The root system is the **descending** (growing downwards) portion of the plant axis. When a seed germinates, **radicle** is the first organ to come out of it. It elongates to form **primary** or the **tap root**. It gives off lateral branches (**secondary** and **tertiary** roots) and thus forms the root system. Its branches penetrate through large and deep areas in the soil and anchor the plant very firmly. It also plays another vital role of absorbing water and mineral salts from the soil and transporting them upwards. How is the root suited in structure to carry out such functions? You shall learn in this lesson.

### OBJECTIVES

After studying this lesson, you will be able to:

- define and identify root;
- distinguish between different types of root systems;
- describe and illustrate different regions of a root apex;
- describe various modifications and functions of roots;
- describe and distinguish between primary structure of dicot and monocot root;
- illustrate and explain the mode of secondary growth in a dicot root;
- describe the deep-seated (endogenous) origin of lateral roots.

### 6.1. CHARACTERISTICS OF ROOTS

The main features of roots by which you can recognize them are:

- Non-green due to absence of chlorophyll;
- Not divided into nodes and internodes;
- Absence of leaves and buds;
- Positively geotropic (**grow towards gravity**);
- Positively hydrotropic (**grow towards water**);
- Negatively phototropic (**grow away from light**).
6.2. TYPES OF ROOT SYSTEMS

Root systems are mainly of two types:

(i) **Tap root system** — It is the root system that develops from the radicle and continues as the primary root (tap root) which gives off lateral roots. These provide very strong anchorage as they are able to reach very deep into the soil. It is the main root system of dicots e.g. gram, chinorose, neem (Fig. 6.1a).

(ii) **Fibrous root system** — In this root system, the primary root is short-lived. A cluster of slender, fiber-like roots arises from the base of the radicle and plumule which constitute the fibrous root system. They do not branch profusely, are shallow and spread horizontally, hence cannot provide strong anchorage. Fibrous root system is the main root system of monocots, e.g. maize, grasses, wheat (Fig. 6.1b).

6.3 TYPES OF ROOTS

(i) **Tap root** — It is the primary and the main root that develops from the radicle, bears numerous branches and remains underground. It is usually found in dicots e.g. sunflower, mustard, carrot, mango (Fig. 6.1a).

(ii) **Adventitious root** — These are roots that develop from any part of the plant except the radicle. They may be aerial or underground (Fig. 6.1b). They may grow from node (money plant, bamboo), stem cutting (rose), tree branch (banyan) or stem base (fibrous roots in monocots).

INTEXT QUESTIONS 6.1

1. Name the plant organ which grows towards gravity and water but away from light?

..............................................................................................................................................
2. From which part of the germinating seed does the root develop?

........................................................................................................................................

3. Which root system gives better anchorage and why?

........................................................................................................................................

4. Give two examples each of plants having fibrous and tap root system?

........................................................................................................................................

5. Mention three characters by which you can say that carrot which you eat is a root.

........................................................................................................................................

6.4 REGIONS OF ROOT

The apical region of roots of any root system shows the same zones or regions as can be seen in Fig.6.2a. A longitudinal section of root apex (Fig.6.2b) shows the following structures:

1. **Root cap region** — It is a thimble-like structure produced by meristematic (rapidly dividing) zone and protects the tender apex (apical meristem) from harsh soil particles. As the root grows further down in soil, root cap wears out but it is constantly renewed. In aquatic plants (Pistia and water hyacinth) root cap is like a loose thimble, called **root pocket**.

2. **Region of meristematic cells** — is a small region of actively dividing cells called the apical meristem. It consists of:

   (i) Dermatogen (outermost layer whose cells mature into epiblema and root cap);

   (ii) Periblem (inner to dermatogen whose cells mature into cortex) and

   (iii) Plerome (central region whose cells mature into stele). In monocots, cap is formed by independent group of cells known as **Calyptrogen**.

3. **Region of elongation** — This is situated next to the meristematic region, wherein, the cells elongate and enlarge to make the root grow in length.

4. **Region of maturation** — This is next to the region of elongation, wherein the cells mature and differentiate into various tissues constituting (i) **Root hair** or **piliferous region** having unicellular hairs which absorb water and mineral salts from the soil and (ii) **Permanent region** which lies behind the root hair zone and is without hairs. It produces lateral roots, anchors the plant in soil and conducts water and minerals upwards.
In the maize root tip, Clowes (1958) discovered a central cup-like reservoir of inactive cells, lying between the root cap and the active meristematic region, called the **Quiescent Centre**. These cells become active whenever the previously active meristematic cells are damaged.

**Fig. 6.2** (a) Apical part of a root showing four different regions;  
(b) LS through root apex

### INTEXT QUESTIONS 6.2

1. Name the structure which protects the root apical meristem.

2. Give in a sequence, the various regions of root from its tip towards its base.

3. Into which tissues do dermatogen and plerome differentiate?

4. Which region of root absorbs water and mineral salts?

### 6.5 MODIFICATIONS OF ROOTS

Tap roots and adventitious roots can get modified into a variety of forms to perform various functions as can be seen from the following chart and Tables 6.1 and 6.2.
**Root System**

**Modifications of roots**

- Tap root modification
- Adventitious root modification

(i) Conical root  
(ii) Fusiform root  
(iii) Napiform root  
(iv) Tuberous root

(i) Tuberous root  
(ii) Fasciculated root  
(iii) Nodulose roots  
(iv) Moniliform roots 
(v) Annulated roots  
(vi) Assimilatory roots  
(vii) Epiphytic roots  
(viii) Pneumatophores/Respiratory roots  
(ix) Sucking roots or haustoria  
(x) Prop roots  
(xi) Stilt roots  
(xii) Climbing roots  
(xiii) Clinging roots  
(xiv) Floating roots

---

**A. Tap root modifications**

Tap roots become fleshy for storage of food (Table 6.1)

**Table 6.1 – Tap root modifications for food storage**

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conical (Fig. 6.3a)</td>
<td>Base is broad and tapers gradually towards apex</td>
<td>Carrot</td>
</tr>
<tr>
<td>2. Fusiform (Fig. 6.3b)</td>
<td>Swollen in middle, tapering towards both ends</td>
<td>Radish</td>
</tr>
<tr>
<td>3. Napiform (Fig. 6.3c)</td>
<td>Spherical at base tapering sharply towards the tip</td>
<td>Turnip</td>
</tr>
<tr>
<td>4. Tuberous (Fig. 6.3d)</td>
<td>Thick and fleshy with no definite shape</td>
<td>4 O’clock plant</td>
</tr>
</tbody>
</table>
Fig. 6.3 Modifications of tap root (a) Conical (carrot); (b) Fusiform (radish); (c) Napiform (turnip); (d) Tuberous (4 o’clock plant)

B. Adventitious root modifications

Adventitious roots get modified for various functions (Table 6.2)

Table 6.2 – Adventitious root modifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Modifications for food storage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Tuberous</td>
<td>Swollen roots developing from nodes of prostrate stem</td>
<td>Sweet Potato</td>
</tr>
<tr>
<td>(Fig 6.4a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Fasciculated</td>
<td>Swollen roots developing in a cluster from the stem</td>
<td>Dahlia</td>
</tr>
<tr>
<td>(Fig. 6.4b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Nodulose</td>
<td>Only apices of roots become swollen like single beads</td>
<td>Mango-ginger</td>
</tr>
<tr>
<td>(Fig. 6.4c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Moniliform</td>
<td>Roots alternately swollen and constricted presenting a beaded or moniliform appearance</td>
<td>Grasses, Sedges</td>
</tr>
<tr>
<td>(Fig. 6.4d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Annulated</td>
<td>Looks as if formed by a number of discs placed one above the other</td>
<td>Ipecac</td>
</tr>
<tr>
<td>(Fig. 6.4e)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii) Modification for photosynthesis</td>
<td>Roots which when exposed to sun develop chlorophyll, turn green and manufacture food</td>
<td>Tinospora</td>
</tr>
<tr>
<td>Assimilatory roots</td>
<td>(Fig 6.4f)</td>
<td>(aerial root), orchid</td>
</tr>
</tbody>
</table>
(iii) Modification for absorbing atmospheric moisture

**Epiphytic roots** (Fig. 6.4f)

Aerial roots of epiphytes are greenish and covered with spongy tissue (Velamen) with which they absorb atmospheric moisture. (Orchids, *Vanda*)

---

![Diagram](image)

**Fig. 6.4** Adventitious root modifications (a) Tuberous root (sweet potato); (b) Fasciculated roots (*Dahlia*); (c) Nodulose roots (mango ginger); (d) Moniliform roots (grass); (e) Annulated roots (*Ipecac*); (f) Assimilatory and epiphytic roots (orchid)

(iv) Modification for better gaseous exchange

**Pneumatophores or respiratory roots** (Fig. 6.5a)

Some roots grow vertically up (negatively geotropic) into air. Mangroves (marshy plants) (e.g., *Rhizophora*)

Exposed root tips possess minute pores through which roots respire, appear like conical spikes coming out of water.

---

(v) Modification for sucking nutrition from host

**Sucking roots or haustoria** (Fig. 6.5 bi, bii)

Parasitic plants give out sucking roots or haustoria which penetrate living host plant and suck food from phloem. (e.g., *Cuscuta*)
Fig. 6.5 Adventitious root modifications (a) Pneumatophores of a mangrove plant; (bi) *Cuscuta* (parasite) on host; (bii) Section showing sucking root or haustorium penetrating the host plant

(vi) **Modification for strong support**

1. **Prop roots**
   (Fig. 6.6a)
   Roots develop from tree branches, Banyan hang downwards and ultimately penetrate the ground, thus provide support to heavy branches.

2. **Stilt roots**
   (Fig. 6.6b)
   Extra roots developing from nodes near the base of stem, grow obliquely downwards and penetrate the soil giving strong anchorage.

3. **Climbing roots**
   (Fig. 6.6c)
   Weak climbers twine around and clasp the support with the help of climbing roots arising from their nodes.

4. **Clinging roots**
   (Fig. 6.4f)
   Special clinging roots arise, enter the crevices of support and fix the epiphyte orchids.

(vii) **Modification for buoyancy and respiration**

**Floating roots**
(Fig. 6.6d)
Spongy, floating roots filled with *Jussiaea* air, arise from nodes of some aquatic plants, and help in floating and respiration.
The great Banyan tree in Sibpur, Kolkata is more than 200 years old, forming a crown of over 404 meters in circumference and has about 1600 prop roots.

**Fig.6.6** Adventitious root modifications – (a) Prop roots in banyan; (b) Stilt roots of sugarcane; (c) Climbing roots of betel; (d) Floating roots of *Jussiaea*.

### 6.6 FUNCTION OF ROOTS

(i) **Anchorage** – Roots anchor the plant firmly to the soil (mechanical function).

(ii) **Absorption** – Roots absorb water and mineral salts and conduct them upwards (physiological function).

(iii) **Special functions** – By undergoing modifications in their structure, roots perform special physiological functions like food storage, assimilation, absorption of atmospheric moisture, sucking food from host, better gaseous exchange and mechanical functions like floating (buoyancy), stronger anchorage and climbing.
1. Are carrot, radish and turnip roots? Justify. Why have they become fleshy?

