# ↦ Anatomy of Flowering plants :-

## ▶ KATHERINE ESAU

→ She was born in 1998 in Ukraine.
→ studied agriculture in Russia and Germany.
→ She was awarded the Phd in the United States in 1931.
→ She stated that the curly top virus spreads via the food - conducing or Phloem tissue through a plant.
→ Dr. Esau's plant Anatomy Published in 1954.
→ In 1960 → Anatomy of seed plant was Published.
→ she was elected to the national academy of Sciences in 1957.
→ She was the 6th woman to recive the Honor.
↳ "NATIONAL ACADEMY OF SCIENCE".
→ In 1989 → recieved NATIONAL MEDAL OF SCIENCE.
→ She was also the Director of Analomy and Morphology, Missouri Botanical Garden.
→ She lived 99 years and died in 1997.

ANATOMY : Study of → Internal appearance
or
Study of (Tissue)

A Group of cells that have a common Origin and usually Performing a Common function is known as a Tissue.

### MERISTEMATIC

→ Plant growth is generally confined to specific regions of the active cell division.
→ exists in all growing tips.
→ cellulosic cell with thin walls.
→ no. Intercellular space.
→ of - two types.

### PERMANENT

→ newly developed cells are structurally & functionally specialized.
→ lose the ability to differentiate
→ termed as Permanent or mature cells.
→ having cells with identical structure & function called simple tissues.
→ different type of cells call Complex tissues.

* PRIMARY MERISTEM

→ Occurs early in a plants life and lead to the formation of primary plant body (initial growth).
It is two types and they both are primary meristem.

APICAL MERISTEM

→ Occurs at the tips of roots and shoots and Produce primary tissues.
(Shoot का apex पर or Root का apex पर)
→ It is of two types:

SHOOT APICAL

→ responsible for branch, flower & leaf development
→ axillary bud is formed by certain cells 'left behind' from shoot apical
→ Axillary buds located in the axils of the leaves {forming branch or a flower}.
{ thorn and tendril}

ROOT APICAL

→ tip of a root occupied by the root apical meristem while, the shoot apical meristem occupies the most distant area of the stem axis.

INTERCALARY MERISTEM

→ Occurs at Internode or, b|w the node or, b|w the mature tissues.
→ In grasses (poceae family) intercalary meristem is present and regenerates part lost by the herbivores that graze.
→ formation of growth.

* SECONDARY MERISTEM (b/w node or Internode)

→ Occurs in mature regions of roots & shoot of many plants.
→ Produce woody axis and appear later than primary meristem is called secondary or lateral meristem. also called cylindrical meristems.
→ responsible for producing secondary tissue growth.
→ helps in healing wounds.

Lateral meristem / 2° meristem

Cork Cambium — Vascular Cambium

* Cambium helps in increasing the girth of the stem and root.

| MERISTEMATIC CELLS | PERMANENT CELLS |
|---|---|
| → Thin walled and Isodiametric | → Thin or thick walled. |
| → Can divide and produce new cells. | → have lost the power of division. |
| → cells do not have large central vacuole. | → often have large central vacuole. |

* SIMPLE TISSUES

→ Homogeneous as it is made up of only one type of cells.
→ Various types of simple tissues in plants are:-

1) PARENCHYMA

→ usually isodiametric in nature.
→ Parenchyma cells can be spherical, oval, round, polygonal or elongated in shape.
→ cell walls are thin and consist of Cellulose.
→ either be packed tightly, or have tiny intercellular space.
→ It occurs in all plant organs. Eg: roots, leaves, stems, fruits and seeds.
→ most abundant and Common.
→ functions are:- photosynthesis, storage and secretion.
→ most abundant tissue in plant.
→ epidermis, mesophyll tissue, pith mein found

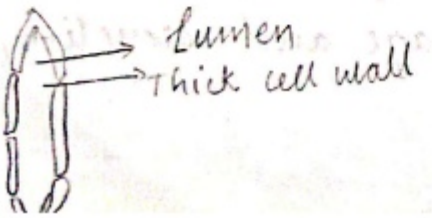
II) COLLENCHYMA

→ occurs as Hypodermis below the epidermis in most
→ Present in the petiole, leaves & stem of (DICOT PLANTS)
→ found as homogeneous but absent in monocot & roots. layer or in Patches.
→ Consist of thickened cells by a deposition of:
  • Cellulose
  • Hemicellulose
  • Pectin at the corners.
→ Cells may be oval, polygonal or spherical.
→ Contains chloroplast → if then assimilate food.
→ no intercellular space.
→ mechanical support for growing plant → young stem & leaf petiole. (in dicot herbs)
→ Both physiological & mechanical roles.

