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Chapter: Tissue and Tissue System

Nehemiah Grew Father of Plant Anatomy 1641–1712

Chapter Outline

The Tissues

Introduction

★ A Tissue is a group of cells that are alike in origin, structure and function.
★ The study of tissue is called Histology.

A plant is made up of different types of tissues.

There are two principal groups:

1. Meristematic tissues
2. Permanent tissues

9.1 Meristematic Tissue

9.1.1 Characteristics and classification

The characters of meristematic tissues:

(Gr. *Meristos*-**Divisible**)

❋ The term meristem is coined by **C. Nageli** 1858.
❋ The meristematic cells are isodiametric and they may be, oval, spherical or polygonal in shape
❋ These are most actively dividing cells.
❋ Meristematic cells are self-perpetuating.

Classification of Meristem

♦ Meristematic tissues comprise of self-perpetuating cells.
♦ Meristems are classified into several types on the basis of position, origin, function and activity.

1. Apical Meristems

- These meristems are located on the tip of the root, stem etc. They help in the growth of the root system as well as the shoot system.
- The various cell divisions along with the cellular enlargement help in the growth of the stem above the ground and the growth of the root below the ground.

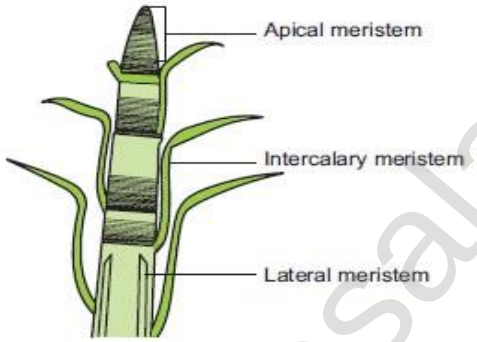

Figure 9.1: Different types of meristems on the basis of position in plant body

2. Intercalary Meristems

- The intercalary meristems are located at the internodes or the base of the leaves.
- The intercalary meristems help in increasing the length of the internode. This is usually seen in monocotyledonous plants.

3. Lateral Meristems

- The lateral meristems are present on the lateral side of the stem and root of a plant. These meristems help in increasing the thickness of the plants.
- The vascular cambium and the cork cambium are good examples of a lateral meristematic tissue.

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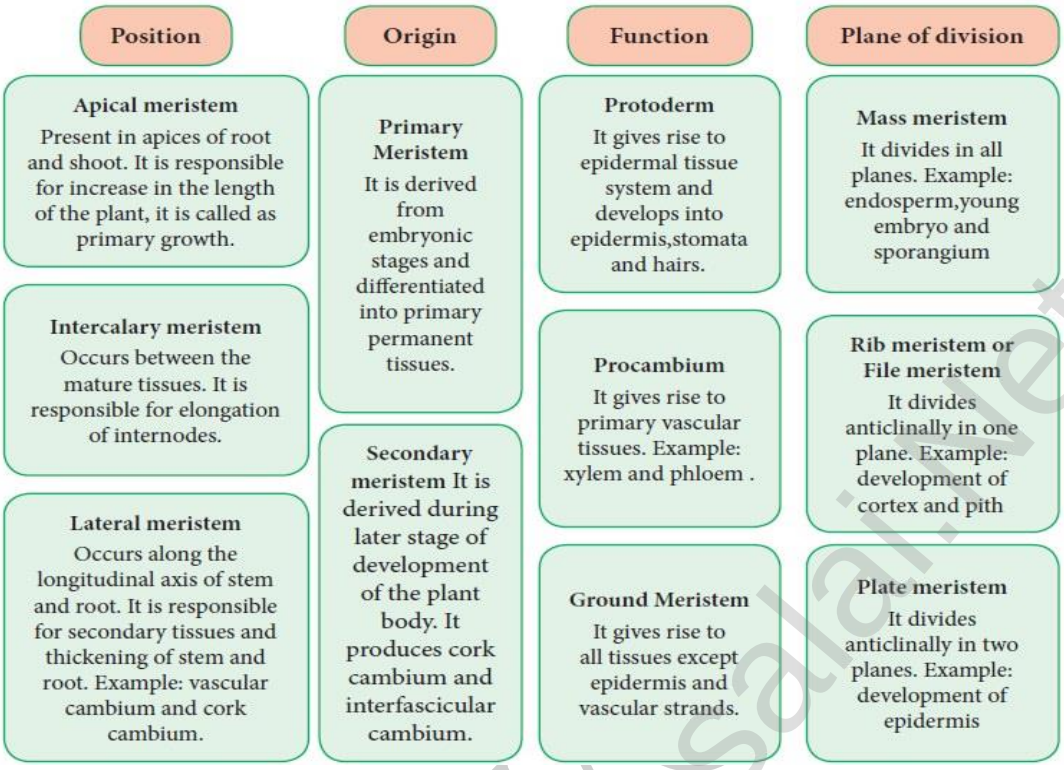
Classification of Meristem



Theories of Meristem Organization and Function

Many anatomists illustrated the root and shoot apical meristems on the basis of number and arrangement and accordingly proposed the following theories

Shoot Apical Meristem	Root Apical Meristem
1. Apical Cell Theory	1. Apical Cell Theory
2. Histogen Theory	2. Histogen Theory
3. Tunica Corpus Theory	3. Korper Kappe Theory
	4. Quiescent Centre Concept

Shoot Apical Meristem

1. Apical Cell Theory

- ✧ Apical cell theory is proposed by **Hofmeister** (1852) and supported by **Nageli** (1859). A single apical cell is the structural and functional unit.
- ✧ This apical cell governs the **growth** and **development of whole plant body**.
- ✧ E.g. Algae, Bryophytes and in some Pteridophytes.

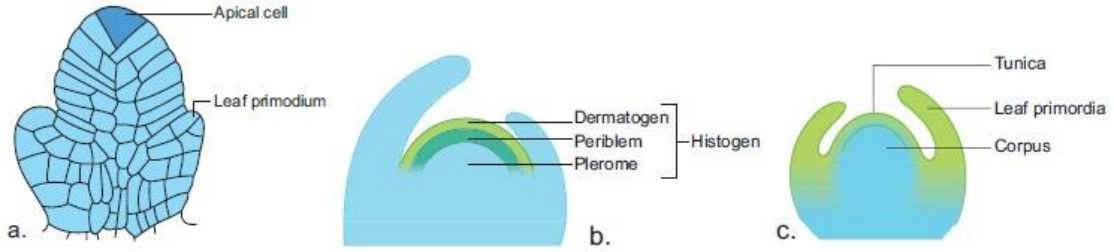


Figure 9.2: Shoot apical meristem a) Apical cell theory, b) Histogen theory, c) Shoot Tunica corpus theory

2. Histogen Theory

- ✧ Histogen theory is proposed by **Hanstein** (1868) and supported by **Strassburgur.**
- ✧ The shoot apex comprises **three distinct zones**.