2. Name the type of root modification found in plants growing in marshy areas. What is their function?

3. What is the tissue in aerial roots of epiphytes known as which helps in absorption of moisture from the atmosphere?

4. What are the two main functions of roots?

5. Match the items of column A with those in column B

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Prop roots</td>
<td>(i) Storage</td>
</tr>
<tr>
<td>(b) Haustorium</td>
<td>(ii) <em>Jussiaea</em></td>
</tr>
<tr>
<td>(c) Sweet potato</td>
<td>(iii) Banyan</td>
</tr>
<tr>
<td>(d) Floating roots</td>
<td>(iv) <em>Cuscuta</em></td>
</tr>
</tbody>
</table>

You would enjoy doing the following activity.

**ACTIVITY 6.1**

**AIM:** To study the characteristics of roots, type of root and modification of root in given plants.

**Material required:** Carrot, radish, turnip, sweet potato, sugarcane, money plant, uprooted grass, mustard/coriander plant.

**Method:** Observe the roots carefully and tabulate your answers to the following questions—

1. Is the root green?
2. Does it have nodes and internodes?
3. Are leaves present on the roots?
4. Are any buds present on the roots?
5. Is it a tap or adventitious root?
6. Name the type of modification, if present.
6.7 PRIMARY STRUCTURE OF ROOTS

A. DICOT ROOT (e.g. gram)

A thin transverse section of dicot root (Fig. 6.7) shows the following structures —

(i) **Epiblema** : Single, outermost layer of thin-walled cells. Some cells are prolonged to form unicellular root hairs. It protects and absorbs water.

(ii) **Cortex** : Large zone, many layered, cells thin-walled parenchymatous with intercellular spaces, stores food and water.

(iii) **Endodermis** : Innermost layer of cortex, cells barrel-shaped, closely packed, that show band like thickenings on their radial walls called *casparian strips*. Some cells (opposite the protoxylem) which lack these strips are called *passage cells*. They help in the movement of water and dissolved salts from cortex directly into xylem.

**Stele** : All tissues inner to endodermis comprise stele.

(iv) **Pericycle** : Inner to endodermis lies a single layer of pericycle. It is the seat of origin of lateral roots and vascular cambium and cork cambium during secondary growth.

(v) **Vascular bundle** : It consists of xylem and phloem patches lying on alternate radii i.e., it is radial. Xylem is *exarch* where *protoxylem* (first formed, having narrow vessels and tracheids) lies towards the periphery and metaxylem...
(differentiates later, has wider vessels and tracheids) lies towards the center. Depending upon the number of xylem patches a root may be diarch (di-2 patches) to hexarch (hexa- 6 patches).

(vi) **Pith**: Sometimes the metaxylem of all xylem patches meet in the centre, and in that case pith is absent or is small and parenchymatous.

(vii) **Conjunctive parenchyma**: Parenchyma which separates xylem and phloem lying on different radii.

**B. MONOCOT ROOT** (e.g. maize root)

A thin transverse section of monocot root (Fig. 6.8) shows the following structures

![Diagram of Monocot Root](image)

**Fig. 6.8** A portion of monocot root in transverse section.

(i) **Epiblema**: Outermost, single layer of thin-walled, closely packed cells. Some cells are prolonged into unicellular root hairs.

(ii) **Cortex**: Large zone, multilayered, composed of parenchymatous cells with intercellular spaces, stores water and food material.
(iii) **Endodermis**: Innermost layer of cortex with characteristic *casparian strips* and *passage cells*.

**Stele**: All the tissues inner to endodermis constitute stele

(iv) **Pericycle**: Single layered, having polygonal thin walled cells. The lateral roots originate from this layer.

(v) **Vascular bundle**: It consists of many patches of xylem and phloem arranged radially. The xylem is exarch and polyarch (poly-many).

(vi) **Pith**: Is situated in the center, large, well developed, parenchymatous or sclerenchymatous, stores food.

(vii) **Conjunctive Parenchyma**: Is located in between the strands of xylem and phloem.

The anatomical differences between Dicot and Monocot roots can be studied from Table 6.3

### Table 6.3 Differences between a Dicot and Monocot root

<table>
<thead>
<tr>
<th>Characters</th>
<th>Dicot root</th>
<th>Monocot root</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Number of vascular</td>
<td>2-6 (<em>di-hexarch</em>)</td>
<td>Many (<em>polyarch</em>)</td>
</tr>
<tr>
<td>bundles</td>
<td>Seat of origin of</td>
<td>Seat of origin of lateral</td>
</tr>
<tr>
<td></td>
<td>lateral roots,</td>
<td>roots only</td>
</tr>
<tr>
<td></td>
<td>vascular and cork</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cambium</td>
<td></td>
</tr>
<tr>
<td>3. Cambium</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>4. Secondary growth</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>5. Pith</td>
<td>Very small or absent</td>
<td>Large</td>
</tr>
</tbody>
</table>

### 6.8 ORIGIN OF LATERAL ROOTS

- The origin of lateral roots is endogenous i.e. from a deeper layers.
- The seat of its origin is pericycle where cells opposite the protoxylem divide and form a hump in the endodermis (Fig. 6.9 a-b).
- The hump penetrates into the cortex (Fig. 6.9 c-d), and emerges as a lateral branch.

**Fig. 6.9** a-d Formation of lateral root (Endogenous origin)- Stages as seen in longitudinal sections of root.
Later, the hump differentiates into 3 regions of the root apex i.e. dermatogen, periblem andplerome.

Finally the lateral root comes out.
The number of lateral roots corresponds to the number of xylem bundles.

**INTEXT QUESTIONS 6.4**

1. Name the condition where protoxylem lies towards the periphery and metaxylem towards centre.
   
   ............................................................................................................................

2. Why is it difficult to pluck lateral roots from carrot?
   
   ............................................................................................................................

3. What is the seat of origin of lateral roots and cambium?
   
   ............................................................................................................................

4. Name the endodermal cells which do not possess casparian strips and help in the movement of water?
   
   ............................................................................................................................

5. Give two major differences between a dicot and monocot root.
   
   ............................................................................................................................

6. If the number of xylem bundles is 4 (tetrarch), how many lateral roots will be formed in that area?
   
   ............................................................................................................................

**6.9 SECONDARY GROWTH IN DICOT ROOTS**

The roots grow in length with the help of apical meristem. It is called **primary growth**. Apart from primary growth, roots grow in width i.e., they increase in girth. This increase is called **secondary growth**. It is found only in dicot roots.

The tissues involved in secondary growth are **lateral meristems** i.e., **vascular cambium** and **cork cambium**.

It is important to remember that the vascular cambium and cork cambium are secondary in origin and arise from the pericycle.

Secondary growth is as follows-

- Pericycle cells outside the protoxylem divide to form a strip of cambium (Fig 6.10b).

- Another strip of vascular cambium appears in the conjunctive tissue on the inner side of phloem bundle (Fig. 6.10 a, b).
These two vascular cambium strips join laterally to form a ring which may initially be wavy (Fig. 6.10c) but later becomes circular due to over production of secondary xylem tissue inner to primary phloem (Fig. 6.11a).

- Cambium cells consist of brick shaped cells which divide and add cells on its either side i.e. towards periphery and towards center. Those added towards the periphery differentiate into secondary phloem and the ones formed towards the center differentiate into secondary xylem.

Secondary tissue formed outer to the protoxylem bundle differentiates into prominent primary medullary ray thus, protoxylem does not get crushed (Fig. 6.11a).
Later, cork cambium (Phellogen) also differentiates in the pericycle (Fig. 6.11b).

- The cork cambium divides and gives rise to cork (Phellem) towards outside and secondary cortex (Phelloderm) towards inside.
- All the three layers i.e. Phellogen, Phellem and Phelloderm together form the Periderm of the root and have protective function.
- Finally all the primary tissues outside the developing cork (i.e. endodermis, cortex and epiblema) are sloughed off.

INTEXT QUESTIONS 6.5

1. Name the lateral meristems found in old dicot roots? What is their function?

2. From which layer does the vascular cambium originate?

3. What is the conjunctive tissue?

4. Define periderm. What role does it play in a root?

5. Do primary roots of dicot plant possess cambium?

WHAT YOU HAVE LEARNT

- The radicle elongates to form the primary or tap root.
- Roots are non-green due to the absence of chlorophyll, lack nodes and internodes, leaves and buds.
- These grow towards gravity (positively geotropic) and water (positively hydrotropic) but grow away from light (negatively phototropic).
- Root systems are of two types – Tap root system (in dicots) and Fibrous root system (in monocots).
- Tap root develops from the radicle while adventitious roots develop from any part of the plant except the radicle.
- Apical region of root has 4 regions namely root cap region, region of meristematic cells, region of elongation and region of maturation.
- Main functions of root are anchorage and absorption of water and minerals.
- In some plants, roots undergo modifications in their structure to perform special physiological functions (food storage, assimilation, respiration, absorption of...
atmospheric moisture and sucking nutrients from host plants) and mechanical functions (stronger anchorage, climbing, buoyancy).

- Internal structure of root shows unicellular hairs, single-layered epiblema, large multilayered cortex, prominent one-layered endodermis with casparian strips and some passage cells. The stele consists of single layered pericycle, radial vascular bundles, exarch xylem and pith.

- Dicot root differs from monocot root in having lesser number of vascular bundles (2-6), very small pith and presence of cambium (secondarily formed).

- Origin of lateral roots is endogenous.

- Number of lateral roots corresponds to the number of xylem bundles.

- Lateral roots, vascular cambium and cork cambium originate from pericycle in dicot roots.

- Due to the presence of cambium dicot roots undergo secondary growth.

- Because of apical meristem roots undergo primary growth and increase in length.

- The dicot roots grow in girth by undergoing secondary growth due to the involvement of lateral meristems (vascular cambium and cork cambium).

- Vascular cambium originates as a strip in pericycle cells lying outside the protoxylem and in conjunctive tissue inner to each phloem bundle.

- Initially the cambium is wavy but later becomes circular.

- The vascular cambium gives rise to secondary phloem towards periphery and secondary xylem towards centre.

- Primary medullary rays differentiate outer to protoxylem.

- Cork cambium (phellogen) also differentiates in the pericycle and gives rise to cork (phellem) towards periphery and secondary cortex (phelloderm) towards inside.

- Phellem, Phellogen and Phelloderm together form the periderm which is protective in function.

**TERMINAL EXERCISES**

1. Describe any four adventitious root modifications.
2. Give one point of difference between:
   (i) Tap root and adventitious root
   (ii) Prop and stilt roots
   (iii) Protoxylem and metaxylem
   (iv) Phelloderm and periderm
   (v) Vascular cambium and cork cambium
3. Describe the various types of edible roots which you have studied.
4. What are pneumatophores? Where are they found and what is their function?
5. Describe secondary growth in dicot roots.
6. Why is it difficult to break the lateral roots from the main root?
7. What is periderm? How is it formed?
8. Give four characteristics by which you can identify a root.
9. What is the function of region of maturation?
10. Give one example each of plants having pneumatophores, climbing roots, floating roots and haustoria.
11. A cross section of plant organ when seen under the microscope shows—radial vascular bundles, exarch xylem, single layered pericycle and unicellular hair. What organ is it?
12. Name the meristematic tissues which help the dicot roots to grow in length and girth.
13. Name the modification of root which supports tree branches.
14. If a transverse section of root shows polyarch condition of vascular bundles, large pith and no cambium, which type of root will it be?
15. Differentiate between stele of dicot and monocot root.

