Unit 08

Plant Physiology

STUDENTS LEARNING OUTCOMES (SLO's)

After studying this unit, 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 erennials.

8.1 NUTRITION IN PLANTS

Q 1 Define nutrition. Explain the importance of nutrients in plants.

Ans. Definition and Importance of Nutrition

Nutrition refers to the collective processes involved in the intake and utilization of nutrients for growth, repair, and maintenance of life activities in an organism. All organisms, including plants, require nutrition for survival and proper functioning. A nutrient is a substance that provides essential elements and compounds required for metabolism.

Types of Nutrients

Specific nutrients, such as carbohydrates, lipids, and proteins, serve as sources of energy. Others, including water, electrolytes, minerals, and vitamins, are essential for various metabolic activities. In plants, nutrients are crucial for physiological processes like photosynthesis, cellular repair, and development.

Q 2 What are macronutrients? Describe the role and deficiency symptoms of major macronutrients in plants.

Ans. Definition of Macronutrients

Macronutrients are nutrients required by plants in relatively large quantities. These elements are vital for plant growth and play structural, metabolic, and physiological roles.

List of Macronutrients

There are nine macronutrients:

1. Carbon (C)
2. Hydrogen (H)
3. Oxygen (O)
4. Nitrogen (N)
5. Potassium (K)
6. Calcium (Ca)
7. Phosphorus (P)
8. Magnesium (Mg)
9. Sulfur (S)

Functions and Deficiency Symptoms

Carbon, Hydrogen, and Oxygen: Involved in making organic compounds like carbohydrates.

Nitrogen: Essential for energy metabolism and protein synthesis. Deficiency causes leaf loss and stunted growth.

Phosphorus: A component of ATP, promotes root growth and flowering. Deficiency leads to delayed flowering and wrinkled leaves.

Potassium: Regulates water balance, supports photosynthesis, and strengthens tissues. Deficiency results in dark patches on leaves.

Calcium: Provides stability to the cell wall, supports cell proliferation and seed development. Its deficiency causes yellow and brown patches.

Magnesium: Core element of chlorophyll, helps in sugar storage and phosphorus transport. Deficiency causes weak stalks and yellowing of old leaves.

Sulfur: Important for nitrogen metabolism. Deficiency leads to lighter leaf color.

Q 3. What are micronutrients? Describe the role and deficiency symptoms of essential micronutrients in plants.

Ans. Definition of Micronutrients

Micronutrients are elements required in very small amounts but are essential for proper plant functioning. They mainly act as cofactors in enzymatic reactions and support physiological processes.

List of Micronutrients

There are seven essential micronutrients:

1. **Iron (Fe)**
2. **Manganese (Mn)**
3. **Zinc (Zn)**
4. **Molybdenum (Mo)**
5. **Copper (Cu)**
6. **Chlorine (Cl)**
7. **Boron (B)**

Functions and Deficiency Symptoms

- **Iron:** Crucial for chlorophyll synthesis and nitrogen metabolism. Deficiency causes interveinal chlorosis.
- **Manganese:** Involved in photosynthesis, nitrogen and carbohydrate metabolism. Its deficiency causes early leaf fall and delayed maturity.

- **Zinc:** Aids in chlorophyll synthesis and root development. Deficiency results in stunted growth.
- **Molybdenum:** Important for nitrogen fixation and metabolism. Deficiency leads to chlorosis in older leaves and stunted growth.
- **Copper:** Needed for lignin synthesis, reproductive development, and enzyme activation. Deficiency causes chlorosis, twisted leaves, and poor growth.
- **Chlorine:** Helps in stomatal regulation, osmosis, and nutrient transport. Deficiency affects plant health and development

4. What is the significance of insectivorous plants? Explain their adaptations and give examples.

Ans. Definition and Significance

Insectivorous plants are a group of plants that supplement their nutrition by capturing and digesting insects. Although they are true autotrophs capable of photosynthesis, they derive additional nitrogenous compounds from animal sources, which enhances their growth in nutrient-poor environments.

Mechanism of Nutrition in Insectivorous Plants

These plants release digestive enzymes to break down the bodies of trapped insects. The products of digestion, especially nitrogen-containing compounds, are then absorbed for use in growth and development.

Examples and Adaptations

1. **Pitcher Plant (Nepenthes):**
   - Leaves are modified into pitcher-shaped sacs partially filled with water.
   - The opening is covered by a hood and surrounded by stiff hairs, preventing escape of trapped insects.

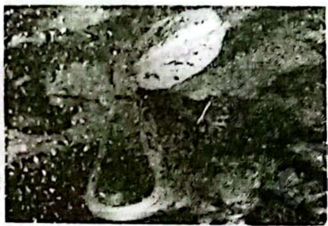
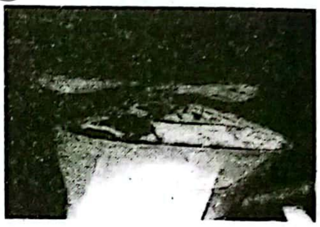

Fig 8.1: Pitcher plant, insects are entrapped within the leaf.

2. **Venus Fly Trap (Dionaea muscipula):**
   - Each leaf has two lobes that close like a trap upon mechanical stimulation.
   - Trichomes trigger rapid closure, and interlocking bristles prevent escape.
   - Digestive enzymes break down prey for nutrient absorption.

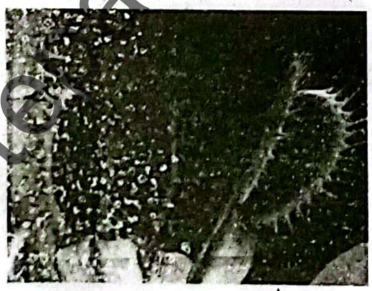


Fig 8.2: Venus-fly trap, prey is trapped between the lobes of a leaf.

3. **Sundew (Drosera):**
   - Leaves are covered in glandular hairs (tentacles) with sticky drops resembling dew.
   - Insects are attracted by the scent and trapped in the sticky substance.
   - Enzymes digest the prey and the nutrients are absorbed.

Fig.8.3: Sundew, insects are entangled by the tentacles .

MCQs

1. **What is a nutrient?**
A) A waste product of metabolism
B) A structural unit of DNA
C) A substance essential for metabolism ✓
D) A substance that causes diseases

2. **Which process refers to the intake and utilization of nutrients?**
A) Photosynthesis B) Digestion
C) Respiration D) Nutrition ✓

3. **Which of the following is NOT a macronutrient?**
A) Carbon B) Manganese ✓
C) Nitrogen D) Phosphorus

4. **How many macronutrients are essential for plants?**
A) Five B) Seven
C) Nine ✓ D) Eleven

5. **Which macronutrient is a part of ATP and promotes root growth?**
A) Calcium B) Phosphorus ✓
C) Potassium D) Magnesium

6. **A deficiency of nitrogen in plants causes:**
A) Yellowing of new leaves
B) Leaf loss and stunted growth ✓
C) Wrinkling of flowers
D) Browning of roots

7. **Which macronutrient helps in regulating water in plants?**
A) Potassium ✓ B) Calcium
C) Phosphorus D) Sulfur

8. **Which nutrient forms the core of the chlorophyll molecule?**
A) Iron B) Zinc
C) Magnesium ✓ D) Sulfur

9. **Which element provides rigidity to the plant cell wall?**
A) Iron B) Copper
C) Calcium ✓ D) Chlorine

10. **Sulfur deficiency in plants causes:**
A) Interveinal chlorosis
B) Light coloration of the plant ✓
C) Browning of the roots
D) Twisting of stems

11. **Which nutrient is required in the highest quantities by plants?**
A) Zinc B) Nitrogen ✓
C) Molybdenum D) Iron

12. **Which of the following is a micronutrient?**
A) Oxygen B) Potassium
C) Boron ✓ D) Carbon

13. **Iron deficiency causes:**
A) Browning of leaves
B) Interveinal chlorosis ✓
C) Yellowing of leaf edges
D) Stem rot

14. **Manganese is involved in which plant process?**
A) DNA replication B) Water transport
C) Photosynthesis and enzyme activation ✓
D) Leaf pigmentation

15. **Zinc is essential for:**
A) Leaf coloration B) Water retention
C) Chlorophyll synthesis and root development ✓
D) Flowering

16. **Molybdenum deficiency results in:**
A) Delayed flowering
B) Chlorosis of older leaves and stunted growth ✓
C) Interveinal spotting D) Leaf curling

17. **Copper helps in:**
A) Lignin synthesis and reproductive development ✓
B) ATP formation
C) Water uptake D) Root expansion

18. **Chlorine in plants helps regulate:**
A) Flowering B) DNA replication
C) Stomatal activity and osmosis ✓
D) Photosynthesis only

19. **Insectivorous plants are:**
A) Heterotrophs B) Parasites
C) True autotrophs ✓ D) Saprophytes

20. **How do insectivorous plants benefit from prey?**
A) They extract water from them
B) They obtain nitrogenous compounds ✓
C) They collect minerals D) They store sunlight

21. **The leaves of pitcher plants are modified into:**
A) Needles
B) Tubes
C) Pitchers or sacs ✓
D) Spikes

22. **What prevents insects from escaping a pitcher plant?**
A) Sweet smell
B) Slippery surface
C) Stiff hairs around the opening ✓
D) Sharp thorns

23. **The Venus flytrap closes its lobes when:**
A) Water touches it
B) Wind blows
C) Trichomes are touched ✓
D) Sunlight increases

24. **The bristles on Venus flytrap serve to:**
A) Attract prey
B) Block sunlight
C) Interlock to trap insects ✓
D) Exude poison

25. **What does the sundew plant use to trap insects?**
A) Nectar
B) Tentacles with sticky dew drops ✓
C) Strong odor
D) Sharp teeth

SQ

1. **What is nutrition in plants?**
Ans. Nutrition in plants refers to the process through which they intake and utilize nutrients for growth, repair, and maintenance. It includes all metabolic activities related to energy production and structural development.

2. **What is a nutrient?**
Ans. A nutrient is a substance that provides essential ingredients required by organisms for metabolism. These ingredients support energy production, structural integrity, and life-sustaining chemical reactions.

3. **What are macronutrients?**
Ans. Macronutrients are elements required by plants in large amounts. They include carbon, hydrogen, oxygen, nitrogen, potassium, calcium, phosphorus, magnesium, and sulfur.

4. **What are micronutrients?**
Ans. Micronutrients are nutrients needed in very small amounts but are essential for plant survival. They include elements like iron, manganese, zinc, molybdenum, copper, chlorine, and boron.

5. **Why are carbon, hydrogen, and oxygen important for plants?**
Ans. Carbon, hydrogen, and oxygen are essential for forming organic compounds in plants. These elements are the basic building blocks of carbohydrates, proteins, and lipids.

6. **What is the role of nitrogen in plants?**
Ans. Nitrogen is vital for energy metabolism and protein production in plants. Its deficiency causes stunted growth and leaf loss.

7. **How does phosphorus benefit plants?**
Ans. Phosphorus is a part of ATP and supports root development and flowering. A lack of phosphorus can lead to wrinkled leaves and delayed blooming.

8. **What is the function of potassium in plant physiology?**
Ans. Potassium regulates water movement and helps in transporting reserve materials. It also boosts photosynthesis and strengthens plant tissues.

9. **Describe the role of calcium in plants.**
Ans. Calcium stabilizes the cell wall and supports seed development. Its deficiency causes yellow and brown spots on leaves.

10. **Why is magnesium necessary for plants?**
Ans. Magnesium forms the central atom of chlorophyll and is essential for photosynthesis. Its deficiency results in chlorosis and weak stems.

11. **How does sulfur help in plant metabolism?**
Ans. Sulfur is crucial for nitrogen metabolism and protein synthesis. A shortage makes the plant pale or light in color.

12. **What is the role of iron in plants?**
Ans. Iron helps in chlorophyll synthesis and acts as a cofactor in nitrogen metabolism. Its deficiency leads to interveinal chlorosis.

13. **How does manganese affect plant growth?**
Ans. Manganese aids in photosynthesis, enzyme activation, and nitrogen metabolism. Lack of manganese can result in early leaf drop and slow maturity.

14. **What is the importance of zinc in plants?**
Ans. Zinc helps in chlorophyll production and root development. Its deficiency leads to stunted growth and poor nutrient absorption.
15. **Why do plants need molybdenum?**
Ans. Molybdenum is vital for nitrogen fixation and sulfur metabolism. Without it, older leaves show signs of chlorosis and the plant's growth is stunted.
16. **What role does copper play in plants?**
Ans. Copper is needed for lignin synthesis and reproductive development. Its deficiency causes chlorosis and twisted leaves.
17. **How does chlorine support plant health?**
Ans. Chlorine is involved in stomatal function, osmosis, and nutrient transport. Its absence negatively affects overall plant health and growth.
18. **What are insectivorous plants?**
Ans. Insectivorous plants are autotrophs that also digest insects to meet their nitrogen needs. They thrive in nitrogen-deficient environments.
19. **How does a pitcher plant trap insects?**
Ans. A pitcher plant has leaves shaped like a pitcher, partially filled with fluid. The opening is covered with a hood and lined with hairs that trap insects.
20. **Describe how the Venus flytrap catches its prey.**
Ans. The Venus flytrap has two lobes that snap shut when trichomes are touched. The closed lobes prevent escape and secrete enzymes to digest the prey.

8.2 GAS EXCHANGE IN PLANTS

5. Explain the structure and function of stomata in plants. How do stomata contribute to gaseous exchange?

Ans. **Structure of Stomata**

Stomata (singular = stoma) are tiny openings or pores located in the tissues of plants, mainly on the leaves and occasionally on some stems. These pores play a crucial role in the gaseous exchange between the plant and its external environment. Each stoma is bordered by two specialized cells known as **guard cells**. These guard cells are typically **bean-shaped** and contain **chloroplasts**, which enable them to perform photosynthesis.

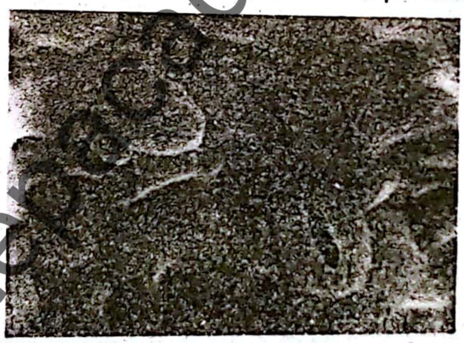

Fig 8.4: Scanning electron micrograph (SEM) of open and closed stomata on a lavender leaf

Function of Stomata in Gaseous Exchange

Stomata serve as the primary gateway for gases such as **carbon dioxide (CO_2)**, **oxygen (O_2)**, and **water vapor (H_2O)**. During daylight hours, stomata open to permit the entry of CO_2 into the leaf, which is essential for **photosynthesis**. This opening also facilitates the release of O_2, a by-product of photosynthesis. At night, photosynthesis halts due to the absence of light, and stomata usually close to minimize **water loss** through **transpiration**. Despite stomatal closure, plants continue to respire, absorbing O_2 and releasing CO_2.

Role of Guard Cells

The guard cells regulate the opening and closing of stomata in response to environmental conditions such as light, humidity, and carbon dioxide concentration. This regulation is vital for balancing the plant's need for gas exchange with its need to conserve water.

6. Describe the mechanisms responsible for the opening and closing of stomata in plants.

Ans. Guard Cells as Hydraulic Valves

Guard cells act as **multisensory hydraulic valves**, adjusting their turgor pressure in response to environmental stimuli. Two main hypotheses explain the mechanism behind stomatal movements: the **Starch-Sugar Hypothesis** and the **Influx of K^+ Ion Hypothesis**.

Starch-Sugar Hypothesis

This hypothesis was first proposed by the German botanist **H. Van Mohl in 1856**. It suggests that guard cells are capable of **photosynthesis** and thus produce **sugars** during the day. As sugar concentration increases in guard cells, their **water potential decreases**, leading to the **influx of water** via osmosis. This water uptake causes the guard cells to become **turgid**, resulting in the opening of the stomata.

At night, photosynthesis stops and the sugars in guard cells are either **converted to starch** or **used in respiration**, reducing the sugar concentration. As a result, **water moves out** of the guard cells, they become **flaccid**, and the stomata **close**. However, this theory does not entirely explain the **rapid turgor changes** observed in guard cells during stomatal movement.

Influx of K^+ Ion Hypothesis

A more accepted and detailed explanation involves the **active transport of potassium ions (K^+)** into guard cells. When K^+ ions are actively transported into guard cells, the **osmotic potential** inside the cells drops, leading to the **osmosis-driven influx of water**. The guard cells swell and become **turgid**, thereby **opening the stomata**. This process is enhanced by **blue light**, which acidifies the surrounding area, promoting K^+ uptake. At night, K^+ ions **passively diffuse out** of the guard cells, causing a **water efflux**, loss of turgidity, and **closure of the stomata**.

