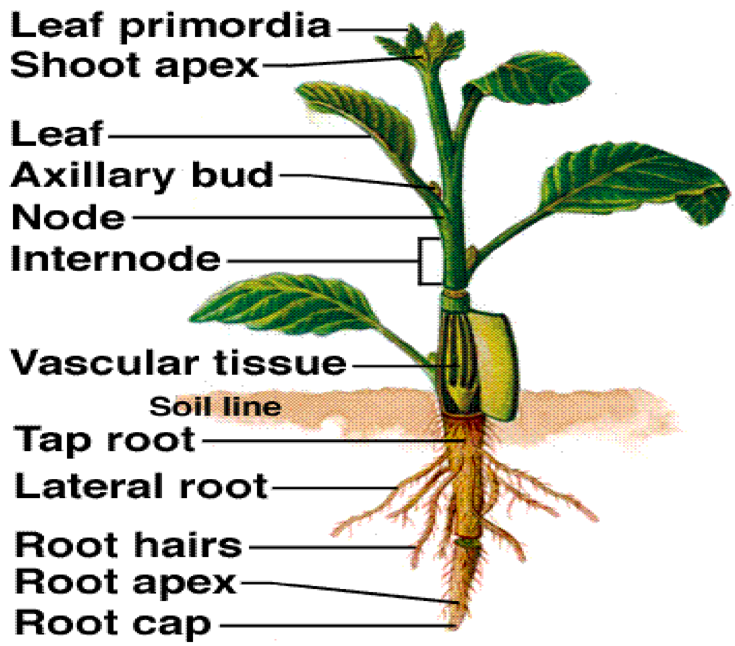
# CHAPTER 3
# The Plant Body

**Plant Tissues**
The plant tissues are classified into four groups: **meristems**, **dermal, ground** and **vascular** tissues.
**Meristems**
Meristematic tissues are highly dividing tissues. Primary plant tissues are formed from them. At the tips of roots and stems are located apical meristems that allow growth in roots and stems. From the apical meristems arise all the primary growth in both roots and stems. Leaves, non-woody stems and roots arise from this primary growth. Another set of meristematic tissues are the vascular cambium and cork cambium that promote secondary growth in the diameter of the stems and roots.

Figure 3.1.
The plant body picture shows the apex of the root and the shoot plus other parts of the plant.

Located at the apex are the meristematic tissues that produce primary tissues of plants.




**Dermal Tissues**
**Epidermis**
The outermost layers of the plants are considered the dermal tissues. They are also called the epidermis in young and non-woody plants. In leaves and stems, the epidermal cells secrete cutin (wax-like) and forms the cuticle. The cuticle makes the leaves and the stems to be waterproof, and prevents evaporation of water from the plants. Some epidermal tissues may have hairs or other projections (example are trichomes). Some epidermal tissues may appear in the form of thorns and prickles, or they may make the tissues feel fuzzy (velvety). Some epidermal tissues are modified to form glandular tissues and may produce secretions. In leaves are found pores in the epidermis called stomata (stoma, singular). These stomata allow exchange of gases, and water evaporation. Within the stomata are pairs of sausage-shaped cells called guard cells. The guard cells contain chloroplasts and regulate the opening and closing of the stomata. As the plants' stem become woody, the epidermis is replaced by another group of tissues called the

**periderm**. The periderm is like a secondary tissue produced by the cork cambium, the tissues are mainly cork tissues. In mature trees, the periderm forms the bark. The cork are dead cells that contain suberin, a lipid substance that makes the tissues waterproof.

**Ground Tissue**

There are three groups of ground tissues, these are **parenchyma**, **collenchyma**, and **sclerenchyma**. The parenchyma are the most numerous, the cells have various shapes and are loosely arranged. They form photosynthetic cells in the plants' leaves, and green plants' stems. They also function as storage cells in plants; examples include potato tubers, cactus stems, and beet roots. The collenchyma cells are support tissues in young plants, they are found in stems, leaves, and petals of flowers. The cells are columnar in shape. They can occur tightly packed below the epidermis of plants. The sclerenchyma cells occur in two forms: the fibers and the sclereids. The mature sclerenchyma fibers are non-living and important in making ropes and clothes and also as support tissues in plants. Sclereids also function as support and protective tissues for plants; they also form the hard wall of seeds.

**Vascular Tissue**

These are the conducting tissues in the plants. In the leaves they form the **veins**, in the root and the stems they form the **xylem** and the **phloem**.

**Xylem**

The xylem conducts water while phloem transports organic food materials. Xylem is made up of **tracheids** and **vessel elements** tissue types. Tracheids are cylindrical cells with openings called pits, the cells taper at the ends. Vessel elements are relatively short cylindrical cells with horizontal end walls. Vessel elements also have pits. In some vascular plants, vessel elements are not present. When xylem arises from the apical meristem it is called primary, when it arises from the vascular cambium it is called secondary xylem. It is the secondary xylem that forms the wood.

**Phloem**

The phloem is made up of sieve tube members or cells. These cells are living, mature ones have no nuclei or organelles. The end walls have pits forming sieve plates. The sieve plates permit conduction between adjacent sieve tube members. Another cell is the companion cell, they aid in transport of organic materials. Phloem tissues exist as primary and also as secondary tissues, the primary arises from the meristematic tissues while the secondary arises from the vascular cambium.

