CHAPTER 10

FORM AND FUNCTIONS IN PLANTS

Number of allotted teaching periods: 27

Major Concepts:

10.1 Nutrition in Plants (1 Period)

10.2 Gaseous Exchange in Plants (2 Periods)

10.3 Transport in Plants (10 Period)

- **10.3.1 Uptake of Water by Roots and Pathways**
- **10.3.2 Ascent of Sap**
- **10.3.3 Opening and Closing of Stomata**
- **10.3.4 Translocation of Organic Matter**

10.4 Homeostasis in Plants (3 Periods)

10.5 Support in Plants (1 Period)

10.6 Growth and Development in Plants (3 Periods)

- **10.6.1 Tissues for Growth – Apical and Lateral Meristems, Primary and Secondary Growth**

10.7 Growth Responses in Plants (7 Periods)

- **10.7.1 Plant Growth Regulators (PRGs)**
- **10.7.2 Geotropism and Phototropism**
- **10.7.3 Photoperiodism**
- **10.7.4 Vernalization**

Nutrition is one of the important life processes of an organism to obtain energy for various life activities. Plants and many microorganisms obtain raw materials from air and soil. All those raw materials that organisms need for various synthetic activities and for the production of energy are called **nutrients**. All the process of the uptake and utilization of raw materials by living organisms for various metabolic activities is called **nutrition**.

10.1 NUTRITION IN PLANTS

How do biologists determine whether an element is essential? It is impossible to conduct mineral nutrition experiments by growing plants in soil because soil is too complex and contains too many elements. Thus, one of the most useful methods to test whether or not an element is essential is **hydroponics**, which is the growing of plants in aerated water to which mineral salts have been added.

Sixteen elements have been found essential for plant growth. Nine of these are required in fairly large quantities (greater than 0.05% dry weights) and are therefore known as **macronutrients**. These include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, calcium and magnesium. The remaining seven **micronutrients** are needed in trace amounts (less then 0.05%dry weight) for normal plant growth and development. These include iron, boron, manganese, copper, molybdenum, chlorine and zinc.

Nutrition In Carnivorous Plants

Carnivorous or insectivorous plants have green leaves which serve for the photosynthesis and have roots which can absorb water and dissolved mineral salts from the soil. But in addition to these organs, insectivorous plants have special devices, such as modified leaves, bright in colours which are used for trapping, attracting and digesting insects and other small organisms.

These plants usually grow in places where nitrogenous salts are not readily available e.g., marshy areas and therefore they use insects and other small organisms as their source of nitrogen. The examples are Pitcher Plant, (*Nepenthes pupurea*), Venus Flytrap (*Dionaea muscipula*), Sundew (*Drosera intermedia*).

Science, Technology and Society Connections

Identify some major symptoms of mineral deficiencies in plants e.g. necrosis, chlorosis, stunted growth etc.

Table 10.1 Mineral Nutrition in Plants

Macronutrients	Major Functions	Deficiency Symptoms
Carbon	Component of carbohydrates, lipids and nucleic acid molecules	Nil
Hydrogen	As above	Nil
Oxygen	As above	Nil
Nitrogen	Components of proteins, nucleic acids, chlorophyll, Coenzymes NAD, NADP, Cytochromes.	Chlorosis, development of purple colour due to formation of anthocyanins. Suppression growth with small leaves early defoliation. Flowering delayed
Phosphorus	In nucleic acids, phospholipids, ATP.	Stunted growth and premature leaf fall, development of anthocyanin pigment, brown necrotic areas appear on leaves, petioles and fruits. Restricted growth of root and shoot. Poor development of vascular tissue, delayed flowering.
Calcium	In cell wall, involved in membrane permeability, enzyme activator.	Meristematic regions badly effected. Chlorosis of margins of young leaves leading to necrosis. Flowering suppressed or premature fall of floweres.
Magnesium	In chlorophyll, enzyme activator in carbohydrate metabolism	Interveinal chlorosis. Formation of anthocyanin pigments. Necrosis in severe cases.
Sulphur	In certain amino acids and vitamins.	Stunted growth. Cholorosis first appearing in younger leaves. Formation of anthocynin.
Potassium	Osmosis and ionic balance, opening and closing of stomata, enzyme activator.	Stunted growth. Mottled chlorosis, necrotic shrivelling of leaves. Decrease in apical dominance. In cereals development of weak stem.
Micronutrients	**Major Functions**	**Deficiency Symptoms**
Chlorine	Ionic balance involved in photosynthesis.	Welting of leaf tips, following by chlorosis, bronzing and necrosis.
Iron	Part of enzymes involved in photosynthesis, respiration and nitrogen fixation	Interveinal chlorosis. Localised or generalized chlorosis.

Manganese	Part of enzymes involved in respiration and nitrogen metabolism, required for photosynthesis.	Chlorotic and necrotic spots in the interveinal regions of leaf. Leaves become mottled.
Copper	Part of enzymes involved in photosynthesis	Necrosis in the young leaves at the tip and along the margins. Exanthema in citrus tree and reclamation disease in cereals and legumes.
Zinc	Part of enzymes involved in respiration and nitrogen metabolism	Decreased growth. Reduction in size of internodes. Mottled leaf condition.
Molybdenum	Part of enzymes involved in nitrogen metabolism	Mottling and necrosis in older leaves. Deficiency causes whiptail disease in cauliflower
Boron	Involved in membrane transport and calcium utilization	Death of stem and root apices. Leaves become thick, curled and brittle. Flower production greatly reduced.

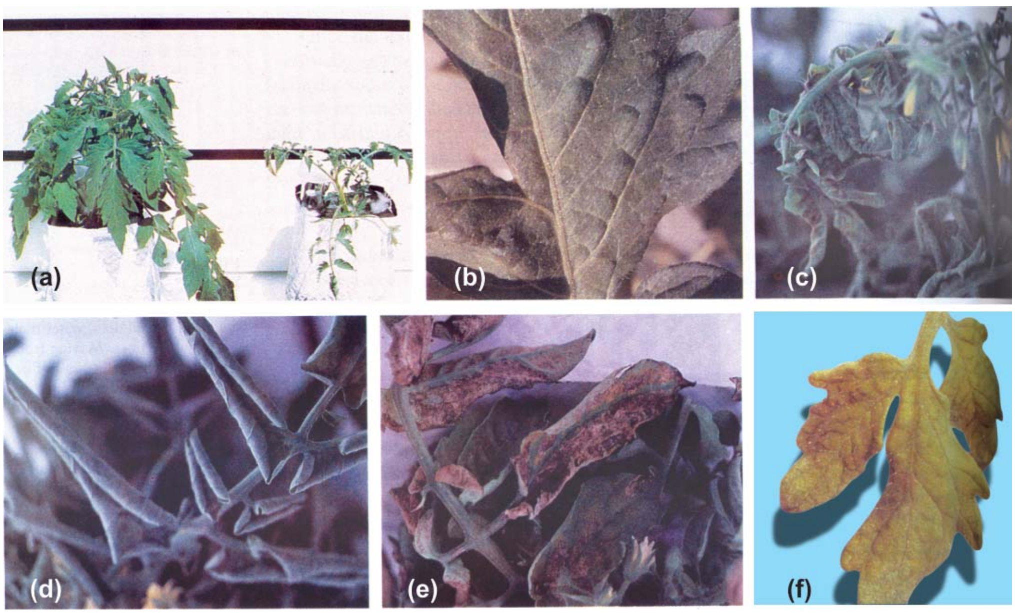


Fig 10.1: Mineral deficiencies in plants (a) Calcium deficiency (b) Leaf of a healthy plant (c) Chlorine-deficient plant leaves with patches of dead tissue (d) Copper- deficient plant with curled leaves (e) Zinc-deficient plant with small, necrotic leaves (f) Manganese-deficient plant, with yellowing between the veins.

10.2 GASEOUS EXCHANGE IN PLANTS

Respiration is one of the most important metabolic activities of all organisms. It occurs at two levels, i.e. organism and cellular level. The respiration occurring at organism level is called **breathing**, **ventilation** or simply the **exchange of gases**. The cellular respiration is directly involved in the production of energy. During this process cell utilizes oxygen and releases carbon dioxide. Exchange of gases between organism and its environment is carried out by diffusion. In the absence of special organs, every cell of plant carries out the exchanges of oxygen and carbon dioxide according to its needs.

Role of Palisade Tissue

Mesophylls are special types of thin walled parenchymatous cells. This is the packing tissue found between the two epidermal layers of leaves. These are modified to carry out photosynthesis. In dicots there are two distinct layers of mesophyll, the palisade mesophyll and the spongy mesophyll. Palisade forms the upper layer of cells which are elongated and column shaped cells. The **spongy mesophyll** forms the lower layers. These cells are used for the exchange of gases. There are also a large number of **intercellular spaces**, which are filled with air and are used for efficient gaseous exchange.

Role of Stomata

The **stomatal transpiration** is the loss of water in the form of water vapors through stomatal openings. It is not only responsible for transportation of water and minerals but also plays a vital role in the exchange of gases. During daylight the stomata are widely open and provides a wide passage for the exchange of gases. In the presence of light the process of photosynthesis increases. It requires more and more carbon dioxide, which is provided by the widely opened stomata from the air. As the photosynthesis increases the evolution of oxygen also increases. The stomata provide a wide path for the release of oxygen in the air.

During day time in the presence of light, rate of photosynthesis is much greater which requires large amount of carbon dioxide, so the carbon dioxide released in respiration, is used within the tissues for photosynthesis and the oxygen needed for the process is made available in the tissues by photosynthesis. So there is a prominent intake of carbon dioxide and release of oxygen during daylights.

During nights as photosynthesis stops, and the stomata are closed, there is no evolution of oxygen so the carbon dioxide liberated in respiration is removed and oxygen is taken by the plant by simple diffusion through scars, gaps etc in the outer surfaces or through cuticle.

Relationship Between Transpiration and Gas Exchange in Plants

The mechanism of opening and closing of stomata enable the land plants to absorb carbon dioxide. The oxygen produced during photosynthesis is released through stomata. Stomata are primarily meant for absorption of carbon dioxide but these also help in exchange of gases. During exchange of gases water vapours also escape through stomata. The rate of transpiration in a plant is an indirect measure of the rate of photosynthesis as it indicates the degree of period of stomatal opening and exchange of gases.