7. How is gaseous exchange facilitated through internal leaf tissues, especially palisade and spongy mesophyll layers?

Ans. Palisade Tissue

Palisade tissue is situated directly beneath the **upper epidermis** of the leaf. It consists of **elongated**, tightly packed cells that are **rich in chloroplasts**. This cellular arrangement is optimized to **maximize light absorption**, thus enabling efficient conversion of light energy into chemical energy through **photosynthesis**.

Pathway of Gas Movement

Carbon dioxide (CO_2) from the atmosphere enters the leaf through the **stomata**. It then diffuses through the **air spaces in the spongy mesophyll layer** and finally reaches the **palisade mesophyll cells**, where it is utilized in the process of photosynthesis.

During photosynthesis, **oxygen (O_2)** is produced as a by-product. This oxygen diffuses from the palisade cells back through the **spongy mesophyll** and exits the leaf via the **stomata**.

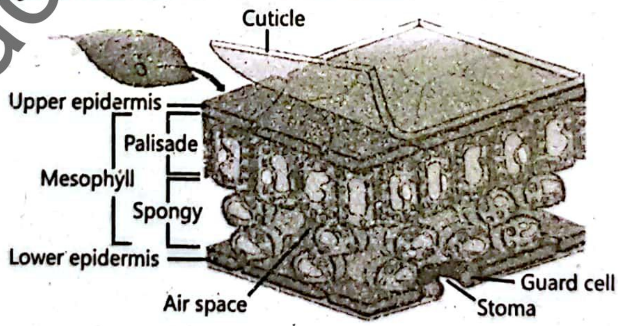

Fig 8.5: Structure of a leaf showing cuticle, epidermis, palisade mesophyll, spongy mesophyll, guard cells and stoma.

Thus, the **internal leaf architecture**, including **spongy and palisade mesophyll**, supports the efficient exchange of gases needed for photosynthesis and respiration.

MCQ's

1. What is the primary function of stomata in plants?
A) Absorption of nutrients
B) Support to leaf structure
C) Gaseous exchange ✓
D) Transport of water

2. Where are stomata usually located in plants?
A) Roots
B) Leaves ✓
C) Flowers
D) Xylem

3. **What type of cells surround each stoma?**
A) Palisade cells B) Spongy cells
C) Guard cells✓ D) Epidermal cells

4. **What is the shape of guard cells?**
A) Round B) Bean-shaped✓
C) Square D) Oval

5. **What do guard cells contain that helps them perform photosynthesis?**
A) Mitochondria B) Vacuoles
C) Chloroplasts✓ D) Nucleus

6. **When do stomata usually open?**
A) At night B) In complete darkness
C) During rainfall D) During daylight✓

7. **What causes stomata to close at night?**
A) Lack of wind B) Increase in oxygen
C) Absence of light✓ D) Presence of sunlight

8. **What happens to guard cells when water leaves them?**
A) They become rigid B) They become turgid
C) They become flaccid✓ D) They enlarge

9. **Which hypothesis explains stomatal movement based on sugar production?**
A) Protein hypothesis
B) Chloroplast hypothesis
C) Starch-sugar hypothesis✓
D) Osmotic pressure hypothesis

10. **Who proposed the starch-sugar hypothesis?**
A) Darwin B) Van Helmont
C) H. Van Mohl✓ D) Linnaeus

11. **What happens to sugar in guard cells at night?**
A) It increases B) It forms protein
C) It is converted into starch✓
D) It remains unchanged

12. **Why does water enter guard cells during the day?**
A) To cool the plant
B) Due to pressure difference
C) Because of low osmotic potential✓
D) To increase sugar levels

13. **Which Ion is actively transported into guard cells to open stomata?**
A) Ca^{2+} B) Na^{+}
C) K^{+} D) Mg^{2+}

14. **What role does blue light play in stomatal opening?**
A) Blocks sunlight B) Prevents water loss
C) Promotes K^{+} uptake✓
D) Destroys chlorophyll

15. **What happens to K^{+} ions in guard cells at night?**
A) They accumulate
B) They convert to sugar
C) They diffuse out✓
D) They become inactive

16. **Where is palisade tissue located in the leaf?**
A) Lower epidermis B) Upper epidermis✓
C) Xylem D) Midrib

17. **What is the main function of palisade cells?**
A) Water storage B) Nutrient absorption
C) Light absorption✓ D) Starch transport

18. **How does CO_2 enter the leaf?**
A) Through xylem B) Through roots
C) Through stomata✓ D) Through veins

19. **Where does CO_2 go after entering the leaf?**
A) Into xylem vessels B) Into guard cells
C) Into palisade mesophyll cells✓
D) Into the roots

20. **What happens to oxygen produced in photosynthesis?**
A) Stored in roots
B) Used for transpiration
C) Diffuses out of the leaf✓
D) Turns into glucose

SQ

1. **What are stomata and where are they found?**
Ans. Stomata are tiny pores found primarily in the leaves of plants, although they may also be present in some stems. These pores are crucial for the gaseous exchange between the plant and the environment.

2. **What is the role of guard cells in stomatal function?**
Ans. Guard cells surround each stoma and regulate its opening and closing. They respond to environmental conditions to help control transpiration and gas exchange.

3. **How do stomata contribute to photosynthesis?**
Ans. Stomata open during daylight to allow carbon dioxide to enter the leaf, which is essential for photosynthesis. This process also facilitates the release of oxygen.

4. **Why do stomata usually close at night?**
Ans. Stomata close at night because photosynthesis stops in the absence of light. Closing the stomata helps the plant conserve water by reducing transpiration.

5. **Do plants respire at night?**
Ans. Yes, plants continue to respire at night by taking in oxygen and releasing carbon dioxide. However, they do so with closed stomata to reduce water loss.

6. **How does the opening and closing of stomata affect transpiration?**

Ans. The stomatal opening increases transpiration by allowing water vapor to escape. Closing the stomata reduces water loss, helping the plant maintain hydration.

7. **What is the starch-sugar hypothesis?**

Ans. The starch-sugar hypothesis suggests that during the day, sugars accumulate in guard cells due to photosynthesis, causing water to enter and open the stomata. At night, sugars convert to starch, reducing water content and causing stomatal closure.

8 **Who proposed the starch-sugar hypothesis and when?**

Ans. German botanist H. Van Mohl proposed the starch-sugar hypothesis in 1856. He suggested that guard cells conduct photosynthesis to regulate stomatal opening.

9. **What causes water to move into guard cells during the day?**

Ans. The accumulation of sugars in guard cells lowers their water potential. As a result, water enters the cells by osmosis, making them turgid and opening the stomata.

10. **Why do guard cells lose turgor pressure at night?**

Ans. At night, sugars are either used for respiration or converted into starch. This increases the water potential, causing water to exit the guard cells and resulting in stomatal closure.

11. **What is the role of potassium ions (K^+) in stomatal movement?**

Ans. Potassium ions actively enter guard cells during the day, lowering osmotic potential. This leads to water influx, guard cell turgidity, and stomatal opening.

12. **How does blue light affect stomatal opening?**

Ans. Blue light promotes the active uptake of potassium ions by acidifying the environment around guard cells. This encourages water absorption and causes the stomata to open.

13. **What happens to K^+ ions at night in guard cells?**

Ans. At night, potassium ions passively diffuse out of guard cells. This causes water to leave, making the guard cells flaccid and closing the stomata.

14. **What is the function of palisade tissue in leaves?**

Ans. Palisade tissue is located beneath the upper epidermis and contains tightly packed cells rich in chloroplasts. Its main role is to absorb light efficiently for photosynthesis.

15. **How are palisade mesophyll cells arranged and why?**

Ans. The cells are elongated and packed closely together. This arrangement helps maximize light absorption, increasing photosynthetic efficiency.

16. **How does carbon dioxide reach the palisade mesophyll cells?**

Ans. Carbon dioxide enters the leaf through stomata and diffuses through the air spaces in the spongy mesophyll. It then reaches the palisade cells for use in photosynthesis.

17. **What happens to oxygen produced during photosynthesis?**

Ans. Oxygen diffuses out of the palisade cells and travels back through the spongy mesophyll. It then exits the leaf through the stomata.

18. **Why is the arrangement of leaf tissues important for gas exchange?**

Ans. The arrangement of spongy and palisade mesophyll creates air spaces that facilitate efficient gas diffusion. This structural design supports both photosynthesis and respiration.

19. **What is the role of spongy mesophyll in gaseous exchange?**

Ans. Spongy mesophyll has loosely packed cells with many air spaces that allow gases to move freely within the leaf. It acts as a channel for CO_2 and O_2 to diffuse between the stomata and palisade cells.

20. **How do environmental conditions influence stomatal behavior?**

Ans. Light, humidity, and carbon dioxide levels affect whether stomata open or close. Guard cells respond to these changes to balance gas exchange and water conservation.

Q 8. What is the role of supporting tissues in plants, and how do they provide support to plants.

Ans. Role of Supporting Tissues

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.

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

- **Fibers (Tracheids)** are elongated and cylindrical in shape. They can be found either as compact bundles inside the xylem or as bundle caps.
- **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.
- **Vessels (Tracheae)** are long tubular structures that are joined end to end to form a long water conducting pipe in xylem.

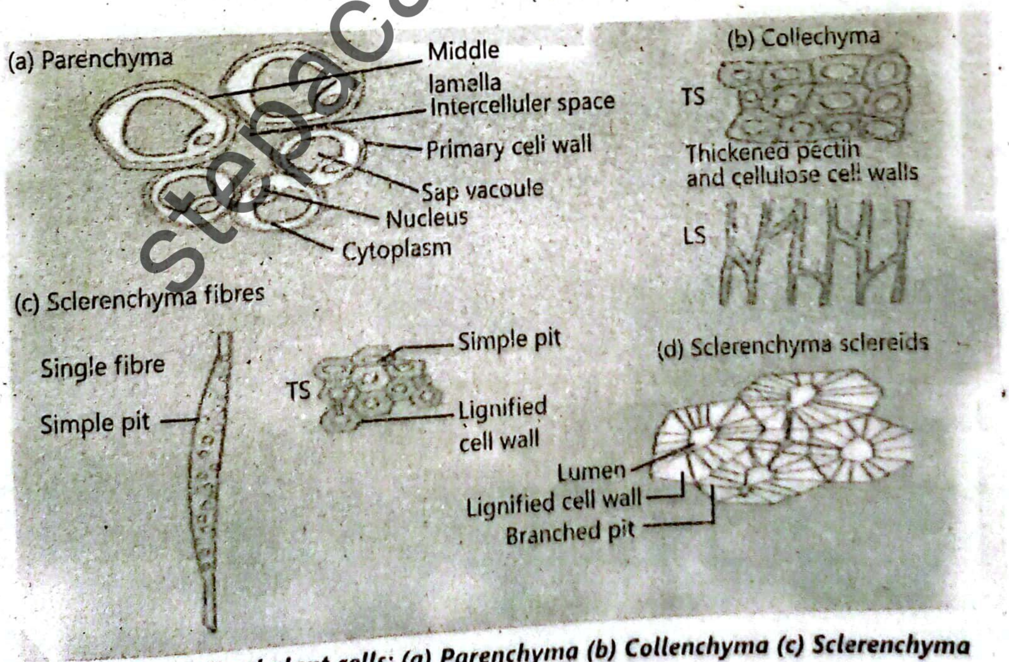

Fig.8.6: Specialized plant cells; (a) Parenchyma (b) Collenchyma (c) Sclerenchyma

1. **Which of the following tissues is NOT a supporting tissue in plants?**
A) Parenchyma B) Collenchyma
C) Phloem D) Meristem✓

2. **What does the parenchyma tissue mainly support in plants?**
A) Woody stems B) Mature leaves
C) Herbaceous plants and parts of larger plants✓ D) Seeds

3. **Turgor pressure is created due to:**
A) Cellulose thickening B) Lignin deposition
C) Water absorption✓
D) Increased transpiration

4. **What is the name of the membrane that surrounds the vacuole?**
A) Plasmalemma B) Tonoplast✓
C) Cell wall D) Chloroplast

5. **How does the tonoplast help maintain turgor pressure?**
A) It breaks down sugars
B) It pumps out water
C) It transports ions into the vacuole✓
D) It stores chlorophyll

6. **Where are collenchyma cells commonly found?**
A) Root tips B) Bark
C) Beneath the epidermis of young stems and leaf stalks✓
D) Flower petals

7. **What is the main structural feature of collenchyma cells?**
A) Thick secondary walls B) Lignified walls
C) Thickened corners of primary walls✓
D) Hollow centers

8. **What is absent in collenchyma cells?**
A) Cytoplasm B) Nucleus
C) Secondary walls✓ D) Vacuoles

9. **What is the function of collenchyma cells during plant growth?**
A) Prevent water loss B) Conduct nutrients
C) Provide support during elongation✓
D) Photosynthesis

10. **Which supporting tissue is mostly composed of non-living cells?**
A) Parenchyma B) Collenchyma
C) Sclerenchyma✓ D) Phloem

11. **Which compound is responsible for the rigidity of sclerenchyma cell walls?**
A) Cellulose B) Glucose
C) Starch D) Lignin✓

12. **Which of the following is NOT a type of sclerenchyma cell?**
A) Fibers B) Sclereids
C) Vessels D) Collenchyma✓

13. **What is the shape of fibers (tracheids)?**
A) Spherical B) Star-shaped
C) Elongated and cylindrical✓ D) Cuboidal

14. **Where are sclereids commonly found?**
A) Leaf tips B) Root hairs
C) Seed coats and shells of nuts✓
D) Flower buds

15. **What is the main function of sclereids?**
A) Photosynthesis B) Water transport
C) Support during bending
D) Protection✓

16. **Vessels (tracheae) are responsible for:**
A) Nutrient storage B) Gas exchange
C) Water conduction✓ D) Photosynthesis

17. **How are vessels (tracheae) structured?**
A) As single large cells
B) As independent round sacs
C) As long tubes formed by joining cells end-to-end✓
D) As flattened sheets

18. **Which tissue has cells that store water to create hydrostatic pressure?**
A) Sclerenchyma B) Phloem
C) Parenchyma✓ D) Collenchyma

19. **Which of the following supporting tissues is actively involved in ion transport into vacuoles?**
A) Xylem B) Collenchyma
C) Parenchyma✓ D) Sclerenchyma

20. **Which tissue supports young plant parts where secondary growth has not occurred?**
A) Parenchyma B) Collenchyma✓
C) Sclerenchyma D) Phloem

SQ

1. **What role do supporting tissues play in plants?**
Ans. 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.

2. **What is the function of parenchyma tissue in plants?**
Ans. The parenchyma tissue provides support to herbaceous plants and parts of larger plants. The parenchyma ... of the epidermis, cortex, and pith absorb water.

3. **How is turgor pressure created in parenchyma cells?**
Ans. Turgor pressure arises from the elevated osmotic pressure within the cell vacuole. This pressure maintains the rigidity of cells.

4. **What is the tonoplast, and what is its function?**

Ans. 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.

5. **How does water enter the vacuole in parenchyma cells?**

Ans. Due to the elevated ionic concentration inside the vacuole, water is drawn into it. This results in turgidity and provides mechanical support to the plant's soft tissues.

6. **What is the arrangement of collenchyma cells?**

Ans. 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.

7. **What structural feature is absent in collenchyma cells?**

Ans. Collenchyma cells lack secondary walls. Their primary walls are thickened at the corners due to extra deposition of cellulose.

8. **When do collenchyma cells elongate?**

Ans. They elongate when the stem or leaf grows lengthwise. They provide support to the young parts of the plant in which secondary growth has not taken place.

9. **What is the main function of sclerenchyma tissue?**

Ans. The main function of this tissue is to provide support to the various components of the plant. This tissue also provides structural support to the plants.

10. **What is the composition of sclerenchyma cell walls?**

Ans. 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.

11. **Are sclerenchyma cells living or non-living?**

Ans. The majority of sclerenchyma cells are non-living. They function mainly to provide support.

12. **What are the three types of sclerenchyma cells?**

Ans. There are three types of sclerenchyma cells which are fibres, sclereids and vessels. Each type has a specific structure and function.

13. **What are fibers (tracheids) and where are they found?**

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

14. **Where are sclereids located and what is their function?**

Ans. Sclereids are present in the seed coats and shells of nuts. Their function is to offer protection.

15. **How are vessels (tracheae) structured, and what is their function?**

Ans. Vessels (Tracheae) are long tubular structures that are joined end to end to form a long water conducting pipe in xylem. They play a crucial role in water transport.