**Plant Organs**

The plant organs include leaves, stems and roots; the leaves are the photosynthetic organs, and they make the plants' food; the stems support the plants, and also function in transport, the roots anchors the plants and also function in transport.

**Stems**

Most plants' stems are vertical or erect and can be seen above the ground, however some are horizontal and underground, others are horizontal and above the ground (see figure 3.2).

**Underground horizontal stems**

Among the **horizontal stems** that are underground include the **rhizomes** (example is the potato tubers, and ginger). Another underground stem is the **bulb**, which is short (an example is the onion bulb). Additionally is the **corm**, which is another type of underground stem (an example is **gladiolus, crocus or cocoyam**).

**Above ground horizontal stems**

Horizontal stems that are above the ground are called **runners or stolons**. Stolons or runners produce adventitious roots to anchor them to the ground (an example is the strawberry stem). Some horizontal stems cannot support themselves, so they intertwine themselves on other plants or sticks for support, these are tendrils (pumpkin, melon plants).

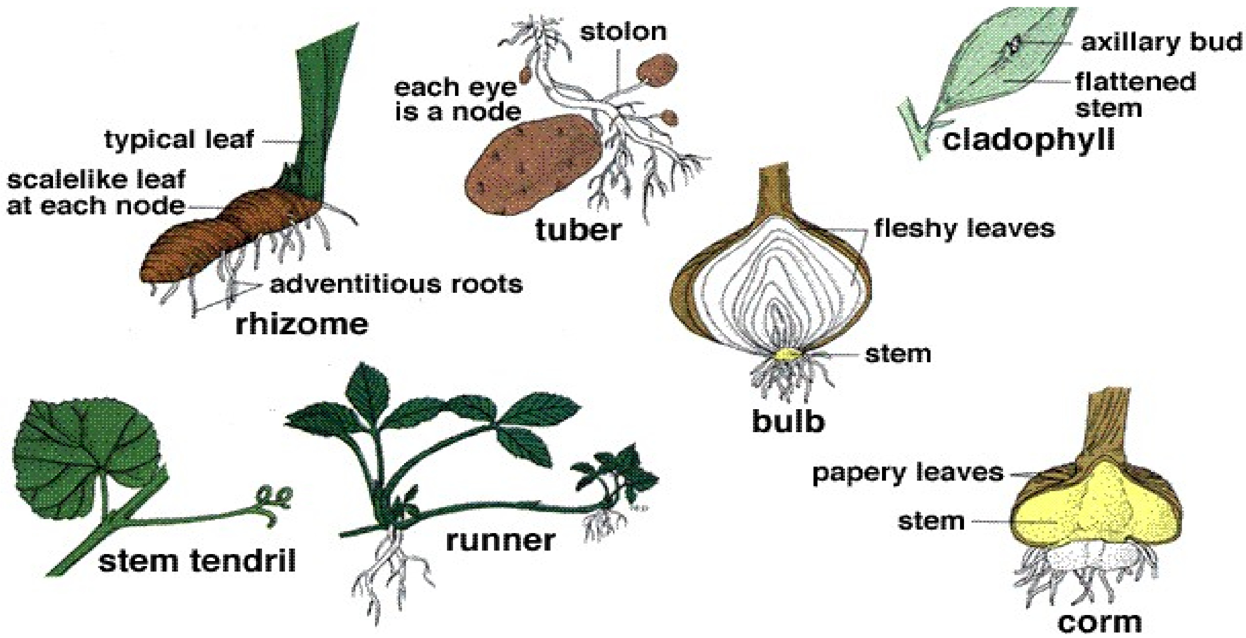



Figure 3.2 Stem Types

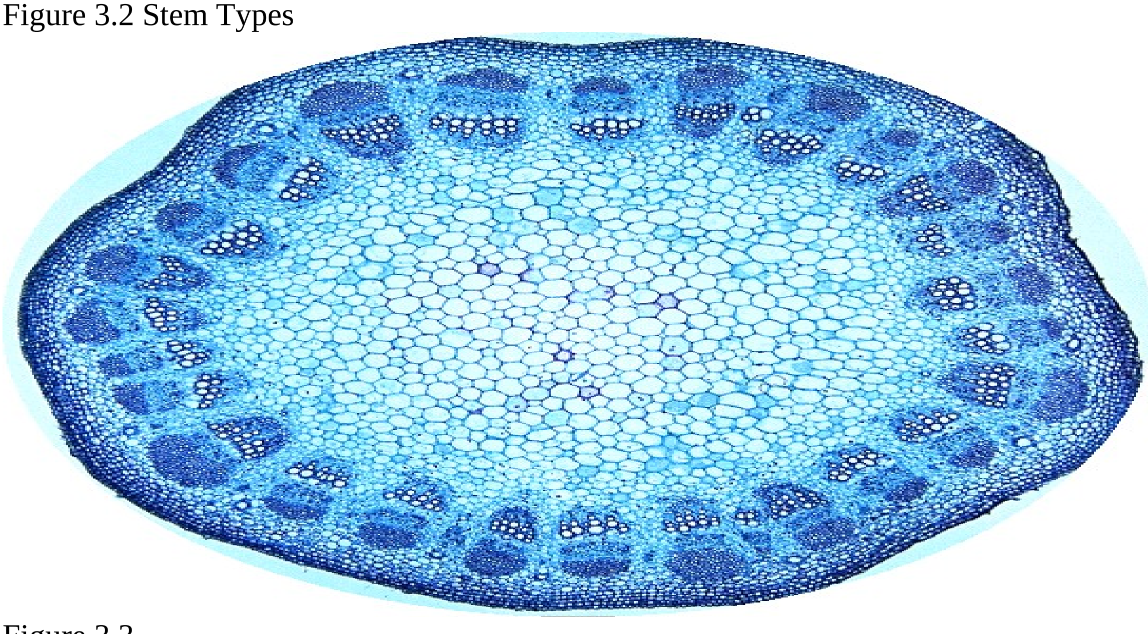


Figure 3.3.

A cross section of a young dicot stem showing vascular bundles in a circle (xylem tissues face the inside while the phloem tissues face the outside); pith in the center, epidermis on the outermost covering followed by the cortex (made up of mainly parenchyma tissues) immediately behind the epidermis.