1. **Dermatogen:** It is a outermost layer. It gives rise to epidermis.
2. **Periblem:** It is a middle layer. It gives rise to cortex.
3. **Plerome:** It is innermost layer. It givesrise to stele

3. Tunica Corpus Theory

- ✧ Tunica corpus theory is proposed by **A. Schmidt** (1924).
- ✧ Two zones of tissues are found in apical meristem.

1. **The tunica**: It is the peripheral zone of shoot apex that forms epidermis.
2. **The corpus**: It is the inner zone ofshoot apex,that forms cortex and stele of shoot.

Root Apical Meristem

Root apex is present opposite to the shoot apex. The roots contain root cap at their apices and the apical meristem is present below the root cap.

The different theories proposed to explain root apical meristem organization is given below.

1. Apical Cell Theory

- ✧ Apical cell theory is proposed by **Nageli.**
- ✧ The single apical cell or apical initial composes the root meristem. The apical initial is tetrahedral in shape and produces root cap from one side. The remaining three sides produce epidermis, cortex and vascular tissues.
- ✧ It is found in vascular cryptogams.

2. Histogen Theory

- ✧ Histogen theory is proposed by **Hanstein (1868)** and supported by **Strassburgur**.
- ✧ The histogen theory as appilied to the root apical meristem speaks of four histogen in the meristem. They are respectively

1. **Dermatogen:** It is a outermost layer. It gives rise to root epidermis.
2. **Periblem:** It is a middle layer. It gives rise to cortex**.**
3. **Plerome:** It is innermost layer. It gives rise to stele
4. **Calyptrogen:** It gives rise to root cap.

3. Korper Kappe Theory

Korper kappe theory is proposed by **Schuepp**. There are two zones in root apex – Korper and Kappe

1. **Korper zone** forms the body.
2. **Kappe zone** forms the cap.

This theory is equivalent to tunica corpus theory of shoot apex.The two divisions are distinguished by the type of T (also called Y divisions).

Korper is characterised by inverted T divisions and kappe by straight T divisions.

4. Quiescent Centre Concept

- ✧ Quiescent centre concept was proposed by **Clowes** (1961) to explain root apical meristem activity. These centre is located between root cap and differentiating cells of the roots.
- ✧ The apparently inactive region of cells in **root promeristem** is called quiescent centre.
- ✧ It is the site of hormone synthesis and also the ultimate source of all meristematic cells of the meristem.

9.2 Permanent Tissues

The cells, which are formed by apical meristem, are differentiated into different types of permanent tissues. These tissues have lost the power of dividing either permanently or temporarily.

They are classified into two types:

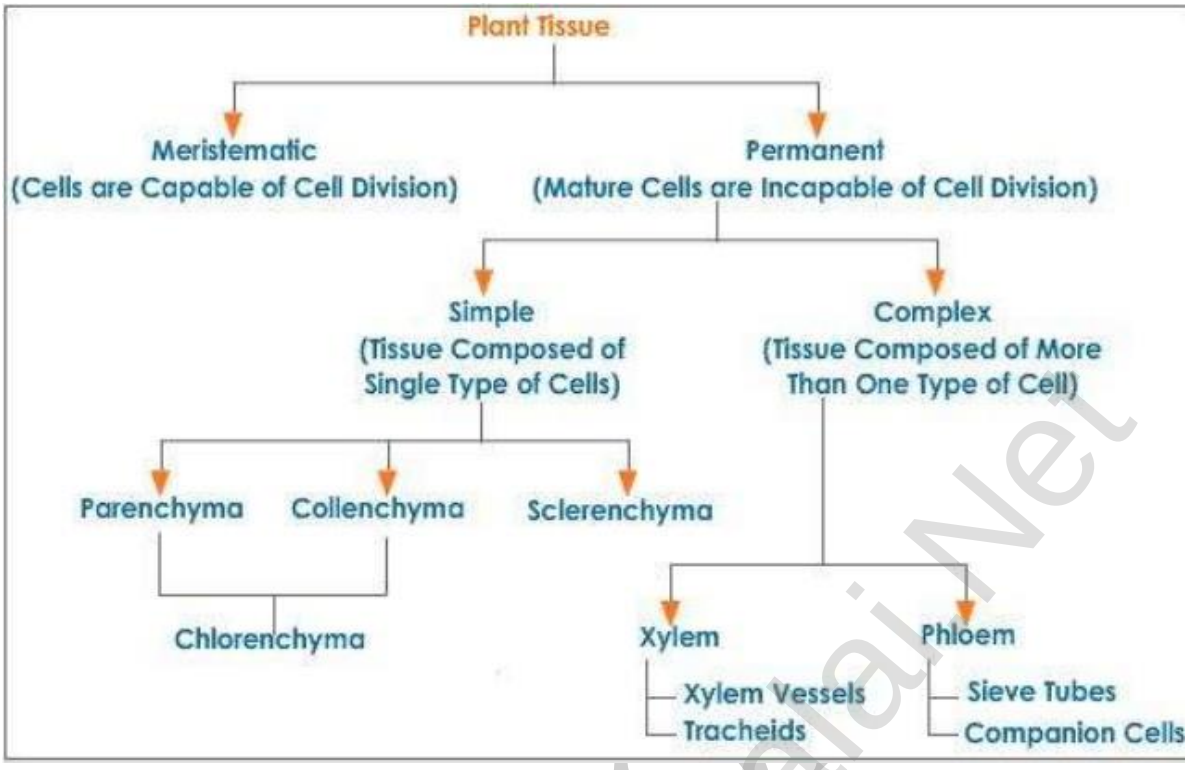
1. Simple permanent tissues.
2. Complex permanent tissue

Simple Permanent Tissues

Simple tissues are composed of one type of cells only. The cells are structurally and functionally similar.

It is of three types.