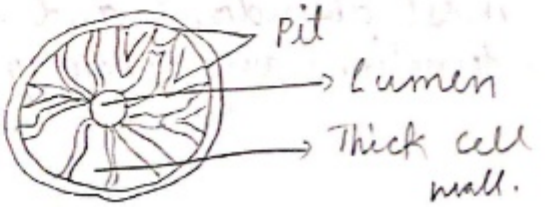
| PARENCHYMA | COLLENCHYMA |
|---|---|
| → found in both outer & inner parts of organs. | → restricted to outer parts of the Plant. |
| → Cell walls are uniformly thickened. | → cell walls are extra thickened at corners. |
| → not have any photosynthesis, storage and secretion. | → living mechanical tissue. |

III) SCLERENCHYMA → provide mechanical support to organs.
→ Usually dead cells without protoplasm.
→ long, narrow with a few or several pits with thick and lignified cell walls.
→ Based on variation in structure form, Origin & development

Fibre




Sclereid



* FIBRE

→ occuring in clusters (usually)
→ thick-walled, elongated and pointed cells.
→ occurs in hypodermis of monocot stem.

* SCLEREIDS

→ Dead cells
→ spherical, oval or cylindrical, extremely thickened cells with very narrow (lumen) cavities.
→ found in → fruits pulp (GPS) → Guava, Pear and Sapota.
→ legume seed coats.
→ tea leaves
→ fruit walls (pericarp) of nuts.

* COMPLEX TISSUES

→ Consist of more than one cell type.
↳ fn's. together as a unit.
→ Complex tissues of the plants are Xylem & Phloem.

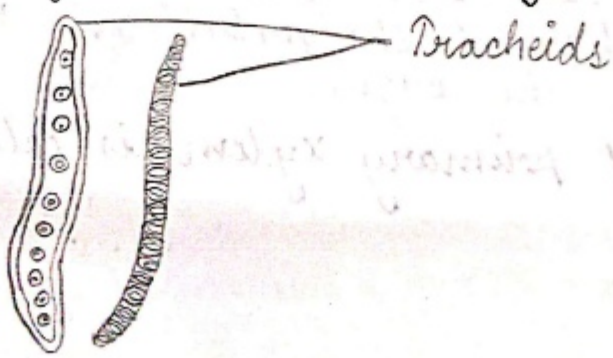
1) XYLEM → movement is unidirectional

→ functions as a conducting tissue for water and minerals from roots to the stem & leaves.
→ provides mechanical strength to plant parts.

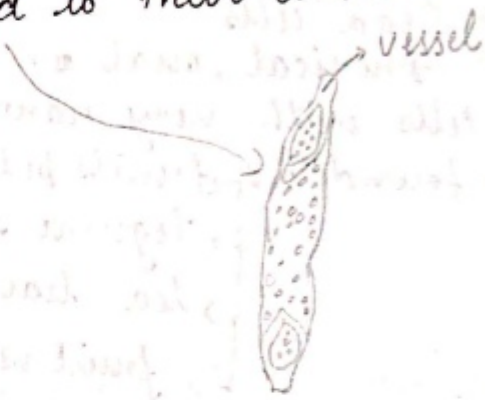
Its component are:-

* Tracheids

→ elongated or tube-like cells with thick and lignified walls & tapering ends.
→ dead without protoplasm.
→ inner layers of the cell form-varying thickness.
→ Tracheids differ from other tracheary elements in being imperforate.



* Vessels
→ Characteristics feature of angiospermic plants.
→ long- cylindrical tube-like structure made up of several cells.
→ lignified walls
→ a wide central cavity called vessel members.
→ large lumen and are devoid of Protoplasm.
→ vessel members are interconnected to their common end-walls via perforation.




