, allowing for gas exchange with the air.
12.	(a)	Moderate environments	• Mesophytes are plants that are adapted to survive in moderate environments, with neither extreme dryness nor wetness.

Exercise **SHORT ANSWER QUESTIONS** Section 02

Q.1 Differentiate between macronutrients and micronutrients?

Ans.

Macronutrients	micronutrients
• Macronutrients are required in larger quantities for plant growth.	• Micronutrients are required in smaller amounts but are still crucial.
• Examples include nitrogen, phosphorus, and potassium.	• Examples include iron, zinc, and boron.

Q.2 What is water potential?

Ans. Water Potential:

- Water potential measures the energy status of water, which makes the water molecules to move from higher to lower concentration.
- Influenced by solute concentration, pressure, and gravity.
- Water moves from high to low water potential.

Q.3 What are the main three pathways for the movement of water between plant cells?

Ans. (i) The Apoplast Pathway:

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

(ii) 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.
- **Limitations:** The symplast pathway is less important, except for minerals in the region of endodermis.

(iii) 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.
- **Limitation:** Movement in vacuolar pathway is **negligible**.

Q.4 Differentiate between hypertonic and hypotonic solution?

Ans.

Hypertonic	Hypotonic
• The more concentrated external environment compared to the cell concentration is termed as hypertonic environment. • The hypertonic environment causes cell solution concentrated and shrink the cell **due to loss of water**. • This condition is also harmful for cell.	• If the external environment has lower solutes conc. compared to the internal cell concentration, it is known as the **hypotonic environment**. • The hypotonic environment osmotically causes entry of water into the cell and diluted the **cell solutions**. • The cell in hypotonic environment becomes turgid due to gain of water. Thus it may be harmed.

Q.5 What are halophytes?

Ans. Halophytes:

- Plants which grow in high salt concentrations.
- Found in coastal or saline environments.
- Specialized mechanisms to tolerate or exclude salt.

Q.6 Differentiate between long day plants and short day plants?

Ans.

Long Day Plants	Short Day Plants
• **Flowering induced by dark periods shorter than a critical length, e.g., henbane 13h. (Under natural conditions equivalent to days longer than a critical length, e.g. henbane 11h).** • **Examples:** henbane (Hyoscyamus niger),. snapdragon cabbage, spring wheat, spring barley.	• **Flowering induced by dark periods longer than a critical length, e.g., cockelbur 8.5 h; tobacco 10-11h. (under natural conditions equivalent to days shorter than a critical length e.g. cocklebur 15.5 h; tobacco 13-14h)** • **Examples:** cocklebur (Xanthium) chrysanthemum, soyabean, tobacco, strawberry

Q.7 Write down the phases of plant growth?

Ans. (i) Cell Division:

- The cells of apical meristems **undergo divisions** 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.

(ii) 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.

(iii) 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. This area is called zone of cell differentiation. In this zone, cells are fully differentiated and each type of cell performs specific function.

Q.8 Differentiate between Vernalin and Florigen.

Ans.

Vernalin	Florigen
• A hypothetical substance for vernalization.	• A hormone-like substance promoting flowering.

Q.9 Differentiate between Thigmotropism and Geotropism.

Ans.

Thigmotropism	Geotropism
• 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.	• It is the movement of plant parts in response to gravity. • Roots display positive geotropism and shoots negative geotropism.

Q.10 How intercalary meristem is different from apical meristem?

Ans.

Aprical Meristems	Intercalary Meristems
• They are found at the tips of roots and shoots. • They are primarily responsible for the extension of the plant body. • These are perpetual 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.	• They 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.

Exercise | **LONG ANSWER QUESTIONS** | **Section 03**

Q.1 Describe osmoregulation in Hydrophytes and Halophytes?

Ans. **See Page No. (248)**

Q.2 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. **See Page No. (250)**

Q.3 What is the role of meristem in the growth of plants?

Ans. **See Page No. (244)**

Q.4 Describe the mechanism of opening and closing of stomata?

Ans. **See Page No. (237)**

Q.5 Explain the concept of photoperiodism and its influence on plant flowering. How do short-day, long-day and day-neutral plants differ in their flowering responses, and what role does phytochrome plays in this process?

Ans. **See Page No. (251)**

Exercise

INQUISITIVE ANSWER QUESTIONS

Q.1 Can you explain the hypothesis regarding the opening and closing of stomata?

Ans. See Page No. (237)

Q.2 What mechanisms enable carnivorous plants to supplement their nutrient uptake despite being autotrophs?

Ans. See Page No. (235)

Q.3 How can you say that parenchyma and schlerenchyma provide support to plants?