8.4 WATER POTENTIAL

Q 9. What is water potential, and how do solute potential and pressure potential contribute to water movement in plant systems?

Ans. **Definition of Water Potential**

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 = Ψw).

Determinants of Water Potential in Plant Cells

In plant cells, two factors determine water potential i.e., Solute potential (Ψs) and Pressure potential (ΨP).

Water Potential of Pure Water

Pure water has maximum water potential which by definition is zero. Water moves from a region of higher Ψw to lower Ψw. All solutions have lower Ψw than pure water and so have negative value of Ψw (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.

Solute Potential (Ψs)

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

Pressure Potential (ΨP)

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 built up inside the cell making the cell turgid and increasing the pressure potential.

Formula of Water Potential

Thus, the total water potential (ΨW) is sum of solute potential (Ψs) and pressure potential (ΨP):

ΨW = ΨS + ΨP

Importance of Water Potential Gradient

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.

mCQ's

1. **What does the symbol Ψw represent?**
   A) Water concentration B) Water pressure
   C) Water potential✓ D) Water vapor
2. **What determines the kinetic energy of water molecules?**
   A) Solute concentration B) Temperature only
   C) Movement in a system✓
   D) Size of the container
3. **What happens to water potential as the concentration of water molecules increases?**
   A) It becomes zero B) It decreases
   C) It becomes negative D) It increases✓
4. **What is the water potential of pure water?**
   A) 1 B) -1
   C) 0✓ D) 100
5. **In which direction does water move?**
   A) From higher Ψw to lower Ψw✓
   B) From lower Ψw to higher Ψw
   C) From pure solute to pure water
   D) Against concentration gradient
6. **What is the water potential of all solutions compared to pure water?**
   A) Higher B) Zero
   C) Same D) Lower✓
7. **What is osmosis?**
   A) Movement of solutes across a membrane
   B) Movement of water from low to high pressure
   C) Movement of water from higher to lower Ψw through a partially permeable membrane✓
   D) Active transport of ions
8. **What does solute potential (Ψs) measure?**
   A) The pressure inside the vacuole
   B) The turgidity of the cell
   C) Change in Ψw due to solutes✓
   D) Temperature of the solution
9. **What is always true about the value of solute potential (Ψs)?**
   A) It is positive B) It is zero
   C) It is always negative✓
   D) It is always equal to Ψw
10. **What happens to Ψs when more solute is added?**
    A) It increases
    B) It becomes more negative✓
    C) It becomes zero D) It becomes positive
11. **What is pressure potential (ΨP)?**
    A) The movement of air inside xylem
    B) Pressure exerted by solutes
    C) Pressure due to water in a system✓
    D) Osmotic potential from outside
12. **What effect does increasing pressure have on water potential?**
    A) Decreases it B) No effect
    C) Increases it✓ D) Makes it zero
13. **What causes turgidity in plant cells?**
    A) Sugar absorption B) Protein movement
    C) Water entering by osmosis✓
    D) Starch synthesis
14. **Which equation correctly expresses water potential?**
    A) Ψw = Ψs − Ψp B) Ψw = ΨP + ΨS✓
    C) Ψw = Ψp − Ψs D) Ψw = Ψs x Ψp
15. **What does a steeper water potential gradient cause?**
    A) Slower water movement
    B) No water movement
    C) Faster water flow✓
    D) Reverse osmosis
16. **How can water potential be used in plants?**
    A) To measure mineral concentration
    B) To measure temperature

C) To predict water movement between systems ✓
D) To track sugar transport

17. **Which system has the lowest water potential?**
A) Pure water
B) Saturated soil
C) Air ✓
D) Plant roots

18. **What is the value of Ψw in pure water at atmospheric pressure?**
A) -1
B) 0 ✓
C) +1
D) -100

19. **What structure must be present for osmosis to occur?**
A) Vacuole
B) Cell wall
C) Permeable membrane
D) Partially permeable membrane ✓

20. **What is the result of water movement from soil to air in plants?**
A) Reduction in Ψs
B) Sugar production
C) Water transport along potential gradient ✓
D) Temperature increase

SQ

1. **What is water potential?**
Ans. Water potential is the total kinetic energy of water molecules in a system. It is represented by the Greek letter psi (Ψw) and determines the movement of water.

2. **What factors determine water potential in plant cells?**
Ans. Water potential in plant cells is determined by two main factors: solute potential (Ψs) and pressure potential (ΨP). These two components together influence the direction and rate of water movement.

3. **What is the water potential of pure water?**
Ans. Pure water has the maximum water potential, which is defined as zero. It serves as a reference point for comparing the water potential of other solutions.

4. **In which direction does water move in terms of water potential?**
Ans. Water moves from a region of higher water potential (Ψw) to a region of lower water potential. This movement occurs through a partially permeable membrane during osmosis.

5. **What is solute potential (Ψs)?**
Ans. Solute potential, also called osmotic potential, is the change in water potential due to the presence of solute molecules. It is always a negative value, and becomes more negative with an increase in solute concentration.

6. **How does solute concentration affect solute potential?**
Ans. Higher solute concentration lowers the solute potential, making it more negative. This decrease contributes to a lower total water potential in the system.

7. **What is pressure potential (ΨP)?**
Ans. Pressure potential is the part of water potential due to the pressure exerted by water. When pressure greater than atmospheric is applied, water potential increases.

8. **What happens when water enters a plant cell by osmosis?**
Ans. When water enters a plant cell, it builds up internal pressure, making the cell turgid. This increases the pressure potential inside the cell.

9. **What is the formula for total water potential?**
Ans. The total water potential (ΨW) is calculated using the formula:

ΨW = ΨS + ΨP

This shows that both solute and pressure potentials contribute to overall water movement.

10. **How does the water potential gradient affect water movement?**
Ans. The steeper the water potential gradient, the faster the water moves. This concept explains water movement from soil to root, leaf to air, and throughout the plant.

8.5 TRANSPORT OF WATER IN PLANTS

Q 10. **How do plants absorb water through their roots, and what are the different pathways of water movement within the root system?**

Ans. Uptake of Water by Roots

Roots of plants provide large surface area for absorption by their extensive branching systems. You know that 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. 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.

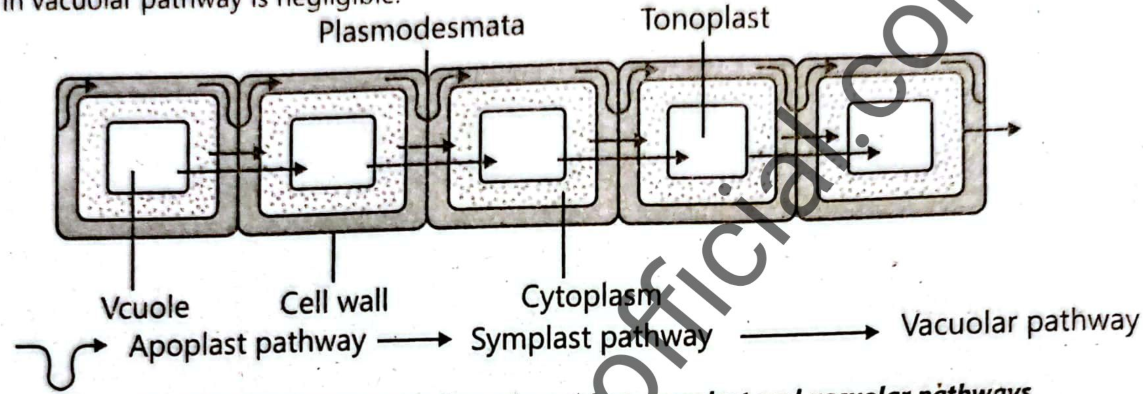

Fig 8.7: Water movement through apoplast, symplast and vacuolar pathways

11. What is the structure and function of xylem tissue in plants?

Ans. Structure of Xylem Tissue

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.

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.

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.

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.

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.

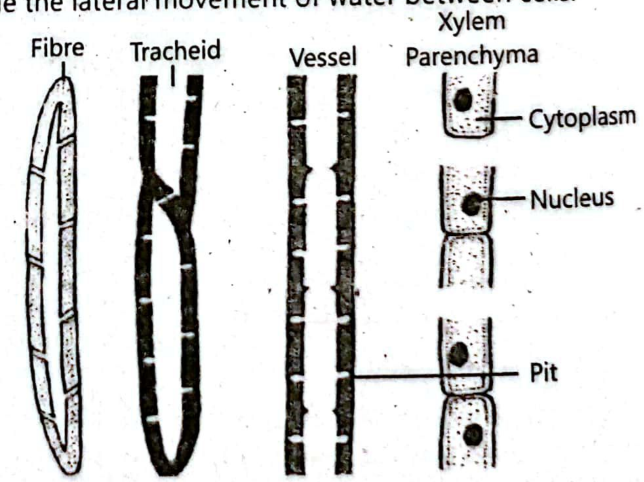

Fig 8.8: Different components of xylem tissue

12. How does water move through xylem tissue, and what is the role of the TACT mechanism in this process?

Ans. 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 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, acts as the primary driving force behind water transport in the xylem.

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

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.

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.

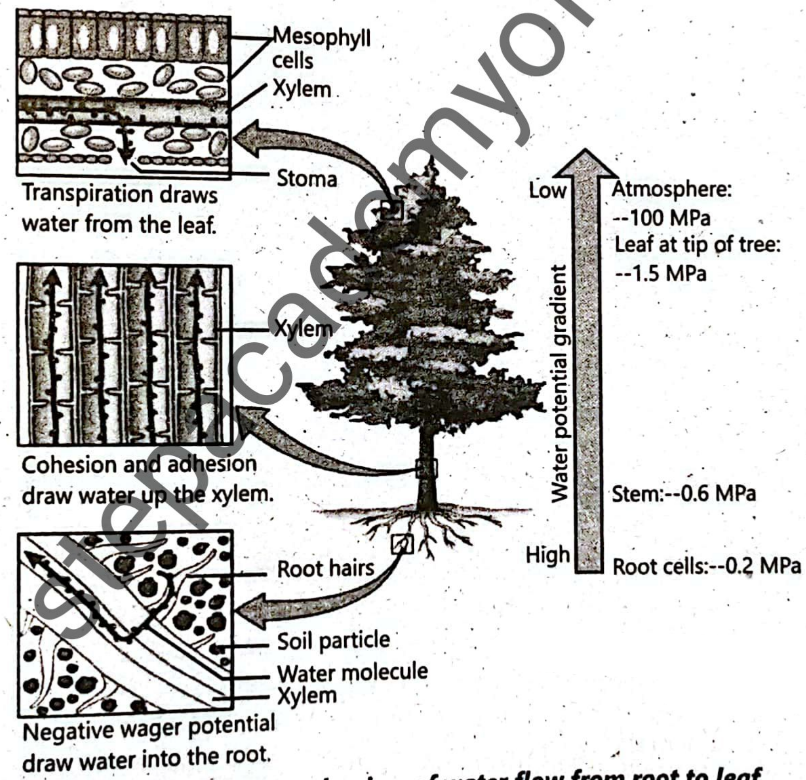

Fig 8.9: The TACT mechanism of water flow from root to leaf.

MCQs

1. **What is the main function of root hairs in plants?**
   A) Photosynthesis
   B) Water and mineral absorption ✓
   C) Gas exchange
   D) Food storage

2. **How do water and minerals enter the root epidermal cells?**
   A) Through stomata
   B) By osmosis only
   C) By active and passive transport ✓
   D) Through chloroplasts

3. **After entering the root epidermis, water and minerals move to:**
   A) Phloem
   B) Cuticle

C) Cortex and then xylem ✓
D) Root hairs again

4. The apoplast pathway involves:
A) Cytoplasm of cells B) Vacuoles
C) Cell walls of adjacent cells ✓
D) Plasma membrane

5. The apoplast pathway is interrupted in the:
A) Cortex B) Epidermis
C) Endodermis ✓ D) Root cap

6. What is the symplast pathway?
A) Movement through cell walls
B) Movement through xylem only
C) Movement through interconnected protoplasts via plasmodesmata ✓
D) Movement in the phloem

7. Which pathway is least significant in water movement?
A) Symplast B) Apoplast
C) Vacuolar ✓ D) Casparian

8. Which vascular tissue is responsible for transporting water in plants?
A) Phloem B) Cambium
C) Xylem ✓ D) Epidermis

9. Which of the following is NOT a component of xylem tissue?
A) Tracheids B) Vessels
C) Guard cells ✓ D) Xylem parenchyma

10. What are tracheids?
A) Round cells with no wall
B) Short and wide cells
C) Elongate, thin cells with thick lignin walls ✓
D) Parenchyma cells for storage

11. How are tracheids connected for water movement?
A) By stomata B) By perforation plates
C) By bordered pits ✓ D) By phloem sieve plates

12. What characterizes xylem vessels?
A) Long and thin
B) Broad and short, arranged linearly ✓
C) Made of living cells D) No walls at all

13. What structure aids water movement in xylem vessels?
A) Plasmodesmata B) Chloroplasts
C) Perforation plates ✓ D) Root caps

14. Which xylem cells are dead at maturity and give support?
A) Xylem parenchyma B) Xylem fibres ✓
C) Tracheids D) Phloem

15. What is the function of xylem parenchyma?
A) Transports sugars
B) Retains water and nutrients ✓
C) Produces food D) Absorbs light

16. What does TACT stand for?
A) Transport, Aeration, Circulation, Tension
B) Transpiration, Adhesion, Cohesion, Tension ✓
C) Transport, Attraction, Capillarity, Tension
D) Translocation, Adhesion, Circulation, Turgor

17. What drives the TACT mechanism in plants?
A) Root pressure B) Osmosis
C) Transpiration ✓ D) Capillary action only

18. Where does transpiration primarily occur?
A) Stems B) Roots
C) Leaves through stomata ✓ D) Xylem vessels

19. What is adhesion in the context of water transport?
A) Attraction of root hairs to soil
B) Binding of minerals to xylem
C) Attraction between water molecules and xylem walls ✓
D) Interaction between phloem cells

20. How does cohesion help in water movement?
A) By helping roots absorb nutrients
B) By making water molecules stick to xylem walls
C) By enabling water molecules to stick to each other ✓
D) By pulling nutrients into phloem

21. What creates the tension in xylem?
A) Soil pressure B) Water uptake by roots
C) Evaporation of water from leaves ✓
D) Capillary pressure in roots

22. Why is adhesion important in tall plants?
A) It helps with photosynthesis
B) It reduces light absorption
C) It prevents the water column from breaking ✓
D) It produces energy

23. What ensures unbroken water column from root to leaves?
A) Cohesion ✓ B) Root pressure
C) Osmosis D) Capillary action

24. Which force pulls water upward due to leaf evaporation?
A) Adhesion B) Gravity
C) Tension ✓ D) Osmotic pull

25. What mechanical role does xylem play in plants?
A) Gas exchange B) Photosynthesis
C) Provides mechanical support ✓
D) Transports food

SQ

1. What is the role of root hairs in water absorption?

Ans. Root hairs are tiny extensions of epidermal cells of roots. Most of the uptake of water and minerals in roots takes place through root hairs.

2. How do water and minerals enter the root cells from soil?

Ans. Water and minerals enter the root epidermal cells by active and passive transport. They then move to the cortex and eventually into the xylem tissue in the root center.

3. **What is the apoplast pathway?**

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

4. **What is the symplast pathway in plants?**

Ans. In the symplast pathway, water and minerals move through interconnected protoplasts of root cells. These protoplasts are connected by plasmodesmata, which are cytoplasmic strands passing through pores in cell walls.

5. **Why is the symplast pathway less important?**

Ans. The symplast pathway is less important except for the movement of minerals in the region of endodermis. Most water follows other pathways.

6. **What is the vacuolar pathway?**

Ans. In the vacuolar pathway, water and minerals pass through cell membranes, cytoplasm, and tonoplast of vacuoles. Movement in this pathway is negligible.

7. **What is xylem and what does it do?**

Ans. Xylem is the vascular tissue in plants that carries water and dissolved minerals from roots to stem and leaves. It also provides mechanical support to the plant body.

8. **What are tracheids in xylem?**

Ans. Tracheids are elongated, thin cells with thick lignin walls. They have tapered ends and are connected through bordered pits for lateral water movement.

9. **Describe vessels in xylem tissue.**

Ans. Vessels are shorter and broader than tracheids and arranged in a linear fashion. They contain perforation plates that enable efficient water movement.

10. **What are xylem fibres and their function?**

Ans. Xylem fibres are elongated cells with thick lignified walls. At maturity, they are dead and provide structural support to the plant.

11. **What is the role of xylem parenchyma?**

Ans. Xylem parenchyma are living cells with thin walls that store nutrients and water. They help in lateral movement of water and in healing of xylem tissue.