1. Parenchyma
2. Collenchyma
3. Sclerenchyma



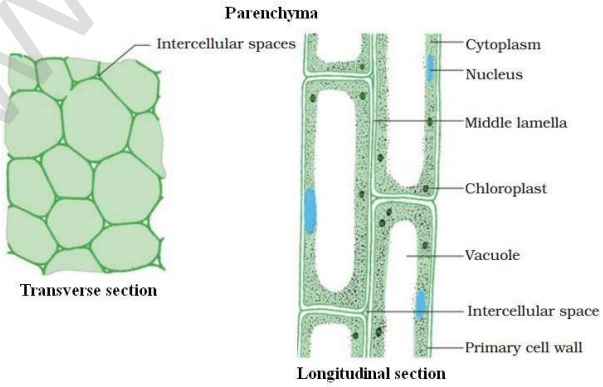
1. Parenchyma (Gk: *Para*-beside; *enehein*- to pour)

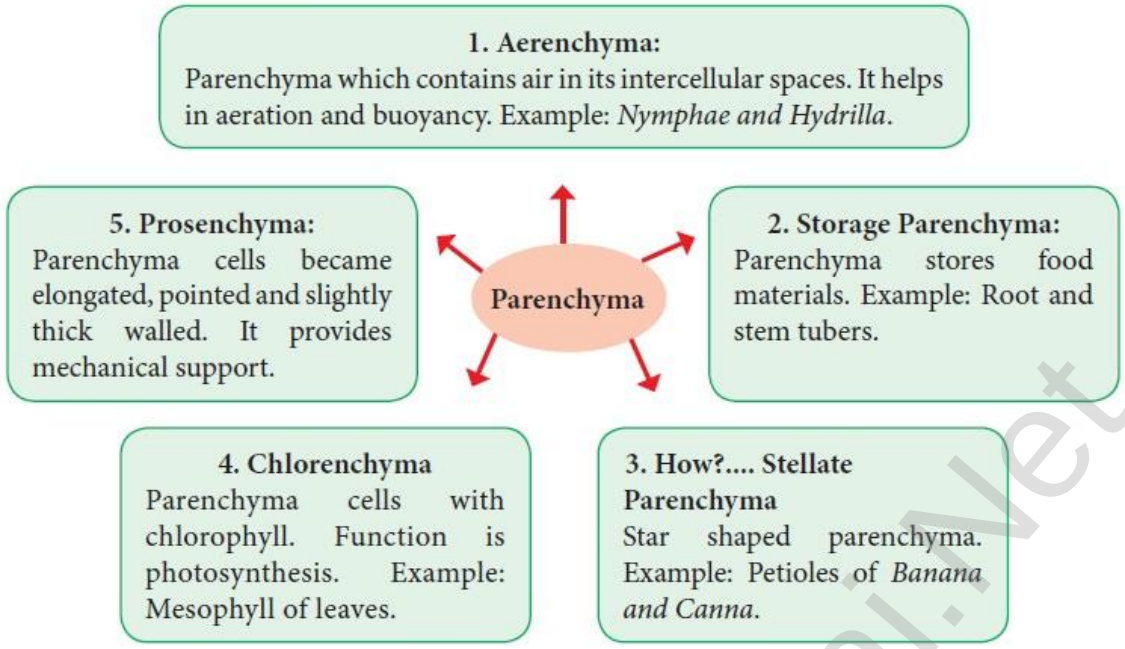
★ *Parenchyma* is generally present in all organs of the plant.

★ It forms the ground tissue in a plant. Parenchyma is a living tissue and made up of thin walled cells.

★ Parenchyma may store various types of materials like, water, air, ergastic substances. It is usually colourless.

★ Occsionally Parenchyma cells which store resin, tannins, crystals of calcium carbonate, calcium oxalate are called idioblasts.





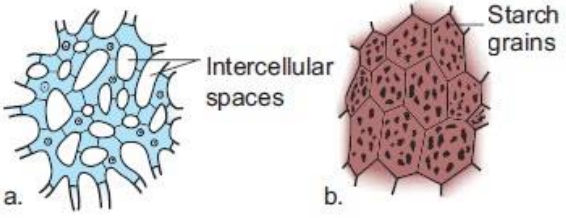


Figure 9.5: Types of Parenchyma
a) Aerenchyma, b) Storage parenchyma

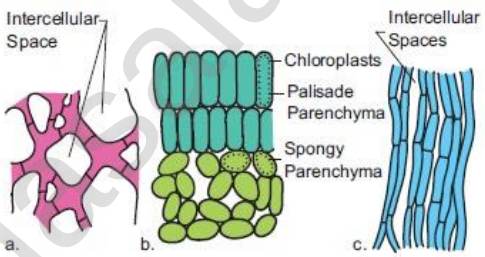


Figure 9.5: c) Stellate parenchyma, d) Chlorenchyma, e) Prosenchyma

2. **Collenchyma (Gk. Colla-glue; enchyma – an infusion)**

★ Collenchyma is a simple, living mechanical tissue. Collenchyma generally occurs in hypodermis of dicot stem.

★ It is absent in the roots and also occurs in petioles and pedicels.

★ It provides mechanical support and elasticity to the growing parts of the plant. Collenchyma consists of narrow cells.

★ Based on pattern of pectinisation of the cell wall, there are **three** types of collenchyma

Types of Collenchyma

1. Angular collenchyma

It is the most common type of collenchyma with irregular arrangement and thickening at the angles where cells meets.

Example: Hypodermis of *Datura* and *Nicotiana*

2. Lacunar collenchyma

The collenchyma cells are irregularly arranged. Cell wall is thickening on the walls bordering intercellular spaces. Example:Hypodermis of *Ipomoea*

3. Lamellar collenchyma

The collenchyma cells are arranged compactly in layers (rows). The Cell wall is thickening is at tangential walls.These thickening appear as successsive tangential layers. Example:Hypodermis of *Helianthus*

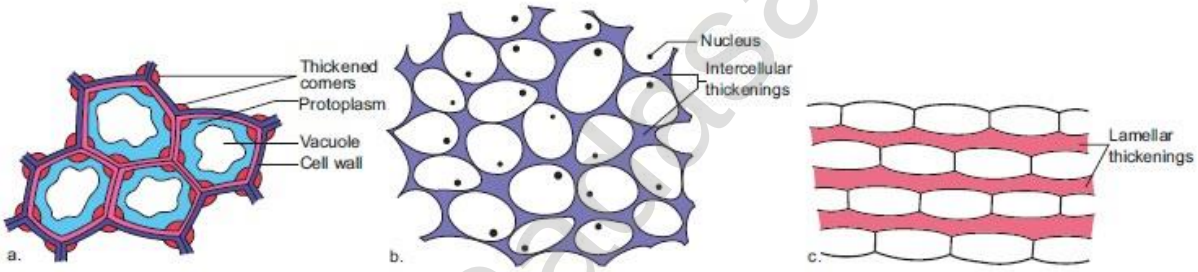


Figure 9.6: Types of Collenchyma a) Angular collenchyma, b) Lacunar collenchyma, c) Lamellar collenchyma

3. Sclerenchyma (Gk. Sclerous- hard: enchyma-an infusion)

The sclerenchyma is a dead cell and lacks protoplasm. The cells are long or short, narrow thick walled and lignified secondary walls.