Q. What gases would you expect a leaf to be (a) taking in, (b) giving out, in bright sunlight and in darkness?

10.3 TRANSPORT IN PLANTS

There are two types of conducting tissues in plants, namely xylem and phloem. These tissues constitute the vascular tissues. Xylem conducts mainly water and minerals from the roots upto other parts of the plants. While phloem conducts organic food from the leaves both up and down the plant.

Xylem Tissues

Beside conduction these tissues are also used for support. It consists of four cell types; the tracheids, vessel elements, parenchyma and fibres. **Tracheids** are single cells, which are elongated, tapering and lignified. They have mechanical strength and give support. Tracheids function very efficiently, e.g. conifers rely exclusively on tracheids for the transportation of water. In angiosperms relatively there are fewer tracheids than vessels. **Vessels** are more effective structures for transportation, which are needed by angiosperms for high rates of transpiration in the group.

Xylem vessels are the conducting units of angiosperms. These are very long, tubular structures formed by the fusion of several vessel cells (vessel elements) end to end in a row. Vessels are shorter than tracheids and act as the pipeline. **Xylem parenchyma** occurs in both primary and secondary xylem. It is more extensive and important in secondary xylem. The functions of xylem parenchyma include food storage, deposition of crystals, radial transport of food and water and gaseous exchange through the intercellular spaces.

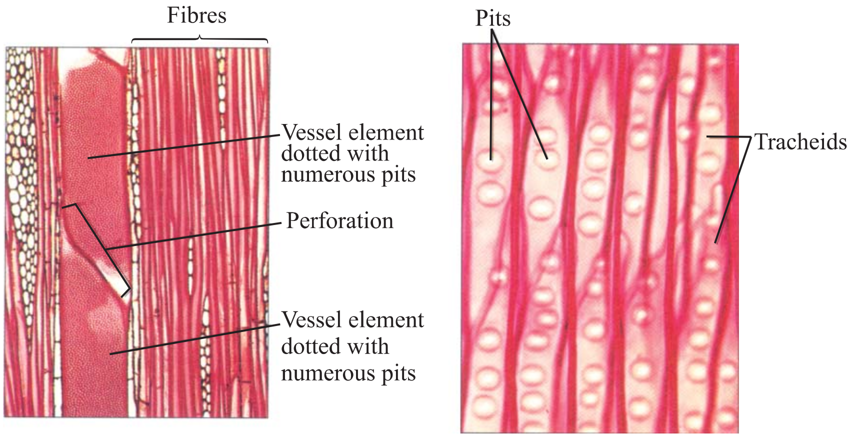


Fig: 10.2 Vessels and Tracheids

Xylem fibres are originated from tracheids. They are shorter and narrower than tracheids. They have much thicker walls. They are not involved in the conduct of water.

Phloem Tissues

These are composed of living cells and have no mechanical function. There are five types of cells, namely, sieve tube elements, companion cells, parenchyma fibres and sclereids. **Sieve tubes** are the long tube like structures, which translocate solutions of organic solutes (sucrose) throughout the plant. These are formed by the end-to-end fusion of cells called sieve tube elements or sieve elements. **Sieve tube elements** have walls made up of cellulose and pectic substances but the nuclei are lost as they mature. The cytoplasm confined to periphery of the cell. The sieve elements remain living but are dependent on the adjacent **companion cells**. The two, i.e. sieve elements and companion cells, together form a functional unit. **Plasmodesmata** run through the walls but the canals enlarge to form pores, making the walls look like a sieve and allows a flow of solution from one element to the next.

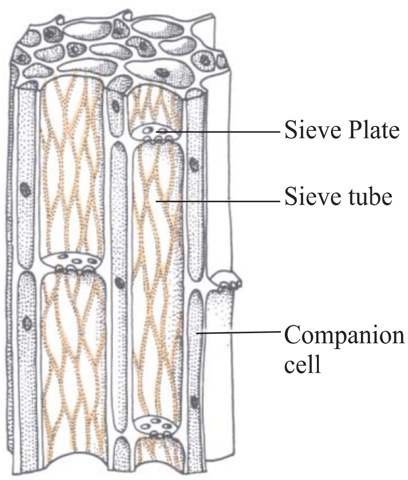


Fig: 10.3 Phloem

Movement of Water

Transport or movement of materials in between the organisms and their environment, as well as the transport of materials in various parts of a living organism is vital event, which determines the overall life activities of the organisms. In plants all their required substances (except light and carbon dioxide) are supplied through soils by the roots. The water, carbon dioxide and different mineral nutrients are used by the plants and are converted into energy rich organic food like carbohydrates, lipids and proteins by the universal phenomenon of photosynthesis. In this process the source of energy is sun.

Diffusion is the movement of substances in the form of molecules or ions from the regions of their higher concentrations to the regions of their low concentrations. It is the basis of transportations in all types of living organisms. This process is deadly slow so it may not be used alone as transporting means.

Osmosis is the diffusion of water through living membranes. The special nature and structure of cell membranes makes the process very efficient. **Osmosis** is the phenomenon of movement of water from its high potential (high conc.) to the region of low potential through a semipermeable membrane. The mineral nutrients are transported in dissolved form. In living organisms the transport of materials is in the form of solutions so the phenomenon may be defined as the movement of water from **hypotonic solutions** (dilute solutions) to the regions of hypertonic condition through a semipermeable membrane. The movement will continue until an equilibrium is maintained. At this level the two solutions across

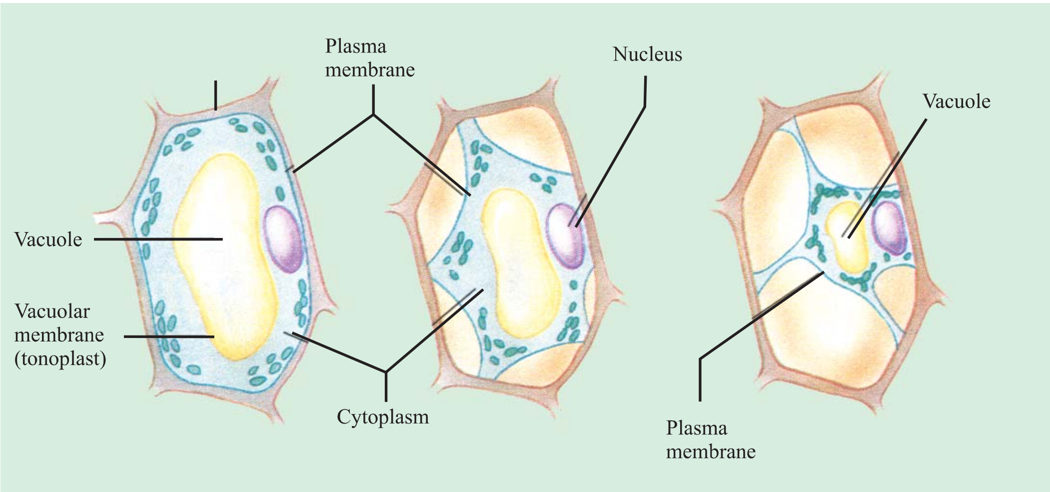


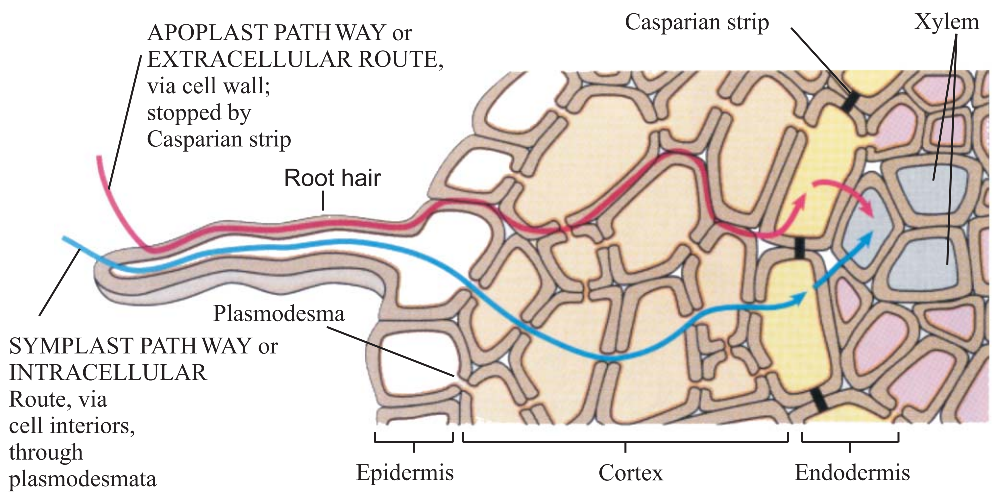
Fig: 10.4 Plasmolysis

the membrane are called **isotonic**. The plant as a whole and the individual cells get water and other substances by several other means besides diffusion and osmosis. Some of them are described below:

Plasmolysis can be defined as the shrinkage of the protoplasm of a cell due to exosmosis when it is placed in hypertonic solution. The cell in this condition is called **plasmolysed**. However if a plasmolysed cell is placed in a hypotonic solution the cell attains its normal state i.e. it becomes turgid again. The phenomenon is called **deplasmolysis** and occurs due to endosmosis.

10.3.1 UPTAKE OF WATER BY ROOTS AND PATHWAYS

The cell wall of epidermal cells of roots is freely permeable to water and other minerals. The cell membrane is differentially permeable. From root hairs water enters the epidermal cells by osmosis. The water moves along the concentration gradient. It passes through cortex, endodermis, pericycle and reaches the xylem vessels. There are three pathways taken by water to reach the xylem tissues: (a) The apoplast pathway, (b) The symplast pathway, (c) The vacuolar pathway.