12. **What is the function of bordered pits in tracheids?**

Ans. Bordered pits connect adjacent tracheids and allow lateral movement of water. This ensures continuous water supply even if one tracheid becomes blocked.

13. **How does water move in plants through xylem?**

Ans. Water moves from roots to leaves through the xylem. This upward movement is explained by the TACT mechanism involving transpiration, adhesion, cohesion, and tension.

14. **What does the TACT mechanism stand for?**

Ans. TACT stands for Transpiration, Adhesion, Cohesion, and Tension. These four principles work together to move water upward through the plant.

15. **What is transpiration and its role in water movement?**

Ans. Transpiration is the evaporation of water from leaf surfaces, especially through stomata. It creates a negative pressure that pulls water upward from the roots.

16. **What is adhesion and how does it help water transport?**

Ans. Adhesion is the attraction between water molecules and the walls of xylem vessels. It helps water stick to vessel walls and prevents breaks in the water column.

17. **How does cohesion support water movement in plants?**

Ans. Cohesion is the force between water molecules due to hydrogen bonding. It helps maintain an unbroken water column from roots to leaves.

18. **What is the role of tension in xylem water transport?**

Ans. Tension is the negative pressure created by transpiration at the leaves. It pulls the cohesive water column upward through the xylem.

19. **How does the xylem prevent the water column from breaking?**

Ans. Adhesion to xylem walls and cohesion between water molecules maintain the continuity of the water column. These forces resist gravity and keep the flow intact.

20. **Why is the xylem important for tall plants?**

Ans. In tall plants, the TACT mechanism ensures water can travel long distances against gravity. Xylem structure and the properties of water make this possible.

8.6 TRANSLOCATION OF FOOD IN PLANTS

13. Describe the structure and components of phloem tissue in plants.

Ans. Introduction to 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. In such plants, the phloem constitutes the inner bark.

Components of Phloem

Phloem comprises various specialized cells, including:

- **Sieve elements**
- **Companion cells**
- **Phloem fibres**
- **Phloem parenchyma**

Sieve Tube Elements

The primary cells responsible for transporting sugars and other organic materials throughout the plant are known as **sieve tube elements** or **sieve tube cells**. These cells have specialized regions called **sieve areas**, which are portions of the cell wall containing pores that interconnect adjacent sieve tube elements. Some sieve areas are commonly found in the end walls of sieve tube elements. These end walls allow the cells to join together in a longitudinal series to form structures known as **sieve tubes**.

Companion Cells

Each sieve tube element is typically associated with one or more **companion cells**. These cells are in direct communication with sieve tube elements through structures called **plasmodesmata**, which are cytoplasmic connections between cells. Companion cells play a crucial role by supplying **ATP** and **proteins** to the sieve tube elements, which are essential for the functioning of phloem transport.

Phloem Parenchyma

Phloem parenchyma serves as a storage tissue within the phloem. It stores various substances such as **sugars, resins, latex, and mucilage**. These substances are important for multiple functions, including **plant defence mechanisms** and **moisture retention**.

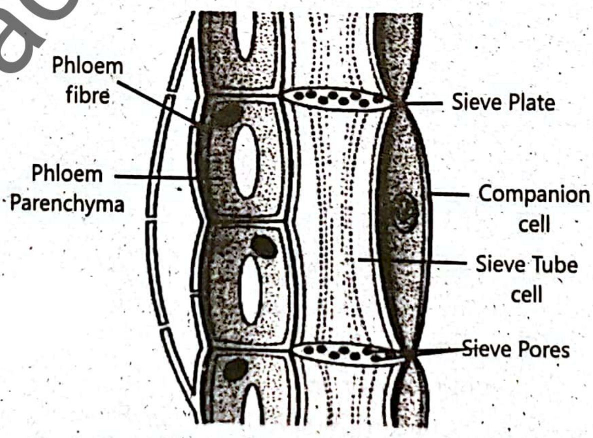

Fig 8.10: Different components of phloem tissue

14. Explain the mechanism of translocation of food in plants.

Ans. Overview of Phloem Transport

The transport of sugars in plants takes place through phloem tissue. Various theories have been proposed to explain the mechanism of phloem transport. Among them, **passive diffusion** is considered too slow to account for the rapid movement of sugars. For example, the average velocity of sugar movement in phloem is about **1 meter per hour**, while diffusion would take nearly **eight years** to cover the same distance.

Pressure-Flow Theory (Mass-Flow Hypothesis)

The **pressure-flow theory**, also known as the **mass-flow hypothesis**, is the most widely accepted explanation for the translocation of sugars in plants. This theory was proposed by **Ernst Munch in 1930** and explains how sugar moves from the **source** (where it is synthesized) to the **sink** (where it is used or stored).

Step-by-Step Mechanism of Pressure-Flow Theory

1. **Conversion of Glucose into Sucrose**
   The glucose produced during **photosynthesis** in mesophyll cells is first used for **respiration**. The excess glucose is then **converted into sucrose**, which is a **non-reducing sugar** suitable for long-distance transport.

2. **Loading of Sucrose into Phloem**
   Sucrose is **actively transported** from the mesophyll cells into the **companion cells** of the phloem. From the companion cells, sucrose moves into the **sieve tubes** through **plasmodesmata**. As a result, the concentration of sucrose increases within the sieve tubes.

3. **Osmosis into Sieve Tubes**
   Due to the high concentration of sucrose (a solute) in the sieve tubes; **water enters the sieve tubes by osmosis** from the nearby **xylem vessels** of the leaf. This leads to an **increase in water potential** at the source end of the sieve tubes.

4. **Unloading of Sucrose at Sink**
   At the **sink end**, sugar is **actively unloaded** from the sieve tubes into the sink tissues where it is needed or stored. Water also follows the sugar by **osmosis**. The **exit of water** from the sieve tubes at the sink end **lowers the water potential** in that region.

5. **Mass Flow of Solution**
   Because there is a higher water potential at the source and a lower water potential at the sink, a pressure gradient is established. This difference causes water to flow from the source to the sink through the phloem. Since sucrose is dissolved in water, it is carried along with the flowing water from the source to the sink.

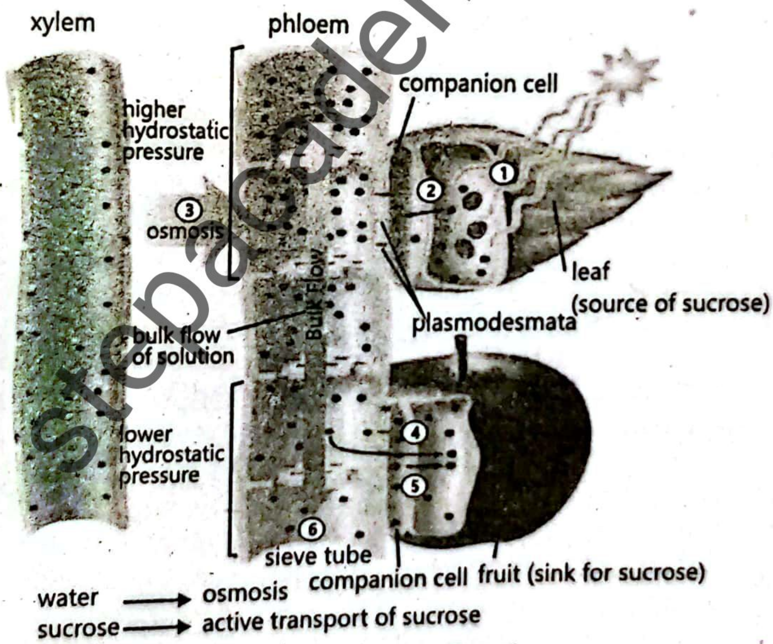

Fig 8.11: The pressure-flow theory

Conclusion

This pressure-flow mechanism explains how organic nutrients are efficiently transported over long distances in plants. It highlights the coordinated function of various cellular structures within the phloem and the reliance on osmotic pressure differences to achieve **mass flow**.

MCQ's

1. **What is the main function of phloem in plants?**
A) Transport of water B) Mechanical support
C) Transport of organic nutrients✓
D) Photosynthesis

2. **Which of the following is NOT a component of phloem?**
A) Xylem fibres✓ B) Sieve tube elements
C) Companion cells D) Phloem parenchyma

3. **Sieve tube elements are connected by:**
A) Pits B) Stomata
C) Sieve areas✓ D) Tracheids

4. **The sieve tube elements are assisted by:**
A) Xylem vessels B) Guard cells
C) Companion cells✓ D) Tracheids

5. **The inner bark of a plant is mainly composed of:**
A) Xylem B) Phloem✓
C) Parenchyma D) Cork

6. **Phloem transport is mainly responsible for moving:**
A) Water B) Sugars✓
C) Oxygen D) Minerals

7. **Who proposed the pressure-flow theory?**
A) Robert Hooke B) Ernst Munch✓
C) Charles Darwin D) Julius von Sachs

8. **In the pressure-flow theory, sugars move from:**
A) Sink to source B) Roots to stem
C) Source to sink✓ D) Phloem to xylem

9. **The sugar most commonly translocated in plants is:**
A) Glucose B) Fructose
C) Sucrose✓ D) Maltose

10. **Plasmodesmata are used in phloem transport to:**
A) Strengthen the cell wall B) Exchange gases
C) Connect sieve tubes and companion cells✓
D) Move water through roots

11. **Sucrose is initially synthesized in:**
A) Root cells B) Stem cortex
C) Mesophyll cells✓ D) Companion cells

12. **What happens to the sucrose concentration in sieve tubes at the source?**
A) It decreases B) It stays constant
C) It increases✓ D) It becomes zero

13. **Water enters sieve tubes from the xylem due to:**
A) Active transport B) Capillarity
C) Osmosis✓ D) Cohesion

14. **The sink end of phloem has:**
A) High water potential
B) Low solute concentration
C) Low water potential✓
D) High sugar concentration

15. **Which process helps move sugar solution from source to sink?**
A) Active transport B) Transpiration
C) Diffusion D) Mass flow✓

16. **Diffusion is not a valid explanation for phloem transport because:**
A) It consumes too much energy B) It's too fast
C) It causes water loss D) It's too slow✓

17. **Companion cells are responsible for:**
A) Evaporation
B) Providing structural support
C) Supplying ATP and proteins to sieve tubes✓
D) Photosynthesis

18. **Phloem parenchyma helps in:**
A) Guarding stomata B) Water conduction
C) Nutrient storage and defense✓
D) Absorption of sunlight

19. **The pores in sieve areas allow for:**
A) Water loss B) Mechanical support
C) Sugar flow between cells✓
D) Oxygen diffusion

20. **The movement of water and sugars in phloem is caused by:**
A) Transpiration pull B) Root pressure
C) Difference in water potential✓
D) Active transport only

SQ

1. **What is the function of phloem in plants?**

Ans. Phloem is a vascular tissue that transports organic nutrients, especially sugars produced during photosynthesis, from leaves to other parts of the plant. This process ensures that all tissues receive the energy and building blocks they need.

2. **Where is phloem located in plants with secondary growth?**

Ans. In plants with secondary growth, phloem is found on the outer side of the vascular tissue. It constitutes the inner bark of such plants.

3. **What are the main components of phloem tissue?**

Ans. Phloem tissue consists of sieve elements, companion cells, phloem fibres, and phloem parenchyma. Each type of cell performs specialized functions to support food transport.

4. **What are sieve tube elements and their function?**

Ans. Sieve tube elements are phloem cells that transport sugars and organic materials. They are interconnected through pores in their walls, forming a series known as sieve tubes.

5. **What are sieve areas and where are they located?**
Ans. Sieve areas are parts of the cell wall with pores that connect sieve tube elements. They are commonly located at the end walls of sieve cells.

6. **What is the function of companion cells in phloem?**
Ans. Companion cells support sieve tube elements by providing ATP and proteins. They are connected to sieve tubes through plasmodesmata.

7. **How do companion cells communicate with sieve tube elements?**
Ans. Companion cells are linked to sieve tube elements through cytoplasmic connections called plasmodesmata. These connections allow for the exchange of materials and signaling molecules.

8. **What substances are stored by phloem parenchyma?**
Ans. Phloem parenchyma stores sugars, resins, latex, and mucilage. These substances help in plant defense and moisture retention.

9. **Why is diffusion not sufficient for sugar transport in plants?**
Ans. Diffusion is too slow to transport sugars over long distances. For instance, diffusion would take eight years to move sugars one meter, whereas phloem does it in about an hour.

10. **Who proposed the pressure-flow theory and when?**
Ans. The pressure-flow theory was proposed by Ernst Munch in 1930. It is the most accepted model for explaining sugar transport in plants.

11. **How is sucrose formed in plants before translocation?**
Ans. Glucose formed during photosynthesis is first used for respiration. The excess is converted into sucrose, a non-reducing sugar suitable for transport.

12. **How does sucrose enter the phloem for translocation?**
Ans. Sucrose is actively transported from mesophyll cells into companion cells. It then diffuses into sieve tubes through plasmodesmata.

13. **What happens when sucrose concentration increases in sieve tubes?**
Ans. Water enters the sieve tubes by osmosis from nearby xylem due to the high solute concentration. This raises the water potential at the source end.

14. **How is sugar unloaded at the sink end of phloem?**
Ans. At the sink, sucrose is actively removed from sieve tubes. Water also leaves the sieve tubes by osmosis, reducing the water potential there.

15. **What causes the movement of sugar solution from source to sink?**
Ans. The difference in water potential between the source and sink creates a pressure gradient. This pressure drives the mass flow of sucrose solution through phloem.

8.7 GROWTH IN PLANTS

Q 15. What is meant by growth in plants and how does it occur in different plant types?

Ans. **Definition of Plant Growth**

Growth in plants refers to a **permanent increase in size**, which can occur in various dimensions such as **height, width, and mass**. Throughout their life, plants continuously add new organs like **branches, leaves, and roots**.

Patterns of Growth

The size of plant organs increases from their **tips**, but the **rate of growth is not uniform** throughout the plant body. In **lower plants**, the entire plant body can grow. However, in **higher plants**, growth is restricted to specific regions known as **growing points**.

Growing Points and Meristems

Growing points consist of special groups of cells called **meristems**, which are capable of **continuous cell division**. These meristematic regions are crucial for the ongoing growth and development of the plant.

Q 16. What are the types of meristems in plants and what roles do they play in growth?

Ans. **Types of Meristems**

There are three main types of meristems in plants:

1. **Apical Meristems**
2. **Intercalary Meristems**
3. **Lateral Meristems**

Apical Meristems

Apical meristems are found at the **tips of roots and shoots**. They are primarily responsible for the **extension** of the plant body. These meristems are **zones of perpetual growth** and contribute to the **increase in the number of cells** at the tips of roots and stems. They play a central role in **primary growth**.

Intercalary Meristems

These meristems are **separated from the apex** by **permanent tissues**. They are located at the **bases of internodes** in many plants such as **grasses**. Intercalary meristems play an important role in the **production of leaves and flowers**. These are **temporary meristems**.

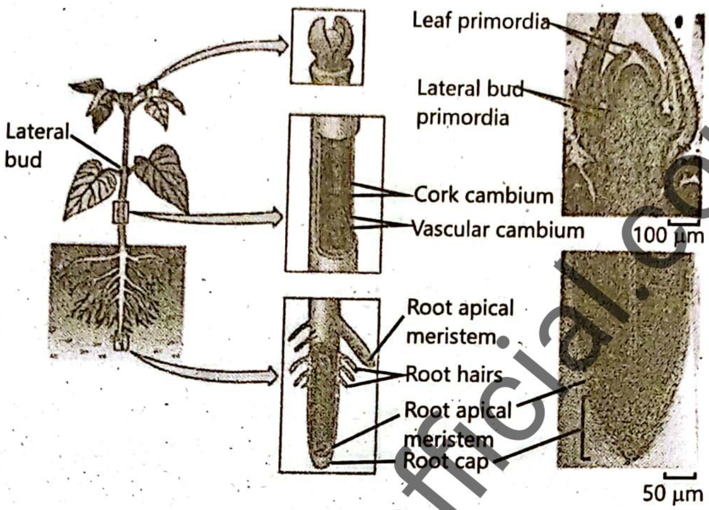

Fig 8.12: Apical meristem produces the primary plant body and lateral meristem produces the secondary plant body.

Lateral Meristems

Lateral meristems form **cylinders of dividing cells** present along the **peripheral regions** of stems and roots. They are responsible for **growth in thickness**, which is especially important in **woody plants** and contributes to **secondary growth**.

There are **two main forms** of lateral meristems:

- **Vascular Cambium**: Located between **xylem and phloem**, it produces **secondary xylem and secondary phloem**.
- **Cork Cambium**: Found in the **outer layers** of stems and roots. It produces **cork cells**, which replace the **epidermis** and form the **protective outer bark**.