* Xylem or Wood fibres
→ highly thickened walls.
→ Central lumens are obliterated.
→ lignified cells.
→ either be septate or aseptate.
→ provides mechanical support.

* Xylem or Wood parenchyma
→ Cell walls made up of cellulose.
→ living and thin-walled.
→ fns. to store starch or fat and tannins
→ The radial water Conduction is performed by the ray parenchymatous cells.

* Primary Xylem is of two types
i) Protoxylem
ii) Metaxylem

The first (early) formed primary xylem called PROTOXYLEM.

The later formed primary Xylem called METAXYLEM

* In stem and leaves, the protoxylem lies towards the centre (pith) and the metaxylem lies towards the periphery of the organ.
[This type of primary xylem is called endarch].

* In roots, the protoxylem lies towards periphery and metaxylem lies towards the centre.
This type of primary xylem called exarch.
↓
protoxylem faces Pericycle.

* In endarch condition
↓
Centrifugal
(development of xylem takes place towards periphery)

* In exarch condition
Centripetal
development of xylem takes place towards centre.

ii) PHLOEM → movement is bidirectional or multidirectional.
{BAST}

fns: Transportation of food / organic materials
from ⟶ leaves to other parts of plant.

* Consist four type cells:-
i) Sieve tube elements
ii) Companion cells
iii) Phloem Parenchyma
iv) Phloem or bast fibres. (secondary phloem)

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This type of primary xylem called exarch.

↓

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* In endarch condition

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* Sieve tube elements:
→ To form sieve plates
→ end walls perforated in sieve-like fashion.
→ mature sieve element possesses a cytoplasm that is peripheral
→ a large vacuole.
→ not have nucleus or is (enucleate)
→ long, tube like structures, longitudinally arranged
→ Connected to the companion cells.
→ Its fns are regulated by the companion cells
→ Cellulosic walls;
→ transports food.

* Companion cells:
→ specialized parenchymatic cells
→ Sieve tube elements & the companion cells connected by their common longitudinal walls by presence of pit fields.
→ It maintains the pressure gradient in the sieve tubes.

* Phloem Parenchyma:
→ elongated, cylindrical tapering cells
→ dense cytoplasm and nucleus.
→ consists of cellulose & has pits
→ plasmodesmatal connections
→ stores food material as well as resins, latex & mucilage.
→ In most monocotyledons, phloem parenchyma absent.

* Phloem or bast fibres:
→ Sclerenchymatous cells formed.
→ primary phloem these are usually absent, but present in secondary phloem.
→ elongated unbranched & have pointed apices resemble needles.
→ cell wall very thick
→ lose their protoplasm at maturity and die.
→ phloem fibres of jute, flax & hemp used commercially.

* Jute Fibres
  → Secondary Phloem fibres, anatomically.

NOTE:

A transversed section of stem stained first with safranin preparation of Permanent slide.
Colour of stained xylem and phloem
  → red
  → green

PROTOPHLOEM
→ 1st formed primary phloem.
↓
Consist of narrow sieve tubes.

METAPHLOEM
→ formed later & has bigger sieve tubes.

The Tissue system

- Dermal or Epidermal T.S
  - → Epidermis
  - → Stomata
  - → Epidermal appendages
- Fundamental or ground T.S.
  - → Cortex
  - → Pericycle
  - → Pith
- Conducting or vascular T.S.
  ↓
  Vascular bundles
  - → Radial vascular bundle eg: roots.
  - → Conjoint vascular bundle eg: stem & leaves.

**Tissue** → Structure
→ Location

→ ① Epidermal tissue
- → Outermost layer of plant.
- → made up of Parenchyma
  - → elongated
  - → Compact
  - → Single layer
  - → Continuous
  - → Small Cytoplasm
  - → large vacoule

→ outside of epidermis
↓
Thick waxy coating called cuticle
↓
fns: to reduce water loss i.e. transpiration.