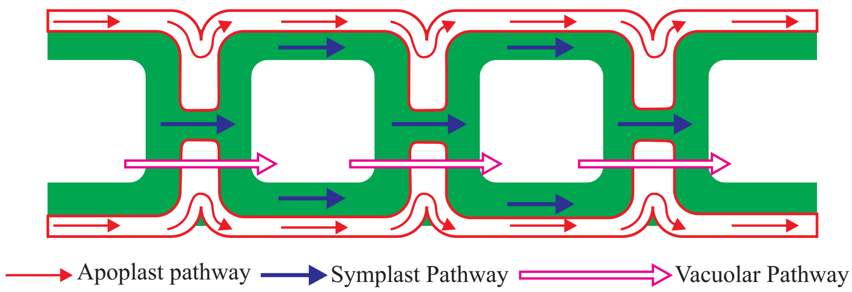


Fig. 10.5 Pathway of Water

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

Symplast Pathway: Movement of cell sap that involves cytoplasmic connection of adjacent cells is termed as symplastic transport or pathway. The **symplast** is the system of interconnected protoplast in the plant. The **cytoplasm** of neighboring **protoplast** is linked by the **plasmodesmata**, the cytoplasmic strands which extend through pores in adjacent cell walls. Once water and any solutes it contains is taken into the cytoplasm of one cell it can move through the symplast without having to cross further membranes. Movement might be aided by cytoplasmic streaming. The symplast is an important pathway of water movement.

Vacuolar Pathway: In the **vacuolar pathway** water moves from vacuole to vacuole through neighbouring cells, crossing the symplast and apoplast in the process and moving membranes and tonoplast by osmosis. It moves down a water potential gradient.

10.3.2 ASCENT OF SAP

Once water and mineral enter the root xylem, they still must be moved to the leaves of the plant. Four important forces combine to transport water solution from the roots through xylem elements and into the leaves. These **TACT forces** are: (1) Transpiration (2) Adhesion (3) Cohesion (4) Tension.

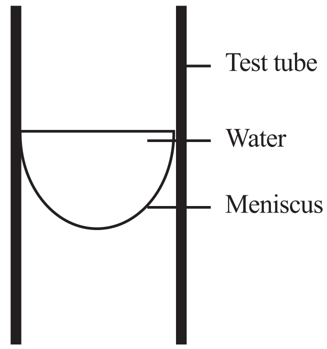
Transpiration

The loss of water vapours by evaporation from aerial parts of the plants is called **transpiration**. When stomata are open the water molecules move from high potential of water (inside the cells) to a region of low potential (in the air).

Adhesion

Adhesion is the attractive force between water molecules and other substances. Because both water and cellulose are polar molecules so there is a strong attraction for water within the hollow capillaries of the xylem.

Adhesion of the string of water molecule to the wall of the xylem cells assists upward movement of the xylem sap counteracting the downward gravity. Adhesion also helps, hold water in the xylem when transpiration is not occurring.



Cohesion

You may recall from chapter 2 section 2.2 that water is a polar molecule, with the oxygen carrying a slight negative charge while the hydrogen carry a slight positive charge. As a result, nearby water molecules attract one another, forming weak hydrogen bonds. The network of individually weak hydrogen bond within water collectively produces a very high **cohesion**.

The column of water molecule within the xylem is at least as strong and as unbreakable as a steal wire of the same diameter. "Hydrogen bonds among water molecules provide the cohesion that holds together the 'string' of water extending the entire height of the plant within the xylem." Supplementing the cohesion between water molecules is adhesion between water molecules and the walls of xylem tubes help the water move upward, just as water is pulled up into a very narrow glass tube. This principle, called **capillary action**,

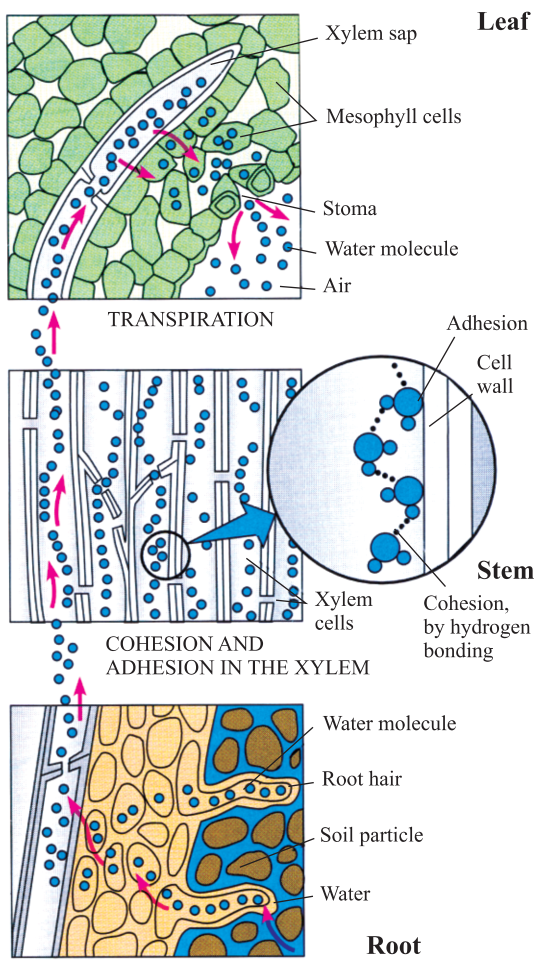


Fig. 10.6 Movement of Water in Xylem Through TACT Mechanism

helps water move upward within xylem. The U shaped surface formed by water as it climbs the walls of the tube is called **meniscus**.

Tension

What effect does transpiration have on a vertical string of water of xylem tubes? Before a water molecule can leave the leaf, it must break off from the top of the string. In effect, it is pulled off by a large diffusion gradient between the moist interior of the leaf and the surrounding air. Cohesion resists the pulling force of diffusion gradient, but it is not strong enough to overcome it. The molecules break off, and the opposing forces of cohesion and transpiration put tension on the rest of the molecular string.

As long as transpiration continues, the string is kept **tense** and is pulled upward as one molecule, exits the leaf and one right behind it is tugged up into its place. “Tension is a negative pressure – a force that pulls water from locations where the water potential is greater. The bulk flow of water to the top of a plant is driven by solar energy since evaporation from leaves is responsible for transpiration pull.

10.3.3 OPENING AND CLOSING OF STOMATA

There are two hypothesis which may explain the opening and closing of stomata: (a) Starch sugar hypothesis, (b) Influx of K^+ ions hypothesis.

Starch Sugar Hypothesis

It was proposed by German botanist **H. Van Mohl**. The guard cell absorbs CO_2. Some CO_2 reacts with water in which it is dissolved to form carbonic acid. In the presence of light energy, carbonic acid in the guard cell is converted into CO_2 and water, which are rapidly used in the synthesis of carbohydrates. The contents of illuminated guard cell are: (i) The acid concentration is low i.e. pH is high. (ii) Sugar concentration is high. As sugar concentration increases in the guard cells, as a result water enters the guard cells. The guard cells become **turgid** (swollen with water). The thin outer walls bulge out and force the inner thick wall into a crescent shape. In this way a stoma or pore is formed between each pair of guard cell.

Closing of Stomata

In the dark, most of the sugar molecules are removed by respiration or are converted into insoluble starch. So there is an increase in the acidity of the cell contents. As sugar molecules are removed from the guard cell and the

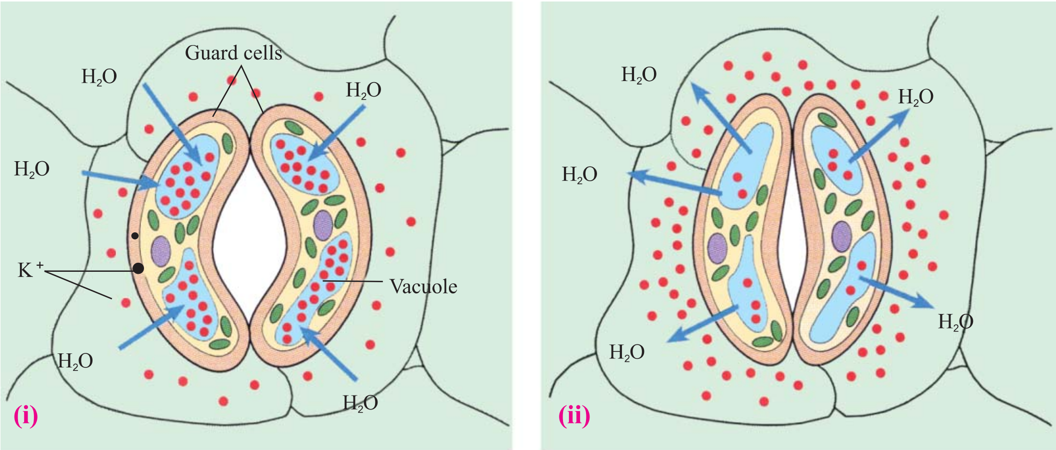


Fig: 10.7 (i) Stomata opening (ii) Stomata closing

relative concentration of H_2O in the guard cell increases, water molecules diffuse out to the epidermal cells. As the guard cell loses water, it becomes **flaccid**. In contrast to turgidity, the loss of water causes them to become weak limp and soft. This condition is known as **flaccidity** and the cells are said to be flaccid. The inner thick wall moves together until the pore between them is closed. Closing of stomata prevents (i) loss of water vapour (ii) the entry of CO_2 into the leaf. The CO_2 produced during respiration is used for photosynthesis even though the stomata are closed.

Influx of K^+ ions Hypothesis

The K^+ ion concentration in guard cells increase many times depending upon plant species. K^+ ions (shown in red dots in the fig. 10.7) enter guard cells from the surrounding epidermal cells by active transport. The accumulation of K^+ decreases the **osmotic potential** of guard cells. Water (shown in blue arrows) enters the guard cell by **osmosis**. The guard cells become turgid and are stretched and stomata are opened. The guard cells remain in this condition only so long as the pumping of K^+ ions into the cell is continued. So for keeping the stomata open a constant expenditure of energy is required. In darkness K^+ ions move out of the guard cells into surrounding epidermal cells. The **water potential** of the guard cells increase as a result water moves out of the cells. The loss of pressure makes the guard cells change their shape again and **stomata closes**. Level of CO_2 decreases in the spaces inside the leaf and light controls the movement of K^+ into and out of guard cells. A low level of CO_2 favours opening of the stomata and thus allow an increased CO_2 level and increased rate of photosynthesis.

10.3.4 TRANSLOCATION OF ORGANIC MATTER

Phloem tubes are delicate structures. These tubes are punctured by a small greenish insect, **aphid** during its feeding from the young shoots of a plant. Aphids are fluid (phloem) feeders. They suck sugary substance from phloem tissues. Biologists found that if the feeding aphid is removed by surgery and its style (pointed, tubular mouth part) is allowed to remain intended in the phloem tube. The phloem contents are continued to come out. On examining the contents it is found that it contains upto 30 percent sugars (sucrose), remaining 70 percent is water.