The sclerenchymatous cells are of two types:

1. Sclereids
2. Fibres

1. Sclereids (Stone Cells)

- Sclereids are dead cells, usually these are isodiametric but some are elongated too. The cell wall is very thick due to lignification.

- Sclereids are **mechanical in function**.

- They give hard texture to the seed coats, endosperms etc.,
- Sclereids are classified into the following 5 types.

Types of Sclereids

1. Branchysclereids or Stone cells:

Isodiametric sclereids, with hard cell wall. It is found in bark, pith cortex, hard endosperm and fleshy portion of some fruits. Example: - Pulp of *Pyrus*.

2. Macrosclereids:

Elongated and rod shaped cells, found in the outer seed coat of leguminous plants.

Example: *Crotalaria and Pisum sativum*.

3. Osteosclereids (Bone cells):

Rod shaped with dilated ends. They occur in leaves and seed coats.

Example: seed coat of *Pisum and Hakea*

4. Astrosclereids:

Star cells with lobes or arms diverging form a central body. They occur in petioles and leaves.

Example: *Tea, Nymphae and Trochodendron*.

5. Trichosclereids:

Hair like thin walled sclereids. Numerous small angular crystals are embedded in the wall of these sclereids, present in stems and leaves of hydrophytes.

Example: *Nymphaea leaf* andAerial roots of *Monstera*.

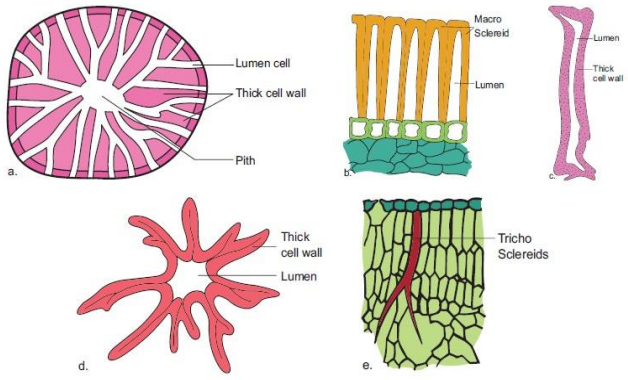


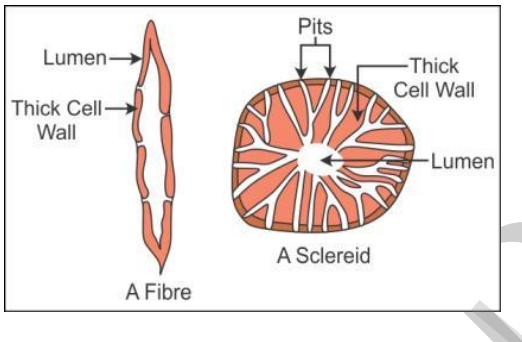
Figure 9.7: Types of Sclereids a) Brachysclereids, b) MacroSclereids, c) Osteosclereids, d) Astrosclereids, e) Trichosclereids

2. Fibres

Fibres are very much elongated sclerenchyma cells with pointed tips.

- Fibres are dead cells and have lignified walls with narrow lumen.

- They have simple pits. They provide mechanical strength and protect them from the strong wind. It is also called supporting tissues.
- Fibres have a great commercial value in cottage and textile industries.



These are of four types.

a. Libriform fibres
b. Fibre tracheids
c. Septate fibres
d. Gelatinous fibres.

Fibres are the longest plant cells. **Longest Fibres** occur in *Boehmeria* (Ramie fibre) 55 cm long

a) **Libriform fibres:** These fibres have slightly lignified secondary walls with simple pits. These fibres are long and narrow.
b) **Fibre tracheids:** These are shorter than the libriform fibres with moderate secondary thickenings in the cell walls. Pits are simple or bordered.
c) **Septate fibres:** Fibres that have thin septa separating the lumen into distinct chambers. Eg. Teak
d) **Gelatinous fibres:** Fibres in which lignin is less in amount and cellulose is more in this cell walls. These fibres are characteristic of tension wood which is formed in the underside of leaning stems and branches.

Fibres in Our Daily Life

Economically fibres may be grouped as follows

1. **Textile Fibres:** Fibres utilized for the manufacture of fabrics, netting and cordage etc.
   a. **Surface Fibres**: Example: Cotton.
   b. **Soft Fibres**: Example: Flax, Jute and Ramie
   c. **Hard fibres:** Example: Sisal, Coconut, Pineapple, Abaca *etc.*
2. **Brush fibre:** Fibres utilized for the manufacture of brushes and brooms.
3. **Rough weaving fibres:** Fibres utilized in making baskets, chairs, mats etc.
4. **Paper making fibres:** Wood fibres utilized for paper making.
5. **Filling fibres:** Fibres used for stuffing cushions, mattresses, pillows, furniture etc. Example: *Bombax* and Silk cotton.

2. Complex Tissues

A complex tissue is a tissue with several types of cells but all of them function together as a single unit.

It is of **two** types

1. Xylem and
2. Phloem.

Xylem **is called** hadrome **and** phloem **is called** leptome. **These terms arecoined by** haberlandt (1914)

1. Xylem

- The xylem is the principal water conducting tissue in a vascular plant. The term xylem was introduced by **Nageli**(1858) and is derived from the Gk. *Xylos* – wood.

- The xylem which is derived from Procambium is called **primary xylem** and the xylem which is derived from vascular cambium is called **secondary xylem**.
- Early formed primary xylem elements are called protoxylem, whereas the later formed primary xylem elements are called metaxylem. Protoxylem lies towards the periphery and metaxylem that lies towards the centre is called **Exarch.** It is common in *roots*.
  - Protoxylem lies towards the centre and meta xylem towards the periphery this condition is called **Endarch**. It is seen in *stems*.
  - Protoxylem is located in the centre surrounded by the metaxylem is called **Centrarch**. In this type only one vascular strand is developed. Example: *Selaginella sp.*
  - Protoxylem is located in the centre surrounded by the metaxylem is called **Mesarch**. In this type several vascular strands are developed. Example: *Ophioglossum sp.*

Xylem Consists of Four Types of Cells

1. Tracheids
2. Vessels or Trachea
3. Xylem Parenchyma
4. Xylem Fibres

2. Phloem

- Phloem is the food conducting complex tissues of vascular plants. The term phloem was coined by **C. Nageli** (1858)
- The Phloem which is derived from procambium is called primary phloem and the phloem which is derived from vascular cambium is called secondary phloem.

☞ Early formed primary phloem elements are called **protophloem** whereas the later formed primary phloem elements are called **metaphloem**. Protophloem is short lived. It gets crushed by the developing metaphloem.