Ans. See Page No. (238)

Q.4 How do the annual rings depict climatic variability?

Ans. See Page No. (246)

Q.5 How does Pressure Flow Theory explain the movement of sugars through a plant?

Ans. See Page No. (243)

Q.6 What strategies would you adopt to induce flowering in a plant?

Ans. Strategies in Plants to Induce Flowering:

i. **Photoperiodism:** By manipulating light exposure, plants can be induced to flower by providing the required day length (short or long), depending on their type (short day or long-day plants).

ii. **Vernalization:** Exposing plants to prolonged low temperatures (e.g., 4°C) can trigger flowering in some species, especially biennials and winter annuals, by satisfying their cold requirement.

ADDITIONAL MCQs

1. **Which of the following macronutrients is primarily involved in osmoregulation and stomatal opening in plants?**
A. Potassium B. Calcium C. Magnesium D. Nitrogen
2. **Which insectivorous plant uses sticky tentacles to trap insects?**
A. Nepenthes (Pitcher plant) B. Drosera (Sundew)
C. Dionaea (Venus flytrap) D. Utricularia (Bladderwort)
3. **Which gas primarily exits the plant during daytime through stomata?**
A. Oxygen B. Carbon dioxide C. Nitrogen D. Methane
4. **What happens to guard cells when stomata close?**
A. They swell and become turgid B. They lose water and become flaccid
C. They divide rapidly D. They release glucose
5. **Which plant tissue provides support while allowing flexibility in growing parts like petioles and stems?**
A. Parenchyma B. Collenchyma C. Sclerenchyma D. Xylem
6. **Which factor decreases the water potential of a solution?**
A. Increase in pressure potential B. Addition of pure water
C. Addition of solutes D. Increase in temperature
7. **In plant cells, when is water potential equal to zero?**
A. When solute potential is zero B. When the cell is fully turgid
C. When pressure and solute potentials are equal and opposite
D. When the cell is plasmolyzed
8. **Which pathway requires water to cross multiple membranes, including vacuolar membranes?**
A. Symplast pathway B. Apoplast pathway C. Vacuolar pathway D. Xylem pathway

9. **What is the primary function of xylem fibers?**
A. Transport of water B. Mechanical support C. Food storage D. Photosynthesis
10. **Which xylem cells are living and involved in storage and lateral transport?**
A. Vessels B. Xylem parenchyma C. Tracheids D. Xylem fibers
11. **Which property of water helps maintain an unbroken column of water in xylem vessels?**
A. Adhesion B. Cohesion C. Surface tension D. Diffusion
12. **Which phloem cell type is primarily responsible for the actual transport of food in plants?**
A. Companion cells B. Phloem fibres C. Sieve tube elements D. Phloem parenchyma
13. **Which phloem component is dead at maturity and provides mechanical support?**
A. Sieve elements B. Companion cells C. Phloem fibres D. Phloem parenchyma
14. **Intercalary meristem is mainly responsible for:**
A. Secondary thickening B. Healing of wounds
C. Rapid elongation at internodes D. Root cap formation
15. **Cork cambium gives rise to which tissues?**
A. Secondary xylem and phloem B. Cortex and pith
C. Periderm (phellem and phelloderm) D. Epidermis and cuticle
16. **Which of the following is not involved in secondary growth?**
A. Vascular cambium B. Cork cambium C. Apical meristem D. Formation of periderm
17. **Which of the following is a characteristic of spring wood?**
A. Narrow xylem vessels with thick walls B. Formed during dry seasons
C. Wide xylem vessels with thin walls D. Dark, dense appearance
18. **Which plant hormone promotes cell elongation and apical dominance?**
A. Cytokinin B. Gibberellin C. Auxin D. Abscisic acid
19. **Ethylene is unique among plant hormones because it:**
A. Is transported via xylem B. Promotes cell elongation
C. Is a gaseous hormone D. Inhibits fruit ripening
20. **Which solution has the same solute concentration as the cell sap?**
A. Hypotonic B. Hypertonic C. Isotonic D. Saline
21. **Which plant type is best adapted to resist water loss in dry conditions?**
A. Hydrophytes B. Mesophytes C. Xerophytes D. Halophytes
22. **Which process helps in cooling plant surfaces under high temperature?**
A. Respiration B. Guttation C. Transpiration D. Photosynthesis
23. **Which plant process is inhibited during extreme cold conditions?**
A. Absorption of CO_2 B. Root elongation
C. Transpiration D. Cell division and enzymatic activity
24. **A common adaptation in plants against freezing temperatures is:**
A. Stomatal closure B. Accumulation of antifreeze proteins
C. Rapid transpiration D. Thicker cuticle
25. **The downward growth of roots in response to gravity is an example of:**
A. Negative geotropism B. Positive phototropism
C. Positive geotropism D. Thigmotropism
26. **Which pigment is primarily involved in perceiving photoperiod in plants?**
A. Auxin B. Chlorophyll C. Phytochrome D. Carotene
27. **Short-day plants flower when:**
A. Night length is longer than the critical period B. Day length is longer than the critical period
C. Exposed to continuous light D. Temperature is high