Q 17. Describe the process and phases of primary growth in plants.

Ans. Definition of Primary Growth

Primary growth results in an **increase in the length** of the plant. It occurs due to the **activity of apical meristems**. In **herbaceous plants**, this type of growth is more dominant with **less secondary growth** compared to woody plants.

Phases of Primary Growth

Primary growth consists of **three main phases**:

1. **Cell Division**
2. The cells of **apical meristems** divide to **increase cell number**. This occurs at the **tips of roots and shoots** in a region called the **zone of cell division**. Here, the cells are **small, non-vacuolated**, and have **spherical nuclei** located centrally in the cytoplasm.
3. **Cell Elongation**
4. Once new cells are formed, their **volume increases** due to **water uptake**. The **plasticity of the cell wall increases** and wall pressure is reduced. This phase occurs **slightly away from the tips**, in the **zone of cell elongation**. In this zone, cells are **vacuolated and large**, with nuclei located at the **peripheries of the cytoplasm**.

5. Different cells elongate in various dimensions depending on their destiny:
    - Cells developing into **pith and cortex** don't elongate much length-wise.
    - Cells forming **xylem tissues** elongate **more length-wise.**

6. **Cell Differentiation**
7. After attaining final size and shape, cells stop elongating and begin **specializing for specific functions**. Their **cell walls thicken**, and they develop **new structural features**. This happens in the **zone of cell differentiation**, where **fully differentiated cells** perform specialized roles.

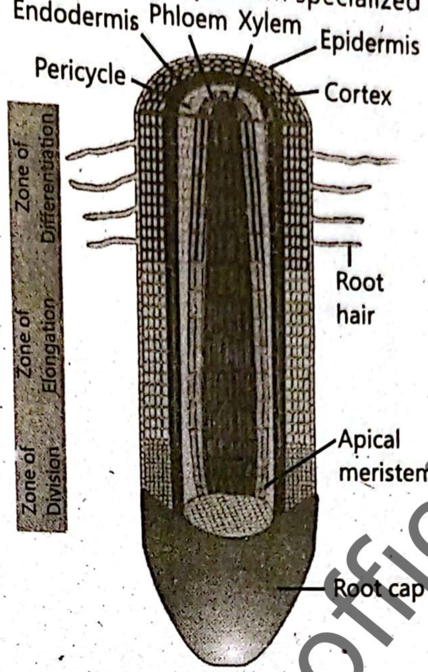

Fig 8.13: Primary growth in a root

Q 18. What is secondary growth in plants and how does it contribute to plant structure?

Ans. Definition of Secondary Growth

Secondary growth refers to the **increase in thickness or girth** of **stems and roots**. It is caused by the activity of **lateral meristems**, particularly the **vascular cambium and cork cambium**. This growth is most notable in **woody perennial plants**, whereas **herbaceous plants** primarily exhibit only primary growth.

Role of Vascular Cambium

The **vascular cambium** divides and produces **new cells** on both **outer and inner margins:**

- **Outer margin**: Produces **secondary phloem**
- **Inner margin**: Produces **secondary xylem**

The accumulation of **secondary xylem**, in particular, results in the **thickening of stems.**

Role of Cork Cambium

The **cork cambium** divides to form cells on both sides. These cells become **new cork**, which forms the **outer protective layer** of the stem.

The region outside the vascular cambium, containing secondary phloem, cork cambium, and cork, is known as the bark.

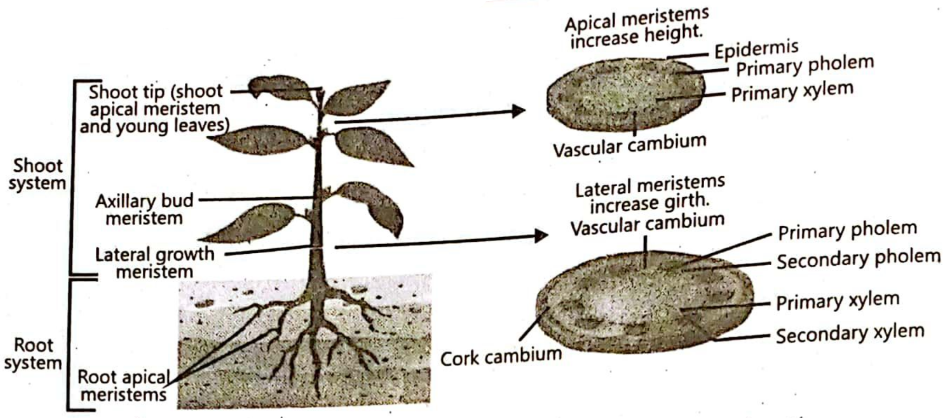

Fig 8.14: Primary and secondary growth in a plant.

19. How are annual rings formed in plants and what do they signify?

Ans. Annual Rings and Seasonal Activity

Annual rings are formed due to **seasonal variations in cambial activity**. These rings consist of two distinct types of wood:

1. **Spring Wood (Early Wood)**: Formed during favorable conditions (spring). It contains **large amounts of xylem** with **wider vessels** and appears **lighter** in color.
2. **Autumn Wood (Late Wood)**: Formed during less favorable conditions (autumn). It has **fewer xylem cells** with **narrower vessels** and appears **darker**.

Structure and Significance of Annual Rings

Each **annual ring** is composed of one band of spring wood followed by autumn wood. The formation of a new ring each year allows scientists to determine the **age of a tree**, a process known as **dendrochronology**.

The **transition** from spring to autumn wood is **gradual**, while the shift from **autumn back to spring** in the next year is **abrupt**, creating a distinct ring boundary. This data also provides insights into **past climate conditions** and **environmental changes** over the years.

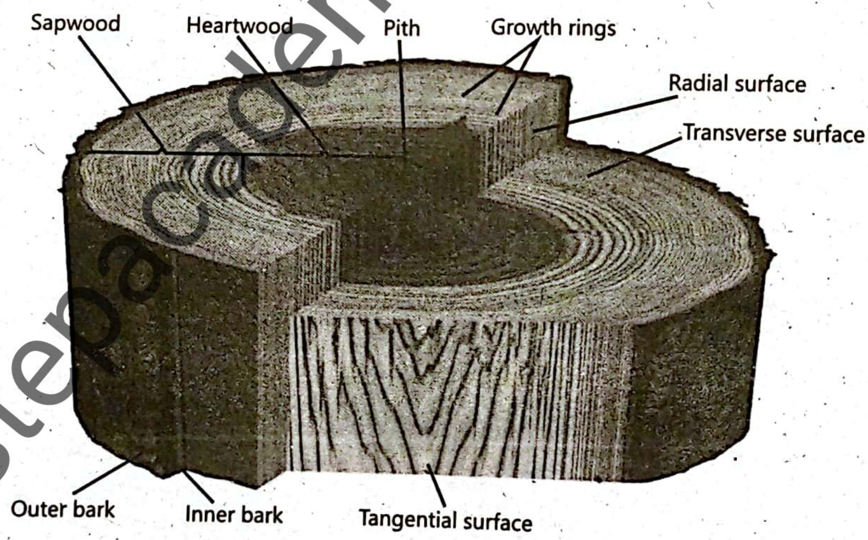

Fig 8.15: Anatomy of a tree trunk showing annual rings

mQ's

1. **What does growth in plants refer to?**
A) Temporary change in shape
B) Permanent decrease in size
C) Permanent increase in size ✓
D) Increase in photosynthesis

2. **Which plant structures continue to grow throughout life?**
A) Flowers
B) Branches, leaves, and roots ✓
C) Fruits
D) Seeds

3. **In which plants is the entire body capable of growth?**
A) Lower plants✓ B) Higher plants
C) Woody plants D) Flowering plants

4. **In higher plants, where does growth occur?**
A) Everywhere in the body B) Only in flowers
C) In growing points D) In mature leaves

5. **What are meristems?**
A) Non-dividing cells
B) Groups of continuously dividing cells✓
C) Dead tissues D) Photosynthetic cells

6. **How many types of meristems are there in plants?**
A) Two B) Three✓
C) Four D) Five

7. **Where are apical meristems found?**
A) Base of leaves
B) Tips of roots and shoots✓
C) Along the stem D) In fruits

8. **What is the primary function of apical meristems?**
A) Secondary growth
B) Extension of plant body✓
C) Leaf shedding D) Seed formation

9. **Where are intercalary meristems located?**
A) At the tip of the stem
B) At the base of internodes✓
C) In leaves D) In roots

10. **Which meristems are responsible for temporary growth?**
A) Apical B) Intercalary✓
C) Lateral D) Cork cambium

11. **What type of growth do lateral meristems support?**
A) Primary growth B) Secondary growth✓
C) Root elongation D) Leaf formation

12. **Which meristem is involved in thickening of stems?**
A) Apical B) Lateral✓
C) Intercalary D) Epidermal

13. **What is the function of vascular cambium?**
A) Forms flowers
B) Produces secondary xylem and phloem✓
C) Develops seeds D) Absorbs water

14. **Where is vascular cambium found?**
A) In flowers
B) Between xylem and phloem✓
C) In roots only D) Around the epidermis

15. **What does cork cambium form?**
A) Xylem B) Phloem
C) Cork cells✓ D) Leaves

16. **What is primary growth responsible for?**
A) Increase in stem thickness
B) Increase in plant length✓
C) Leaf drop D) Bark formation

17. **Which plants usually show only primary growth?**
A) Herbaceous plants✓ B) Woody plants
C) Trees D) Vines

18. **What is the first phase of primary growth?**
A) Cell division✓ B) Cell elongation
C) Differentiation D) Maturation

19. **What happens during cell elongation?**
A) Cells increase in volume✓ B) Cells multiply
C) Cells become permanent D) Cells shrink

20. **Where does cell elongation occur?**
A) Root tips B) Zone of elongation✓
C) Epidermis D) Bark

21. **What is the third phase of primary growth?**
A) Cell shrinkage B) Water absorption
C) Cell differentiation✓ D) Seed germination

22. **What characterizes the zone of cell differentiation?**
A) Cells are undifferentiated
B) Cells divide rapidly
C) Cells specialize and perform functions✓
D) Cells have thin walls

23. **What is secondary growth?**
A) Formation of leaves B) Elongation of roots
C) Increase in thickness✓ D) Decrease in height

24. **What tissue is mainly responsible for secondary growth?**
A) Apical meristem B) Lateral meristem✓
C) Intercalary meristem D) Parenchyma

25. **Which cells form secondary xylem?**
A) Cells on inner side of vascular cambium✓
B) Cells of intercalary meristem
C) Root cap cells D) Epidermal cells

26. **What do cells outside the vascular cambium form?**
A) Cork B) Bark
C) Secondary phloem✓ D) Cuticle

27. **What structures make up the bark?**
A) Phloem only
B) Secondary phloem, cork cambium, cork✓
C) Xylem only D) Intercalary tissues

28. **What are annual rings?**
A) Rings formed due to cambial activity each year✓
B) Marks on leaves
C) Bud scars D) Root layers

29. **What causes spring wood to appear lighter?**
A) Absence of xylem B) Thicker cell walls
C) Wider vessels and high cambial activity✓
D) Less water absorption

30. **What is dendrochronology?**
A) Study of seeds
B) Determining age of trees by rings✓
C) Study of leaves
D) Plant classification method

SQ

1. What is meant by growth in plants?

Ans. Growth in plants refers to a permanent increase in size. It can be observed in height, width, and mass.

2. **How do plants continue to grow throughout their life?**

Ans. Plants continue to grow by adding new organs like branches, leaves, and roots. This process happens mainly from specific growing points.

3. **Is the growth rate uniform throughout the plant body?**

Ans. No, the growth rate is not uniform throughout the plant. It varies in different parts and stages of development.

4. **How does growth differ in lower and higher plants?**

Ans. In lower plants, the entire plant body can grow. In higher plants, growth is limited to certain areas known as growing points.

5. **What are growing points in plants?**

Ans. Growing points are specific regions where active growth occurs. These regions contain meristematic cells that divide continuously.

6. **What is a meristem?**

Ans. A meristem is a group of cells capable of continuous cell division. These cells are responsible for growth in plants.

7. **Name the three types of meristems in plants.**

Ans. The three types of meristems are apical meristems, intercalary meristems, and lateral meristems. Each has a distinct function in plant growth.

8. **Where are apical meristems located?**

Ans. Apical meristems are found at the tips of roots and shoots. They are responsible for the elongation of plant bodies.

9. **What is the main function of apical meristems?**

Ans. Apical meristems facilitate primary growth. They increase the number of cells at root and shoot tips.

10. **What are intercalary meristems and where are they found?**

Ans. Intercalary meristems are located at the bases of internodes in some plants like grasses. They help in the production of leaves and flowers.

11. **Are intercalary meristems permanent?**

Ans. No, intercalary meristems are temporary. They become inactive after a certain period.

12. **What is the role of lateral meristems in plants?**

Ans. Lateral meristems help in increasing the thickness of stems and roots. They are active in woody plants and contribute to secondary growth.

13. **Where are lateral meristems located?**

Ans. Lateral meristems are located along the peripheral regions of stems and roots. They form cylinders of dividing cells.

14. **Name two types of lateral meristems.**

Ans. Two types of lateral meristems are vascular cambium and cork cambium. Both are involved in secondary growth.

15. **What is the function of vascular cambium?**

Ans. Vascular cambium produces secondary xylem and phloem. It is found between the primary xylem and phloem.

16. **What does cork cambium produce?**

Ans. Cork cambium produces cork cells. These replace the epidermis and form the protective outer bark.

17. **What is primary growth in plants?**

Ans. Primary growth increases the length of the plant. It is due to the activity of apical meristems.

18. **Which plants show more primary growth?**

Ans. Herbaceous plants show more primary growth. They have little or no secondary growth.

19. **What are the three phases of primary growth?**

Ans. The three phases of primary growth are cell division, cell elongation, and cell differentiation. Each phase plays a unique role.

20. **What happens during the cell division phase?**

Ans. In the cell division phase, apical meristem cells divide to increase their number. This occurs in the zone of cell division.

21. **Describe the zone of cell division.**
Ans. This zone has small, non-vacuolated cells. The cells have centrally located spherical nuclei.
22. **What occurs during the cell elongation phase?**
Ans. Cells increase in size due to water uptake. The plasticity of the cell wall also increases during this phase.
23. **Where is the zone of elongation located?**
Ans. It is found just beyond the zone of cell division. Cells in this zone are vacuolated and large.
24. **How do cells elongate differently in plants?**
Ans. Cells elongate according to their future roles. For example, xylem cells elongate more than cortex cells.
25. **What happens during cell differentiation?**
Ans. Cells attain their final shape and specialize in specific functions. Their walls become thicker, and structural features develop.
26. **Where does cell differentiation take place?**
Ans. It takes place in the zone of differentiation. This zone lies next to the zone of elongation.
27. **What is secondary growth in plants?**
Ans. Secondary growth refers to an increase in thickness or girth. It occurs due to the activity of lateral meristems.
28. **How do vascular cambium cells contribute to secondary growth?**
Ans. They divide and produce secondary phloem on the outside and secondary xylem on the inside. This increases stem thickness.
29. **What is bark made of?**
Ans. Bark consists of secondary phloem, cork cambium, and cork. It is located outside the vascular cambium.
30. **How are annual rings formed in trees?**
Ans. Annual rings are formed due to seasonal activity of the cambium. They consist of spring wood and autumn wood, showing yearly growth patterns.

Plant Growth Regulators

Q 20. What are Plant Growth Regulators and what role do they play in plants?

Ans. Plant growth regulators, also known as plant hormones, are special chemical messengers that regulate the rates of growth and metabolism in plant cells. These regulators play crucial roles in controlling various physiological and developmental processes in plants, such as cell division, elongation, differentiation, dormancy, flowering, fruit development, and senescence. There are five major groups of plant growth regulators:

1. Auxins
2. Cytokinins
3. Gibberellins
4. Abscisic acid
5. Ethylene

Each group has specific functions and effects on plant growth and development.

Q 21. What are Auxins and what are their primary functions in plant growth?

Ans. Auxins are a group of plant growth regulators mainly represented by indole acetic acid (IAA) or its variants. They regulate numerous growth activities in plants:

- **Stem:** Auxins promote cell enlargement in regions just behind the apex (tip) of the stem. They also stimulate cell division in the cambium layer, which contributes to secondary growth or thickening of stems.
- **Root:** At very low concentrations, auxins encourage root growth. However, at higher concentrations, they inhibit root growth. This dual effect is notable in geotropism (growth response to gravity). Auxins also promote the growth of roots from cuttings and calluses, which is important in plant propagation.
- **Shoots and Buds:** Auxins promote bud initiation in shoots but can sometimes act antagonistically to cytokinins and inhibit bud growth.
- **Apical Dominance:** Auxins maintain apical dominance, a phenomenon where the main central stem of the plant grows more strongly than the side branches.
- **Fruit Growth:** Auxins support fruit development and can sometimes induce parthenocarpy (development of fruit without fertilization).