→ In root cuticle absent
→ In epidermis stomata are present.
- ↓ Dicot plant
- ↓ Monocot plant

→ stomata or stomatal apparatus made up of:
- → Guard cell
- → Subsidiary cell
- → stomatal apperature

↓
Gaseous Exchange or Transpiration

## Guard cell

- help in closing & opening of stomata
- Inner thick wall
- outer thin wall

## Subsidiary cell

- In vicinity of guard cell modified epidermal cell.

## Stomatal apperature

- When open there will be transpiration gaseous exchange.
- when close ↓ ×

## * Epidermal appendages

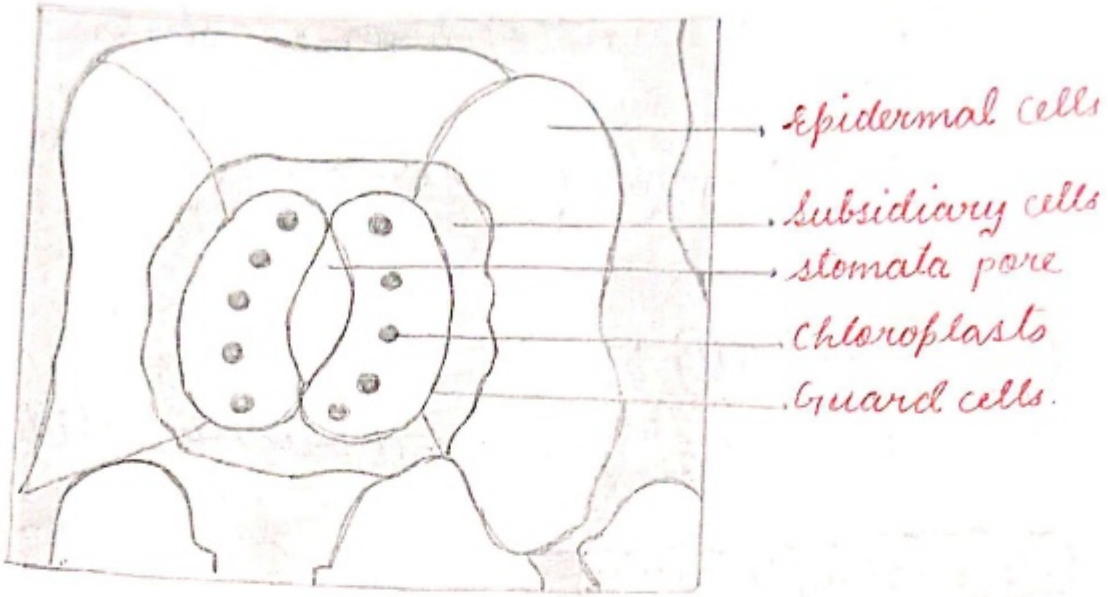
### Root hairs

- Unicellular
- epidermal cells
- absorption of water & minerals from soil

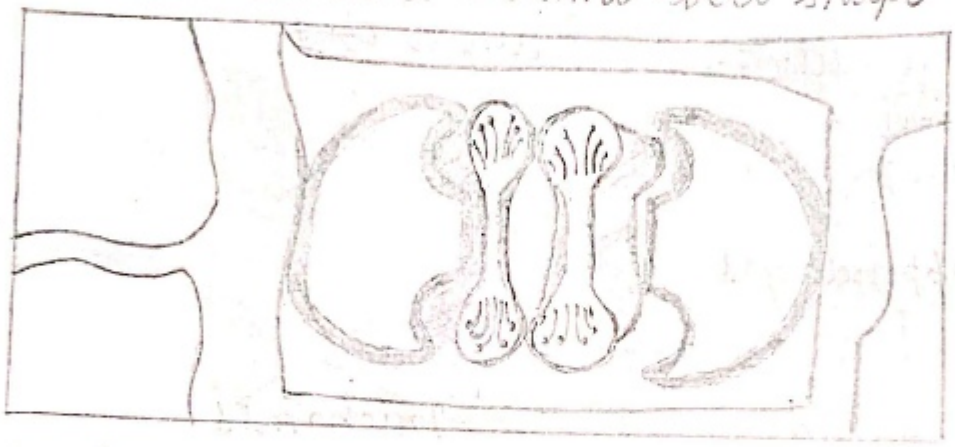
### Trichomes

- epidermal hair on stem.
- usually multicellular
- branched or Unbranched
- soft or rigid (stiff)
- Secretory
- preventing water loss by transpiration
- used in defense.