**Stem Structure**
Structurally, stems of common plants, (dicots and monocot) have vascular bundles, however the difference is in the arrangement of the bundles in these stems. In monocots, the bundles are scattered in the stem, (see figure 3.4). while in the dicots, the bundles are arranged in a circle leaving a central area, called the pith (see figure 3.3). Each vascular bundle consists of a xylem and a phloem. In monocots the ground tissues are composed of sclerenchyma and parenchyma cells. The sclerenchyma tissues are found just beneath the epidermis to provide support for the plants, while the parenchyma cells occupy the rest of the stem. Most monocots are herbaceous, while dicots can be herbaceous (non-woody) or woody.

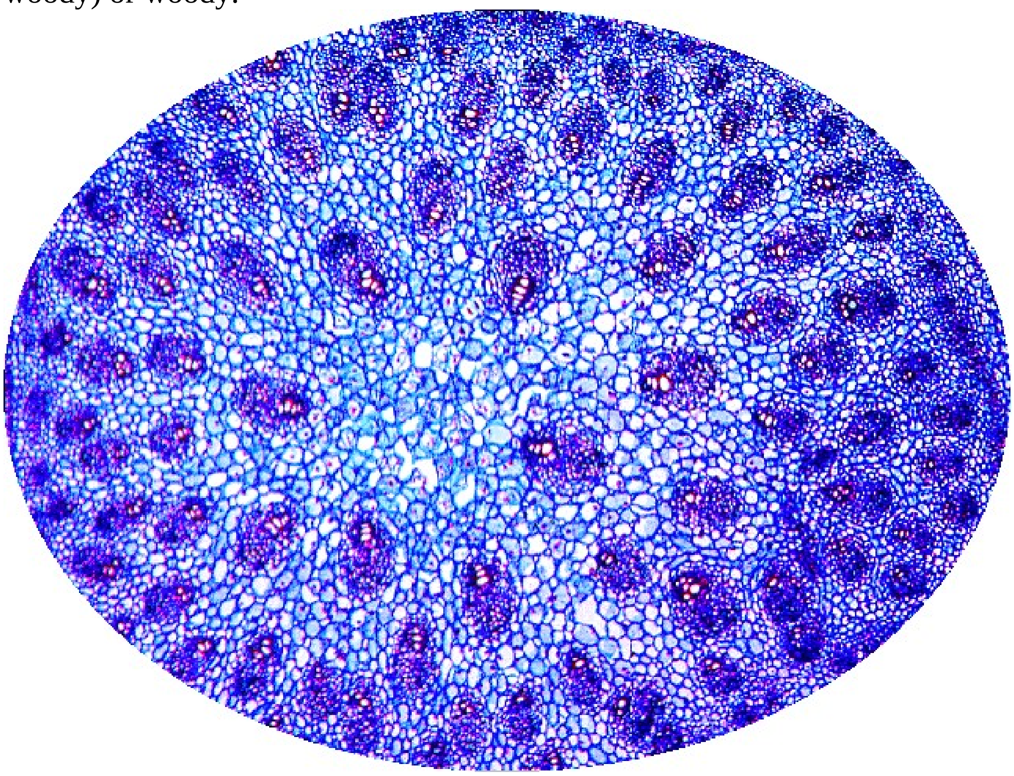


Figure 3.4. A cross section of a monocot stem shows scattered vascular bundles, absence of the pith

In the dicots, the stem tissues are divided into cortex and the central (medulla) region called the pith. The cortex contains mainly parenchyma cells, collenchyma and sclerenchyma cells are found just beneath the epidermis to function as support tissue.

In woody dicots, the vascular cambium in the xylem allows the secondary growth in the stem; annual rings of secondary growth can be seen in cross sections of woody dicots. Each ring represents a season. The rings push the primary xylem and the primary phloem apart in such a way that they occupy the major part of the stem.

Vascular rays composed of parenchyma tissues can be seen running across the annual rings. These tissues are responsible for radial transport of nutrient materials in the plants. The outer tissues of the woody dicot form the Cork or the Periderm.