- **Leaf Senescence and Abscission:** Auxins delay leaf senescence (aging) in certain species and inhibit abscission (the dropping of leaves, flowers, or fruits).

22. What are Gibberellins and how do they affect plant growth and development?

Ans. Gibberellins are another group of plant hormones produced primarily in the apical portions of roots and shoots, and then transported to other parts of the plant. Over 110 different gibberellins have been identified, with gibberellic acid being a prominent one. Their roles include:

- Promoting cell enlargement in the presence of auxins and stimulating cell division in apical meristems and cambium.
- Inducing 'bolting' in some rosette plants, which is the rapid elongation of stems.
- Promoting bud initiation in shoots, as seen in chrysanthemum callus.
- Supporting leaf growth and fruit growth, and potentially inducing parthenocarpy.
- Enhancing the effect of auxins in maintaining apical dominance.
- Breaking dormancy of buds and seeds, thus enabling germination and growth.
- Substituting for red light in some cases, promoting flowering in long-day plants, but inhibiting flowering in short-day plants.
- Delaying leaf senescence in some species.

23. Describe Cytokinins and their roles in plant growth processes.

Ans. Cytokinins are plant growth regulators primarily synthesized in roots, young fruits, and seeds. They are well-known for their ability to promote cytokinesis, or cell division, and to accelerate the rate of DNA replication along with RNA and protein synthesis. Their key functions include:

- Promoting stem growth through cell division in apical meristems and cambium.
- Inhibiting primary root growth while promoting lateral root growth.
- Stimulating bud initiation and leaf growth.
- Encouraging fruit growth, although they rarely induce parthenocarpy.
- Supporting lateral bud growth and breaking bud dormancy.
- Delaying leaf senescence, thereby prolonging leaf lifespan.
- Promoting stomatal opening, which regulates gas exchange and transpiration in leaves.

24. What is Abscisic Acid and what are its major functions in plants?

Ans. Abscisic acid (ABA) is mainly synthesized in mature green leaves, fruits, and root caps. It primarily acts as a growth inhibitor and is involved in several stress responses and developmental processes:

- ABA inhibits both stem and root growth, especially during physiological stress conditions like drought and waterlogging.
- It promotes dormancy in buds and seeds, allowing plants to survive adverse conditions.
- ABA promotes flowering in short-day plants but inhibits flowering in long-day plants, functioning antagonistically to gibberellins.
- It sometimes promotes leaf senescence.
- ABA enhances abscission, the process of dropping leaves, flowers, or fruits.
- Under water stress, ABA promotes the closing of stomata to reduce water loss, preventing wilting.

25. Explain the role of Ethylene as a plant growth regulator and its effects on plant development.

Ans. Ethylene is a gaseous plant hormone produced naturally as a byproduct of plant metabolism. Its main functions include:

- Inhibiting stem growth, particularly during physiological stress.
- Inhibiting root growth.
- Breaking bud dormancy, allowing buds to resume growth.
- Promoting flowering in certain plants such as pineapple.
- Stimulating fruit ripening, which is critical for the maturation and dispersal of seeds.

Ethylene plays a vital role in regulating plant responses to stress and developmental cues related to reproduction and aging.

MCQ's

1. **Which of the following is the main type of auxin in plants?**
a) Gibberellic acid
b) Indole acetic acid (IAA✓)
c) Cytokinin d) Abscisic acid

2. **Auxins primarily promote cell enlargement in which part of the plant?**
a) Roots only
b) Region behind the apex of stems✓
c) Leaves only d) Lateral buds

3. **At high concentrations, auxins inhibit growth in:**
a) Stems b) Leaves
c) Roots✓ d) Flowers

4. **Which hormone promotes apical dominance in plants?**
a) Ethylene b) Cytokinin
c) Auxin✓ d) Abscisic acid

5. **Gibberellins are mainly produced in:**
a) Mature leaves b) Root caps
c) Apical portions of roots and shoots✓
d) Fruits only

6. **Gibberellins promote which of the following?**
a) Seed dormancy b) Leaf senescence
c) Bolting in rosette plants✓
d) Root growth inhibition

7. **Which hormone promotes cell division during cytokinesis?**
a) Auxin b) Cytokinin✓
c) Ethylene d) Abscisic acid

8. **Cytokinins are primarily produced in:**
a) Roots, young fruits, and seeds✓
b) Mature leaves
c) Stem tips d) Bark

9. **Which plant hormone inhibits primary root growth but promotes lateral root growth?**
a) Gibberellins b) Cytokinins✓
c) Auxins d) Ethylene

10. **Abscisic acid is mainly synthesized in:**
a) Apical meristems
b) Mature green leaves, fruits, and root caps✓
c) Young fruits only d) Stem tips

11. **Abscisic acid promotes:**
a) Cell division
b) Seed dormancy and bud dormancy✓
c) Stem elongation
d) Flowering in long-day plants

12. **Which hormone promotes stomatal closing under water stress?**
a) Ethylene b) Gibberellins
c) Abscisic acid✓ d) Cytokinins

13. **Ethylene primarily:**
a) Promotes stem growth
b) Inhibits stem and root growth during stress✓
c) Promotes root growth
d) Promotes seed dormancy

14. **Which hormone promotes fruit ripening?**
a) Auxin b) Ethylene✓
c) Cytokinin d) Abscisic acid

15. **Which hormone breaks bud dormancy?**
a) Gibberellins b) Ethylene✓
c) Abscisic acid d) Auxin

16. **Parthenocarpy (fruit development without fertilization) can be induced by:**
a) Auxins and gibberellins✓
b) Cytokinins only
c) Ethylene only d) Abscisic acid only

17. **Which plant hormone delays leaf senescence?**
a) Abscisic acid b) Cytokinins
c) Gibberellins d) Both b and c✓

18. **Which hormone promotes lateral bud growth and breaks bud dormancy?**
a) Auxin b) Cytokinin✓
c) Ethylene d) Abscisic acid

19. **Gibberellins can substitute for which environmental factor to promote flowering?**
a) Blue light b) Red light✓
c) Temperature d) Moisture

20. **Which hormone inhibits growth notably during physiological stress such as drought?**
a) Ethylene b) Gibberellins
c) Abscisic acid✓ d) Auxin

21. **Auxins promote growth of roots from:**
a) Seeds only
b) Cuttings and calluses✓
c) Flowers only d) Mature leaves

22. **Which hormone promotes flowering in pineapple?**
a) Auxin b) Ethylene✓
c) Gibberellin d) Cytokinin

23. **Which hormone is responsible for promoting cell enlargement in the presence of auxins?**
a) Cytokinin b) Abscisic acid
c) Gibberellins✓ d) Ethylene

24. **Which plant hormone inhibits abscission?**
a) Ethylene b) Auxin✓
c) Abscisic acid d) Cytokinin

25. **Which hormone promotes stomatal opening?**
a) Abscisic acid b) Cytokinins✓
c) Ethylene d) Gibberellins

SQ

1. **What are plant growth regulators?**
Ans. Plant growth regulators are special chemical messengers that regulate the rates of growth and

metabolism in plant cells. They control various developmental processes in plants.

2. **How many major groups of plant growth regulators are there?**

Ans. There are five major groups of plant growth regulators: auxins, cytokinins, gibberellins, abscisic acid, and ethylene. Each group has distinct roles in plant growth.

3. **What is the main auxin found in plants?**

Ans. The main auxin in plants is indole acetic acid (IAA). It plays a crucial role in cell enlargement and division.

4. **How do auxins affect stem growth?**

Ans. Auxins promote cell enlargement in the region behind the apex of stems. They also stimulate cell division in the cambium.

5. **What is the effect of auxins on root growth?**

Ans. Auxins promote root growth at very low concentrations but inhibit it at higher concentrations. This is important in responses like geotropism.

6. **How do auxins influence bud growth?**

Ans. Auxins promote bud initiation in shoots but can sometimes inhibit growth by acting antagonistically to cytokinins. They also maintain apical dominance.

7. **What role do gibberellins play in plants?**

Ans. Gibberellins promote cell enlargement and division, especially in the presence of auxins. They also help in processes like bolting and breaking seed dormancy.

8. **Where are gibberellins produced in plants?**

Ans. Gibberellins are produced mainly in the apical portions of roots and shoots and then transported to other parts of the plant.

9. **What are cytokinins and where are they produced?**

Ans. Cytokinins are plant hormones that promote cell division. They are mainly produced in roots, young fruits, and seeds.

10. **How do cytokinins affect root growth?**

Ans. Cytokinins inhibit primary root growth but promote the growth of lateral roots. This helps in better root system development.

11. **What is the function of abscisic acid in plants?**

Ans. Abscisic acid inhibits growth during stress conditions like drought. It also promotes seed and bud dormancy to help plants survive unfavorable conditions.

12. **How does abscisic acid affect stomata?**

Ans. Abscisic acid promotes the closing of stomata under water stress. This helps reduce water loss and prevents wilting.

13. **What is the role of ethylene in plants?**

Ans. Ethylene inhibits stem and root growth during stress and promotes fruit ripening. It also breaks bud dormancy and promotes flowering in some plants.

14. **How does ethylene affect fruit development?**

Ans. Ethylene promotes fruit ripening, which is essential for seed dispersal. This hormone controls the timing of maturation in many fruits.

15. **What is apical dominance and which hormone controls it?**

Ans. Apical dominance is the phenomenon where the main shoot grows more strongly than side shoots. Auxins are primarily responsible for maintaining apical dominance.

16. **Can auxins induce fruit development without fertilization?**

Ans. Yes, auxins can sometimes induce parthenocarpy, which is fruit development without fertilization.

17. **How do cytokinins influence leaf growth?**

Ans. Cytokinins promote leaf growth by stimulating cell division and expansion. They also delay leaf aging.

18. **What happens to leaf senescence in the presence of auxins and gibberellins?**

Ans. Auxins and gibberellins can delay leaf senescence, keeping leaves healthy for longer periods.

19. **How do gibberellins influence flowering in long-day plants?**

Ans. Gibberellins can substitute for red light and promote flowering in long-day plants. However, they may inhibit flowering in short-day plants.

20. **What is the effect of cytokinins on bud dormancy?**

Ans. Cytokinins break bud dormancy and promote lateral bud growth, encouraging branching in plants.

8.8 OSMOREGULATION IN PLANTS

Q 26. What is osmoregulation, and why is it important for organisms, especially plants?

Ans. Definition of Osmoregulation:

Osmoregulation is the process by which an organism maintains a stable internal equilibrium of water and dissolved substances, regardless of the surrounding environmental conditions. This regulation is crucial for maintaining cellular function and overall homeostasis.

Significance in Different Organisms:

While many marine organisms can undergo osmosis passively—because their cells have the same osmotic pressure as seawater—others, especially terrestrial and some aquatic plants, must actively regulate the uptake, retention, or elimination of water and salts. This active regulation ensures that the internal water and mineral balance remains optimal for survival despite changes in the external environment.

Q 27. Explain the types of solutions related to osmosis and their effects on plant cells.

Ans. Hypotonic Solution:

A hypotonic solution has a lower solute concentration compared to the cell's interior. In this case, water enters the plant cell by osmosis, causing the cell to swell. This influx of water can be beneficial for plant cells, which rely on turgor pressure for structural support.

Hypertonic Solution:

A hypertonic solution contains a higher solute concentration than the inside of the cell. Water moves out of the cell into the surrounding solution, causing the cell to lose water and shrink. This shrinkage is called plasmolysis and can be harmful as it leads to loss of turgidity and may damage cell function.

Isotonic Solution:

In an isotonic solution, the solute concentration inside the cell is equal to that outside. Consequently, there is no net movement of water across the cell membrane. The cell remains in equilibrium with its environment, maintaining its shape and function.

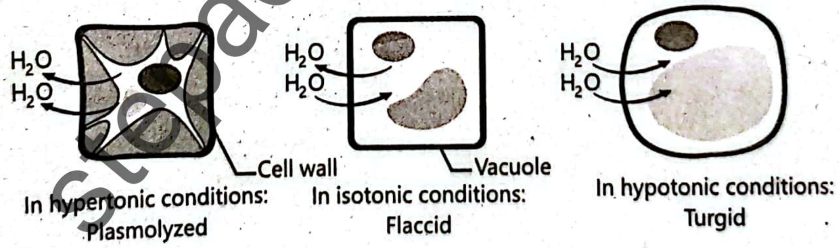

Fig 8.16: Effect of Hypertonic, Hypotonic and isotonic solution to plant cell.

Q 28. How do plants adjust osmotically in different environments? Discuss the adaptations in hydrophytes, mesophytes, xerophytes, and halophytes.

Ans. Introduction to Plant Habitats:

Plants grow in diverse habitats ranging from aquatic to dry terrestrial environments and saline soils. Based on their adaptations to water availability and salinity, plants are categorized into hydrophytes, mesophytes, xerophytes, and halophytes.

Hydrophytes:

Hydrophytes live in aquatic environments like freshwater and marine ecosystems. These plants have evolved specialized osmotic mechanisms to survive in hypotonic or hypertonic surroundings.

Marine Hydrophytes: These grow in saline, hypertonic conditions where water tends to leave the cells. To cope, they excrete excess salts using salt glands and synthesize organic solutes such as proline, glycine betaine, and sugars to increase their internal osmotic potential, helping them retain water. Additionally, thick cuticles reduce water loss, and they possess halophytic traits to tolerate high salinity.

Freshwater Hydrophytes: These face hypotonic environments where water continually enters the cells. To avoid overhydration, they expel excess water through structures like hydathodes or vacuoles. They actively absorb ions such as potassium and calcium to maintain osmotic balance. These plants usually have thin or absent cuticles and reduced root systems, relying on direct absorption from their environment.

Examples: Water lilies, lotus, seaweeds, and tape grass.

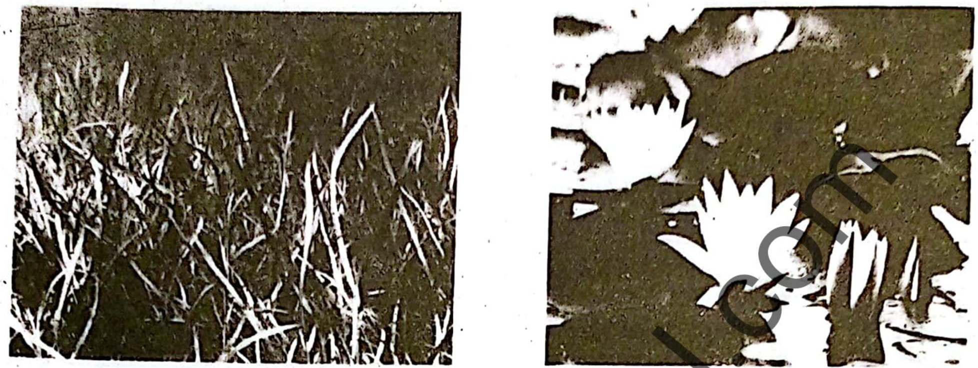

Fig 8.17: (a) Waterlily floating in freshwater. (b) Tape grass in freshwater lake.

Mesophytes:

Mesophytes inhabit moderate environments that are neither too dry nor too wet. They thrive in soil with moderate water and salt content and humidity. These plants have well-developed roots and shoots with a fully functional vascular system. They generally do not require special osmotic adaptations. Their leaves are broad, flat, and green, containing stomata on the surface for gas exchange.

Examples: Rose, tomato, and daisy.

Fig 8.18: Examples of mesophytes, left (rose) and right (daisy) .

Xerophytes:

Xerophytes are adapted to survive dry conditions and minimize water loss. Some store water in fleshy stems or leaves and are called succulents. Other adaptations include waxy leaf coatings to reduce evaporation, leaf shedding during drought, and leaf folding or repositioning to maximize sunlight absorption efficiently. These adaptations help xerophytes conserve and use water effectively.

Examples: Thorn trees, desert marigold, and blue agave.