Phloem Consists of Four Types of Cells

1. Sieve elements
2. Companion cells
3. Phloem parenchyma
4. Phloem fibers

In mature sieve tubes, the pores in the sieve plate are blocked by a substance called **callose** (callose plug).The conduction of food material takes place through cytoplasmic strands. Sieve tubes occur only in Angiosperms.

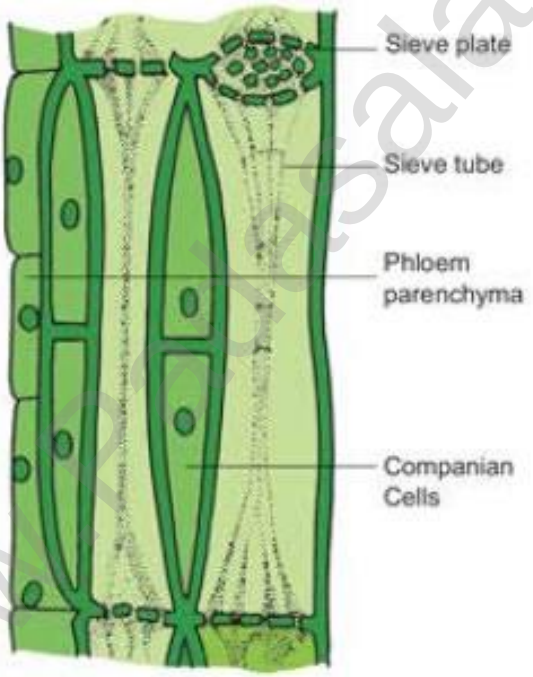


Figure 9.11: Different types of phloem elements

Concept Map

NCTC – C.KARUNAKARAN

Plant tissues

Meristematic tissue:
Capable of active cell division.
Thin walled and living.
Compactly arranged.
Found in root and shoot apex.

Based on position:
1. Apical
2. Intercalary
3. Lateral

Based on origin:
1. Primary
2. Secondary

Based on function:
1. Periderm (Epidermis)
2. Procambium (Primary vascular tissues)
3. Ground meristem (Cortex and Pith)

Based on division:
1. Mass meristem: Divides in all planes
2. Rib meristem: Anticlinal division in one plane
3. Plate meristem: Anticlinal division in two planes.

Permanent tissues:
Lose the power of cell division.
Have definite shape, size and form.

Simple tissues:
One type of cells.

Parenchyma:
Thin walled,isodiametric, found in all the parts.
Types:
1. Aerenchyma.
2. Storage parenchyma.
3. Stellate parenchyma.
4. Chlorenchyma.
5. Prosenchyma.

Collenchyma:
Hypodermal position. Provide mechanical strength.
Types:
1. Angular collenchyma.
2. Lacunar collenchyma.
3. Lamellar collenchyma.

Sclerenchyma: Dead cells and lignified walls.
Types:
1. Sclereids
2. Fibres

Sclereids:
1. Brachysclereids: Stone cells
2. Macro sclereids: Rod shaped
3. Osteosclereids: Bone shaped
4. Astrosclereids: Star shaped
5. Trichosclereids: Hair cells

Fibres:
1. Wood fibres xylary fibres
2. Bastfibres: Extra xylary fibres
3. Surface fibres: *Cottan*
4. Mesocarp fibres: *Ccoconut*
5. Leaf fibres: *Musa, Agave*

Complex tissues:
More than one type of cells.

Xylem: Water conducting tissue.
1. Tracheids: Dead, elongated with tapering end
2. Vessels: Made of row of dead cells
3. Xylem fibres: Lignified and sclerenchymatous.
4. Xylem parenchyma: Living and cellulosic

Phloem: Food conducting tissue
1. Sieve elements: Sieve cells & sieve tubes
2. Companion cells: Only in Angiosperms.
3. Phloem parenchyma: Living & absent in Monocots.
4. Phloem fibres: Thick walled & sclerenchymatous, giving mechanical strength.

Syncyte: Cell which is formed by fusion of cell is called Syncyte.

Example: Vessels (Dead syncyte), sieve tube (living syncyte)

9.3 The Tissue System

A group of tissues performing a similar function, irrespective of its position in the plant body, is called a ***tissue system***. In 1875,

German Scientist ***Julius von Sachs*** recognized **three tissue systems** in the plants.

They are:

1. Epidermal tissue system (derived from protoderm)
2. Ground tissue system (derived from ground meristem)
3. Vascular tissue system (derived from procambium)

9.4 Epidermal Tissue System

Introduction

Epidermal tissue system is the outer most covering of plants. It is in direct contact with external environment. It consists of epidermis derived from protoderm.

It is consist regions. They are

1. **Root Epidermis** -The outer layer of the root is known as ***piliferous layer* or *epiblema.***

2. Stem Epidermis -It is protective in function and forms the outermost layer of the stem.

3. **Leaf Epidermis**

The leaf is generally *dorsiventral*. It has upper and lower epidermis. The epidermis is usually made up of a single layer of cells that are closely packed.

The minute openings found on the epidermis are called ***stomata (singular: stoma)*.**

A stoma is surrounded by a pair of specialized epidermal cells called **guard cells**. In mostdicots and monocots the guard cells are bean-shaped.

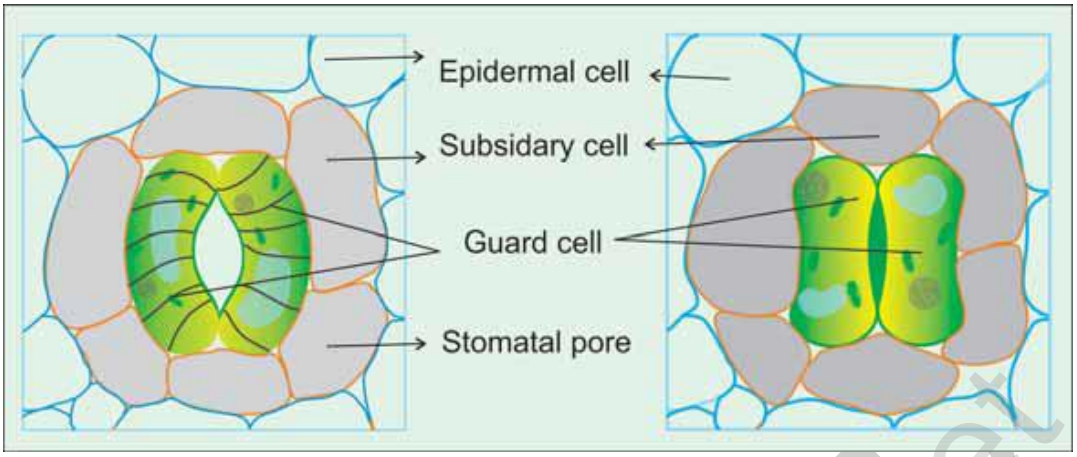


Figure 9.14: (a) Stoma with bean-shaped guard cells. (b) Stoma with dumb-bell shaped guard cell

Some cells of upper epidermis (Example: Grasses) are larger and thin walled. They are called **bulliform cells** or **motor cells**.