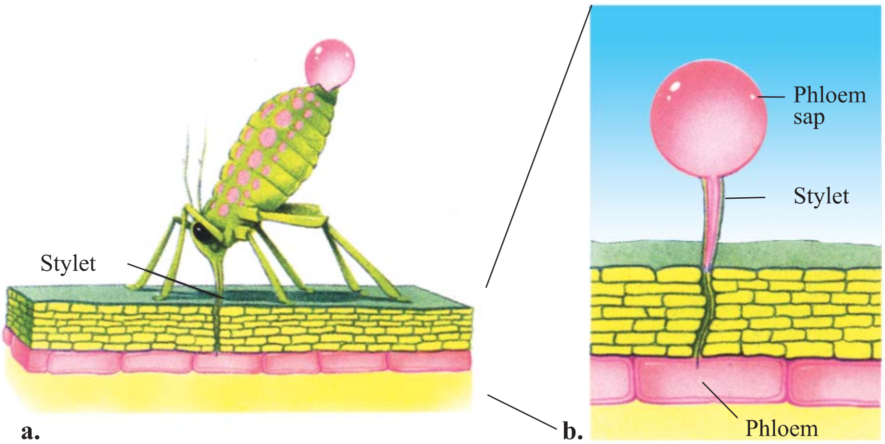
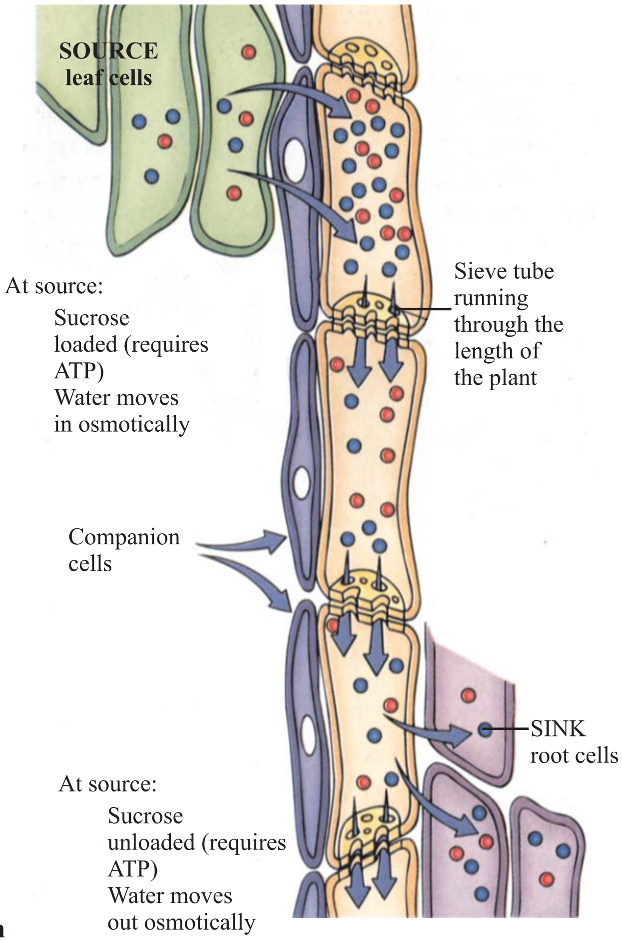


Fig 10.8 Aphid feeding on the branch of a tree. Excess sugar is released as a drop of honey-dew that serves as food for ants. The sap in the phloem enters the insect's mouth parts under pressure.

With the use of radioactive carbon dioxide during photosynthesis the path of the photosynthate may be traced. Biologists by conducting several of such experiments discovered that sugar flow involves a mass movement of phloem fluid based on bulk flow the movement of fluid from an area of high pressure (source) to an area of low pressure (**sink**). The plant physiologists suggest that sugars produced in **source regions**, such as photosynthesizing leaves or storage places are loaded into the phloem's sieve tube elements by the companion cells. The **active transport** increases the concentrations of sugars in the phloem. As a result water moves to phloem by osmosis from the nearby xylem cells and increases turgor pressure in the phloem cells, which pushes forcibly the sugary solution away from the leaf (**source**). Meanwhile the root cells absorb the organic solutes from the phloem, making the phloem solution hypotonic and so the water from the phloem flows back to the xylem tubes.



Sugar is actively loaded into the sieve tube at the source. As a result, water moves into the sieve tubes by osmosis. At the sink, the sugar is actively unloaded and water leaves the sieve tube by osmosis.

The pressure gradient from source to sink causes translocation from the area of higher hydrostatic pressure (the source) to the area of lower hydrostatic pressure (the sink)

Fig: 10.9 Pressure flow Mechanism for Phloem Transport

By studying carefully the whole mechanism it may be concluded here that the water pressure and the loading activities of companion cells provide the base for the movement of sugars, amino acids and a few mineral ions from sources to sinks. In a plant the same organ may be a source at one time and at some other time it may act as a sink e.g. beetroot.

Skills: Performing and Recording

- Illustrate diagrammatically the pathway of water in root, stem and leaf.

10.4 HOMEOSTASIS IN PLANTS

Specialized structural and physiological adaptations allow different organisms to exploit their environment in different ways. The physiological systems continuously adjust to the aspects of surrounding environment outside the cells and making it suitable for efficient functionings of the body cells.

An organism may be defined as a physiochemical system existing in a steady state with its external environment. **Homeostasis** is the ability to maintain a steady state within a constantly changing environment that contributes towards the success of living systems.

Osmotic Adjustments

Plants differ in their ability to survive and grow under water stress. Plants that are exposed to severe drought use dehydration tolerance mechanism such as maintenance of high water potential either through stomatal regulation or extraction of water through an extensive root system. Generally growth of plants exposed to low water potential is reduced but dehydration tolerant plants are more productive compared to non-tolerant plants. Such plants can continue to grow at a reduced rate under low water potential because of low osmotic potential or **osmotic adjustment**, which maintain turgor. The lowering of osmotic potential by active solute accumulation is known as osmotic adjustment.

Isotonic, Hypertonic and Hypotonic Conditions

Dissolved in the fluid compartment of every living cell are salts, sugars and other substances that give that fluid a certain osmotic pressure. When a cell is placed in a fluid with exactly the same **osmotic pressure**, no net movement of water molecules occurs, either into or out of the cell, the cell neither swells not shrinks. Such a fluid is said to be **isotonic** (i.e. of equal osmotic pressure) to the fluid within the cell. If the surrounding has a concentration of dissolved substances greater than the concentration within the cell, it has a higher osmotic pressure than the cell is said to be **hypertonic** to the cell and cell would lose water. If the surrounding contains a lower concentration of dissolved materials than does the cell, it has a lower osmotic pressure and is said to be **hypotonic** to the cell water that enter the cell and causes it to swell (fig. 10.10).

Q. Why does over watering a plant often kill it?

Neither gains nor loses water	Loses water	Gains water
When solute concentrations outside the cell equal concentrations inside the cell, the cell neither gains nor loses water.	When solute concentrations outside the cells exceed those inside the cell, the cell shrinks as it loses water to its environment.	When solute concentrations outside the cell are lower than those inside the cell, the cell swells as it gains water from its environment.

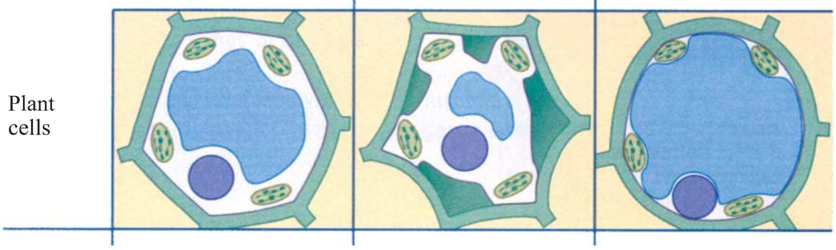


Fig: 10.10 Plant Cells Respond to Isotonic, Hypertonic and Hypotonic solution

Osmotic Adjustment in Hydrophytic, Xerophytic and Mesophytic Plants

Plants are considered simply in relation to their environment and are divided into the following categories.

Hydrophytes: Plant cells in fresh water are surrounded by a hypotonic environment. Hydrophytes have larger **surface area** of leaves, by which water is lost extensively. Moreover the presence of large number of **stomata** on upper surface of leaf promotes the loss of water at high rates. Osmotic adjustment in marine plants takes place through accumulation of solutes facilitates maintenance of cell turgor and water retention.

Mesophytes: They are moderate in water availability. The majority of flowering plants are mesophytes. The features which help to reduce water loss are both structural (xeromorphic) and physiological. The presence of waxy cuticle, protected stomata (at lower surfaces of leaves), the regulations of stomatal openings, variable leaf shape, abscission, their ecological distribution and many other adaptations enable these plants for their osmoregulation.

Xerophytes: The plants adapted to live in dry places and able to survive long period of drought are called xerophytes. These plants constitute the typical flora of deserts and semi-desert regions. Xerophytes show many structural (xeromorphic) and physiological adaptations to survive in extremely dry conditions. e.g. waxy cuticle, few and sunken stomata in leaves, reduced or fleshy succulent leaves and stems, an extensive and deep root system etc.

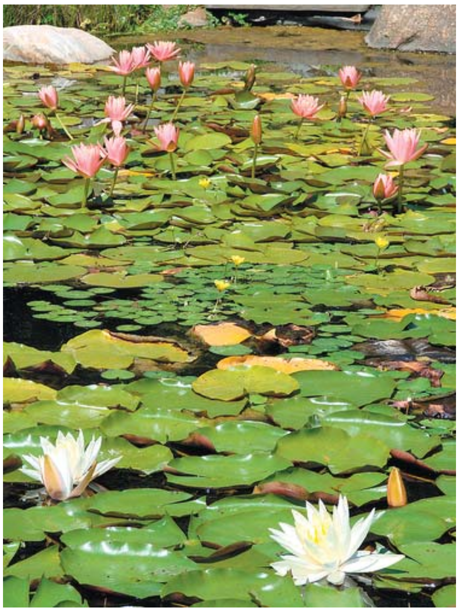


Fig: 10.11 Hydrophytic Plants

Fig: 10.12 Xerophytic Plants

Osmotic Adjustment of Plants in Saline Soils

High salinity soils are characteristics of salt marshes. As salt water from the ocean inundates and recedes from the system in a daily cycle, sodium chloride is deposited into marsh soils where evapotraspirtion amplifies soils concentrations. Saline soils can be detrimental to plants in a variety of ways; therefore, plants living in saline environments have adapted mechanisms to deal with these problems. These are:

Salt Exclusion: Salt can be excluded from entering the plant through its root system by exchanging K^+ ions for N^+ ions as they passed through the xylem.