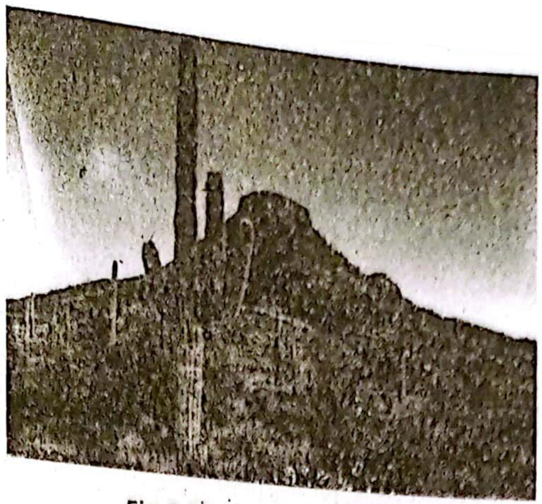

Fig 8.19: A xerophytic plant

Halophytes:

Halophytes grow in saline soils or water with high salt concentrations such as NaCl, $MgCl2$, and $MgSO4$. They tolerate high salt levels by having succulent leaves and sometimes stems that store water. Some halophytes also have leaves modified into spines to reduce surface area and water loss.

Examples: Sea arrowgrass and sea lavender.

Fig 8.20: Sea Arrowgrass

29. What are the key physiological mechanisms used by marine hydrophytes to survive in hypertonic environments?

Ans. Challenges in Hypertonic Environments:

Marine hydrophytes live in saline water where the surrounding solution has higher solute concentration than their cells. This condition causes water to move out of the cells by osmosis, which can lead to dehydration and cellular damage.

Adaptations to Maintain Water Balance:

To prevent water loss, marine hydrophytes have specialized salt glands that excrete excess salts out of the plant, thereby reducing internal salt concentrations and helping retain water. Additionally, these plants synthesize organic solutes such as proline, glycine betaine, and sugars, which increase their internal osmotic potential. This higher osmotic potential inside the cells helps in retaining water and maintaining turgor pressure.

Physical Adaptations:

Marine hydrophytes also possess thick cuticles that serve as barriers to water loss. Their overall physiology exhibits halophytic traits that enable them to tolerate the stressful saline environment effectively.

30. Describe the osmotic challenges faced by freshwater hydrophytes and their adaptations to maintain osmotic balance.

Ans. Challenges in Hypotonic Environments:

Freshwater hydrophytes exist in environments where the external solution has a lower solute concentration than their cells. Water continuously enters the cells by osmosis, which can cause overhydration and bursting of cells.

Osmoregulatory Adaptations:

To counteract excessive water intake, freshwater hydrophytes expel surplus water through specialized structures called hydathodes or store it temporarily in vacuoles. They also actively absorb essential ions like potassium and calcium to maintain the osmotic balance between the internal and external environments.

Structural Adaptations:

These plants often have thin or absent cuticles, which facilitate efficient water exchange. Their root systems may be reduced because they can absorb nutrients and water directly from their aquatic environment.

MCQs

1. **What is osmoregulation in plants?**
   A) Energy production in cells
   B) Maintenance of temperature
   C) Regulation of water and solute balance ✓
   D) Leaf formation
2. **What happens when a plant cell is placed in a hypotonic solution?**
   A) Water enters the cell ✓ B) Water exits the cell
   C) Cell undergoes plasmolysis
   D) The cell dies immediately
3. **Which condition causes plasmolysis in plant cells?**
   A) Hypotonic environment
   B) Hypertonic environment ✓
   C) Isotonic environment D) Waterlogging
4. **In an isotonic solution, the net movement of water is:**
   A) Into the cell B) Out of the cell
   C) Zero ✓ D) Unpredictable
5. **Plants growing in aquatic environments are called:**
   A) Mesophytes B) Hydrophytes ✓
   C) Xerophytes D) Halophytes
6. **Which of the following plants is an example of a freshwater hydrophyte?**
   A) Desert marigold B) Water lily ✓
   C) Sea arrowgrass D) Blue agave
7. **Marine hydrophytes combat salinity by:**
   A) Increasing transpiration B) Absorbing more salt
   C) Excreting excess salt and producing solutes ✓
   D) Closing their stomata permanently
8. **What do freshwater hydrophytes use to remove excess water?**
   A) Salt glands B) Stomata
   C) Hydathodes and vacuoles ✓ D) Leaf hairs
9. **Which plant has a thin or absent cuticle and reduced root system?**
   A) Xerophyte
   B) Freshwater hydrophyte ✓
   C) Halophyte D) Mesophyte
10. **What are mesophytes?**
    A) Plants in saline water
    B) Plants in moderate environments ✓
    C) Desert plants D) Marine plants
11. **Which of the following is a mesophyte?**
    A) Cactus B) Tape grass
    C) Rose ✓ D) Sea lavender
12. **What is a common feature of mesophyte leaves?**
    A) Needle-shaped leaves B) Waxy thick cuticle
    C) Flat, broad leaves with stomata ✓
    D) Spiny and succulent
13. **What are xerophytes?**
    A) Plants adapted to dry environments ✓
    B) Plants that live in water
    C) Salt-loving plants D) Temperate forest plants
14. **Succulents are a type of:**
    A) Mesophyte B) Xerophyte ✓
    C) Halophyte D) Hydrophyte
15. **Which adaptation is common in xerophytes?**
    A) Thin cuticle
    B) Waxy coatings and leaf drop ✓
    C) Enlarged vacuoles D) Salt excretion
16. **Halophytes grow in:**
    A) Freshwater lakes B) Humid jungles
    C) Saline soils or salty water ✓
    D) Shaded areas
17. **A plant with succulent leaves and saline tolerance is a:**
    A) Mesophyte B) Halophyte ✓
    C) Xerophyte D) Hydrophyte
18. **Which of the following is an example of a halophyte?**
    A) Tomato B) Sea arrowgrass ✓
    C) Lotus D) Rose
19. **What are salt glands used for in plants?**
    A) Water absorption B) Nutrient exchange
    C) Salt excretion ✓ D) Leaf expansion
20. **What are hydathodes?**
    A) Roots that absorb nutrients
    B) Structures that expel water ✓
    C) Salt-secreting glands D) Waxy cuticle pores
21. **Why do xerophytes fold or reposition their leaves?**
    A) To release water
    B) To absorb sunlight efficiently and reduce water loss ✓
    C) To increase surface area D) To attract pollinators
22. **Plasmolysis is a result of placing a plant cell in:**
    A) Hypotonic solution
    B) Hypertonic solution ✓
    C) Isotonic solution D) Distilled water
23. **Which of these plants stores water in stems?**

A) Succulents ✓ B) Mesophytes
C) Halophytes D) Aquatic ferns

24. **In mesophytes, which structure is well developed?**
A) Salt glands B) Leaf hairs
C) Vascular system ✓ D) Hydathodes

25. **Freshwater hydrophytes actively absorb ions such as:**
A) Sodium and chlorine B) Magnesium and sulfur
C) Potassium and calcium ✓ D) Iron and zinc

26. **Which adaptation is common in marine hydrophytes but not in freshwater hydrophytes?**
A) Hydathodes B) Salt glands ✓
C) Reduced roots D) Broad leaves

27. **What do halophytes and xerophytes have in common?**
A) Thin cuticles B) Hydathodes
C) Succulent tissues ✓
D) Stomata on upper surface only

28. **Why do hydrophytes often have reduced root systems?**
A) To absorb more nutrients
B) Because they absorb nutrients directly from water ✓
C) To anchor in soil better
D) To support taller stems

29. **What causes swelling in plant cells?**
A) Water entering in hypotonic solution ✓
B) Loss of water in hypertonic solution
C) Equal solute balance
D) Active transport

30. **What is the main challenge for plants in saline environments?**
A) Nutrient deficiency
B) Water loss due to high salt concentration ✓
C) Excess sunlight D) Poor air quality

SQ

1. **What is osmoregulation in plants?**
Ans. Osmoregulation is the process by which plants maintain a stable internal balance of water and dissolved substances. This helps them survive despite changing environmental conditions.

2. **Why do marine organisms sometimes not require osmoregulation?**
Ans. Many marine organisms have cells with the same osmotic pressure as seawater. Therefore, they can undergo osmosis without needing active regulation.

3. **What happens to a plant cell in a hypotonic solution?**
Ans. Water enters the cell by osmosis because the external solute concentration is lower. This causes the cell to swell.

4. **What is plasmolysis?**
Ans. Plasmolysis occurs when a cell loses water in a hypertonic solution, causing it to shrink. This happens because water moves out of the cell.

5. **How does an isotonic solution affect plant cells?**
Ans. In an isotonic solution, the solute concentration inside and outside the cell is equal. There is no net movement of water, so the cell remains stable.

6. **What are hydrophytes?**
Ans. Hydrophytes are plants adapted to live in aquatic environments like fresh or saltwater. They have special mechanisms to manage water balance.

7. **How do marine hydrophytes deal with high salinity?**
Ans. They excrete excess salts through salt glands and produce organic solutes to retain water. These adaptations help them survive in salty water.

8. **What is the role of organic solutes in marine hydrophytes?**
Ans. Organic solutes such as proline and glycine betaine increase the plant's internal osmotic potential. This helps retain water in a saline environment.

9. **How do freshwater hydrophytes prevent overhydration?**
Ans. They expel excess water using structures like hydathodes and vacuoles. This prevents their cells from bursting due to too much water intake.

10. **What are mesophytes?**
Ans. Mesophytes are plants that live in moderate environments, neither too dry nor too wet. They do not need special osmotic adaptations.

11. **Describe the leaf structure of mesophytes.**
Ans. Mesophytes have broad, flat leaves with stomata on the surface. These leaves facilitate normal gas exchange and water regulation.

12. **What adaptations do xerophytes have for dry environments?**

Ans. Xerophytes have waxy coatings on leaves, store water in fleshy stems, and may shed leaves during drought. These features minimize water loss and conserve moisture.

13. **What are succulents?**

Ans. Succulents are plants that store water in their fleshy stems or leaves. They are a type of xerophyte adapted to dry conditions.

14. **How do xerophytes use leaf folding?**

Ans. Leaf folding reduces the surface area exposed to sunlight and wind, thus decreasing water loss. It also helps in efficiently absorbing sunlight

15. **What kind of environment do halophytes inhabit?**

Ans. Halophytes grow in saline soils or water with high concentrations of salts like NaCl and MgCl2. They are specially adapted to tolerate these salty conditions.

16. **How are halophyte leaves adapted to saline conditions?**

Ans. Many halophytes have succulent leaves that store water, and some have leaves modified into spines to reduce water loss. These adaptations help them survive high salinity.

17. **What is the function of salt glands in marine hydrophytes?**

Ans. Salt glands actively remove excess salts from the plant's tissues. This helps to maintain osmotic balance and prevent salt toxicity.

18. **Why do freshwater hydrophytes have reduced root systems?**

Ans. Because they absorb water and nutrients directly from their aquatic environment, their roots are often reduced. This adaptation suits their habitat where roots are less essential.

19. **What happens to plant cells in a hypertonic solution?**

Ans. Water moves out of the cells causing them to shrink. This results in plasmolysis, which can damage the cells.

20. **Why is maintaining osmotic balance important for plants?**

Ans. Osmotic balance ensures that cells neither swell excessively nor shrink. This is vital for maintaining cell structure and function.

21. **How do xerophytes reduce water loss through their leaves?**

Ans. They have waxy coatings and may shed leaves during dry periods. These features reduce transpiration and conserve water.

22. **What adaptations help mesophytes survive without special mechanisms?**

Ans. Mesophytes live in balanced environments with adequate water and nutrients. They have well-developed roots, shoots, and vascular systems to support normal growth.

23. **What are hydathodes and what is their role?**

Ans. Hydathodes are structures in plants that expel excess water. They help freshwater hydrophytes avoid water overload.

24. **How does leaf senescence relate to osmoregulation?**

Ans. Leaf senescence or aging can be influenced by water stress. Some plant hormones that regulate osmoregulation also affect the timing of senescence.

25. **What role do vacuoles play in freshwater hydrophytes?**

Ans. Vacuoles store excess water temporarily to prevent overhydration. They help maintain cell turgidity and osmotic balance.

8.9 THERMOREGULATION IN PLANTS

Q 31. What is thermoregulation in plants, and how do plants respond to heat stress?

Ans. Definition and Importance

Thermoregulation in plants is a type of homeostasis in which organisms, including plants, maintain their internal body temperature despite variations in environmental temperature. This process is crucial because high temperatures can denature enzym s and damage vital metabolic pathways.

Response to High Temperature

To cope with elevated temperatures, plants utilize **evaporative cooling**, primarily through the evaporation of water via stomata. This helps in dissipating excess heat. However, in hot and dry climates, water becomes scarce, leading to the closure of stomata to prevent water loss. This, in turn, reduces the plant's ability to cool itself and can lead to thermal stress.

Plants, especially those in temperate regions that often experience temperatures of **40°C or higher**, have evolved certain adaptations. They synthesize large quantities of **heat-shock proteins**, which play a vital role in protecting enzymes and structural proteins from denaturation. These proteins act like molecular chaperones, helping other proteins maintain their functional conformations during heat stress.

Q 32. How do plants respond to low temperatures, and what adaptations help them survive freezing stress?

Ans. **Effects of Low Temperature**

Low temperatures affect the **fluidity of the cell membrane**. The lipids in the membrane become locked into rigid crystalline structures, impairing **solute transport** and damaging membrane-bound proteins. Such structural changes disrupt normal cellular functions.

Adaptations to Cold Stress

To counter these effects, plants increase the proportion of **unsaturated fatty acids** in their cell membranes. These unsaturated fats maintain membrane fluidity by preventing the formation of crystalline structures, thus preserving membrane integrity at low temperatures. This adjustment, however, is **gradual**, making sudden cold exposure more harmful than a slow decline in temperature.

Freezing Stress and Ice Formation

Exposure to freezing temperatures can lead to **ice crystal formation**. If ice forms **outside the protoplasm**, such as around the cell wall, the damage is minimal, and the plant can survive. However, **ice formation within the protoplasm** leads to the perforation of membranes and organelles, ultimately killing the cell.

Plants native to cold climates—such as **oaks, maples, and roses**—have adapted by altering the **solute composition** in their cytoplasm. These solutes lower the freezing point and enable **supercooling** of the cytosol without forming ice, even though ice may still form in the cell walls.

MCQs

1. **What is thermoregulation in plants?**
   A) Regulation of water content
   B) Control of photosynthesis
   C) Maintenance of internal temperature ✓
   D) Reproduction under heat

2. **What helps plants cope with high temperatures?**
   A) Photosynthesis B) Transpiration
   C) Evaporative cooling ✓ D) Root growth

3. **What causes stomata to close during hot and dry weather?**
   A) Increased sunlight B) Excess oxygen
   C) Water deficiency ✓
   D) Decreased photosynthesis

4. **What are heat-shock proteins responsible for?**
   A) Breaking down enzymes
   B) Enhancing transpiration
   C) Preventing protein denaturation ✓
   D) Cooling leaves

5. **What happens to membrane lipids in low temperatures?**
   A) They become more fluid
   B) They form crystalline structures ✓
   C) They evaporate
   D) They break into amino acids

6. **What kind of fatty acids increase in cold stress adaptation?**
   A) Saturated fatty acids B) Trans fatty acids
   C) Unsaturated fatty acids ✓ D) Aromatic fatty acids

7. **What type of temperature drop is more harmful to plants?**
   A) Gradual drop B) Rapid chilling ✓
   C) Constant low temperature D) Sudden heating

8. **What does intracellular ice formation cause?**
   A) No harm B) Increased metabolism
   C) Perforation of membranes ✓
   D) Cell elongation

9. **How do cold-region plants prevent intracellular ice formation?**
   A) Increase cell wall thickness
   B) Use stomatal closure
   C) Change solute composition ✓
   D) Freeze cytoplasm

SQ

1. What is thermoregulation in plants?

Ans. Thermoregulation is a form of homeostasis where plants maintain their internal temperature despite changes in environmental temperature. This helps protect their enzymes and metabolic activities from heat or cold damage.

2. **How do plants cope with high temperatures?**

Ans. Plants use evaporative cooling through the opening of stomata to lose heat. However, in hot and dry conditions stomata may close due to water deficiency, reducing their ability to cool.

3. **What are heat-shock proteins and what is their function?**

Ans. Heat-shock proteins are special proteins synthesized by plants under heat stress. They stabilize and protect enzymes and other proteins from denaturation.

4. **How does low temperature affect the cell membrane of plants?**

Ans. Low temperature causes the lipids in the cell membrane to form crystalline structures, making the membrane less fluid. This impairs solute transport and affects membrane protein function.

5. **How do plants adapt to cold temperatures at the membrane level?**

Ans. Plants increase the proportion of unsaturated fatty acids in their membranes. This helps maintain membrane fluidity and prevents crystal formation during cold stress.

6. **Why is rapid chilling more harmful to plants than gradual cooling?**

Ans. Rapid chilling does not give the plant enough time to adapt its membrane composition. Gradual cooling allows time for the necessary physiological adjustments.