28. **Vernalization refers to:**
A. Exposure of seeds to light before germination
B. Induction of flowering by low temperature
C. Delay of flowering due to cold
D. Inhibition of germination by hormones

ANSWER KEY

1. A	2. B	3. A	4. B	5. B	6. C	7. C	8. C	9. B	10. B	11. B	12. C
13. C	14. C	15. C	16. C	17.C	18. C	19. C	20. C	21. C	22. C	23. D	24. B
25. C	26. C	27. A	28. B								

ADDITIONAL SHORT ANSWER QUESTIONS

Q.1 What role does calcium play in plant cell walls?

Ans. Role of Calcium Play in Plant:
- Calcium is crucial for forming and stabilizing cell walls by binding with pectins.
- It also plays a role in membrane integrity and cell signaling.

Q.2 What is the role of copper in photosynthesis?

Ans. Role of Copper in Photosynthesis:
- Copper is involved in the electron transport chain in photosynthesis.
- It also functions in enzyme activation and lignin synthesis, contributing to plant strength and defense.

Q.3 Why do insectivorous plants trap and digest insects?

Ans. Insectivorous Plants trap and Digest Insects:
- These plants grow in nutrient-poor, acidic soils, especially lacking nitrogen.
- To meet their nitrogen needs, they trap and digest insects, absorbing nutrients through specialized structures.

Q.4. What is the role of potassium ion influx in stomatal opening?

Ans. Role of Potassium Ion Influx in Stomatal Opening:
- In light, potassium ions actively enter guard cells.
- This lowers their water potential, drawing water in by osmosis.
- The increased turgor pressure causes the guard cells to curve, opening the stomata.

Q.5 How does parenchyma provide support in plants?

Ans. Parenchyma Provide Support in Plants:
- Parenchyma cells are living, with thin walls and large vacuoles.
- In softer plant parts, turgidity of these cells provides internal support, along with their roles in storage and photosynthesis.

Q.6 What are the main features of sclerenchyma cells?

Ans. Main Features of Sclerenchyma Cells:
- Sclerenchyma consists of dead cells with very thick, lignified cell walls.
- They provide hardness and rigidity, found in mature plant parts like seed coats and vascular bundles.

Q.7 What is the role of pressure potential in plant cells?

Ans. Role of Pressure Potential in Plant Cells:
- Pressure potential (Ψp) refers to the physical pressure exerted by the cell wall against the protoplast.
- It is usually positive in healthy plant cells and helps maintain turgor pressure, supporting cell rigidity.

Q.8 Define the apoplast pathway of water movement in plants.

Ans. Apoplast Pathway:
- In the apoplast pathway, water moves through cell walls and intercellular spaces without entering the cytoplasm.
- It is a faster route but is blocked at the endodermis by the Casparian strip, redirecting water into the symplast.

Q.9 Describe the structure and function of vessels in xylem.

Ans. Structure and Function of Vessels in Xylem:
- Vessels are wide, tube-like cells connected end-to-end with perforated end walls.
- They conduct water rapidly and efficiently in angiosperms, making them the primary water-conducting element.

Q.10 Why are xylem parenchyma cells important?

Ans. Xylem Parenchyma cells Important:
- Xylem parenchyma cells are living cells involved in storing nutrients and aiding lateral transport of water and minerals across xylem tissue, supporting overall plant physiology.

Q.11 What is the role of adhesion in the ascent of water?

Ans. Role of Adhesion in the Ascent of Water:
- Adhesion helps water molecules cling to the walls of xylem vessels, preventing the water column from breaking and assisting water movement against gravity.

Q.12 Describe the Role of Phloem Parenchyma.

Ans. Role of Phloem Parenchyma:
- Phloem parenchyma consists of living cells that store food and assist in the lateral transport of nutrients.
- They also play a supportive role in maintaining the phloem structure.

Q.13 Where is intercalary meristem found and what is its role?

Ans. Intercalary Meristem:
- Intercalary meristems are found at internodes or the base of leaves, especially in monocots.
- They help in rapid regrowth after grazing or cutting by contributing to elongation of stem segments.

Q.14 How does cork cambium help in plant protection?