Some of the epidermal cells of the grasses are filled with silica. They are called **silica cells.**

In some plants addition to guard cells, specialised epidermal cells are present which are distinct from other epidermal cells. They are called **Subsidiary cells**.

Functions of Epidermal Tissue System

1. This system in the shoot checks excessive loss of water due to the presence of cuticle.
2. Epidermis protects the underlying tissues.
3. Stomata is involved in transpiration and gaseous exchange.
4. Trichomes are also helpful in the dispersal of seeds and fruits, and provide protection against animals.
5. Prickles also provide protection against animals and they also check excessive transpiration
6. In some rose plants they also help in climbing.
7. Glandular hairs repel herbivorous animals.

9.5 Fundamental Tissue System

The ground or fundamental tissue system constitutes the main body of the plants. It includes all the tissues except epidermis and vascular tissues.

Generally in dicot stem, ground tissue system is differentiated **into three main zones** 1. Cortex, 2. pericycle and 3. Pith.

It is classified into **extrastelar ground tissue** (Examples: cortex and endodermis) and **intrastelar ground tissue** (Examples: pericycle, medullary ray and pith)

1. Extrastelar Ground Tissue

The ground tissues present outside the stele is called extrastelar ground tissue.
(Cortex)

2. Intrastelar Ground Tissue

The ground tissues present within the stele are called intrastelar ground tissues.
(pericycle, medullary rays and pith).

Casparian strips.

In true root endodermis, radial and inner tangential walls of endodermal cells possess thickenings of **lignin, suberin and some other carbohydrates** in the form of strips they are called **casparian strips**.

The endodermal cells, which are opposite to the protoxylem elements, are thin walled without casparian strips. These cells are called **passage cells**.

Their function is to transport water and dissolved salts from the cortex to the protoxylem.

Albuminous Cells: The cytoplasmic nucleated parenchyma, is associated with the sieve cells of Gymnosperms. Albuminous cells in *Conifers* are analogous to companion cells of Angiosperms. It also called as strasburger cells.

9.6 Vascular Tissue System

- This section deals with the vascular tissue system of gymnosperms and angiosperms stems and roots.The vascular tissue system consists of xylem and phloem.
- The elements of xylem and phloem are always organized in groups. They are called **vascular bundles.**
- The structural and organizational variation in vascular bundles is shown below.

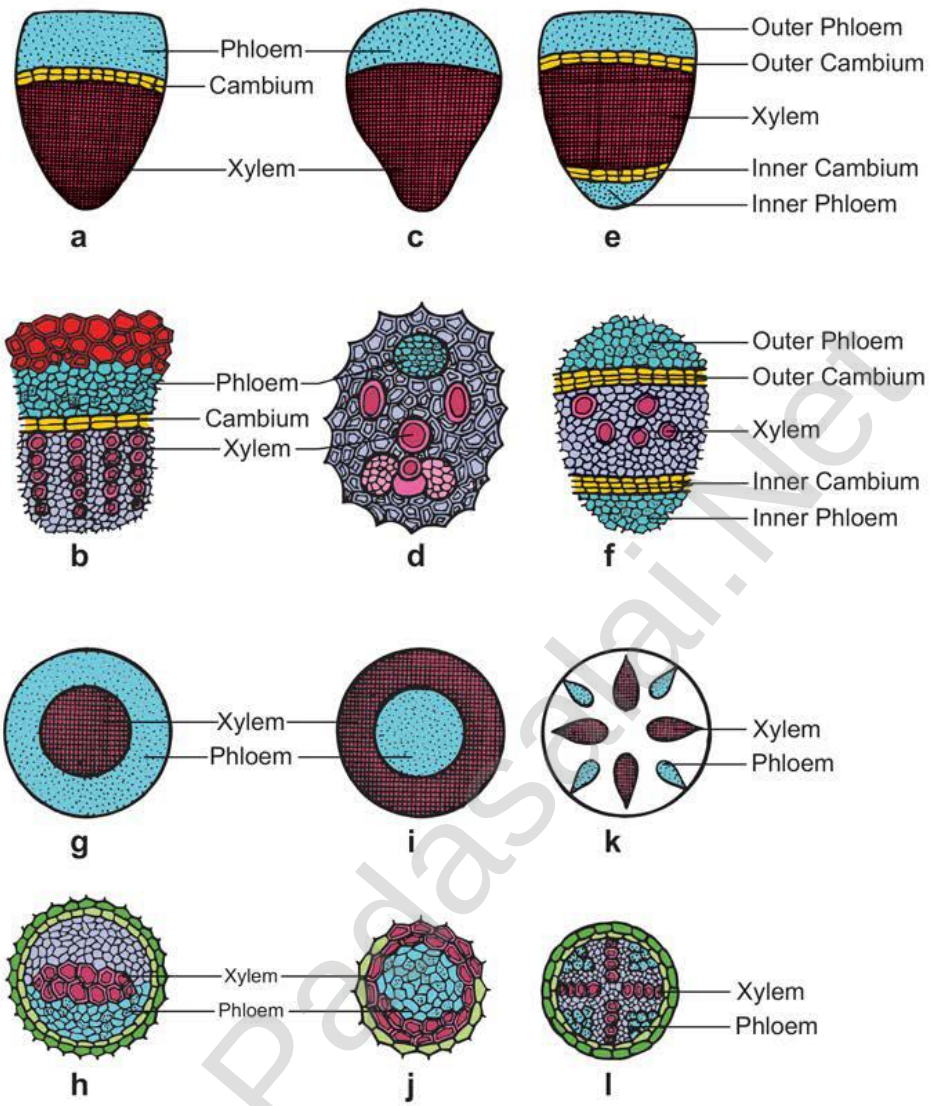
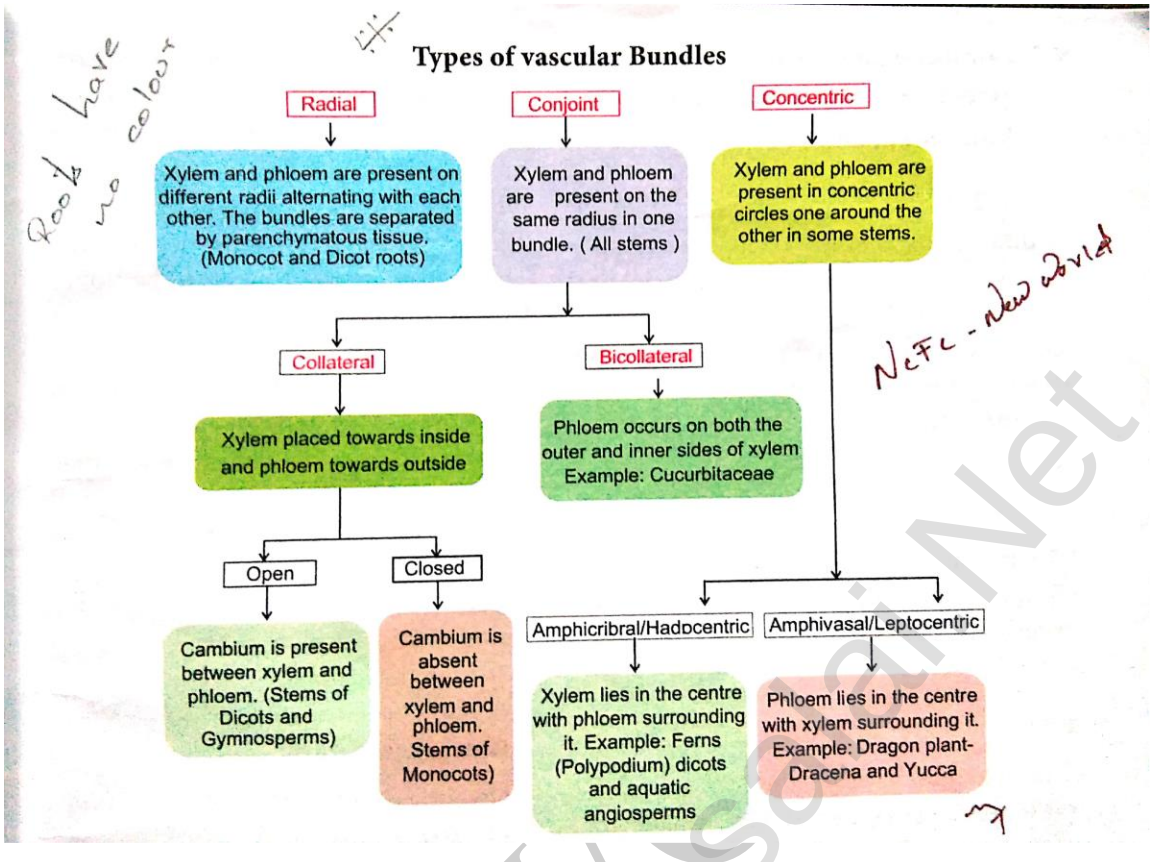