Salt Excretion: Some plants simply get rid their systems of salt by excreting it back into the environment.

Succulence: One defence against salt in plant tissues is simply to dilute the concentration of ions. Plant achieve this by increasing their storage volume by developing thick, fleshy, succulent structure.

Osmotic Adjustment: Some salt tolerant plants control the accumulation of salt ions to counterbalance low water potential created by saline soils. Salt ions are compartmentalized in vacuoles to protect proteins and membranes from ion toxicity by active transport. Plants also produce osmotically active organic solutes called **compatible solutes**, such as amino acids and amides e.g. proline and soluble carbohydrates etc.

Osmoregualtion: Water uptake and flow through a plant is driven by a water potential gradient where water flows from least to most negative water potentials. Some plants living in saline soils adjust their water potentials through the accumulation of solutes in plant tissues.

Thermoregulation in Plants

Heat is a form of energy. It is important to maintain a living system because all living systems require a continuous supply of heat. The major source of heat for all living systems is the sun. Solar radiations are converted into an exogenous source of heat. The extent and effect of the radiations depend upon geographical location. The organisms may be found living in a vast range of temperature 4°C (arctic region) to 50°C (desert region) temperatures. Majority of living organisms are found in confined temperatures between 10-35°C. Various organisms show a number of adaptations, enabling them to live in both extremes of temperatures.

Temperature indicates the amount of heat energy in a system. Temperature can act as a limiting factor in the growth and development of plants by influencing the rates of cell division, cell metabolism and photosynthesis. The dark reactions of photosynthesis is a temperature dependent phase. The rate of photosynthesis, enables the plant to complete its life cycle.

Adaptations to Low Temperatures in Plants

The vegetation of the northern temperate areas and the tundra shows several adaptations. Most of the temperate woody perennials are deciduous, to prevent water loss by transpiration. Wind and snow damages are also avoided by the shedding of leaves of the plants. The buds are protected by scale leaves and their activities are made slow by a regulator substance, called ‘dormin’. Many conifers dominate the vegetation of these areas and have needle like leaves with a thick cuticle. Many species of annual plants have a brief growing period and survive the winter by producing resistant seeds or other structures.

Adaptations to High Temperatures in Plants

The leaves are thin and with a large surface area to facilitate gaseous exchange and light absorption. A thin leaf has relatively low heat capacity. In hot areas the plants develop a shiny cuticle, which reflects much of the incident light. Thus preventing the heat absorption and overheating by the plant. The leaves contain numerous stomatal openings, which allow the loss of water (transpiration), and also remove the heat from the plant. **Wilting** is a common response to high temperatures.In some plants, growing in hot regions, special types of proteins called **heat shock proteins** are, produced. They protect enzymes from denaturing.

Skills: Interpreting and Analyzing

- Interpret the adaptive differences through survey of xerophytic, mesophytic and hydrophytic plants.
- Illustrate the structure and position of stoma in xerophytic, mesophytic and hydrophytic plants.

Science, Technology and Society Connections

Correlate climatic record with tree growth.

Q. In tropical climates, many tall plants shut stomata during the hot days and open at night. If their stomata are closed during day, why doesn't the water within the plant fall down the stem?

10.5 SUPPORT IN PLANTS

When the life started on land from water, one of the very important needs for the organisms was to gain some sort of support and strength for keeping their bodies in shapes. In plants the cells have large central vacuoles, which are filled with water. The water causes pressure on the surrounding walls, when the cells are turgid. This pressure on the walls keep the cells, stiff and hard and is called **turgor pressure**. In herbaceous plants where the specialized supporting tissues are not common, the turgidity of the cells provides support and strength and it grows uprightly. In these cases the plant may wilt or collapse due to a decrease in turgidity (decrease in the internal hydrostatic pressure). Besides the hydrostatic pressure the plants specially shrubs and trees have some supporting tissues, like collenchyma, sclerenchyma, and conducting tissues.

Collenchyma

The collenchyma is characterized by the extra cellulose deposition at the corners of these cells. It is a mechanical tissue, providing support particularly in young plants, herbs and leaves etc. (Where secondary growth does not occur) collenchyma is living so it can grow and stretch freely. In

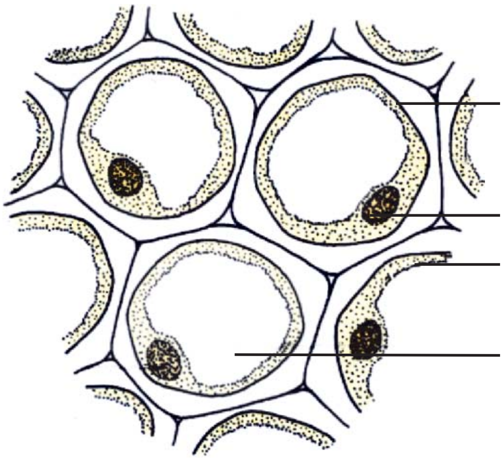
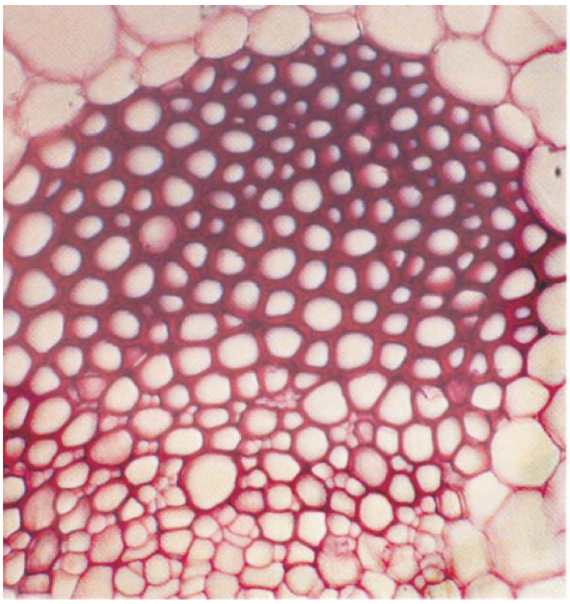


Fig: 10.13 Collenchyma

stems and petioles it plays more important role in support because of its location in peripheral regions near epidermis.

Sclerenchyma

These tissues are solely means for giving support and mechanical strength for the plants. The mature cells are dead and their entire walls are lignified (deposition throughout the walls). The sclerenchyma is of two types



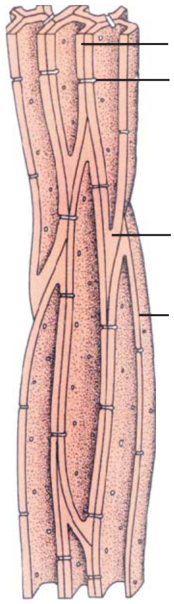


Fig: 10.14 (a) T.S. of Sclerenchyma Cells **(b) L.S. of Sclerenchyma Cells**

i.e. fibres and sclereids. Fibres are elongated cells and sclereids are roughly spherical otherwise both have heavily thickened walls with lignin and with great tensile strength.

Fibres are arranged in strands or sheets and provide collectively a greater strength to the plant. Moreover their ends interlock with one another to give more strength. Fibres are found in the pericycle of stems forming a solid rod of tissue. Fibres also found in xylem and phloem tissues.

Sclereids are generally scattered singly or in groups anywhere in the plant body, but common in the cortex, pith, phloem, fruits and seeds. In seeds they toughen the seed coat.

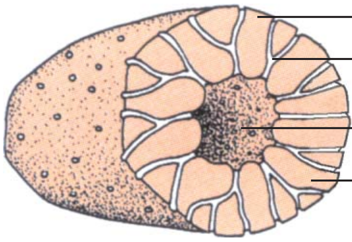


Fig: 10.15 T.S. of Sclereids

Xylem Tissues

These also provide support and strength beside conduction of water and salts. Their role is already discussed in 'Transport in Plants' (section 10.3).

10.6 GROWTH AND DEVELOPMENT IN PLANTS

Growth is the phenomenon of life. Like animals plants also show growth. The growth in plants differs from growth in animals. In plants the growth is of 'open growth' i.e. plants add new organs like, branches, leaves, roots etc throughout life. The growth may be defined as an increase in the size and volume. It is achieved by the mitotic cell division and the enlargement of the dividing cells.

10.6.1 TISSUES FOR GROWTH- Apical and Lateral Meristems

The continual growth is based on 'meristems' the tissues which retain their dividing ability and gives rise to new cells. Meristems allow adult plants to produce eggs and sperms as well as new tissues and organs. Plants have two types of meristems: (a) Apical meristems (b) Lateral meristems

Apical Meristems

These are the growth zones at the tips of roots and stems. It allows shoots to grow upward towards the light and allows roots to grow into the soil to a water source. The growth by apical meristems is called primary growth.