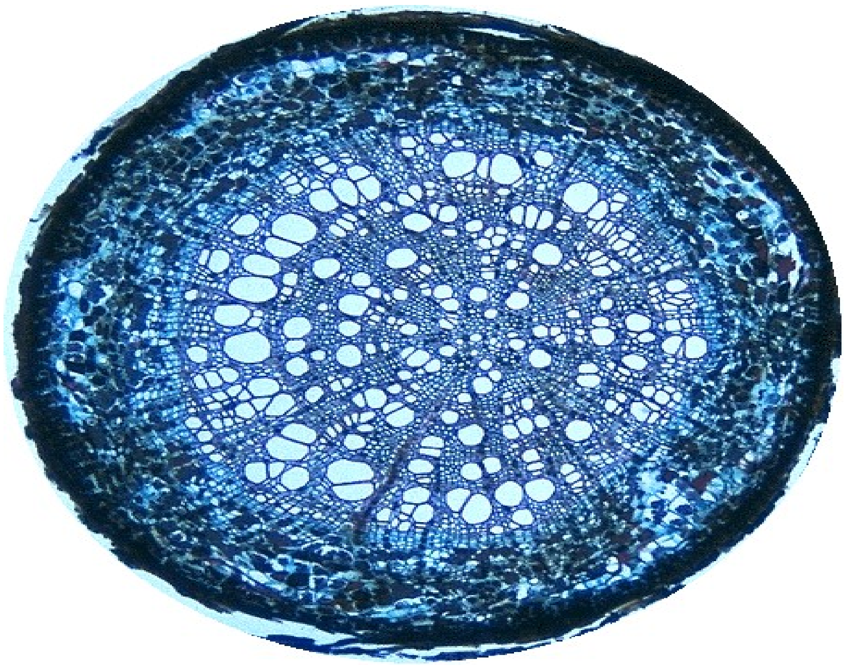


Figure 3.5: *An old dicot stem showing annual rings of secondary xylem tissues and vascular rays of parenchyma tissues. The epidermis has become the periderm or bark.*

**Roots**

There are two main types of roots; these are the **tap** and the **fibrous** roots. Tap roots are usually in the form of one large main root; most can form storage organs for plants; example includes carrots. Fibrous roots are highly branched with no central main root; examples include grasses and corn plants. Most monocots have fibrous roots. Some roots are modified to form storage organs (figure 3.6)

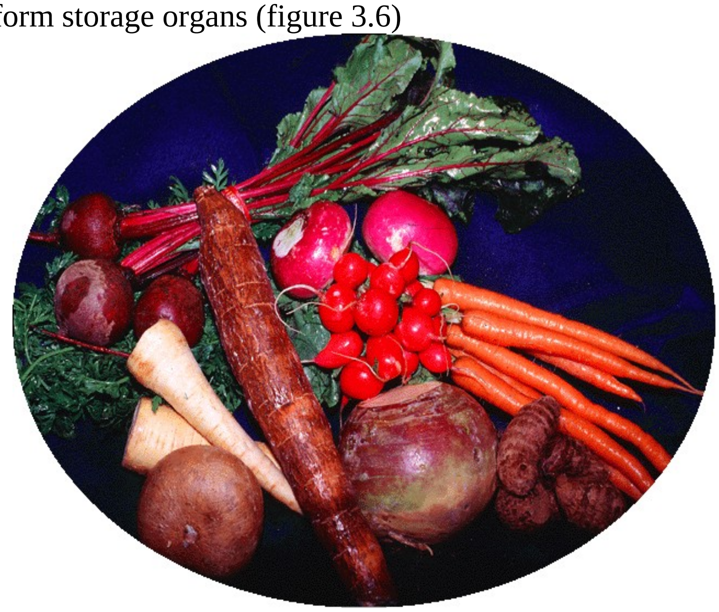


Figure 3.7: modified roots and stems: carrot as a root, corms, cocoyam, radishes as stems.

There are also specialized supporting root systems that include aerial roots in orchids and prop roots in corn. Every root has a set of tissues at its tip called **Root Cap**. The root cap protects the apical meristem that allows primary growth in roots and promotes roots' elongation. In roots, the xylem and phloem are arranged in such a way that they alternate each other.