7. **What happens when ice crystals form within the protoplasm of plant cells?**

Ans. Ice crystals in the protoplasm perforate membranes and organelles, causing cell death. This is much more damaging than ice forming around the cell wall.

8. **How do cold-region plants avoid intracellular ice formation?**

Ans. Plants like oaks and roses change the solute composition in their cells to supercool the cytosol. This prevents ice formation inside the protoplasm while allowing ice formation in the cell wall.

8.10 MOVEMENTS IN PLANTS

33. Describe different types of movements observed in plants in response to external stimuli.

Ans. Movement in Plants

Although plants are fixed organisms and cannot move from place to place like animals, they do exhibit movements in response to external and internal stimuli. These movements are primarily expressed through altered **growth patterns.**

Tropic Movements

Tropic movements or **tropisms** are growth movements in plants triggered by specific stimuli. They result in the curvature of a plant organ either **towards or away** from the stimulus.

Types of Tropisms

1. **Phototropism:** Movement in response to light. Shoots usually show **positive phototropism** (towards light), while roots exhibit **negative phototropism** (away from light).
2. **Geotropism:** Response to gravity. Roots display **positive geotropism**, growing downward, while shoots show **negative geotropism**, growing upward.
3. **Thigmotropism:** Movement in response to touch. For example, **climbing vines** show this when tendrils coil around a support due to differential growth on the side opposite to the point of contact.
4. **Chemotropism:** Movement in response to chemicals. An example includes **fungal hyphae** that grow towards chemical signals.

mQ's

1. **Why can't plants show locomotion like animals?**
   A) They lack energy
   B) They are rooted in place ✓
   C) They have no legs
   D) They photosynthesize

2. **What are tropic movements?**
   A) Locomotive movements
   B) Internal movements
   C) Growth in response to stimuli ✓
   D) Random bending

3. **What kind of phototropism do shoot tips show?**
   A) Neutral
   B) Negative
   C) Positive ✓
   D) Irregular

4. **What is geotropism?**
   A) Response to chemicals
   B) Response to gravity ✓

C) Response to water D) Response to light

5. **Which part of the plant shows positive geotropism?**

A) Leaves B) Stem

C) Roots✓ D) Flowers

6. **What is thigmotropism?**

A) Response to heat B) Response to sound

C) Response to touch✓ D) Response to light

7. **What is an example of chemotropism?**

A) Root bending toward gravity

B) Tendrils coiling around a support

C) Hyphae growing toward chemicals✓

D) Shoot growing toward light

8. **What is photoperiodism?**

A) Response to temperature

B) Response to air pressure

C) Response to day length✓

D) Response to water availability

SQ

1. **Why can't plants show locomotion like animals?**

Ans. Plants are fixed organisms and cannot move from place to place. They respond to stimuli through growth movements instead.

2. **What are tropic movements in plants?**

Ans. Tropic movements are growth movements in response to external stimuli. These movements involve bending toward or away from stimuli like light, gravity, and touch.

3. **What is phototropism?**

Ans. Phototropism is plant movement in response to light. Shoots show positive phototropism while roots typically show negative phototropism.

4. **What is geotropism and how do roots and shoots respond to it?**

Ans. Geotropism is plant movement in response to gravity. Roots grow downward showing positive geotropism, while shoots grow upward showing negative geotropism.

5. **What is thigmotropism?**

Ans. Thigmotropism is movement in response to touch. An example is the coiling of tendrils around a support structure.

6. **What is chemotropism in plants?**

Ans. Chemotropism is a plant's growth response to chemical stimuli. Fungal hyphae, for example, grow toward certain chemicals.

8.11 PHOTOPERIODISM

34. What is photoperiodism in plants, and how does it influence flowering?

Ans. Definition and Discovery

Photoperiodism is the response of plants to the length of day and night, enabling them to adapt to seasonal environmental changes. The phenomenon was first studied in **1920 by Garner and Allard**, who discovered that certain plants like tobacco only flower after being exposed to a specific sequence of short days.

Classification of Plants Based on Photoperiod

Based on their flowering response to photoperiod, plants are classified into:

- **Short-day plants (SDPs)**: Flower when the dark period exceeds a critical length.
- **Long-day plants (LDPs)**: Flower when the dark period is shorter than a critical length.
- **Day-neutral plants (DNPs)**: Flowering is **independent** of photoperiod.

Table 7.2: Classification of Plants According to Photoperiodic Requirements

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 8.5 h; tobacco 10-11h).	Flowering induced by dark periods shorter than a critical length (e.g., henbane 13h).	Flowering independent of photoperiod.
Examples: cocklebur (*Xanthium*), chrysanthemum, soybean, tobacco, strawberry.	**Examples**: henbane (*Hyoscyamus niger*), snapdragon, cabbage, spring wheat, spring barley.	**Examples**: cucumber, tomato, garden pea, maize, cotton.

35. Explain the mechanism of flowering in plants with reference to phytochrome and florigen.

Ans. Role of Phytochrome

The flowering response is closely linked to a **photoreceptor protein** called **phytochrome**, which exists in two interconvertible forms:

- **P660 (inactive)**: Absorbs red light (660 nm) and converts to P730.
- **P730 (active)**: Absorbs far-red light (730 nm) and converts back to P660.

In natural conditions:

- **Daylight** converts P660 to P730.
- **Darkness** converts P730 back to P660.

This **interconversion mechanism** acts as a biological **"clock"** that measures the duration of darkness.

Effect on Flowering

- In **short-day plants**, red light (which promotes P730) **inhibits** flowering.
- In **long-day plants**, red light and the presence of P730 **promote** flowering.

If the long dark period of a short-day plant is interrupted with light, it prevents flowering. Conversely, interrupting the night in long-day plants **induces** flowering.

Florigen: The Flowering Hormone

Recent research suggests that phytochrome interconversion is **not the sole mechanism** for flowering. The **biological clock** within the plant triggers the production of a **flower-inducing hormone** called **florigen** in the **leaves**. Florigen travels through the **phloem** to the **floral buds**, initiating flowering processes.

MCQs

1. **Who first studied photoperiodism in 1920?**
A) Darwin and Lamarck B) Hooker and Linnaeus
C) Garner and Allard ✓ D) Mendel and Watson

2. **Which plant was studied by Garner and Allard?**
A) Tomato B) Maize
C) Tobacco ✓ D) Rose

3. **What type of plants flower under long nights?**
A) Long-day plants B) Short-day plants ✓
C) Day-neutral plants D) Biennials

4. **Which plants flower without being influenced by day length?**
A) Day-neutral plants ✓ B) Short-day plants
C) Long-day plants D) Annuals

5. **What is the critical factor for flowering in photoperiodism?**
A) Day length B) Light intensity
C) Dark period length ✓ D) Water availability

6. **What happens if the dark period is interrupted in short-day plants?**
A) Flowering occurs faster B) No effect
C) Flowering is prevented ✓
D) Leaf fall begins

7. **What does the phytochrome P660 absorb?**
A) Far-red light B) Blue light
C) Red light at 660 nm ✓ D) UV light

8. **What does phytochrome P730 absorb?**
A) Red light B) Blue light
C) Far-red light at 730 nm ✓
D) UV light

9. **What happens to P730 during the night?**
A) It is stabilized B) It converts to P660 ✓
C) It remains active D) It is destroyed

10. **What is the hypothetical hormone responsible for flowering?**
A) Auxin B) Florigen ✓
C) Cytokinin D) Abscisic acid

11. **Where is florigen produced?**
A) Roots B) Floral buds
C) Stems D) Leaves ✓

12. **What does florigen travel through to reach floral buds?**
A) Xylem B) Stomata
C) Phloem ✓ D) Chloroplasts

13. **Which of the following is a long-day plant?**
A) Tobacco B) Chrysanthemum
C) Henbane ✓ D) Strawberry

SQ

1. **What is photoperiodism?**

Ans. Photoperiodism is the plant's response to the relative lengths of day and night. It allows plants to adapt to seasonal changes in their environment.

2. **What discovery did Garner and Allard make about flowering in plants?**

Ans. They discovered that tobacco plants flower only after a series of short days. This led to the classification of plants based on their flowering response to day length.

3. **What are the three types of plants based on photoperiodic response?**

Ans. Plants are classified into short-day, long-day, and day-neutral plants. Each type flowers under different conditions of light and dark.

How does light interruption affect flowering in short-day plants?

Ans. If a long night is interrupted by light, flowering is prevented in short-day plants. This shows the importance of continuous darkness for their flowering.

5. **What is the role of phytochrome in photoperiodism?**

Ans. Phytochrome acts as a photoreceptor that exists in two forms: P660 and P730. These forms interconvert in response to red and far-red light, helping the plant measure darkness duration.

6. **What is florigen and what role does it play in flowering?**

Ans. Florigen is a hypothetical flowering hormone produced in the leaves. It travels through the phloem to floral buds and initiates flowering.

8.12 VERNALISATION

36. Explain the process of vernalisation in plants.

Ans. Introduction to Vernalisation

Biennial and perennial plants are stimulated to flowering by exposure to low temperature. This is called **vernalisation.**

Site of Stimulus

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.

Types of Response in Plants

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

Duration and Temperature Requirement

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.

Hormonal Response

It stimulates the production of a hormone called **"vernalin"**, which induces vernalisation.

Role in Plant Reproduction

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.**

MCQ's

1. **What is vernalisation?**
   A. Induction of dormancy in plants
   B. Stimulation of flowering by high temperature
   C. Stimulation of flowering by low temperature ✓
   D. Suppression of seed germination

2. **Which plant parts receive the vernalisation stimulus?**
   A. Leaves B. Roots
   C. Shoot apex or seed embryo ✓
   D. Stem internodes

3. **What is the effective temperature for vernalisation?**
   A. 25°C B. 15°C
   C. 10°C D. 4°C ✓

4. **How long can the chilling period for vernalisation last?**
   A. 1 to 2 hours B. 1 day only
   C. 4 days to 3 months ✓ D. 6 months to 1 year

5. **What hormone is believed to be produced due to vernalisation?**
   A. Auxin B. Gibberellin
   C. Vernalin ✓ D. Cytokinin

6. **What is the function of vernalin?**
   A. Inhibits flowering
   B. Stimulates seed dormancy
   C. Induces flowering ✓
   D. Promotes root growth

7. **In which plants is vernalisation an absolute requirement?**

A. All annual plants
B. Some biennial and perennial plants ✓
C. Aquatic plants only
D. Photoperiodic plants

8. What is the purpose of vernalisation in relation to the environment?
A. Inhibits seed germination
B. Promotes leaf development in summer
C. Synchronises reproduction with favourable conditions ✓
D. Causes early dormancy in winter

9. How does vernalisation promote genetic variability?
A. By changing the structure of DNA
B. By ensuring simultaneous flowering for cross pollination ✓
C. By producing hybrid seeds
D. By altering chlorophyll content

10. Which of the following is NOT true about vernalisation?
A. It requires high temperatures. ✓
B. It involves the shoot apex or seed embryo.
C. It induces flowering.
D. It can last from four days to three months.

SQ

1. What is vernalisation?
Ans. Vernalisation is the stimulation of flowering in biennial and perennial plants by exposure to low temperature. It helps align the plant's reproductive phase with favourable environmental conditions.

2. Which part of the plant receives the stimulus for vernalisation?
Ans. The low temperature stimulus for vernalisation is received by the shoot apex of a mature stem or the embryo of the seed. Unlike photoperiodism, the leaves do not perceive this stimulus.

3. What is the role of vernalin in vernalisation?
Ans. Vernalin is a hormone produced in response to low temperature exposure. It is responsible for inducing flowering after vernalisation has occurred.

4. How long does the low-temperature treatment for vernalisation usually last?
Ans. The chilling treatment for vernalisation varies from four days to three months. A temperature around 4°C is found to be most effective.

5. How do photoperiodism and vernalisation benefit plants?
Ans. Photoperiodism and vernalisation help synchronise the reproductive behaviour of plants with the seasons. This ensures flowering at optimal times and promotes cross pollination for genetic diversity.

SOLVED EXERCISE

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct answer.

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 hair (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) Xerophytes ✓ (b) Hydrophytes (c) Mesophytes (d) Halophytes

LONG QUESTIONS

Q1. Describe osmoregulation in Hydrophytes and Halophytes?

Ans. See long question number 28.

Q2. 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 long question 31 and 32.

Q3. What is the role of meristem in the growth of plants?

Ans. See long question 16

Q4. Describe the mechanism of opening and closing of stomata?

Ans. See Long question 6

Q5. 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 long question 34 and 35.

INQUISITIVE QUESTIONS

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

Hypothesis on Stomatal Movement:

The opening and closing of stomata are primarily controlled by the turgor pressure changes in guard cells. When guard cells take up potassium ions (K^+), water enters by osmosis, increasing turgor pressure that causes the stomata to open. Conversely, loss of K^+ leads to water exiting guard cells, reducing turgor pressure and causing stomatal closure. This mechanism helps plants regulate gas exchange and water loss according to environmental conditions

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

Supplementary Nutrient Uptake in Carnivorous Plants:

Carnivorous plants perform photosynthesis like other autotrophs but grow in nutrient-poor soils, especially lacking nitrogen. They have evolved specialized structures such as sticky traps, pitfall traps, or snap traps to capture and digest insects and other small organisms, absorbing nutrients like nitrogen and phosphorus from their prey to supplement their growth requirements.

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

Support Role of Parenchyma and Sclerenchyma:

Parenchyma cells provide flexible support by filling spaces and storing nutrients, helping maintain the plant's shape. Sclerenchyma cells have thick, lignified walls that provide rigid mechanical support and strength to mature plant parts, protecting against bending and breaking.

4. How do the annual rings depict climatic variability?

Annual Rings as Indicators of Climate:

Annual rings in trees form due to variations in growth speed throughout seasons, typically wider rings during favorable conditions (warm and wet) and narrower rings during stress (cold or drought). By studying the thickness and density of these rings, scientists can infer past climatic conditions and changes over years.

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

Pressure Flow Theory of Translocation:

According to the Pressure Flow Theory, sugars produced in leaves (sources) are actively transported into sieve tubes of the phloem. This increases osmotic pressure, drawing water in and creating a pressure gradient that pushes the sugar solution toward sink areas (roots, fruits), where sugars are unloaded and used or stored.

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

Strategies to Induce Flowering:

Flowering can be induced by manipulating environmental factors such as light duration (photoperiodism) or temperature (vernalization). Additionally, applying plant hormones like gibberellins or interrupting dark periods with light can stimulate flowering in some plants.

Self-Assessment Unit 08

Max. Marks: 28 Time allowed 60 Mins

Q1. Each of the following question has four options. Select the correct answer. (10x1=10)

1. **The process by which water vapor exits the leaf surface, mainly via stomata, is known as:**
   (a) Transpiration (b) Guttation (c) Imbibition (d) Cohesion
2. **Which part of the plant is primarily responsible for the majority of transpiration?**
   (a) Root hairs (b) Phloem (c) Xylem (d) Stomata
3. **The TACT mechanism mainly accounts for:**
   (a) Nutrient movement in plants
   (b) Water transport through plant tissues
   (c) Mineral uptake from soil
   (d) Energy production in photosynthesis
4. **Which of the following is *not* considered a function of xylem tissue?**
   (a) Conducting water (b) Transporting dissolved minerals
   (c) Moving sugars (d) Providing structural support
5. **Which plant structure features a perforated cell wall to aid in transport?**
   (a) Vessel element (b) Fibre (c) Tracheid (d) Sclereid
6. **The stimulation of flowering in biennials and perennials by exposure to cold is called:**
   (a) Dormancy (b) Photoperiodism (c) Vernalization (d) All of the above
7. **Plants specifically adapted for arid, dry environments are called:**
   (a) Xerophytes (b) Hydrophytes (c) Mesophytes (d) Halophytes
8. **If a cell accumulates more sugar, increasing solute concentration, the water potential will:**
   (a) Increase (b) Decrease (c) Remain stable (d) Be unaffected
9. **In advanced plants, which structure is responsible for the transport of food substances?**
   (a) Companion cells (b) Sieve tube elements (c) Vessel cells (d) Tracheid elements
10. **Which plant hormone is known to suppress growth in roots and stems?**
    (a) Auxin (b) Ethylene (c) Cytokinin (d) Gibberellin

Q2. Write short answers to the following questions. (5x2=10)

1. Differentiate between macronutrients and micronutrients?
2. What are the main three pathways for the movement of water between plant cells?
3. Differentiate between hypertonic and hypotonic solution?
4. Write down the phases of plant growth?
5. Differentiate between Vernalin and Florigen.

Q3. Write detailed answer to the following question. (4+4=8)

1. Describe the mechanism of opening and closing of stomata?
2. Describe osmoregulation in Hydrophytes and Halophytes?