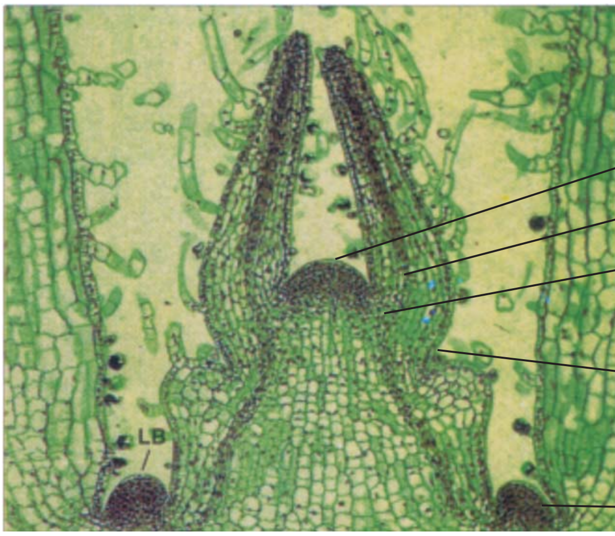


Fig: 10.16 Photomicrograph of Shoot, Apical Meristem

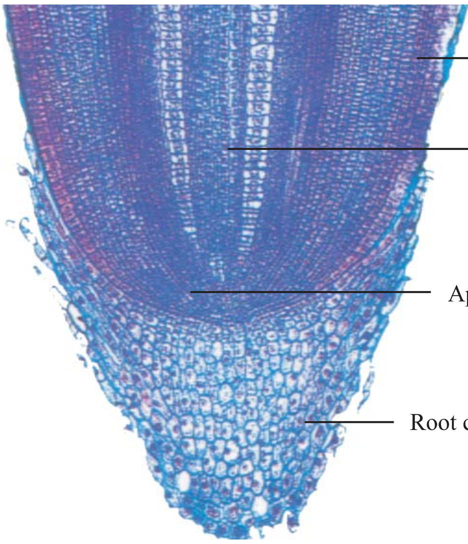


Fig: 10.17 Photomicrograph of Root Apical Meristem

Primary growth occurs by the meristems of two apices (i.e. root apex and shoot apex) so it results in an increase in the size of plants.

Lateral meristems

These meristems are cylinders of dividing cells in stems and roots of dicots and gymnosperms and increase their thickness and diameter. This increase in diameter of plants by lateral meristems is called 'secondary growth'. During **secondary growth** the bulk of tissues added laterally is mainly secondary xylem and is called **wood**.

The lateral meristem is generally called **'cambium'**. It may be located between primary xylem and phloem and is called **vascular cambium** whereas the **cambium** present on the surface (outside cortex) is called **cork cambium** and adds cork cells.

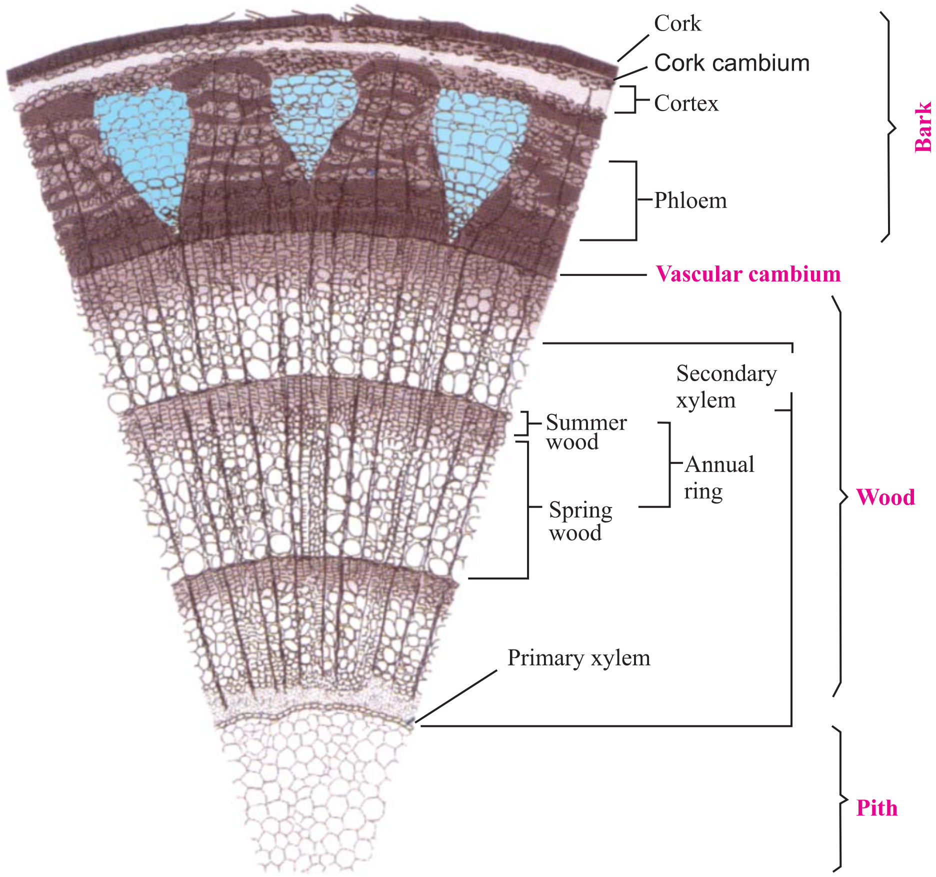


Fig: 10.18 Secondary Growth in Dicot Woody Stem

The production of secondary xylem in growing plants increases the efficiency of conduction of water and salts. The size of xylem tissues depend on the needs and availability of water. During spring and summer water is plentiful and also the light conditions are better whereas during winter and autumn the water available and light conditions are not suitable. The xylem tissues are formed accordingly and the two xylem tissues (spring and autumn) are differentiated on the basis of their large sizes in spring and small sizes

Skills: Performing and Recording

- Locate annual rings in the log of a tree
- Calculate the age of a plant by counting number of annual rings.

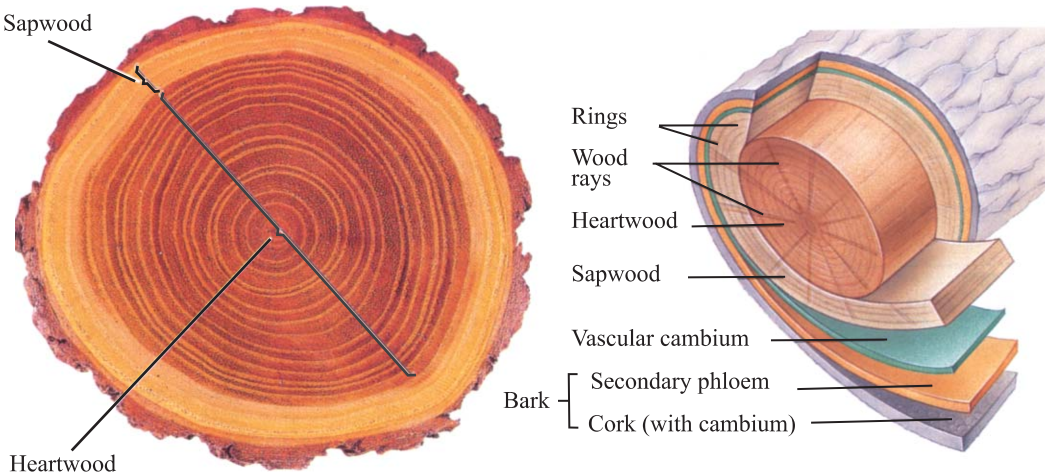


Fig: 10.19 Secondary Growth

during autumn. It makes ring structures. These are called **'annual rings'** and are used to determine the age of the plant.

Apical Dominance

It is a phenomenon in which the presence of a growing apical bud inhibits growth of lateral buds. It also includes the suppression of lateral root growth by growth of the main root. The removal of the shoot apex results in the growth of lateral branches. It is known that **auxins** promotes growth in the stem but inhibits growth of lateral buds. Auxins continuously break down as it moves down the stem, its concentration drops off. Apical dominance is a classical example of one part of a plant controlling another via the influence of a growth substance. This is called **growth correlation**.

Apical Meristem and the Growth of Lateral Shoots

Development of shoot is carried out by apical shoot meristem. The same meristem is also responsible for the growth of leaves and lateral branches of the plants. Leaves arise as small outgrowths, called **leaf primordia**. They contain groups of meristematic cells.

The primordial elongate rapidly and soon enclose and protect the apical meristem, both physically and by the heat they generate in respiration. Then they grow and increase in area to form the leaf blade. Soon after the leaves start to grow, **buds** develop in the axils. These are small groups of meristematic cells, which had retained the capacity to divide and grow.

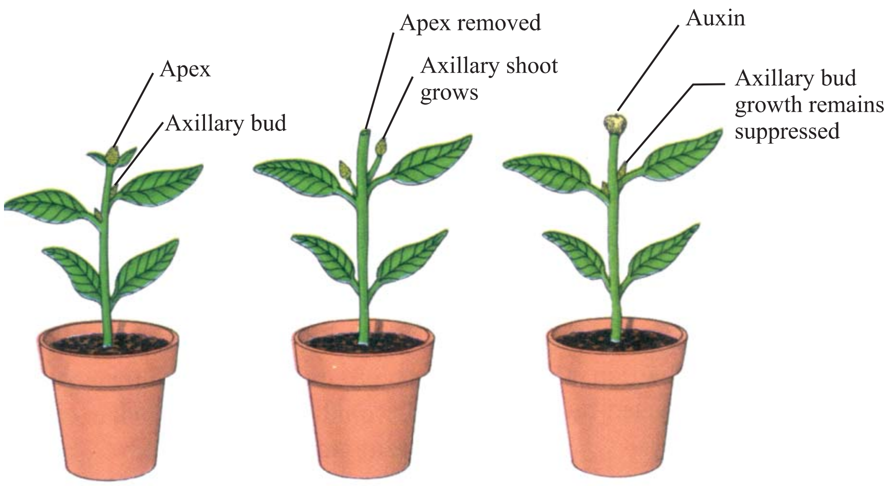


Fig: 10.20 Experiment to show influence of Auxin on Apical Dominance

They become active at this stage and start the formation of lateral branches or specialized structures such as flowers, rhizomes or tubers. It is known that growths are under the control of apical meristem.

10.7 GROWTH RESPONSES IN PLANTS

Plants unlike animals cannot move from one place to the other as a whole. They show response against various factors, which may be beneficial or harmful. These responses are shown by their parts like shoots, roots, etc. Plants generally adjust themselves to changing environment by growth. The changes in plant shape or functions are often regulated by **plant hormones** (growth substances) produced in response to environmental factors. The plant hormones act at the level of cells to induce cell division, enlargement or cell maturation.

10.7.1 PLANT GROWTH REGULATORS (PRGs)

Plants are co-ordinated by chemicals which necessarily move from their sites of synthesis and because their effects are usually on some aspect of growth, they are called **growth substances**. Five major types of growth substances are recognised (a) auxins (b) gibberellins (c) cytokinins (d) abscisic acid (e) ethene.

Auxins

These are **indole acetic acid** (IAA) or their varieties. The discovery of auxins was the result of investigations into phototropism that began with the experiment of **Charles Darwin** and his son **Francis**(1880).