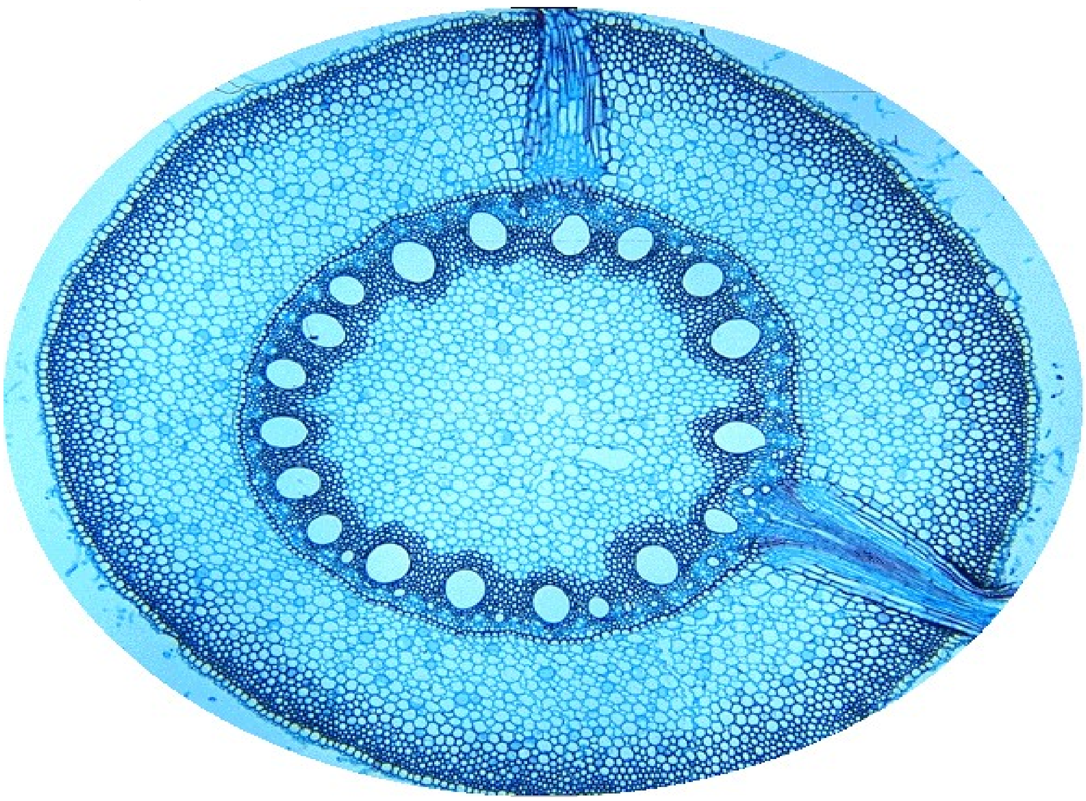


Figure 3.8

*A cross section of a monocot root showing the vascular bundles arranged in a circle; xylem and phloem alternate each other. The large circles are the xylems while the small ones are the phloems. Surrounding them is the pricycle that produces the lateral roots; also can be seen the cortex external to the ring while the internal central part forms the pith.*

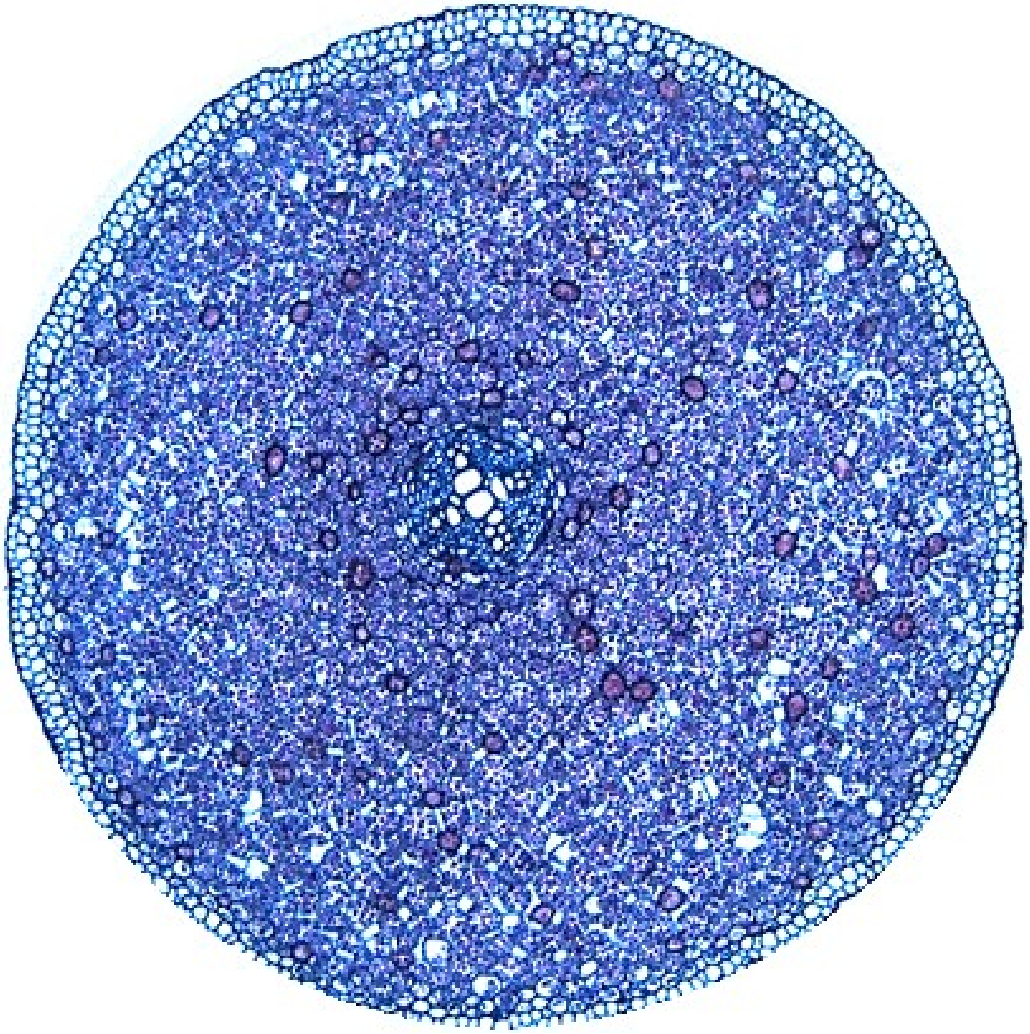
In the monocots, the vascular tissue form a ring surrounded by 2 other rings of tissue called **Pericycle and Endodermis** respectively. The pericycle is a meristematic tissue that allows growth of new branch roots. External to the pericycle and the endodermis is the cortex. The cortex can store food. A waxy material known as the **Casparian Strip** surrounds the endodermis. In the center of the root is a small central pith area.