**ANSWERS TO INTEXT QUESTIONS**

6.1 1. Root
2. Radicle
3. Tap root system gives better anchorage because it is very deep seated, and branches profusely which ramify through large areas in soil.
4. Fibrous root system in maize, sugarcane and tap root system in sunflower, mango.
5. Absence of nodes and internodes, buds and leaves.

6.2 1. Root cap
2. Root cap region, region of meristematic cells, region of elongation, region of maturation.
3. Dermatogen differentiates into epiblema and cap, whereas plerome differentiates into stele.
4. Root hair or piliferous region /Region of maturation.

6.3 1. Yes, they are roots since they do not have nodes and internodes, buds or leaves; they become fleshy for storage of food.
2. Pneumatophore, respiration
3. Velamen
4. Anchorage and absorption of water and mineral salts
5. (a) – (iii); (b) – (iv); (c) – (i); (d) – (ii)

6.4 1. Exarch
2. Because these arise from the inner layer i.e. pericycle/ endogenous origin
3. Pericycle
4. Passage cells
5. In dicot root 2-6 vascular bundles and cambium is present but in monocot root many vascular bundles are present while cambium is absent.
6. Four

6.5 1. Vascular cambium and cork cambium; Vascular cambium forms secondary vascular tissue while cork cambium forms cork and secondary cortex.
2. Pericycle and conjunctive tissue.
3. Conjunctive tissue is the parenchyma tissue lying between xylem and phloem patches that are arranged radially in roots.
4. Periderm is a tissue which is formed during secondary growth and consists of phellem, phellogen and phelloderm; protection.
5. No, cambium is absent in the primary dicot root.
Shoot system is an aerial and erect part of plant body which grows upwards. It is usually above the soil and develops from plumule of the embryo. It consists of stem, branches, leaves, flowers, fruits and seeds. In this lesson you will study about the structure, types, modifications and functions of stem, leaf, flower and fruit.

**OBJECTIVES**

After studying this lesson, you will be able to -

- list the general characteristics of stems and distinguish them from those of root;
- describe the shoot apex and explain the origin of lateral branches;
- explain the types, modifications and functions of stem;
- describe the primary structure of dicot and monocot stems with the help of diagrams and distinguish between them;
- describe secondary growth in a dicot stem;
- define wood and its types;
- describe the general morphology of leaf and explain phyllotaxy;
- describe and illustrate various modifications of leaf highlighting their functions;
- describe and compare the internal structure of a typical dicot and monocot leaf;
- define inflorescence and describe its major types;
- define a flower and describe its structure and functions;
- define placentation and describe different kinds of placentation;
- define and explain the structure of fruit and enlist its major categories with examples.
7.1 STEM

7.1.1 Characteristics of Stem

(i) Arises as a prolongation of plumule (one end of an embryo).
(ii) Grows and bends towards light (positively phototropic) and away from gravity (negatively geotropic).
(iii) Divided into nodes (point of attachment of leaf) and internodes (regions between two nodes).
(iv) Bears leaves, branches and flowers on nodes.
(v) Bears vegetative buds which could be terminal (apical bud) for plant to grow upwards or axillary (bud in the axil of leaf) which give rise to lateral branches.
(vi) Bears floral buds (terminal or axillary) that grow into flowers.

7.1.2 Differences between stem and root

Table 7.1 gives the difference in morphology between stem and root.

<table>
<thead>
<tr>
<th>Stem</th>
<th>Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develops from plumule.</td>
<td>Develops from radicle.</td>
</tr>
<tr>
<td>2. Young stem is green because of chlorophyll.</td>
<td>Non green because chlorophyll is absent.</td>
</tr>
<tr>
<td>3. Divided into nodes and internodes.</td>
<td>Not divided into nodes and internodes.</td>
</tr>
<tr>
<td>4. Bears leaves, vegetative and floral buds.</td>
<td>Absent.</td>
</tr>
<tr>
<td>5. No cap present at the apex.</td>
<td>Root cap is present at the apex.</td>
</tr>
<tr>
<td>7. Origin of lateral branches is exogenous (originating from outer layers i.e. endodermis).</td>
<td>Origin of lateral roots is endogenous (originating from inner layers i.e. pericycle).</td>
</tr>
</tbody>
</table>

INTEXT QUESTIONS 7.1

1. Name the part of plant which bears nodes, leaves and flowers.

2. Lateral branch develops from which bud?

3. Why is it difficult to break lateral roots and not lateral branches on stem?

4. Roots are negatively phototropic and positively geotropic, what pattern of growth does the stem show?
7.1.3 The Shoot Apex

Shoot apex is the terminal, dome shaped part of shoot, formed of meristem called **apical shoot meristem** responsible for the development and differentiation of primary permanent tissue and mainly causes growth in length. It is divided into two regions - **Tunica** and **Corpus** (Fig. 7.1)

![Fig.7.1 a-b L.S. of shoot apex to show tunica and corpus](image)

(i) **Tunica** (covering)- An outer zone of shoot apex, 1-3 layers in thickness. It gives rise to epidermis and is responsible for surface growth, and its cells divide only anticlinally.

(ii) **Corpus** (body)- Inner multi-layered zone of cells which divide in all directions. They finally give rise to **procambium** (forms vascular tissue) and **ground meristem** (forms ground tissue). These cells also form leaf primordia (a newly developing leaf).

7.1.4 Origin of Lateral branches

Branches arise from axillary buds present in the axil of leaves (Fig 7.1). Each axillary bud is a small, compact, underdeveloped shoot covered with a large number of overlapping leaf primordia. Internodes of this bud enlarge and develop into a branch. Therefore the development of branches is **exogenous** (exo = outside).

INTEXT QUESTIONS 7.2

1. Name the meristematic zone in which cells divide in all planes.

2. From which meristematic layer does the vascular tissue develops?

3. Which structure gives rise to a lateral branch? Name the type of its origin.

4. What is the structure known as which covers the apical meristem of root but is absent in stem?
7.1.5 Types of stem

The stem may be (i) **aerial** (erect, rigid, strong and upright as in herbs, shrubs and trees) (ii) **sub aerial** (weak, unable to stay upright and trail on ground as **creepers** or climb up as **climbers**) or (iii) **underground** (buried in soil and produces aerial branches under favourable conditions only).

7.1.6 Modifications of Stem

Stems are variously modified into underground, sub aerial and aerial stems for performing functions like manufacturing and storing food, perennation (overcoming unfavourable climatic conditions), providing mechanical support and protection and for propagating vegetatively.

### Types of stem and modifications

<table>
<thead>
<tr>
<th>Underground</th>
<th>Subaerial</th>
<th>Aerial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhizome</td>
<td>Runner</td>
<td>Tendrils</td>
</tr>
<tr>
<td>Corm</td>
<td>Stolon</td>
<td>Thorns</td>
</tr>
<tr>
<td>Bulb</td>
<td>Offset</td>
<td>Phylloclade</td>
</tr>
<tr>
<td>Tuber</td>
<td>Sucker</td>
<td>Cladode</td>
</tr>
</tbody>
</table>

**Underground modified stems** – Since underground, they may seem like roots but you can recognise them as stem due to the presence of:

(i) Nodes and internodes, (ii) scaly non green leaves, (iii) buds.

They serve two functions -

- Act as perennating structures by remaining leafless and dormant in winter but giving off aerial shoots under favourable conditions (next season)
- Store food and become thick and fleshy.

The various types of underground modified stems are given in Table 7.2.

### Table 7.2 Underground Modified Stems

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rhizome</td>
<td>Thick, fleshy, flattened horizontally growing stem near the soil surface. Bears scale leaves on nodes, terminal and axillary buds, adventitious roots.</td>
<td>Ginger (Adrak) Turmeric (‘haldi’)</td>
</tr>
<tr>
<td>2. Corm</td>
<td>Fleshy, spherical stem with flattened base, grows vertically; bears many scale leaves, distinct nodes and internodes, buds and adventitious roots.</td>
<td>Saffron (‘kesar’) Yam (‘zimikand’) Gladiolus</td>
</tr>
</tbody>
</table>
3. **Bulb**  
(Fig.7.2ci,ii)  
Reduced, flattened discoid stem with crowded nodes bearing overlapping fleshy (inner) and dry (outer) scale leaves. Terminal bud (in centre) forms foliage (green) leaves. Adventitious roots grow from discoid base.  
Onion

4. **Tuber**  
(Fig.7.2d)  
Swollen tips of underground lateral branches of stem, store food as starch, bear “eyes”. Each eye is a node which bears bud and scar of scale leaves.  
Potato

---

Fig.7.2 Underground modifications of stem – (a) Rhizome of Ginger, (b) Corm of Yam, (ci) Bulb of Onion (cii) V.S. bulb, (d) Tuber of potato.

**Sub aerial modifications Of stem**- Stems are weak, therefore lie prostrate on the ground or may get partially buried in the top soil. The plants bearing such stems are called creepers. Their stems serve the function of vegetative propagation.

**Table 7.3 Modifications of Sub aerial stems**

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 1. **Runner**  
(Fig.7.3a) | Long, weak, slender branch with long internodes.  
Runs horizontally on soil surface giving off adventitious roots at nodes | Grass, *Oxalis*                  |
| 2. **Stolon**  
(Fig. 7.3b) | Weak lateral branch which grows upwards then arches down to meet the soil, strike roots and produce daughter plants. | Mint (‘Pudina’), Jasmine         |
| 3. **Offset**  
(Fig.7.3c) | Like runner but thicker and shorter, grow for a short distance then produce cluster (rosette) of leaves above and adventitious roots below; generally in aquatic plants | Water hyacinth, water lettuce    |
| 4. **Sucker**  
(Fig.7.3d) | Underground runner which grows horizontally for a distance under soil then emerges obliquely upwards, strikes roots and forms daughter plants | Chrysanthemum                    |
Aerial stem modifications - Whole stem or its part (axillary or terminal bud) gets modified to perform definite functions. You can recognise them as stems by following features:

(i) Arise in the axil of leaf (ii) Bear nodes and internodes (iii) May bear leaves, buds, flowers.

**Table 7.4 Types of aerial stem modifications**

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stem tendrils (Fig.7.4a)</td>
<td>Thread like, spirally coiled, leafless structures (tendrils) which twine around neighbouring objects and help weak plants to climb</td>
<td>Grape vine</td>
</tr>
<tr>
<td>2. Thorns (Fig.7.4b)</td>
<td>Straight, pointed, hard structures; modifications of axillary (<em>Citrus</em>) or terminal (<em>Carissa</em>) bud; act as defence organs or as climbing organs</td>
<td><em>Citrus</em>, <em>Duranta</em> <em>Carissa</em> ('<em>Karonda</em>')</td>
</tr>
<tr>
<td>3. Phylloclade (Fig.7.4c)</td>
<td>Green, flattened or cylindrical fleshy stem, with nodes and internodes; bears spines (modified leaves to check evaporation); carries out photosynthesis, stores water. Found in plants growing in dry regions</td>
<td><em>Opuntia</em> (prickly pear)</td>
</tr>
<tr>
<td>4. Cladode (Fig.7.4 di,di)</td>
<td>It is a phylloclade with limited growth i.e. with only one or two internodes; help in photosynthesis</td>
<td><em>Asparagus</em></td>
</tr>
</tbody>
</table>
7.1.7 Functions of stem

A. Primary functions

1. **Support and orient the leaves** in a manner that they are exposed to maximum sunlight and for efficient gaseous exchange during photosynthesis and respiration.
2. **Conduct water and minerals** from roots to leaves and manufactured **food** from leaves to different parts of the plant.