The **effects of auxins** are (a) In stem, promote cell enlargement in region behind apex. Promote cell division in cambium. (b) In root promote growth at very low concentrations. Inhibit growth at higher concentrations. e.g. geotropism. Promote growth of roots from cutting and callus. (c) Promote bud initiation in shoots but sometimes antagonistic to cytokinins and is inhibitory. (d) Promote apical dominance and fruit growth. (e) Sometimes can induce parthenocarpy. Cause delay in leaf aging in a few species. (f) Inhibit abscission.

Discovery of IAA lead to the synthesis of a wide range of active compounds with similar structure. Synthetic auxins have proved commercially useful in a variety of ways. They are cheaper than IAA to produce and often more physiologically active because plants generally do not have necessary enzymes to break them down.

Gibberellins

The compound extracted from fungus Gibberella (now called Fusarium) is called gibberellins. The third and most active gibberellin isolated is called gibberellic acid (GA3). Now more than 50 naturally occurring gibberellins are known.

Fig 10.21 The biennial plant called honesty will "bolt" when it is treated with gibberellins.

The **effects of Gibberellins** are: (a) The main effect of gibberellins is on stem elongation, mainly by affecting cell elongation. Cause cell division in apical meristem and cambium (b) Promote bolting in some rosette stage of plants e.g, a lettuce plant, typically formed into a compact head can be made to "bolt" that is to stretch its stem upward and separate the leaves. (c) Promote bud (shoot) initiation in Chrysanthemum callus. Sometimes promote in intact plant if apical dominance is broken. (d) Promote leaf growth and fruit growth can sometimes induce parthenocarpy. (e) In apical dominance, enhance action of auxins. Break bud dormancy (f) Break seed dormancy e.g. cereals. (g) Sometimes substitute for red light. Therefore promote flowering in long day plants, inhibit in short day plants (h) Delay leaf senescence (aging) in a few species.

The **commercial applications** of the of gibberellins are: (1) They promote fruit setting e.g. in tangerines and pears and are used for growing seedless grapes, (parthenocarpy) and also increase the berry size. (2) GA3 is used in brewing industry to stimulate a amylase production in barley and this promotes "malting". (3) To delay ripening and improve storage life of bananas and grape fruits.

Cytokinins

Cytokinins are most abundant where rapid cell division is occuring, particularly in fruits and seeds where they are associated with embryo growth.

The **effects of cytokinins** are: (1) Cytokinins promote cell division in the apical meristem, only in the presence of auxins. Gibberellins may also play a role, as in the cambium. (2) Inhibit primary root growth. (3) Promote lateral root growth. (4) Promote bud initiation and leaf growth. (5) Promote fruit growth but can rarely induce parthenocarpy. (6) Promote lateral bud growth, also break bud dormancy. (7) Cause delay in leaf senescence. (8) Promote stomatal opening.

The **commercial applications** of cytokinins are that they delay aging of fresh crops, such as cabbage and lettuce, as well as keeping flowers fresh. They can also be used to break dormancy of some seeds.

Abscisic acid

The substances which accelerated abscission (an act of cutting off) was called abscisic acid (ABA) in 1967.

The **effect of ABA** are: (1) Inhibits stem and root growth notably during physiological stress e.g. drought, waterlogging. (2) Promotes bud and seed dormancy. (3) Promotes flowering in short day plants and inhibits in long day plants (antagonistic to gibberellins). (4) Sometimes promotes leaf senescence. (5) Promotes abscission. (6) Promotes closing of stomata under conditions of water stress (wilting)

The **commercial applications** of **ABA** are that they can be sprayed on tree crops to regulate fruit drop at the end of the season. This removes the need for picking over a long time-span.

Ethene

Ethene is made by most or all plant organs and tends to escape more easily from the plant surface.

The **effects of ethene** are: (1) Inhibits stem growth, notably during physiological stress. (2) Inhibits root growth. (3) Break dormancy of bud.

(4) Promotes flowering in pine apple. (5) Promotes fruit ripening. (6) Like ABA it acts as a growth inhibitor in some circumstances and can promote abscission of fruits and leaves.

The **commercial applications** of ethene are that they induces flowering in pineapple. Stimulates ripening of tomatoes and citrus fruit. The commercial compound ethephon breaks down to release ethene in plants and is applied to rubber plant to stimulate the flow of latex.

Science, Technology and Society Connections

Describe the reasons for bushy and cylindrical growth.

10.7.2 GEOTROPISM AND PHOTOTROPISM

Unlike animals, the plants have no nervous system and for their coordination they completely depend on hormonal coordination. It is very slow and generally shown in the form of **growth**. This growth results in some sort of movements of some organs of the plant. The plants as their characteristics do not show locomotion, but the individual plant organs may show movements in response of some stimulus (internal or external).

Phototropism: It is the response of a shoot or a root towards the source of light (positive in shoots) or away from light (negative in roots).

Thigmotropism: These movements are due to the touch stimulus.

Geotropism: Movement of shoots and roots against and towards force of gravity.

Chemotropism: The stimulus is a chemical e.g. movement of hyphae is chemotropic.

10.7.3 PHOTOPERIODISM

Photoperiodism may be defined as the effect of the length of light period on the formation of flowers in plants.

Light exerts its influence on living organisms through variation in day length called photoperiod. In plants, photoperiod and temperature affects flowering, fruit and seed production, bud and seed dormancy, leaf fall and germination. **Photoperiod** affect flowering, when shoot meristem, starts producing floral buds instead of leaves and lateral buds.

In 1920 **W.W. Garner** and **H.A Allard** (agronomist in USA) were working with various varieties of tobacco plants. Tobacco plants (*Nicotiana tobacum*) are self pollinated and gave flowers in summer. One day it was noticed that a single plant was quite different from other varieties. It had broad leaves, was 3 metres tall and did not flower. It was named **Maryland mammoth tobacco plant**.

Under field condition during summer when the days were warm and long, all other tobacco plants flowered profusely, but Maryland mammoth showed no sign of flowering. At the end of the growing season, they transferred the plant to green house to protect it from frost. In the middle of December the plant flowered. It was then allowed to self pollinate and seeds were obtained. These seeds produced new Maryland mammoth plants. The plants flowered in winter.

Garner and Allard put seedlings of the mutant i.e. Maryland mammoth plant in special chamber, where day lengths could be regulated. When day lengths were shortened artificially to about 9 hours, the plant flowered.

Experiment on Soyabean: Garner and Allard made a series of soyabean (soybean) planting over a period of several weeks. In the late summer, they observed the flowering time of the plants in the various groups. Despite age difference due to different planting time, all the soyabean flowered surprisingly close to the same time, in late summer as the day shortened.

The critical factor in both tobacco and soyabean was the length of the day. Flowering occurred when the day shortened below a critical length. This phenomenon is called **photoperiodism**. Photoperiodism is any response by a plant to a relative lengths of daylight and darkness.

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

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

Long-day plants: They flower, only when the day length exceeds from the critical length period e.g. spinach, sugar beet, clove, lettuce, Henbane (*Hyoscyamus niger*), snapdragon, cabbage, spring wheat, spring barley etc.

The critical lengths for both long day and short day plants tend to fall in the 12-14 hours range.

Day-neutral plants: In these plants the flowering is not affected by day length or darkness. Thus the plants flower in response to some other type of stimulus, either external or internal e.g. tomato, pansy, bean, sweet, pea, rose, etc.

Now it has been discovered that the actual stimulus for flowering is the uninterrupted dark period rather than the light period. So the short day plants are actually **long night plants** and long-day plants are **short-night plants**.

Mechanism of Photoperiodism

For more than one hundred years, biologists have searched for a flowering hormone, a substance that causes the growth changes leading to a flower development. What evidence is there for a flowering hormone? Evidence has been accumulated since 1936 when **M.H. Chaila-khyan** and his colleagues in Russia experimented with photoperiodic induction of flowering and found that a flowering stimulus appeared to be transmitted from leaves to other parts of the plants. He proposed that leaves produce a chemical, flowering substance that is transported through the plant. He suggested that the substance be called **'florigen'** (meaning flower maker), but the flowering hormone has not, yet, been isolated.

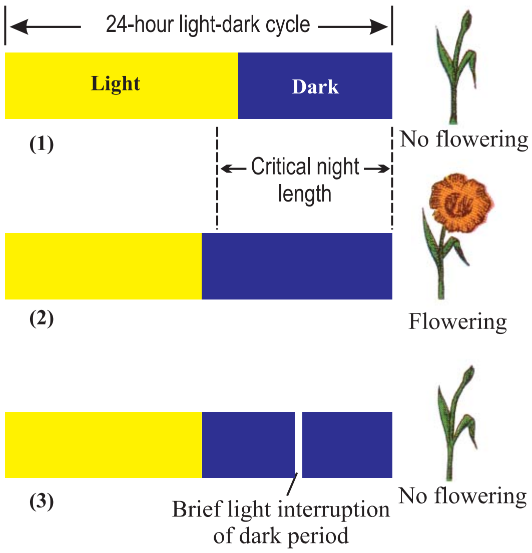


Fig: 10.22 Phytochrome detects varying periods of day length and darkness.

For biological response to light, there must be a photoreceptor (light sensitive pigment) in the organisms to absorb light. The **photoreceptor** involved in photoperiodism is called **phytochrome**. Although present in exceedingly small amounts, Phytochrome has been isolated from plant tissues. It is a protein to which is attached a non-protein part. Phytochrome is a blue-green pigment.

One form of phyto-chrome, designated as P_R, strongly absorbs red light (at 660 nm). In the process the shape of the phytochrome molecule changes to the second form of phytochrome P_{FR}. Red light of longer wavelengths than P_R, described as far-red light (at 730 nm). When P_{FR} (P730) absorbs far-red light, it reverts back to the original form, P_R (P660). The P_{FR} (P730) form is less stable than the P_R (P660) form and so it reverts to P_R in the dark. The form of phytochrome that triggers physiological responses such as flowering is P_{FR}, (P730)

The sunlight has more red light (P660) than far-red light (P730). Therefore, the phytochrome in a plant exposed to the sunlight is a mixture of both P_R (P660) and P_{FR} (P730), with P_{FR} (P730) predominating. During day P_R (P660) is converted to P_{FR}, (P730) and during the night, the P_{FR} (P730) slowly reverts back to P_R (P660).