**Dicot Root Structure**

In the dicot roots, the xylem occupies the central portion leaving no pith. The xylem and the phloem together form a Vascular Cylinder or Stele. In the center of the stele is the xylem appearing in the shape of a star. The external covering of the root is the epidermis, some epidermis have root hairs that provide a large surface area for water and mineral absorption. In large dicot plants, there could be also secondary growth; therefore they can be seen annual rings in the cross sections of some roots.

Figure 3.9.

A cross section of a dicot root. The vascular bundles appear like a star. The xylem tissues form the star-like arms while the phloem tissues alternate the arms.



**Leaves**

A leaf is the photosynthetic part of the plants. It is made up of a stalk (petiole) and the blade (the main leaf). The stalk attaches the blade to the stem at a point called the node. Between two leaves are internodes. Some leaves have appendages at their bases (or nodes) called stipules. Leaves can be arranged on the stems at alternately or opposite or in a pattern known as whorl (a cluster of leaves at a node). Leaves could take any shape, simple to compound. The simple leaves have one blade attached to a stalk, while the compound leaves have many blades attached to one stalk. Some compound leaves are pinnately arranged; others are palmately arranged. The leaf veins form the vascular tissue of the leaves. The venation could be parallel in monocot leaves and net-like or reticulate in dicot leaves. A waxy cuticle covers the epidermis of the leaf blade. Stomata are widely distributed in the leaves, the number varies in different leaves.

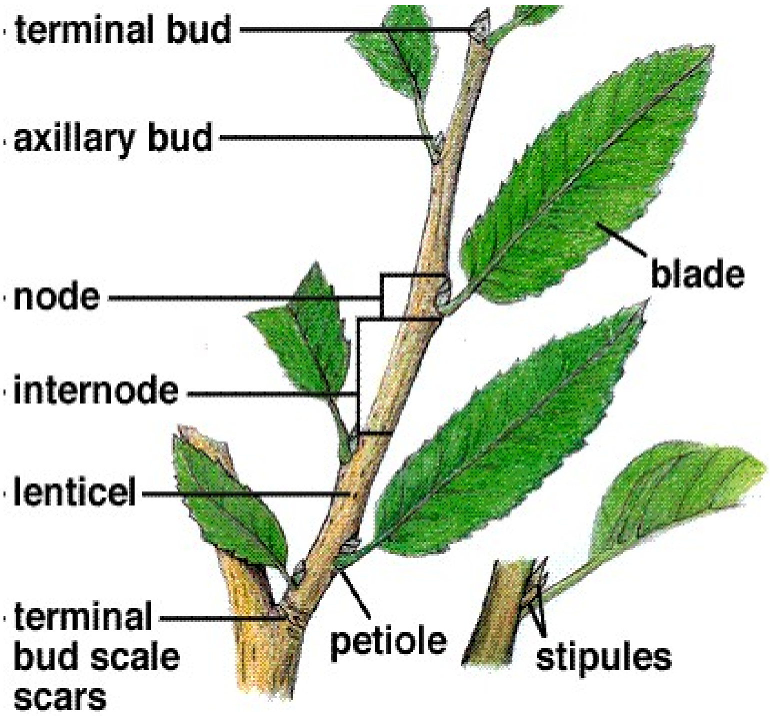



Figure 3.10

A twig showing leaves, nodes, internodes etc.

Internally, a typical dicot leaf has parenchyma cells in between the epidermis; the first group of cells are columnar cells, tightly arranged in an orderly manner to form **Palisade Mesophyll** while the second group are spherical cells, randomly arranged with intercellular air spaces to form **Spongy Mesophyll**. Within the spongy mesophyll are vascular bundles of phloem and xylem (form the veins in the leaves). The internal arrangement of these cells may vary in the monocot leaves, and also in non-flowering plants (example pine leaves).