3. **Bear flowers and fruits**

**B. Secondary Functions**

1. **Storage** - Stems store food and water in some plants e.g. potato

2. **Perennation** - The underground stems help tide over the unfavourable growing periods e.g. ginger.

3. **Vegetative propagation** - Stem can be a means of vegetative propagation e.g. rose, and sugarcane.

4. **Photosynthesis** - in certain plants like xerophytes (desert plants) where leaves are reduced, the stem takes up the function of photosynthesis. These stems possess chlorophyll e.g. *Opuntia*

5. **Protection** - In some plants the axillary bud modifies into thorn and protects the plants from grazing animals e.g. citrus, *Duranta*.

6. **Climbing** - Tendrils or hooks are modified branches or buds. They coil around the support and help the plant to climb e.g. grape vine

**INTEXT QUESTIONS 7.4**

1. Give one primary function of stem.

2. How does sugarcane plant multiply?

3. Match the following in column A with column B

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Opuntia</td>
<td>(i) Conduction</td>
</tr>
<tr>
<td>(b) Duranta</td>
<td>(ii) Storage of food</td>
</tr>
<tr>
<td>(c) Ginger</td>
<td>(iii) Photosynthesis</td>
</tr>
<tr>
<td>(d) Potato</td>
<td>(iv) Perennation</td>
</tr>
<tr>
<td>(e) Stem</td>
<td>(v) Protection</td>
</tr>
</tbody>
</table>

**7.1.8 Internal (anatomical) structure of stem**

The internal structure can be studied if you cut the stem transversely and observe it under a compound microscope.

**A. Internal structure of dicot stem (e.g., Sunflower)**

In a transverse section of a young dicot stem you will see the following structures (Fig. 7.5a and 7.5b)

1. **Epidermis** - Outermost single layered, covered with cuticle, bears multicellular hairs, protective function.
2. **Cortex** - Inner to epidermis, there are three regions.
   - **Hypodermis** - 4-6 layers of collenchyma for mechanical support.
   - **Middle layers** - Few layers of parenchyma.
   - **Endodermis** - Innermost layer of cortex, has barrel shaped cells. As cells contain starch grains, it is also called **starch sheath**.

3. **Stele** - All the tissues lying internal to endodermis constitute the stele.
   - (i) **Pericycle** - Inner to endodermis, multilayered, parenchymatous with patches of sclerenchyma.
   - (ii) **Vascular bundles** - Arranged in a ring (Fig. 7.5a); each vascular bundle is (a) **conjoint** (xylem and phloem together in one bundle), (b) **collateral** (xylem and phloem on the same radius with phloem towards the periphery) and (c) open (cambium present in between xylem and phloem). Xylem is **endarch** (protoxylem towards centre and metaxylem towards periphery).

![Fig. 7.5 T.S. Dicot stem. a-Diagrammatic b-A portion enlarged.](image)

(iii) **Medullary rays** - Narrow regions of parenchymatous cells in between the vascular bundles.

(iv) **Pith** - The central parenchymatous zone with intercellular spaces.
B. Internal structure of monocot stem (e.g., maize)

A transverse section of monocot stem reveals the following structures (7.6a and b)

1. **Epidermis** - Single layered, covered with cuticle, stem hairs absent.

2. **Ground tissue** - A mass of parenchymatous tissue. Only a few peripheral layers below epidermis are sclerenchymatous called **hypodermis**.

   1. **Vascular bundle** - Numerous, scattered in the ground tissue each enclosed by sclerenchymatous bundle sheath. Each bundle is (a) **collateral** and (b) **closed** (no cambium strip between xylem and phloem) with (c) **endarch** xylem. Xylem occurs in the form of letter ‘Y’ and innermost protoxylem disintegrates to form a water cavity.

![Diagram of Monocot Stem](image)

---

**Fig. 7.6** T.S. Monocot stem. (a) Diagrammatic (b) A portion enlarged (c) A vascular bundle magnified.

Anatomical differences between dicot and monocot stem, and anatomical differences between root and stem are given in Tables 7.5 and 7.6
### Table 7.5 Differences between monocot stem and dicot stem

<table>
<thead>
<tr>
<th>Characters</th>
<th>Dicot stem</th>
<th>Monocot stem</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Epidermal hairs</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>2. Hypodermis</td>
<td>Collenchymatous</td>
<td>Sclerenchymatous</td>
</tr>
<tr>
<td>3. Ground tissue</td>
<td>Differentiated into cortex, endodermis, pericycle, pith and medullary rays</td>
<td>Undifferentiated</td>
</tr>
<tr>
<td>4. Vascular bundles</td>
<td>(i) Number not very large</td>
<td>(i) Numerous</td>
</tr>
<tr>
<td></td>
<td>(ii) Uniform in size</td>
<td>(ii) smaller near periphery, bigger in the centre</td>
</tr>
<tr>
<td></td>
<td>(iii) arranged in a ring</td>
<td>(iii) scattered</td>
</tr>
<tr>
<td></td>
<td>(iv) open</td>
<td>(iv) closed</td>
</tr>
<tr>
<td></td>
<td>(v) bundle sheath absent</td>
<td>(v) bundle sheath present</td>
</tr>
<tr>
<td></td>
<td>(vi) xylem vessels arranged in a radial row</td>
<td>(vi) xylem vessels arranged in shape of letter “Y”</td>
</tr>
<tr>
<td></td>
<td>(vii) water cavity absent</td>
<td>(vii) water cavity present</td>
</tr>
<tr>
<td>5. Secondary growth</td>
<td>Present</td>
<td>Mostly absent</td>
</tr>
</tbody>
</table>

### Table 7.6 Anatomical differences between stem and root

<table>
<thead>
<tr>
<th>Characters</th>
<th>Stem</th>
<th>Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cuticle</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>2. Hair</td>
<td>Multicellular</td>
<td>Unicellular</td>
</tr>
<tr>
<td>3. Ground Tissue</td>
<td>Differentiated</td>
<td>Differentiated</td>
</tr>
<tr>
<td>4. Cortex</td>
<td>Narrow (dicot) or undifferentiated (monocot)</td>
<td>Wide</td>
</tr>
<tr>
<td>5. Pericycle</td>
<td>Many layered, of sclerenchymatous and parenchymatous cells</td>
<td>Single layered, of parenchymatous cells only</td>
</tr>
<tr>
<td>6. Vascular bundles</td>
<td>Many, conjoint and collateral</td>
<td>Fixed number, radial</td>
</tr>
<tr>
<td>7. Xylem</td>
<td>Endarch</td>
<td>Exarch</td>
</tr>
</tbody>
</table>

### INTEXT QUESTIONS 7.5

1. Differentiate between conjoint and collateral vascular bundle.

2. What is the region between two vascular bundles in a dicot stem known as?

3. Where will you find radially arranged vascular bundles with exarch xylem?
4. If you want to study the internal structure of a monocot and a dicot stem, name the plants you would select for the study.

7.1.9 **Secondary growth in stem**

You have learnt in lesson 6 about the secondary growth in dicot roots and its importance, let us study it in stem. It occurs only in dicot stem a little away from the shoot apex and helps the plant to (a) grow in girth (thickness) and (b) makes it very strong to stand upright for many years. That is why you see that very tall trees can withstand strong winds, and lashing rains without falling down but monocot plants like wheat, rice, maize, and grasses bend easily due to absence of secondary growth in their stems.

Growth in thickness in dicot stem becomes possible due to the formation of new tissues entirely by the activity of two lateral meristems -(i) Vascular cambium and (ii) Cork cambium (Fig.7.7 a-d). These tissues thus formed are known as secondary tissues and growth in girth is referred as secondary growth.

(i) **Activity of vascular cambium** - Forms secondary vascular tissues as follows

- The strip of cambium present in the vascular bundle is called **Fascicular Cambium** (Fig.7.7a).
- The cells of medullary rays adjoining the strip of vascular (Fascicular) cambium become meristematic and form **interfascicular cambium** (Fig. 7.7b).
- Both fascicular and interfascicular cambium join to form a continuous cambium ring (Fig. 7.7b,c).

![Diagram (a-d) T. S. Dicot Stem- Various stages in secondary growth (Diagrammatic)](image)

- Cambium divides and adds cells on internal side (towards pith) which mature into **secondary xylem** and cells added towards external side (periphery) mature into secondary phloem (Fig 7.7c).
- Amount of secondary xylem produced is comparatively more than secondary phloem (Fig 7.7d)

(ii) **Activity of cork cambium** - Forms periderm as follows:

- Cork cambium or **phellogen** develops in the cortex.
- **Phellogen** divides and adds cells on both the inner and the outer side.

- The inner cells differentiate into **phelloderm** or **secondary cortex** while outer cells into **phellem** or **cork** (Fig.7.7d).

- Cork cells are compactly arranged and become dead and suberized (deposition of suberin) except in regions of **lenticels** (Fig. 7.8) where cells are loosely arranged (complimentary cells) and non-suberized. It is through the lenticels that woody branches and tree trunks can undergo gaseous exchange.

- Phellogen, phelloderm and phellem together constitute the **periderm** (Fig7.8). Due to internal increase in thickness, periderm replaces the epidermis, becomes protective in function.

- All the dead cells lying outside the active phellogen constitute the **bark**.

---

![Diagram](image-url)

- **Fig. 7.8** T.S. of old stem, A Portion enlarged

In *Betula bhojpatra* bark peels off like sheets of paper. Ancient manuscripts are still preserved on them. Cork tissue becomes very thick in Cork tree (*Quercus suber*) and is used commercially as, bottle-stoppers, insulators, and shoe soles.
1. Name the two lateral meristems which are responsible for increase in girth of stem.
........................................................................................................................................

2. From which region does the interfascicular cambium develop?
........................................................................................................................................

3. Define bark.
........................................................................................................................................

4. Why are lenticels, non suberized?
........................................................................................................................................

5. The stems of grasses, and rice, remain weak and thin, why?
........................................................................................................................................

6. Which layers constitute the periderm? What is it’s function?
........................................................................................................................................

7.1.10 Wood
Wood is the secondary xylem produced by the activity of vascular cambium in dicot stem.

Annual Rings (A secret to know the age of tree)
In temperate regions, the climatic conditions show pronounced seasonal variations. The activity of vascular cambium also becomes periodical as a result, distinct growth layers are formed in xylem. In spring season cambium is very active and produces a greater number of vessels with wider cavities. The wood formed during spring is called early wood (or spring wood). In summer, cambium is less active and forms narrow vessels, this wood is called late wood (or summer wood). These two kinds of woods in a transverse view appear as alternate concentric rings together forming an annual ring (Fig 7.8). By counting the number of these annual growth rings we can know the age of a tree. Science dealing with predicting the age of a tree by counting the annual growth rings is called as Dendrochronology.