Dicot stomata → bean shaped




Monocot stomata → dumb-bell shape



II) Ground Tissue
or
Fundamental tissue

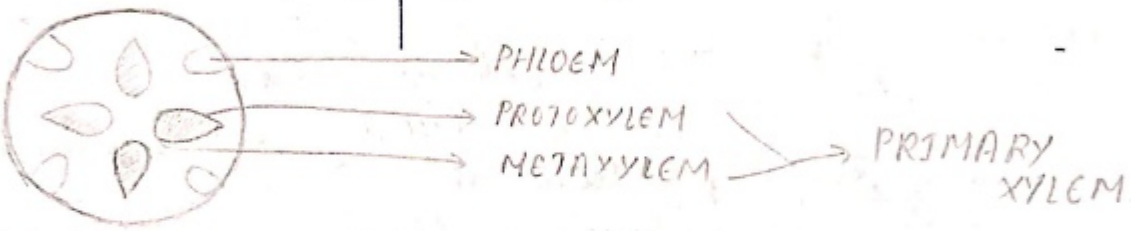
→ made up of → Parenchyma
→ collenchyma
→ Sclerenchyma

→ Parenchyma → epidermis
→ Cortex
→ Pericycle
→ Pith
→ medullary rays.
} Primary stem roots.

↓
In leaf chloroplast containing Parenchyma called mesophyll cells.
do photosynthesis

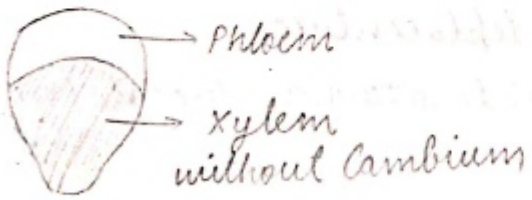
iii) Vascular Bundle
- Xylem
- Phloem

Root
- Radial Vascular bundle : when xylem & Phloem are alternate or present on different radius.
- Exarch Vascular bundle or centripetal
  - protoxylem towards periphery & metaxylem towards centre.

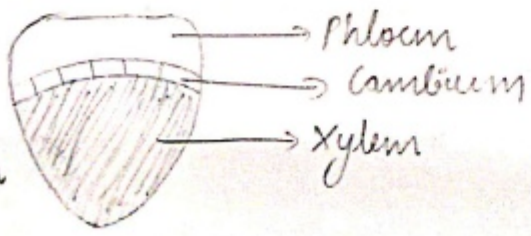



Dicot stem

Conjoint → when xylem & Phloem are present on same radius.
- ① Collateral : when xylem present towards inside & Phloem present towards outside.
  - open → when cambium present b/w xylem & Phloem.
    Eg: Dicot stem.
    - endarch → centrifugal protoxylem centre & meta xylem periphery.