Figure 9.18: Types of vascular bundles
(a) and **(b)** - Conjoint, collateral and open; **(c)** and **(d)** - Conjoint, collateral and closed
(e) and **(f)** - Conjoint, bicollateral and open; **(g)** and **(h)** - Concentric and amphicribral;
(i) and **(j)** - Concentric and amphivasal; **(k)** and **(l)** - Radial

- The stems of both groups have a eustele while roots are protostele. In eustelic organization, the stele contains usually a ring of vascular bundles separated by interfascicular region or medullary ray

- The structural and organizational variation in vascular bundles is shown below.



9.7 Comparison of Primary Structure – Dicot and Monocot Root, Stem and Leaf

1. Anatomy of Dicot and Monocot Roots

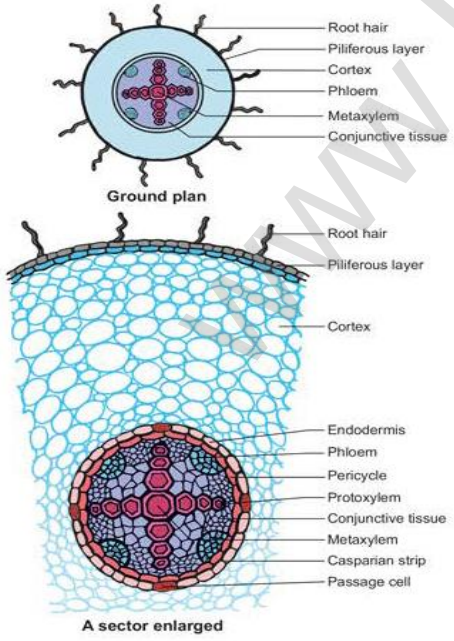


Figure 9.19: T.S. of Dicot root (Bean root)

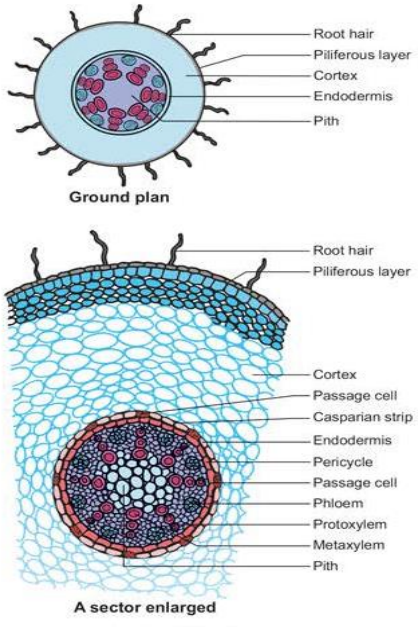


Figure 9.20: T.S of Monocot root (Maize root)

2. Anatomy of Dicot and Monocot Stems

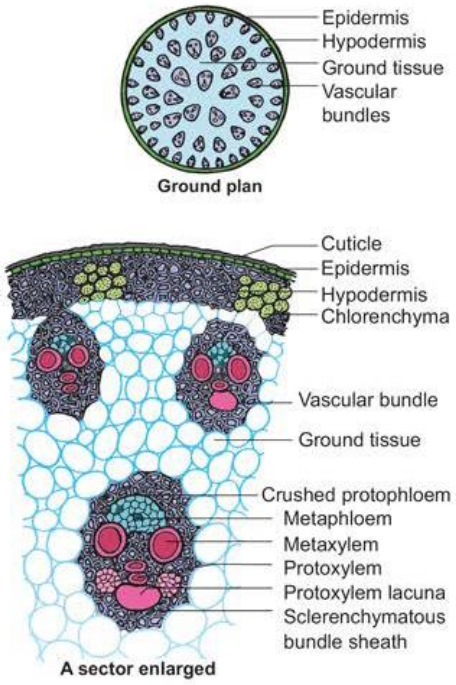


Figure 9.22: T.S. Monocot stem (Maize stem)