Sap Wood and Heart Wood
Outer part of wood which is functional and consists of recently formed secondary xylem having some living cells is called sap wood. As the plant ages in the central part of stem, the inner cells of sap wood that become non-functional and dark in colour constitute, heart wood (Fig 7.9)
Fig. 7.9 T.S. old stem showing Heart wood and Sap wood.

Table 7.7 enlists the main differences between sap wood and heart wood.

**Table 7.7 Differences between sap-wood and heart wood**

<table>
<thead>
<tr>
<th>SAP WOOD</th>
<th>HEART WOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is the outer light coloured wood of an old stem</td>
<td>It is the central dark colored wood of an old stem</td>
</tr>
<tr>
<td>2. Light coloured</td>
<td>Dark coloured due to presence of gums, resins, oils, tannin etc.</td>
</tr>
<tr>
<td>3. Contains living cells</td>
<td>Living cells are absent</td>
</tr>
<tr>
<td>4. Vessels not plugged and help in upward movement of water and minerals</td>
<td>Vessels are plugged with tyloses</td>
</tr>
<tr>
<td>5. Wood is lighter in weight</td>
<td>Heavier in weight</td>
</tr>
<tr>
<td>6. Less durable because of susceptibility to attack of pathogens</td>
<td>More durable, resistant to attack of the pathogens</td>
</tr>
<tr>
<td>7. Commercially less valuable</td>
<td>Commercially more valuable</td>
</tr>
</tbody>
</table>

**Mechanical tissues in stem** - The stem of a tall tree needs to i) resist against pulling forces of wind and ii) to stand erect against gravity. Stem gets this strength from Sclerenchyma in hypodermis and it’s patches in the pericycle and secondary phloem, abundant lignified vessels, tracheids and fibres in secondary xylem i.e. wood and sclereids in pith.

**INTEXT QUESTIONS 7.7**

1. Which type of wood is formed when the cambium is less active?

2. How can you determine the age of a tree?

3. Why is heart wood commercially more valuable?
4. Why does a tall tree stand erect even in strong wind and lashing rain?

5. Define wood.

---

**7.2 LEAF**

Leaf is a flattened and expanded lateral appendage of stem or branch developing from its node. It originates from leaf primordium formed by the shoot meristem and bears a bud in its axil called **axillary bud**. It is the seat of very important physiological processes like photosynthesis, transpiration and respiration. Besides protecting axillary buds, leaf can get modified into structures for storing food and water, climbing, and vegetative propagation.

**7.2.1 Structure of Leaf**

A typical leaf has three parts (Fig. 7.9)

(i) **Leaf base** - Lower most part of leaf by which it is attached to the stem node. It may be expanded as sheath (in monocots) or bear lateral outgrowths (stipules) as in dicots.

(ii) **Petiole** - Is the stalk of leaf. Leaf can be **petiolate** (with petiole) as in many dicots or **sessile** (without petiole) as in most monocots. Petiole may get modified and swell (e.g. water hyacinth) or develop wings (e.g. orange) or become flat like a leaf (e.g. Australian Acacia).

(iii) **Lamina or leaf blade** - It is a green, thin, flattened and expanded part of leaf with veins and veinlets traversing through its surface. The most prominent vein running from base to apex and present in the middle of leaf blade is called **mid rib**. Veins provide support and conduct water, minerals and prepared food.

Leaf shows a lot of variation in -

(i) Shapes of lamina (Fig. 7.10) (ii) Leaf apices (Fig. 7.11), and (iii) Leaf margins (Fig. 7.12)
7.2.2 Venation in leaves

Arrangement of veins and veinlets in the lamina is known as **Venation**. It is of two types:

- **Reticulate venation** - veins forming a network e.g. dicots (Fig. 7.13A-a,b)
- **Parallel venation** - veins arranged in parallel rows e.g. monocots (Fig. 7.13B c,d).
- Reticulate and parallel venation may be **unicostate** (Fig. 7.13 a,c) with one mid rib, giving out secondary veins like in feather, hence **pinnate** or, **multicostate** (Fig. 7.13 b, d) having many strong veins spreading out from a common point like fingers from palm, hence **palmate** as seen in Fig.7.13.
INTEXT QUESTIONS 7.8

1. Define venation.

2. Differentiate between unicostate and multicostate venation.

3. What is the type of venation found in peepal and palm leaves?

4. Name the structure which arises in the axil of leaf

5. What is the prominent vein called which is present in the middle of lamina and runs from base to apex?

7.2.3 Types of leaves

There are two types of leaves Simple and Compound. Since a leaf bears a bud in its axil, you can recognize a compound leaf from a simple one by locating the axillary bud. A bud is present in the axil of both simple and a compound leaf but not in the axil of leaflets. The differences between the two types of leaves are given in table 7.7

<table>
<thead>
<tr>
<th>Simple leaf</th>
<th>Compound leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The leaf has a single undivided lamina (Fig. 7.9)</td>
<td>The lamina is divided into many segments called leaflets (Fig. 7.14)</td>
</tr>
<tr>
<td>2. If divided, the incisions do not touch the mid rib (Fig. 7.13d)</td>
<td>Incisions touch the mid rib (Fig. 7.15)</td>
</tr>
</tbody>
</table>

Types of Compound leaves - They are of two types as shown in table 7.8

<table>
<thead>
<tr>
<th>Pinnate</th>
<th>Palmate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Leaflets are attached to mid rib or rachis and are arranged laterally (Fig. 7.15)</td>
<td>Leaflets radiate from the end of petiole like fingers of a palm (Fig. 7.14)</td>
</tr>
<tr>
<td>2. Leaflets and mid rib may get further divided to form compound leaves that are unipinnate, bipinnate, tripinnate and decipinnate (Fig. 7.15)</td>
<td>Depending upon the number of leaflets compound leaves are bifoliate, trifoliate, quadrifoliate and multifoliate (Fig. 7.14)</td>
</tr>
</tbody>
</table>
Fig. 7.14 Palmately compound leaf and its types

Fig. 7.15 Pinnately compound leaves and its types

INTEXT QUESTIONS 7.9

1. Name the structure to which the leaflets are attached in a compound leaf.

2. What is the structure which helps you differentiate a leaf from a leaflet?

3. What are the two types of compound leaves known as?

You will enjoy doing the following activity

ACTIVITY 7.1

Aim - To collect and study a few leaves.

Material required — Collect leaves of peepal, neem, banana, palm, rose, grass, imli and tulsi.
Method - Observe the following features in the collected material

(i) Simple or compound leaf
(ii) Reticulate or Parallel venation.

On the basis of the type of venation, group the leaves into monocot and dicot leaves.

7.2.4 Phyllotaxy

It is the arrangement of leaves on stem or branch. The orientation and arrangement of leaves is such that they get appropriate amount of sunlight for photosynthesis. It is of three types

(i) Alternate (Fig. 7.16d) - a single leaf arising at each node e.g. china rose, mango.

(ii) Opposite (Fig. 7.16a-b) - Leaves occur in pairs at each node. This arrangement may be

   (a) Decussate (Fig. 7.16a) - When the successive pairs of leaves at upper and lower nodes are at right angles e. g., “Tulsi”, Calotropis

   (b) Superposed (Fig. 7.16b) - when the successive leaf pairs at upper and lower nodes are exactly in the same plane e.g. guava

(iii) Whorled (Fig. 7.16c) - When there are more than two leaves at each node arranged in a circle or whorl e.g. Nerium.

![Fig. 7.16 (a-d) Phyllotaxy- (a) Opposite-Decussate; (b) Opposite-Superposed; (c) Whorled; (d) Alternate](image)

7.2.5 Modifications of leaves

Although the function of leaves is to synthesize food, in some cases they get modified into distinct structures to perform special functions like support and protection to plant, storage of food and water or to catch insects as in case of insectivorous plants (Table 7.9).
### Table 7.9 Modifications of leaves

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Leaf Tendril (Fig. 7.17a)</td>
<td>Here leaves or leaflets get modified to form thin wiry, closely coiled sensitive structure called the <strong>tendril</strong> that helps the plant to climb the support.</td>
<td>Pea, Glory lily</td>
</tr>
<tr>
<td>2. Spines (Fig. 7.17b)</td>
<td>The leaves are modified into sharp and pointed structures which protect the plant and help in reducing transpiration.</td>
<td>Prickly poppy (Argemone) Opuntia, Aloe</td>
</tr>
<tr>
<td>3. Phyllode (Fig. 7.17c)</td>
<td>The petiole of compound leaf becomes flattened leaf like and helps in photosynthesis; the leaflets gradually disappear.</td>
<td>Australian acacia</td>
</tr>
<tr>
<td>4. Leaves of Insectivorous plants (Fig. 7.17d, e)</td>
<td>In pitcher plant the whole leaf gets modified into pitcher while in bladderwort some segmented leaves get modified into bladders. They help in trapping insects</td>
<td>Pitcher plant (Nepenthes) Bladderwort (Utricularia)</td>
</tr>
</tbody>
</table>

![Fig. 7.17 Modifications of Leaf a-d (a) Leaf tendril; (b) Spines; (c) Pitcher plant; (d) Bladderwort](image)

**Heterophylly** (*heteros = different*) - Some plants show more than one type of leaves in the same plant, this phenomenon is called heterophylly. It is found in some plants which remain partly submerged in water e.g. Water chestnut, and *Limnophila*

### INTEXT QUESTIONS 7.10

1. What is the type of phyllotaxy found in mango, ‘tulsi’ and guava plants?

...........................................................................................................................................................................
2. Match the following items of column A with those of column B

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Pitcher</td>
<td>(i) Photosynthesis</td>
</tr>
<tr>
<td>(b) Spines</td>
<td>(ii) Climbing</td>
</tr>
<tr>
<td>(c) Phyllode</td>
<td>(iii) Trapping insects</td>
</tr>
<tr>
<td>(d) Tendril</td>
<td>(iv) Protection</td>
</tr>
</tbody>
</table>

3. Give two examples of insectivorous plants.

............................................................................................................................

4. Water chestnut shows two different types of leaves on the same plant, what is such a condition known as?

............................................................................................................................

7.2 6 Functions of Leaf

Leaf performs following functions:

(i) **Photosynthesis** - Leaves manufacture food in the presence of sunlight.

(ii) **Exchange of gases** - Stomata help in exchange of gases which are important for respiration and photosynthesis.

(iii) **Transpiration** - Evaporation of excess of water in vapour form takes place through stomata which helps in ascent of sap and cooling of leaf surface.

(iv) **Guttation** - Exudation of excess of water containing salts takes place in liquid form from leaf margins in plants growing in humid climate.

(v) **Modifications for special functions** - In certain plants leaves perform functions like manufacturing and storing food, providing support and protection, vegetative propagation and trapping insects.

7.2.6. Internal structure of leaf (Figs. 7.18-19)

A General features

- Leaves of most dicot plants are dorsiventral (oriented horizontally, with differentiated mesophyll) where as those of monocots are isobilateral (oriented vertically, mesophyll undifferentiated).