Ans. Importance of Cork Cambium:
- Cork cambium (phellogen) produces cork (phellem) and phelloderm, forming the periderm.
- Cork is waterproof and dead at maturity, helping to protect the plant from water loss and pathogen entry.

Q.15 What is the difference between determinate and indeterminate growth?

Ans.

Determinate	Indeterminate
• Determinate growth stops after reaching a specific size (e.g., leaves, flowers).	• Indeterminate growth continues throughout the life of the plant (e.g., root and shoot tips). • Indeterminate growth is maintained by active meristematic tissue.

Q.16 What is secondary growth and which tissues are involved?

Ans. Secondary Growth:
- Secondary growth increases the girth of stems and roots.
- It is controlled by lateral meristems—vascular cambium (produces secondary xylem and phloem) and cork cambium (produces cork and phelloderm for protection).

Q.17 How are annual rings formed in trees?

Ans. Annual Rings:

- Annual rings are formed by the alternating production of spring wood (light, wide vessels) and autumn wood (dark, narrow vessels) by the vascular cambium each year.
- The number of rings indicates the age of the tree.

Q.18 What is the role of auxins in plant growth?

Ans. Role of Auxins in Plant Growth:

- Auxins regulate cell elongation, root initiation, and maintain apical dominance.
- They are produced in the shoot apex and help bend stems towards light (phototropism).

Q.19 Describe two main functions of cytokinins in plants.

Ans. Two main Functions of Cytokinins in Plants:

- Cytokinins promote cell division and delay leaf senescence.
- They also work with auxins to influence organ development—higher cytokinin levels promote shoot formation in tissue culture.

Q.20 What is a hypotonic solution and how does it affect plant cells?

Ans. Hypotonic Solution:

- A hypotonic solution has lower solute concentration than the cell sap.
- Water enters the cell by osmosis, causing the vacuole to expand and the cell to become turgid, which supports the plant's structure.

Q.21 Name and describe one structural adaptation in desert plants for high temperature.

Ans. Adaptation in Desert Plants:

- Desert plants often have thick cuticles and spines instead of leaves.
- These adaptations reduce water loss and heat absorption, helping the plant survive in hot environments.

Q.22 Define geotropism and give one example.

Ans. Geotropism:

- Geotropism is the plant's growth response to gravity.
- For example, roots grow downward (positive geotropism) while shoots grow upward (negative geotropism), helping proper plant orientation.

Q.23 What is the critical photoperiod?

Ans. Critical Photoperiod:

- Critical photoperiod is the minimum or maximum duration of light (or darkness) required by a plant to initiate flowering.
- It varies among short-day and long-day plants.

Q.24 What is vernalization and why is it important?

Ans. Vernalization:

- Vernalization is the process where exposure to low temperature (around 4°C) induces flowering in some plants. It ensures that flowering occurs in favorable seasons, typically in spring, avoiding harsh winter.

SELF-ASSESSMENT Chapter # 08

Total Mark: 30

Q.1 Encircle the correct option. (1 × 6 = 06)

i. **Which pathway is responsible for the movement of water through the cell walls of root cells?**
(a) Symplast pathway (b) Apoplast pathway (c) Vacuolar pathway (d) Transmembrane pathway

ii. **Which of the following is NOT a factor that influences the opening and closing of stomata?**
(a) Light intensity (b) CO_2 concentration (c) Temperature (d) Soil pH

iii. **Which type of plant is adapted to survive in environments with low water availability?**
(a) Hydrophytic (b) Xerophytic (c) Mesophytic (d) Halophytic

iv. **Which plant growth regulator is involved in cell elongation?**
(a) Auxin (b) Gibberellin (c) Cytokinin (d) Ethylene

v. **Process by which water evaporates from surface of leaf primarily through stomata:**
(a) Transpiration (b) Guttation (c) Imbibition (d) Cohesion

vi. **Which of the following is not a function of xylem?**
(a) Transport of water (b) Transport of minerals (c) Transport of food (d) Mechanical support

Q.2 Write short answers of the following questions. (2 × 8 = 16)

i. Name two examples of carnivorous plants and describe their habitat.
ii. What is the function of stomata in gas exchange?
iii. What is the symplast pathway in root water absorption?
iv. What is the effect of a hypertonic solution on plant cells?
v. What are halophytes?
vi. Differentiate between Vernalin and Florigen.
vii. What is secondary growth and which tissues are involved?
viii. Describe two main functions of cytokinins in plants.

Q.3 Extensive Questions. (4 × 2 = 8)

(a) What is the role of meristem in the growth of plants?
(b) Describe the mechanism of opening and closing of stomata?