Phytochrome Affects Flowering

In **short-day plants** the active form of phytochrome P_{FR}, inhibits flowering in short-day plant. In order to flower, these plants need long night. The long period of darkness allows the P_{FR} to completely revert back to P_R so the plant has some minimum time during the 24-hour period with no P_{FR} present. This initiates flowering.

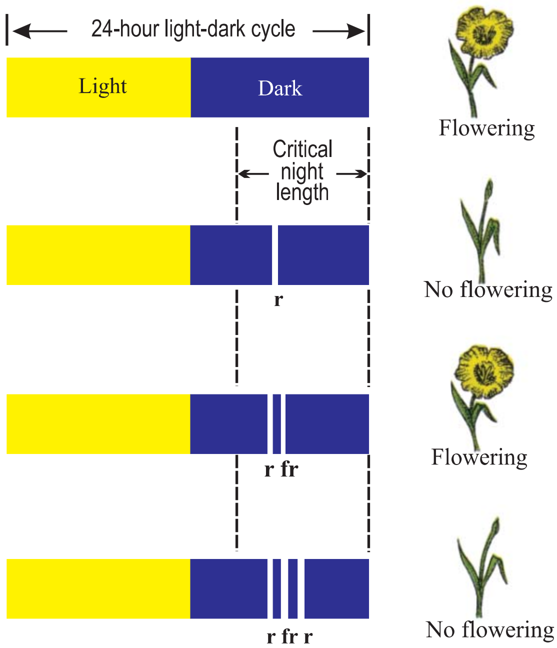


Fig: 10.23 Night interruption experiments on short-day plants using a red light interruption and combinations of red and far-red (fr) light interruptions

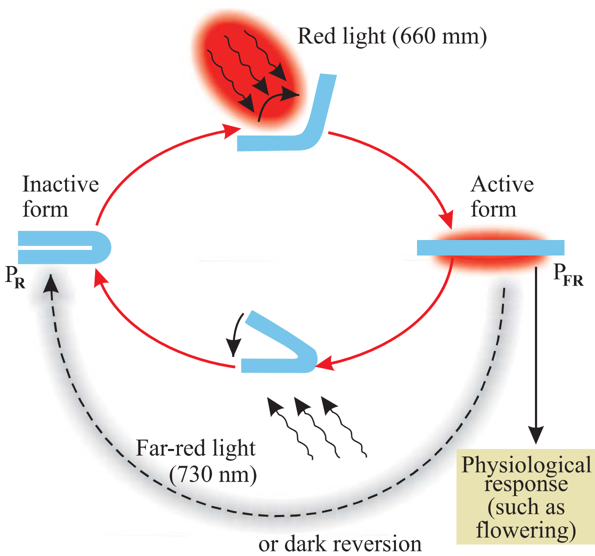


Fig: 10.24 Interconversion of two forms of phytochromes

Short-day plants were grown under a short day/long-night condition. The night was interrupted with a short burst of red light. Exposure to red light for a brief period as 10 minutes in the middle of the night prevents flowering in short day plants. This effect occurs because the brief exposure to red light converts some of the phytochrome from the P_R (P660) form to the P_{FR} (P730)form.

Therefore the plant does not have a sufficient period of time at night for the conversion of P_{FR} (P730). Short day plants need long nights to allow complete dark for reversion of P_{FR}(P730) to P_R (P660) to initiate flowering. A brief flash of **red light** in the middle of the night converts P_R (P660) to P_{FR} (P730). However, if this is followed by a brief period of **far red light**, the P_{FR} (P730) is converted back to P_R (P660). Therefore, flowering occurs.

In **Long-day Plants** the active form of Phytochrome P_{FR} (P730) induces flowering in long-day plants. Long-day plants exposed to a long-day/short-night condition flower. The long days cause these plants to produce predominantly P_{FR} (P730). During the short night some P_{FR} (P730) is slowly changed to P_R but sufficient P_{FR} (P730) remains to induce flowering. Plant biologists are puzzled by the observation that P_{FR} (P730), the active form of **phytochrome**, inhibits flowering in short-day plants and induces flowering in long-day plants. Why different plants respond to opposite way to P_{FR} (P730) is not known at this time.

10.7.4 VERNALIZATION

In certain plants, temperature has an affect on flowering. The promotion of flowering by exposure to low temperature is known as **vernalization** (after a Latin term meaning "to make spring like"). The low temperature stimulus is received by the shoot apex of a mature or plant embryo (not by the leaves as in **photoperiodism**). Although the exact **temperature** and amount of time required varies among species, most vernalization temperature occur between 0^0C to 10^0C, but temperature around 4^0C is found to be most effective. The part of the plant that must be exposed to low temperature varies. For some plants, the moist seeds must be exposed to several weeks of low temperature in order for flowering to be induced. For other plants, recently germinated seedlings have a cold requirement.

In some plants, the requirement of **low temperature** period is absolute, meaning that they will not flower without vernalization. Other plants will flower sooner if exposed to low temperature but still flower at a late date if not exposed to low temperature.

Examples of plants with a low temperature requirement include biennials (plants lasting for two years) like carrots and annuals like winter wheat. Carrot left in a warm environment and not exposed to low temperature continue vegetative growth indefinitely and do not initiate sexual reproduction. Low temperature stimulates production of **vernalin** hormone which induces vernalization. It is actually **gibberellin**.

Photoperiodism and vernalization serve to synchronize the reproductive behaviour of plants with their environment, ensuring reproduction of the same species flower at the same time for cross pollination and genetic variability.

Exercise

SECTION I : MULTIPLE CHOICE QUESTIONS

Select the correct answer

1. It is found essentically in organic compounds
   - A) calcium B) nitrogen
   - C) carbon D) phosphorus
2) Chlorosis occurs due to the deficiency of
   - A) sulphur B) magnesium
   - C) phosphorus D) calcium
3) Carnivorous plants use insects as a source of
   - A) water B) glucose
   - C) oxygen D) nitrogen
4) Most of the uptake of water and minerals from soil takes place through
   - A) epidermal cells B) root cap
   - C) root D) root hair
5) Which of the following is closest to the centre of a woody stem?
   - A) vasular cambium B) young xylem
   - C) old phloem D) old xylem
6) Symplast is the movement of water through
   - A) vacuoles B) cell walls
   - C) cytoplasm of cells D) inter spaces

7) Guard cells are the only cells of epidermis, which have

A) vacuole B) chloroplasts

C) cytoplasm D) leucoplasts

8) The sugar moves through phloem is mostly in the form of

A) glucose B) sucrose C) maltose D) lactose

9) Succulent tissues are formed in

A) hydrophytes B) thallophytes

C) mesophyll D) xerophytes

10) Why does a plant auxin produce different effects on the growth of a root and of a shoot?

A) gravity affects the action of the auxin

B) the growth rates of shoot and roots differ

C) the shoot and root respond differently to similar auxin concentrations

D) light effects the action of the auxin

11) Collenchyma is a supporting tissue in

A) seeds B) seedlings C) shrubs D) trees

12) The phenomenon of growth includes

A) cell differentiation B) cell elongation

C) cell maturation D) cell decomposition

13) A researcher, who wants to study the composition of a plant's sap, inserts a capillary tube into the phloem. What causes the sap to flow out of the tube?

A) capillarity B) hydrostatic pressure

C) root pressure D) transpiration stream

SECTION II : SHORT QUESTIONS

1. Define osmosis in terms of diffusion.
2. What is water potential?
3. Why exchange of gases occurs more effeciently in air than water?
4. Give adaptive characters in hydrophytes

5. Name the hormones involved in each of the following physiological processes: (a) germination of seeds: (b) stem elongation: (c) ripening of fruits: (d) abscission of leaves; (c) dormancy of seeds.
6. Differentiate between: collenchyma and sclerenchyma, photoperiodism and phototropism, transpiration and evaporation.
7. What do you understand by open growth?
8. Define: nutrition, nutrients, osmotic adjustment, primary growth, secondary growth, homeostasis, cohesion and adhesion
9. Why support is needed in terrestrial life?
10. What is the path of salts and water in vascular plants?
11. How does symplast differ from apoplast?
12. Why support is needed? Enlist the names of supporting tissues in plants.
13. What are annual rings? Define primary and secondary growth in plants.
14. Physiological processes are coordinated in organisms. Give an example to show that plant hormones are involved in coordinating physiological processes.
15. What happens to the primary tissue of a stem when secondary growth occurs?
16. Why does the wood of many tropical trees lack annual rings?
17. Why is hardwood more desirable than softwood for making furniture?

SECTION III : EXTENSIVE QUESTIONS

1. What are nutrients? Describe the role or mineral in plants.
2. Describe the role of stomata in the exchange of gases in plants.
3. Explain water movement between plant cells.
4. Discuss the movement of water in xylem through TACT mechanism.
5. How sugars move in plants? Why it is called translocation?
6. How guard cells control the rate of water loss from a plant on a hot dry day. Why is this both helpful and harmful to the plant?

7. What are the adaptations in plants to cope with low and high temperature.

8. Explain the types and role of meristems.

9. Discuss the role of important growth regulators.

10. What is photoperiodism? What is the role of phytochromes in the mechanism of photoperiodism?

11. Describe the pressure flow theory.

12. Name the elements that make up most of plant's body. What are essential minerals nutrients and beneficial mineral nutrients?

ANSWER MCQS

1. C 2. C 3. D 4. D 5. D. 6. C 7. B 8. B 9. D 10. C 11. B

12. B 13. B

SUPPLEMENTARY READING MATERIAL

1. Madar, S.S., Biology, 6th edition, WCB, McGraw-Hill, USA, 1998.

2. Mauseth, J.D. Botany: An Introduction to Plant Biology, 2nd ed., Philadelphia, Saunders College Publishing, 1995.

3. Taylor, D.J., Green, N.P.O. and Stout, G.W. Biological science 3rd Ed. Cambridge university press, reprint, 2004.

USEFUL WEBSITES

1. www.scipub.net/botany/root-hairs.html

2. www.sirinet/~jgjohnso/plants.html

3. hcs.osu.edu/mg/manual/botany.html

4. plantphys.info/Plant_Biology/lecppt/root.ppt

5. en.wikipedia.org/wiki/Vascular_tissue