- V.S. of leaf shows three main parts (i) **Epidermis** (ii) **Mesophyll** (iii) **Vascular system**.

  (i) **Epidermis** - Present on both upper and lower surface of leaf. Some epidermal cells give rise to guard cells that get arranged to form openings called stomata which help in exchange of gases for photosynthesis, respiration and evaporation of water vapour during transpiration. In some monocot leaves, some epidermal cells in upper epidermis become enlarged to form bulliform cells which lose water so that leaves become tubular to reduce transpiration on hot sunny days.

  (ii) **Mesophyll** - Consists of chloroplast - containing parenchyma (chlorenchyma) and is responsible for carrying out photosynthesis. It is differentiated into **palisade** and **spongy** cells in dicot leaves. In monocot leaves, palisade tissue is lacking, thus, mesophyll has only spongy tissue.
- **Palisade cells** - occur below upper epidermis in dicot leaf.
  - Cells are radially elongated, compactly arranged.
  - Possess abundant chloroplasts

- **Spongy cells** - Occur below the palisade cells in a dicot leaf.
  - Cells irregular and loosely arranged - Contain fewer chloroplasts
  - Store gases in the inter cellular spaces

(iii) **Vascular Bundles** - They are **conjoint, collateral and closed**
  - In each bundle, xylem is located on upper side (ventral) and phloem on lower side (dorsal)
  - Most vascular bundles are surrounded by colourless parenchyma called **bundle sheath or border parenchyma**.

---

**Fig. 7.18** V.S. of a dicot (Dorsiventral) Leaf

**Fig. 7.19** V.S. of a Monocot (Isobilateral) Leaf
Shoot System

**Structure of stomatal apparatus**: In dicot leaves, stomatal apparatus is made up of two semi circular guard cells surrounding a pore-stoma (Fig. 7.21) The guard cells contain chloroplasts and regulate the opening and closing of stomata. Stomatal pore opens into the inter cellular spaces (substomatal cavity) of mesophyll (Fig. 7.19). The number, shape and distribution of stomata vary (Table 7.10) depending upon the plant whether it is xerophyte or mesophyte.

**Table 7.10 Distribution of stomata.**

<table>
<thead>
<tr>
<th>Plants</th>
<th>Stomatal characters</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dicots</td>
<td>Guard cells semicircular reniform occur generally on lower surface</td>
<td>Mango, neem</td>
</tr>
<tr>
<td>2. Monocots</td>
<td>Guard cells dumbbell shaped, occur on both the surfaces</td>
<td>Maize</td>
</tr>
<tr>
<td>3. Xerophytes</td>
<td>To reduce transpiration- (i) occur only on lower surface, (ii) are absent or less in number on the upper surface (iii) may be sunken</td>
<td>Nerium</td>
</tr>
<tr>
<td>4. Hydrophytes</td>
<td>Occur only on upper surface</td>
<td>Lotus</td>
</tr>
<tr>
<td>– with floating leaves</td>
<td>Stomata absent</td>
<td>Hydrilla</td>
</tr>
</tbody>
</table>

Now you can compare the internal structures of dicot and monocot leaves from Figs. 7.18-19 and Table 7.11

**Table 7.11 Difference between internal structure of Dicot and Monocot Leaf**

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Dicot leaf (Dorsiventral leaf)</th>
<th>Monocot leaf (Isobilateral leaf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Epidermis (i) Stomata</td>
<td>Occur generally in lower epidermis</td>
<td>Occur both in upper and lower epidermis</td>
</tr>
<tr>
<td>(ii) Bulliform cells</td>
<td>Absent</td>
<td>Present in upper epidermus</td>
</tr>
<tr>
<td>2. Mesophyll</td>
<td>Differentiated into palisade and spongy parenchyma</td>
<td>Only spongy parenchyma present</td>
</tr>
<tr>
<td>3. Vascular system (i) in the form of network</td>
<td>(ii) vascular bundle in mid rib region is large, rest of the vascular bundles decrease in size towards the leaf-margin.</td>
<td>(ii) vascular bundle of midrib is large, but other vascular bundles are small generally of same size.</td>
</tr>
</tbody>
</table>

**B. Special features**

(i) **Bulliform Cells** (Fig 7.19)
- These are special type of cells (motor cells) found on upper leaf surface of some monocots (e.g. maize, bajra, jowar).
They help the leaf to roll and unroll due to change in their turgidity.

Leaf rolls when these cells lose water due to high rate of transpiration especially at Mid-day on hot sunny days.

Thus, under dry conditions they help in reducing the loss of water vapour through stomata.

(ii) **Hairs**

- Hairs are present especially on leaves of plants growing in dry conditions. They check the rate of transpiration.
- They protect the leaf from bright sunlight, high temperature and air pollution.

(iii) **Hydathodes (water stomata)**

- These are specialised structures (Fig. 7.20) present in leaves of angiosperms (garden nasturtium) occurring in humid climate.
- Through these openings excretion of water and minerals plus simple organic compounds in liquid form (guttation) takes place. When water absorption by a plant is more and transpiration is less.

**Table 7.12 Difference between Stomata and Hydathode**

<table>
<thead>
<tr>
<th>Characters</th>
<th>Hydathode</th>
<th>Stomata</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Size</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>2. Location</td>
<td>Located at vein endings near leaf margins only</td>
<td>Present throughout the leaf surface</td>
</tr>
<tr>
<td>3. Structure</td>
<td>Always remain open</td>
<td>They open and close depending upon light intensity</td>
</tr>
<tr>
<td>4. Loss of water</td>
<td>Water comes out in liquid form and contains dissolved salts &amp; sugars</td>
<td>Water loss is in vapour form</td>
</tr>
<tr>
<td>5. Occurrence</td>
<td>Found in plants of humid areas</td>
<td>In plants occurring in all climates</td>
</tr>
<tr>
<td>6. Physiological process</td>
<td>Guttation</td>
<td>Transpiration</td>
</tr>
</tbody>
</table>
INTEXT QUESTIONS 7.11

1. How is the mesophyll tissue of dicot leaf different from that of monocot leaf? What is its function?

2. Where are stomata located in a grass leaf?

3. Name the structure through which plants growing in humid areas get rid of excess of water in liquid form.

4. Match the following item of column A with that of column B

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Bulliform cells</td>
<td>(i) Protection</td>
</tr>
<tr>
<td>(b) Transport of water and mineral salts</td>
<td>(ii) Guttation</td>
</tr>
<tr>
<td>(c) Stomata only on lower surface</td>
<td>(iii) Monocot leaf</td>
</tr>
<tr>
<td>(d) Hydathode</td>
<td>(iv) Dicot leaf</td>
</tr>
<tr>
<td>(e) Hair</td>
<td>(v) Stomata</td>
</tr>
<tr>
<td>(f) Exchange of gases</td>
<td>(vi) Xylem</td>
</tr>
</tbody>
</table>

7.3 FLOWER
Flowers are a thing of beauty for us but for the plants they are vital as they are the seat of sexual reproduction. They produce fruits and seeds.

A flower is a modified shoot because it has (i) nodes very close to one another and (ii) floral leaves arranged in successive whorls.

7.3.1 Parts of a typical flower (Fig 7.22)

Take a flower of any colour or size growing in your area, you’ll find it’s basic plan to be the same i.e. the flower is borne on a stalk called pedicel. The pedicel has a swollen tip known as thalamus or receptacle on which are borne four whorls successively in definite order as given below:

Accessory whorls
1. Calyx (collection of sepals) - The outer most whorl of green sepals whose main function is protection.
2. Corolla (collection of petals) - The next whorl of variously coloured petals. They help in attracting insects for pollination.

Reproductive whorls
3. Androecium (male reproductive part) consists of collection of stamens. Each stamen has a long slender filament with a bilobed anther at it’s tip with a connective. Anthers produce pollen grains for pollination.
4. **Gynoecium** (female reproductive part) - centrally located. It consists of a collection of one or more **carpels** which organise to form one or more **pistils**. Each pistil has three parts -
   - **Ovary** - It is the swollen basal part, one to many chambered (called **locules**) containing ovules which get fertilized to form seeds and the, fertilized ovary forms the fruit.

   ![Fig.7.22 A typical flower](image)

   - **Style** - It is the elongated tube connecting the upper part of ovary to stigma.
   - **Stigma** - It is the receptive surface for pollen.

**Common variations in flower and its floral parts** - Flowers show a lot of variation, some of which you can study from the Table 7.13

**Table 7.13 Variations in flower**

<table>
<thead>
<tr>
<th>Variation</th>
<th>Characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Complete/Perfect</strong> flower</td>
<td>All 4 floral whors present</td>
</tr>
<tr>
<td>2. <strong>Incomplete/Imperfect</strong> flower</td>
<td>Any one or more of floral whors are absent</td>
</tr>
<tr>
<td>3. <strong>Bisexual</strong> (Hermaphrodite)</td>
<td>Both reproductive organs i.e. stamens and carpels present</td>
</tr>
<tr>
<td>4. <strong>Unisexual</strong></td>
<td></td>
</tr>
<tr>
<td>(i) <strong>Staminate</strong> or male flower</td>
<td>Only stamens present</td>
</tr>
<tr>
<td>(ii) <strong>Pistillate</strong> or female flower</td>
<td>Only pistil present</td>
</tr>
<tr>
<td>(iii) On the basis of occurrence of unisexual flowers, plant is</td>
<td></td>
</tr>
<tr>
<td>(a) <strong>Monoecious</strong></td>
<td>Both male and female flower occur on same plant e.g., cucumber</td>
</tr>
<tr>
<td>(b) <strong>Dioecious</strong></td>
<td>Male and female flower occur on different plants e.g., papaya</td>
</tr>
<tr>
<td>5. <strong>Neuter</strong> flower</td>
<td>Both stamens and carpels are absent</td>
</tr>
<tr>
<td>6. <strong>Actinomorphic</strong> (Regular) flower</td>
<td>If it can be divided into two equal halves through any vertical plane e.g., mustard</td>
</tr>
<tr>
<td>7. <strong>Zygomorphic</strong> (irregular bilateral) flower</td>
<td>If it can be divided into two similar halves only through one particular plane e.g., pea</td>
</tr>
<tr>
<td>8. <strong>Asymmetrical</strong> (Irregular)</td>
<td>It cannot be divided into two similar halves in any vertical plane e.g., Canna</td>
</tr>
</tbody>
</table>
A. Variations in sepals and petals
(i) Polysepalous and Polypetalous (poly - free)- sepals or petals are free respectively.
(ii) Gamosepalous and Gamopetalous (gamo - united)- all sepals or petals are fused, respectively.
(iii) Perianth - Sepals and petals not distinguishable e.g. onion

B. Variations in Stamens (Fig. 7.23)
The stamens show variation in their cohesion (fusion).
(i) Monadelphous - filaments fused into one bundle but anthers are free e.g. china rose
(ii) Diadelphous - filaments fused to form two bundles e.g. pea
(iii) Polyadelphous - filaments fused to form many bundles e.g., lemon
(iv) Syngeneious - filaments are free but anthers are fused e.g. sunflower
(v) Synandrous - stamens are fused throughout the length e.g., cocks-comb.
Other variations in stamens are as follows
(vi) Epipetalous - stamens are attached to petals by their filaments but anthers are free e.g., brinjal
(vii) Didynamous - four stamens, two short and two long e.g. tulsi
(viii) Tetradynamous - six stamens, inner four are long and outer two are short e.g., mustard

C. Variation in Carpel
On the basis of number of carpels in a pistil, flowers may be
(i) Monocarpellary – If in a Gynoecium pistil has only one carpel e.g. pea.
(ii) Polycarpellary – If the Gynoecium has many carpels (e.g. china rose). It may be
   (a) syncarpous - two or more carpels are fused to form a pistil. e.g. tomato, mustard
   (b) apocarpous – carpels are free e.g. Ranunculus, lotus.