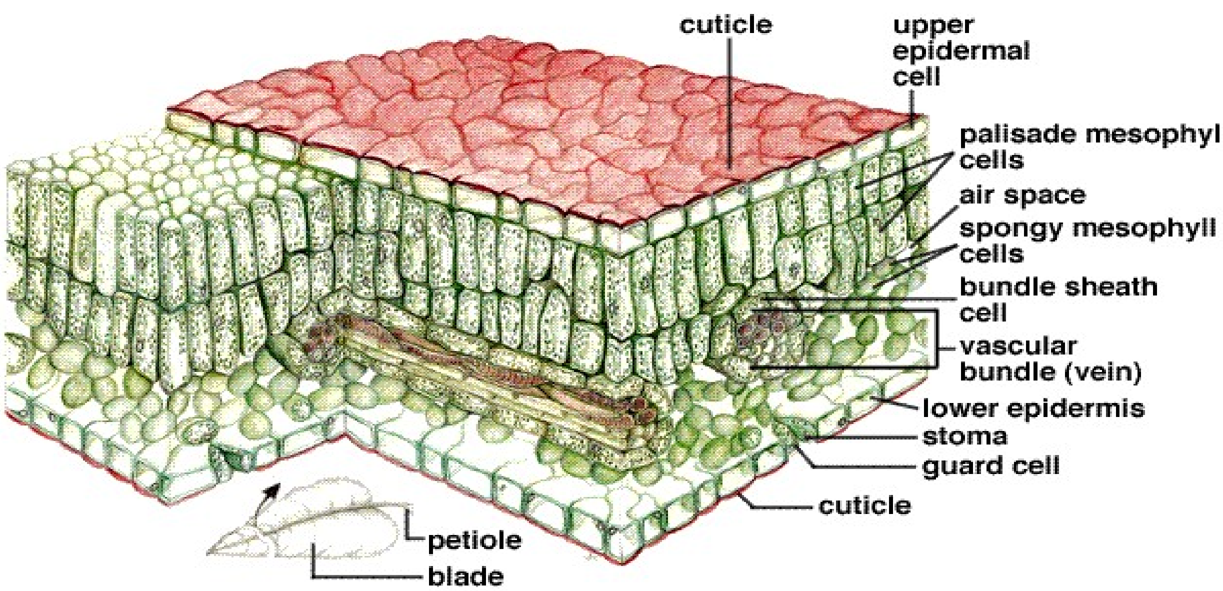



Figure 3.11. Cross section of a dicot leaf.

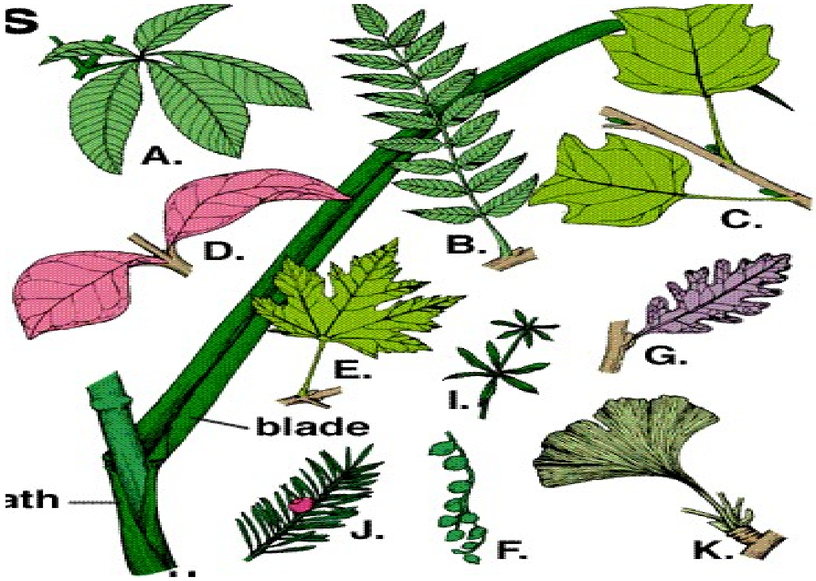



Figure 3.12
Various kinds of leaves and their classifications: A. Compound palmate. B. Compound pinnate C. Simple palmate. D. Simple. E. Simple palmate F. simple G. Simple palmate I. Compound whorled, J. Compound pinnate. K. Simple

Leaves can be modified to form adaptive processes in plants, examples include the venus flytrap, or pitcher plant leaves to trap insects, cactus leaves for water retention, leaves with thick cuticle as in yucca leaves, to prevent excessive water loss, leaves with sharp epidermal structures for defense.

Key Points

**The Plant Tissues**

1. The plant tissues are divided into 2 major groups: meristmatic tissues and dermal tissues.

2. The merismatic tissues are highly dividing tissues. They are located at the apex of roots and stems ( forming apical meristems). The primary tissues of plants arise from these meristems.

3. Another groups of meristematic tissues are vascular combium and cork cambium which later produce secondary plant tissues.

4. The dermal tissues include the epidermis, ground tissue (parenchyma, collenchyma, and sclerenchyma) and the vascular tissues (xylem and phloem).

5. The parenchyma can form photosynthetic cells and also storage cells in plants. The collenchyma tissues are supportive tissues of the plant. The Sclerenchyma tissues are

made up of fiber and sclereids. The fibers are used for clothes, ropes; the sclereids form hard walls of seeds and they function in support and protection.

6. The Vascular tissues are the xylem tissues that conduct solutions / water in plants, while the phloem tissues conduct food (or solid materials) in plants.
7. Xylem tissue are of two kinds: tracheids and vessels. Phloem tissues comprise of companion cells and sieve tube elements.