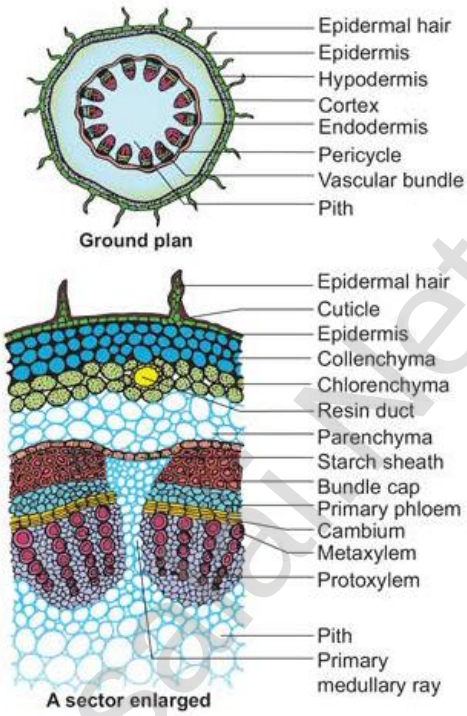


Figure 9.21: T. S of Dicot Stem (Sunflower stem)

3. Anatomy of a Dicot Leaf-sunflower Leaf

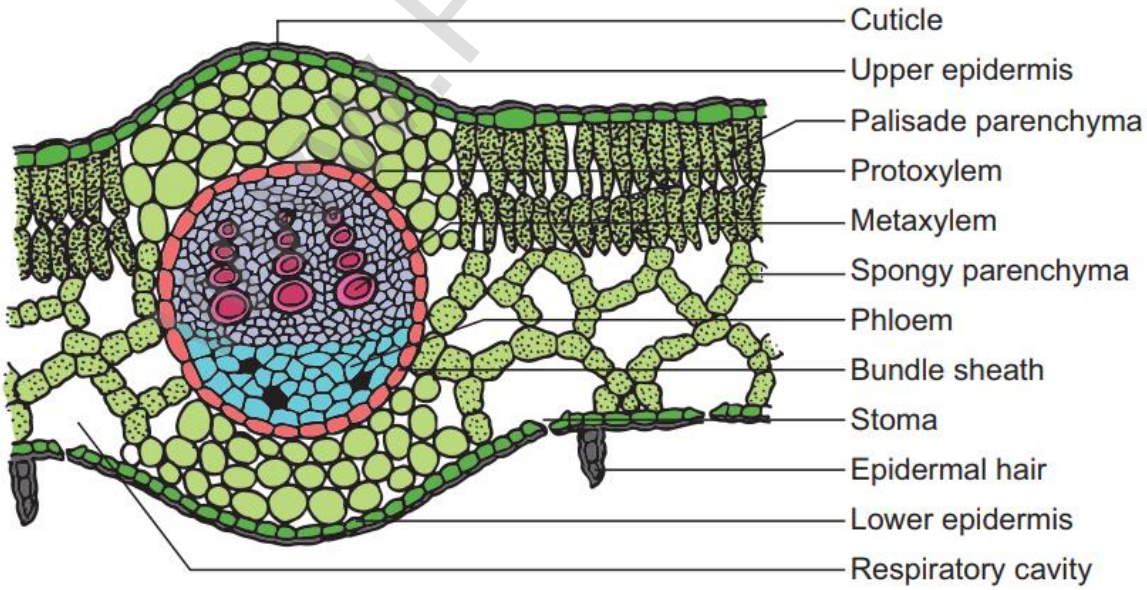


Figure 9.24: T.S. of Dicot Leaf (Sunflower)

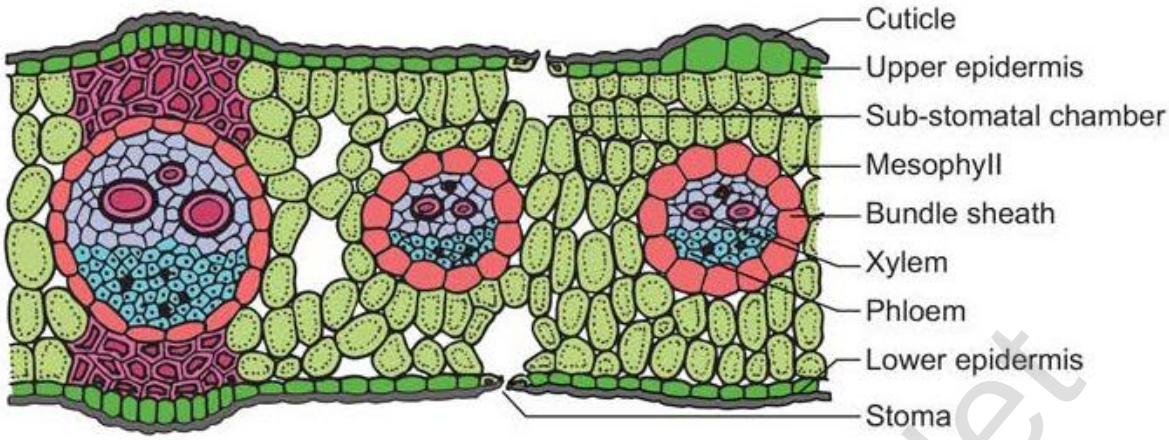


Figure 9.25: T.S. of monocot leaf (Grass)

The vascular tissue system is composed of vascular bundles. They are **collateral** and **closed.** The vascular tissues forms the skeleton of the leaf and are known as **veins**. The veins supply water and minerals to the photosynthetic tissue. Thus the morphological and anatomical features of the leaf help in its physiological functions.

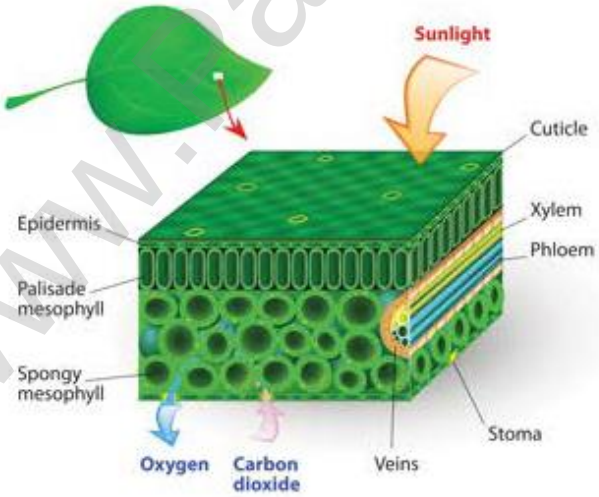


Figure 9.23: Anatomy of Leaf

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Halophiles

- Plants that grow in salty environment are called **Halophiles**.
- Plant growth in **saline habitat** developed numerous adaptations to **salt stress**.
- The secretion of ions by salt glands is the best known mechanism for regulating the salt content of plant shoots.
- Salt glands typically are found in **halophytes**. (Plants that grow in saline environments)

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ALL THE BEST

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