7.3.1a Position of floral whorls on thalamus with respect to ovary
Flower could be of three kinds (Fig. 7.24)
(i) Hypogynous - ovary occupies the highest position on thalamus, other three whorls are successively below it. Ovary is said to be superior e.g. china rose, and mustard.
Forms and Functions of Plants and animals

(ii) **Perigynous** - The thalamus is disc-like on which the ovary is borne in the centre and rest of floral whorls are located on rim of thalamus. Ovary is said to be half inferior e.g. peach, and plum.

(iii) **Epigynous** - thalamus forms a cup-shaped structure; and encloses the ovary completely and fuses with it. The other whorls are positioned above the ovary. The position of ovary is now inferior e.g. sunflower, cucumber.

---

7.3.2 Placentation

It is the manner in which placentae are distributed in the ovary. Placenta is the point of attachment of ovules (or future seed) in the ovary.

Types of placentation (Fig. 7.26)

(i) **Marginal** - The ovary is monocarpellary and one chambered and ovules are arranged along the fused margins of the single carpel. e.g. pea, gram.

(ii) **Axile** - Ovary is polycarpellary syncarpous, having many chambers and ovules present on the placenta develop from the central axis formed by the fusion of the margins of two or more carpels e.g. China rose, tomato, bhindi,

(iii) **Parietal** - Ovary is polycarpellary and syncarpous, having one chamber and ovules are attached on its inner wall where margins of adjoining carpels meet e.g. mustard, cucumber,

(iv) **Basal** – Ovary is bi-or polycarpellary, syncarpous, having one chamber and placenta develops at the base of ovary and bears a single ovule e.g. sunflower.

(v) **Free central** – Ovary is syncarpous and polycarpellary but unilocular as septae are absent. In the central part of the ovary the placenta bears many groups of ovules e.g. *Dianthus*, *Primula*.

---

**Do you know**

Some plants like cashew nuts and mango have neuter, bisexual and unisexual flowers on the same tree.
(vi) **Superficial** - Ovary is polycarpellary syncarpous and multilocular in which entire inner walls of chambers are lined with placental tissue so that ovules develop all around e.g., water lily (*Nymphaea*)

**INTEXT QUESTIONS 7.12**

1. What is the collection of sepals and petals respectively known as?

...........................................................................................................................................................................

2. Match the following items of column A with those of column B

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Flower</td>
</tr>
<tr>
<td>(b)</td>
<td>Polycarpellary</td>
</tr>
<tr>
<td>(c)</td>
<td>Petals</td>
</tr>
<tr>
<td>(d)</td>
<td>Monodelphous</td>
</tr>
<tr>
<td>(e)</td>
<td>Carpel</td>
</tr>
<tr>
<td>(i)</td>
<td>China rose</td>
</tr>
<tr>
<td>(ii)</td>
<td>Pollination</td>
</tr>
<tr>
<td>(iii)</td>
<td>Reproductive organ</td>
</tr>
<tr>
<td>(iv)</td>
<td>Many carpels</td>
</tr>
<tr>
<td>(v)</td>
<td>Modified shoot</td>
</tr>
</tbody>
</table>

3. Define placentation.

...........................................................................................................................................................................

4. Name the type of placentation where ovary is many chambered and ovules are arranged on the central axis.

...........................................................................................................................................................................

7.4 **INFLORESCENCE**

Inflorescence is the arrangement of flowers on the floral axis called peduncle. Inflorescence could be terminal or axillary.

**7.4.1 Types of inflorescence**

The various types of inflorescence depend upon the type of branching of peduncle and arrangement of flowers. There are two major types of inflorescence

(i) **Racemose.** The main axis does not end in a flower but continues to grow.

(ii) **Cymose.** The main axis ends in a flower and the growth is limited.

The major differences between the two are given in table 7.14

<table>
<thead>
<tr>
<th></th>
<th>Racemose</th>
<th>cymose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Main axis shows</td>
<td>unlimited growth</td>
<td>Growth is limited</td>
</tr>
<tr>
<td>2. Axis does not</td>
<td>terminate in a flower</td>
<td>Axis ends in at flower</td>
</tr>
<tr>
<td>3. Flowers occur in</td>
<td>acropetal order (oldest flower below and</td>
<td>Flowers in basipetal order (terminal flower is older)</td>
</tr>
<tr>
<td>flower order (oldest</td>
<td>youngest near the apex)</td>
<td></td>
</tr>
<tr>
<td>flower below and oldest</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 7.15 Types of Racemose Inflorescence  
(Fig. 7.20)

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. With main axis elongated</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Raceme</td>
<td>Flowers present on the floral axis are stalked and arranged acropetally.</td>
<td>Mustard</td>
</tr>
<tr>
<td>2. Spike</td>
<td>Like raceme but the flowers are sessile</td>
<td><em>Achyranthes</em> (‘Latzira’)</td>
</tr>
<tr>
<td>3. Spikelet</td>
<td>Cluster of one or more flowers (florets’ and their associated bracts</td>
<td>Wheat</td>
</tr>
<tr>
<td>4. Catkin</td>
<td>Like spike but the axis is pendulous bearing unisexual flowers</td>
<td>Mulberry</td>
</tr>
<tr>
<td>5. Spadix</td>
<td>Like spike but the axis is fleshy and enclosed by a large showy bract (Spathe)</td>
<td><em>Colocassia</em>, <em>banana</em></td>
</tr>
<tr>
<td><strong>B. With main axis shortened</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Corymb</td>
<td>Lower (older) flowers have longer stalks than the upper younger ones, thus all flowers come to lie at same level</td>
<td><em>Candytuft</em></td>
</tr>
<tr>
<td>7. Umbel</td>
<td>Flower with stalks of equal length arising from the same, point</td>
<td><em>Coriander</em></td>
</tr>
<tr>
<td><strong>C. With main axis flattened</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Head or capitulum</td>
<td>Main axis is flattened into convex receptacle on which sessile flowers (florets) are arranged in centripetal order (older towards periphery). Whole inflorescence is surrounded by involucre of bracts</td>
<td><em>Sunflower</em></td>
</tr>
</tbody>
</table>
Table 7.16 Types of cymose inflorescence
(Fig. 7.27)

<table>
<thead>
<tr>
<th>Type</th>
<th>Characters</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monochasial cyme (Fig. 7.27a)</td>
<td>Main axis ends in a flower. A lateral branch comes from one side and ends in a flower</td>
<td>Cotton</td>
</tr>
<tr>
<td>2. Dichasial cyme (Fig. 7.27b)</td>
<td>Two lateral branches develop from either side of terminal flower and each branch ends in a flower</td>
<td><em>Dianthus, jasmine</em></td>
</tr>
<tr>
<td>3. Multichasial cyme (Fig. 7.27c)</td>
<td>Number of lateral branches come from the sides of terminal flower, each lateral branch ends in a flower.</td>
<td><em>Calotropis</em></td>
</tr>
</tbody>
</table>
7.4.2 Special types of inflorescence

1. **Hypanthodium** (Fig. 7.28a) - The fleshy receptacle forms a cup-like cavity and has an apical opening. The male and female flowers are borne on the inner wall of the cavity, e.g., Fig. Peepal.

2. **Cyathium** (Fig. 7.28b) - A type of inflorescence characteristic of Euphorbia, in which a cup-shaped involucre encloses a single female flower surrounded by a number of male flowers. A nectary is present at the rim of involucre.

3. **Verticillaster** (Fig. 7.28c) - It is a series of condensed dichasial cyme at each node with a cluster of sessile flowers in the axil of leaves, e.g., *Ocimum* (Tulsa), *Salvia*.

**INTEXT QUESTIONS 7.13**

1. What is a cymose inflorescence?

2. Give one difference between Raceme and Spike.

3. Define inflorescence.

4. Name the type of inflorescence found in sunflower and Fig.

**7.5 FRUIT**

A true fruit is a ripened ovary that develops after fertilization. Ovules develop into seeds and the ovary wall matures into fruit wall which is now called pericarp. The pericarp may be thick or thin. In fleshy fruits like mango, pericarp is thick and differentiated into three regions—(a) **epicarp** forms the skin of the fruit (b) **mesocarp**, middle pulpy and (c) **endocarp** inner hard and stony (coconut,
mango) or often thin membranes (orange). In **dry fruits** pericarp, is thin, dry, papery or thick and woody but not divided into three regions.

Sometimes along with ovary other floral parts like thalamus, receptacle or calyx may develop as part of fruit, such fruits are-called false fruits. e.g. apple, pear (thalamus), fig (receptacle).

**Parthenocarpic fruit** -It is a fruit that develops without fertilization. It is seedless or has non-viable seeds e.g. banana, grapes. Horticulturists are producing such fruits artificially.

### 7.5.1 Kinds of fruits - There are three basic types

1. **Simple fruit** - Develops from single mono-to polycarpellary, syncarpous (fused) ovary e.g. pea, tomato.

2. **Aggregate fruit** - Collection (etaerio) of simple fruits or fruitlets on same thalamus developing from polycarpellary, apocarpous (free carpels) ovary e.g. *Calotropis* and *Ranunculus*.

3. **Composite or multiple fruit** - Fruit develops from a number of flowers juxtaposed together or from inflorescence e.g. mulberry, pineapple.

<table>
<thead>
<tr>
<th>Table 7.17</th>
<th>Major categories of fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dehiscent</td>
</tr>
<tr>
<td>Dry</td>
<td>Dry</td>
</tr>
<tr>
<td></td>
<td>Indehiscent</td>
</tr>
<tr>
<td>1. Simple</td>
<td></td>
</tr>
<tr>
<td>Fleshy</td>
<td></td>
</tr>
<tr>
<td>2. Aggregate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Multiple or composite</td>
<td></td>
</tr>
</tbody>
</table>

(i) **Legume** - pea, bean, groundnut
(ii) **Silica** - mustard
(iii) **Follicle** - *Calotropis*
(iv) **Capsule** - cotton, poppy, ‘bhindi’
(i) **Caryopsis** - wheat, rice
(ii) **Nut** - almond, cashewnut
(iii) **Cypsella** - sunflower, marigold
(iv) **Samara** - yam, hiptage
(i) **Drupe** - mango, coconut
(ii) **Berry** - tomato, banana, date palm
(iii) **Pepo** - cucumber, watermelon
(iv) **Hesperidium** - lemon, orange
(v) **Pome** - apple, pear
(i) **Etaerio (cluster) of drupes** - Raspberry
(ii) **Etaerio of achenes** - Strawberry, rose
(iii) **Etaerio of berries** - Custardapple
(iv) **Etaerio of follicles** - periwinkle, larkspur
(i) **Sorosis** - pineapple, mulberry, jackfruit
(ii) **Syconus** - Fig, peepal
### Table 7.18 Common Fruits and their edible parts.