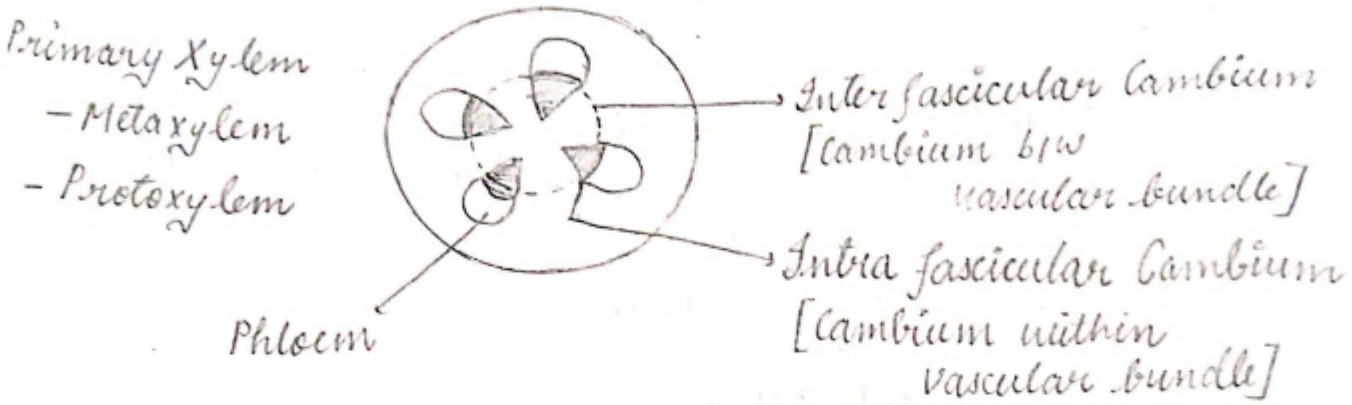



  - close → Cambium absent
    eg: monocot stem

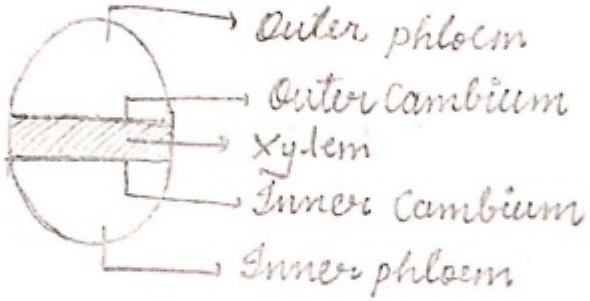


## CONJOINT → Collateral bundles

### Dicot stem



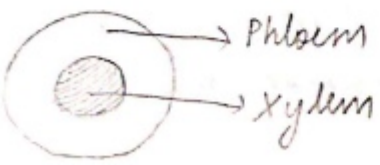

## CONJOINT → Bicollateral bundles



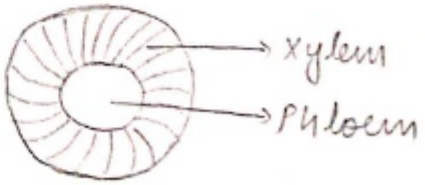

Eg: Cucurbitaceae, pumkin, torai.

# Concentric vascular bundle → xylem surrounded by phloem or vice-versa.

**Amphicribal** or **Hadrocentric**
Eg: Fern, Hydrilla




**Amphivasal** or **Leptocentric**
Eg: Dracaena, Yucca, family Liliaceae



# DICOT STEM

(i) Epidermis → Thin cuticle
→ Trichome hair → Multicellular
→ Secretory
→ Prevent water loss
→ branched & Unbranched.

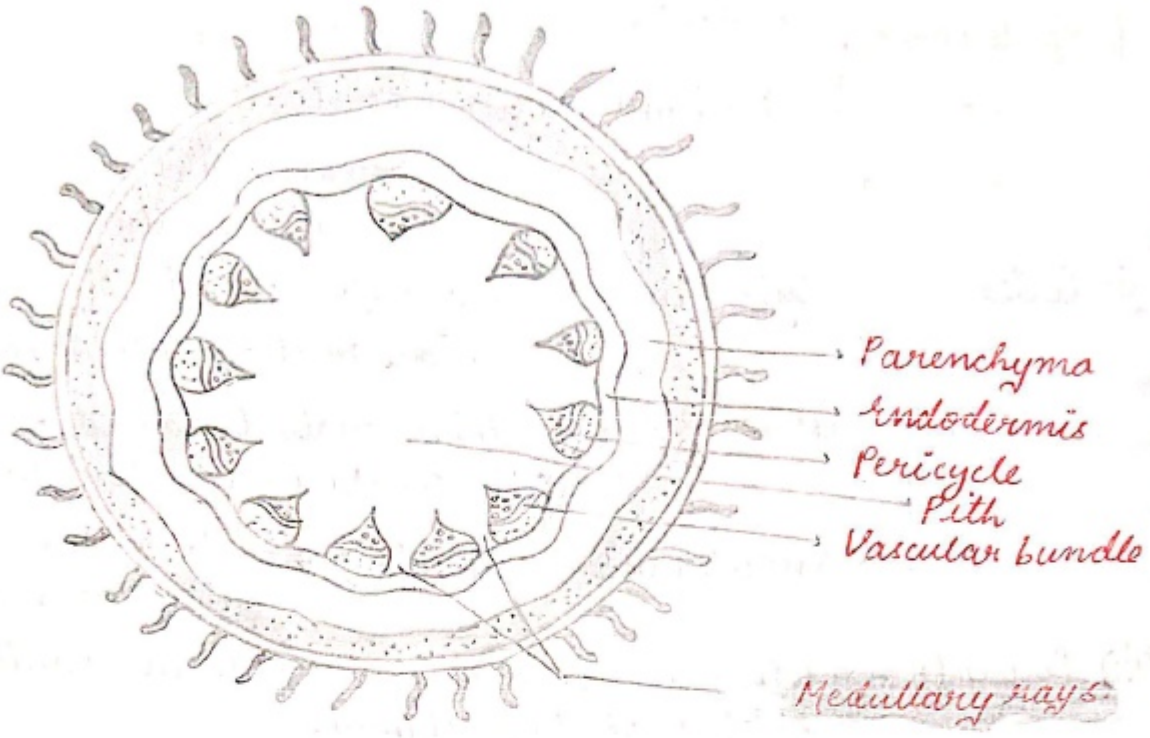
(ii) Cortex → Hypodermis → few layer of collenchyma cells. Provide mechanical support.
→ Cortical layer → thin walled round parenchymatous cells conspicuous intercellular space.
→ Endodermis → starch granule & later form starch sheath.