**PLANT ORGANS (leaves, flowers, stems, and roots)**

8. The leaves make the plant food. The stems function in support and transport. The roots anchor the plants and also function in transport.
9. The common plants can be divided into two groups: monocots and dicots. The monocot stem or root of a plant is different from the dicot stem or root in the arrangement of the vascular bundles (xylem & phloem tissues)
10. In monocot stems' vascular bundles are scattered while dicot stems' vascular bundles are arranged in a circle leaving a central area known as the pith.
11. In woody dicot stems, extensive division of the vascular cambium produces xylem tissues (or wood) known as secondary xylem. Every year new sets of secondary xylem tissues are produced giving rise to annual rings.
12. In large woody dicot stems, another vascular tissues are produced, called VASCULAR RAYS. The Vascular rays are responsible for radial transport of materials.
13. In older dicot woody stems, the corks cambium produces another secondary tissue called Periderm to replace the epidermis. The periderm later forms the bark of the stem. The periderm tissue is made up of cork tissues which are dead tissues with a lipid substance called suberin.
14. In monocot roots, the vascular bundles are arranged in a ring surrounded by other rings of tissues: PERICYCLE and ENDODERMIS. The pericycle produces lateral roots while the endodermis stores the food. The central area forms the pith.
15. In dicot roots, in the central area, the xylem tissues are arranged in a star-like shape, while the phloem are alternately arranged in between the arms of the xylem tissues, in a circular form. The vascular tissues are surrounded by both pericycle and endodermis. There is no pith in the central area of the dicot root.
16. The leaf of a plant is made up of the stalk (petiole), the blade (main leaf), and the veins. The stalk attaches the blade to the stem at the node. The region between one leaf and the next on the stem is called the internode. The leaves can be arranged on the stem as follows: alternate, opposite, whorl (a cluster of leaves at a node). The leaf shape could be simple or compound (pinnate or palmate).
17. Monocot leaves are different from dicot leaves in the arrangement of the veins. The veins are parallel in monocot leaves, while they are net – like or reticulate in dicot leaves.
18. The epidermis (external tissues) of the leaf blade is covered with cuticles which makes the leaves waterproof.
19. On the epidermis are stomata (openings) that allow water and gases to be exchanged between the leaves and the environment. Special cells surround these

stomata, they are called guard cells. The guard cells regulate the opening and closing of the stomata.

20. Internally the leaf is made up of parenchyma cells. There are two groups of parenchyma cells: palisade mesophyll (arranged in parallel) cells, and spongy mesophyll cells (randomly arranged). Among the spongy mesophyll tissues are vascular tissues (or veins).

**STUDY QUESTIONS**

1. Describe the morphology of leaves to show the knowledge of simple, compound, pinnate, palmate, opposite and alternate forms of leave arrangement.
2. Describe the histology of a leaf to show the knowledge and location of palisade mesophyll, spongy mesophyll, epidermis, vascular bundles, stomata and chloroplast.
3. State the location of meristematic tissues in a plant body; name the two examples of meristematic tissues that can be found in a plant.
4. List the dermal tissues in plants.
5. State 3 functions of epidermis.
6. What is a periderm?
7. State the major differences between a monocot and dicot plant.
8. State one major difference between a dicot stem and monocot stem; between a monocot root and a dicot root.
9. What are annual rings? Which tissues form the annual rings? Specifically what tissues are considered annual rings?
10. What are the functions of vascular rays?
11. What is the difference between a taproot and a fibrous root?
12. What is the function of the root cap?
13. Identify the following tissues in a root: pericycle, endodermis, casparian tissue, and the stele.

## CHAPTER 4
## PLANT PHYSIOLOGY

*Transport processes in plants include* ***Transpiration, Water Absorption*** *from the soil,* ***Water Movement*** *and* ***Translocation.***

### Transpiration

This is the process whereby water is lost from the plants through the stomata in the leaves. The guard cells in the stomata regulate the transpiration. As transpiration occurs, gas exchange also occurs, oxygen leaves the cells while carbon dioxide enters. The guard cell also regulates the rate of photosynthesis. During daylight when the sun is high, stomata open and allow transpiration and photosynthesis to occur. At night or when the sunlight is down, the stomata close. To regulate water loss (or transpiration), the stomata close under very high temperature, when water uptake of plants by the roots is less than transpiration rate.

### Water Absorption

Water absorption in the plants occurs through the roots. The water can enter the root cells through the epidermis by simple diffusion, and continue from cell through cell (through plasmodesmata, the cytoplasmic connections of plant cell to plant cell) along the cortex until it enters into the xylem, where the vessels conduct it upwards through the plants, this is known as **symplastic movement.**

Water can also diffuse through the cytoplasm by traveling through the intercellular spaces in the cortex until it arrives at the endodermis where the **casparian strips** regulate its movement into the xylem, this is known as **apoplastic movement**. At the casparian strip, the water is distributed tangentially to other tissues in the roots through the symplastic process.

### Transpiration-Cohesion Theory

When water molecules reach the xylem tissues, they move in the plants by cohesion and adhesion principles. Water molecules form hydrogen bonds among themselves and also cling to the walls of the vessels; this provides a continuous source of water pull that leaves the plants through the stomata (transpiration). This principle that explains the water movement is known as Transpiration-Cohesion Theory.

### Translocation

This is the process where the sieve tube members of the phloem in the vascular tissues of the plants conduct solid molecules (food materials, example sugar) to areas where they are needed for use by the plants, or to be stored in the plants. The most common materials are sucrose, amino acids, minerals, and other organic compounds. Translocation uses the principles of mass Flow or Pressure Flow Hypothesis. This mass flow or pressure flow uses the diffusion principle that is based on concentration difference of food materials in the phloem cells.