<table>
<thead>
<tr>
<th>Names</th>
<th>Types</th>
<th>Edible Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Banana</td>
<td>Berry – simple, fleshy</td>
<td>Mesocarp and endocarp</td>
</tr>
<tr>
<td>2. Apple</td>
<td>Pome – simple, fleshy</td>
<td>Fleshy thalamus</td>
</tr>
<tr>
<td>3. Coconut</td>
<td>Fibrous Drupe – simple, fleshy</td>
<td>Endosperm</td>
</tr>
<tr>
<td>4. Custard Apple</td>
<td>Etaerio of Berries – aggregate</td>
<td>Pericarp</td>
</tr>
<tr>
<td>5. Date Palm</td>
<td>Berry – simple, fleshy</td>
<td>Pericarp</td>
</tr>
<tr>
<td>6. Cashew Nut</td>
<td>Nut – simple, dry indehiscent</td>
<td>Peduncle and Cotyledons</td>
</tr>
<tr>
<td>7. Mango</td>
<td>Drupe – simple, fleshy</td>
<td>Mesocarp</td>
</tr>
<tr>
<td>8. Orange</td>
<td>Hesperidium – simple, fleshy</td>
<td>Juicy hairs from endocarp,</td>
</tr>
<tr>
<td>9. Tomato</td>
<td>Berry – simple, fleshy</td>
<td>Pericarp and Placentae</td>
</tr>
<tr>
<td>10. Pear</td>
<td>Pome – simple, fleshy</td>
<td>Fleshy thalamus</td>
</tr>
<tr>
<td>11. Pineapple</td>
<td>Sorosis – composite</td>
<td>Outer portion of receptacle, bracts and perianth</td>
</tr>
<tr>
<td>12. Fig</td>
<td>Syconous – composite</td>
<td>Fleshy receptacle</td>
</tr>
<tr>
<td>13. Litchi</td>
<td>Nut – simple</td>
<td>Juicy aril</td>
</tr>
<tr>
<td>14. Wheat</td>
<td>Caryopsis – simple dry indehiscent</td>
<td>Starchy endosperm</td>
</tr>
<tr>
<td>15. Strawberry</td>
<td>Etaerio of achenes- aggregate</td>
<td>Succulent thalamus</td>
</tr>
</tbody>
</table>

### INTEXT QUESTIONS 7.14

1. Define Fruit.

2. Give two examples of false fruits.

3. What is the fruit wall known as which is formed by the ovary wall?

4. Give the names of three layers of pericarp of a fleshy fruit.

5. Match the following of column A with that of column B

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Apple</td>
<td>(i) Berry</td>
</tr>
<tr>
<td>(b) Hesperidium</td>
<td>(ii) Mesocarp</td>
</tr>
<tr>
<td>(c) Mango-edible</td>
<td>(iii) Endosperm</td>
</tr>
<tr>
<td>(d) Coconut -edible Part</td>
<td>(iv) Orange</td>
</tr>
<tr>
<td>(e) Tomato</td>
<td>(v) False Fruit</td>
</tr>
</tbody>
</table>
Shoot System

**WHAT YOU HAVE LEARNT**

- Stem is aerial, upright, positively phototropic part of plant and bears nodes, internodes, leaves, and buds.
- It has a terminal apical meristem which gives rise to leaves and axillary buds.
- The stems are variously modified into underground, subaerial, and aerial stems for performing special functions.
- Dicot and monocot stems are different anatomically.
- The internal structure of dicot stem shows epidermis, differentiated ground tissue, multilayered pericycle, and vascular bundles arranged in a ring. Each vascular bundle is conjoint, collateral, and open with endarch xylem.
- Monocot stem differs in having undifferentiated ground tissue, scattered vascular bundles which are closed.
- Secondary growth takes place only in dicot stem.
- Wood is of two types—heartwood (dark and non-functional) and sap wood (light and functional).
- The differential activity of vascular cambium during secondary growth forms annual growth rings.
- Origin of lateral stem branches is exogenous.
- The primary function of stem is conduction of water and minerals through xylem and food through phloem; support and orient leaves towards sunlight for better photosynthesis; bear flowers and fruits.
- Stem undergoes modifications for various special functions like food storage, perennation, protection, climbing, photosynthesis, and vegetative propagation.
- Leaf is a specialised organ for photosynthesis.
- It has three parts—leaf base, petiole, and lamina traversed by parallel or reticulate venation. The arrangement of leaves on stem is called phyllotaxy.
- Leaves can be simple or compound.
- Leaves are modified into tendrils, spines, phyllode, pitcher or bladder to perform special functions.
- Internal structure of leaf shows three main tissues—epidermis with stomata, mesophyll differentiated into spongy and palisade tissue in dicot leaf but only spongy tissue in monocot leaf and vascular system.
- In dicot leaves each stomatal apparatus consists of kidney-shaped guard cells surrounding a pore. In monocot leaves stoma is surrounded by two dumbbell-shaped guard cells. Guard cells regulate the opening and closing of stomata, depending upon the presence or absence of sunlight.
Stomata help in gaseous exchange and allow loss of water vapour during transpiration.

Special structures like bulliform cells, hydathodes and hairs occur in leaves of some plants.

Flower is a modified shoot.

A typical flower has accessory whorls i.e., calyx and corolla and reproductive or essential whorls i.e., androecium (male) and gynoecium (female).

Flowers may be bisexual, unisexual or neuter; actinomorphic or zygomorphic; hypogynous, perigynous or epigynous.

Variations occur in floral parts.

Placentation is the manner in which placentae bearing ovules are distributed in the ovary. It is of many types.

Inflorescence is the arrangement of flowers on the floral axis.

It has two major types - racemose and cymose.

Hypanthodium, verticillaster and cyathium are special types of inflorescence.

Fruit is a ripened ovary that develops after fertilization

Ovules develop into seeds and the ovary wall matures into fruit wall called the pericarp which may be thin or differentiated into epicarp, mesocarp and endocarp.

Fruits may be true or false and categorized into simple, aggregate or composite types.

Simple fruits may be dry (dehiscent or indehiscent) or fleshy.

A fruit that develops without fertilization is called parthenocarpic fruit.

TERMENAL EXERCISES

1. Differentiate between
   (i) Dicot stem and monocot stem
   (ii) Root and stem
   (iii) Racemose and cymose inflorescence
   (iv) Stoma and hydathode
   (v) True fruit and false fruit
   (vi) Dicot and monocot leaf

2. Explain the different types of underground modified stem?

3. Explain the process of secondary growth in dicot stem.

4. Draw and label the vertical section of dicot leaf.

5. Define the following
(a) Flower  (b) Actinomorphic  (c) Heterophyly  
(d) Phyllotaxy  (e) Hypogynous  (f) Parthenocarpic fruit  
(g) Venation.

6. What is cork cambium? State its functions.
7 Draw labelled diagrams of the following
   (a) Raceme and corymb inflorescence
   (b) Axile and parietal placentation
8. What is a fruit? Enlist the various types of simple- fleshy fruits giving one example of each type.
9. What are the edible parts of the following fruits
   (a) Mango  (b) Orange  (c) Apple  
   (d) Banana  (e) Coconut  (f) Cashew nut
10. Match the following of column A with that of column B
   
   | A      | B
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Tendril</td>
<td>(i) Protection</td>
</tr>
<tr>
<td>(b) Stolon</td>
<td>(ii) Food, storage</td>
</tr>
<tr>
<td>(c) Thorn</td>
<td>(iii) Reproduction</td>
</tr>
<tr>
<td>(d) Tuber</td>
<td>(iv) Photosynthesis</td>
</tr>
<tr>
<td>(e) Capitulum</td>
<td>(v) Climbing</td>
</tr>
<tr>
<td>(f) Phylloclade</td>
<td>(vi) Sunflower</td>
</tr>
</tbody>
</table>
11. Name the type of modification of an underground, non-green structure bearing nodes and internodes and ‘eyes’.
12. If a section of stem shows scattered vascular bundles which are closed, have ‘Y’ shaped xylem and are surrounded by bundle sheath; what group of plant is it?
13. What is the region outside the phellogen known as?
14. When the cambium is less active which type of wood does it produce?

ANSWERS TO INTEXT QUESTIONS

7.1  1. Stem, 2. Axillary bud
3. Because lateral roots originate from inner layer, that is, pericycle (endogenous origin)
4. Stem is positively phototropic and negatively geotropic

7.2  1. Corpus  2. Procambium
3. Axillary bud, exogenous  4. Root cap

7.3  1. Creeper  2. Sub-aerial
3. Cladode  4. Rhizome, Bulb
5. (a) - (v)  (b) - (iii)  (c) - (i)  (d) - (ii)  (e) - (iv)
7.4 1. Conduction of water and minerals from root to leaf and manufactured food from leaf to other parts of plant
2. Stem cuttings
3. (a) - (iii) (b) - (v) (c) - (iv) (d) - (ii) (e) - (i)

7.5 1. Conjoint is when xylem and phloem are together in one bundle, collateral is when xylem and phloem are on the same radius
2. Medullary ray (3) Root
4. Maize stem for monocot and sunflower for dicot stem

7.6 1. Cork cambium (phellogen) and vascular cambium
2. Medullary ray parenchyma
3. All the tissues outside the functional cork cambium is called bark
4. For gaseous exchange in branches
5. Phellem, Phellogen, Phelloderm, Protection

7.7 1. Late or summer wood
2. By counting the annual rings
3. Durable, resistant to attack of pathogen
4. Presence of abundant mechanical tissue like sclerenchyma and secondary xylem
5. Wood is secondary xylem produced by the activity of vascular cambium in dicot stem

7.8 1. Venation is the arrangement of veins and veinlets in lamina of leaf
2. Unicostate has one strong midrib while multicostate has many strong veins

7.9 1. Rachis
2. Presence of axillary bud in leaf but not in leaflet
3. Pinnately and palmately compound leaf

7.10 1. Alternate, opposite-decussate; opposite-superposed;
2. (a) - (iii) (b) - (iv) (c) - (i) (d) - (ii)
3. Pitcher plant; bladderwort 4. Heterophylly

7.11 1. Mesophyll differentiated into palisade and spongy tissue in dicot leaf but composed of only spongy tissue in monocot leaf; photosynthesis
2. In both surfaces of leaf 3. Hydathodes
4. (a) - (iii)  (b) - (vi)  (c) - (iv)  (d) - (ii)  (e) - (i)  (f) - (v)

7.12 1. Calyx, Corolla
2. (a) - (v)  (b) - (iv)  (c) - (ii)  (d) - (i)  (e) - (iii)
3. Placentation is the manner in which placentae are distributed in the ovary
4. Axile

7.13 1. When the main axis ends in a flower and the growth is limited
2. Flowers are stalked in raceme but sessile in spike
3. Arrangement of flowers on floral axis
4. Capitulum, Hypanthodium

7.14 1. Fruit is a ripened ovary that develops after fertilization
5. (a) - (v)  (b) - (iv)  (c) - (ii)  (d) - (iii)  (e) - (i)