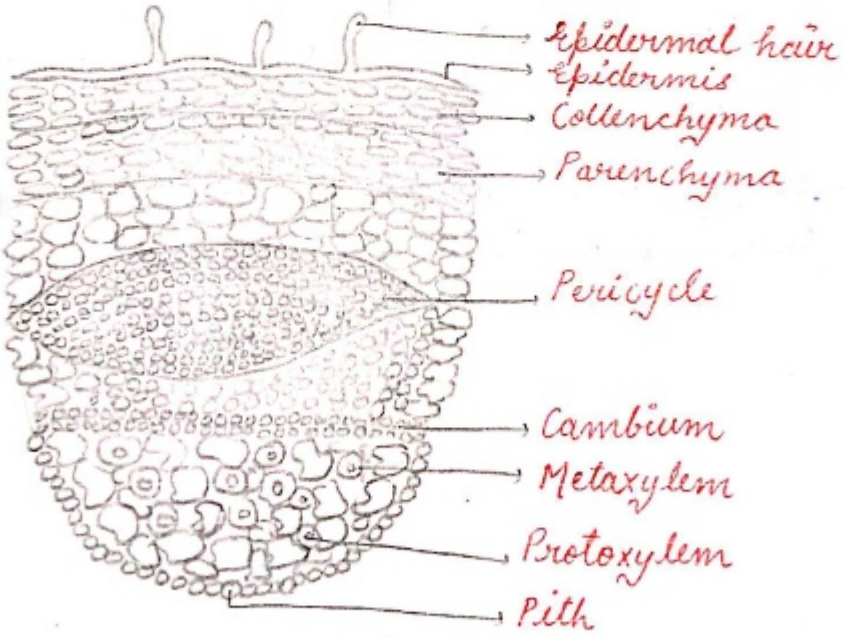
(iii) Pericycle → below endodermis above phloem semilunar patches of Parenchyma.

(iv) Vascular bundle → Radially placed parenchyma cells Constitute medullary rays.
→ V.B → in ring, conjoint, collateral, open & endarch. (centrifugal)
↓
(means cambium present i.e secondary growth takes place)

(v) Pith → large no. of round parenchymatous cells & have large intercellular space.

Dicot stem


Parenchyma
Endodermis
Pericycle
Pith
Vascular bundle
Medullary rays


Epidermal hair
Epidermis
Collenchyma
Parenchyma
Pericycle
Cambium
Metaxylem
Protoxylem
Pith

# MONOCOT STEM

① Epidermis → present

② Hypodermis → Sclerenchymatous cells.

Cortical layer → x

Endodermis → x

③ Pericycle → x

④ Vascular bundle → Surrounded by Sclerenchymatous sheath & Parenchymatous ground tissue.

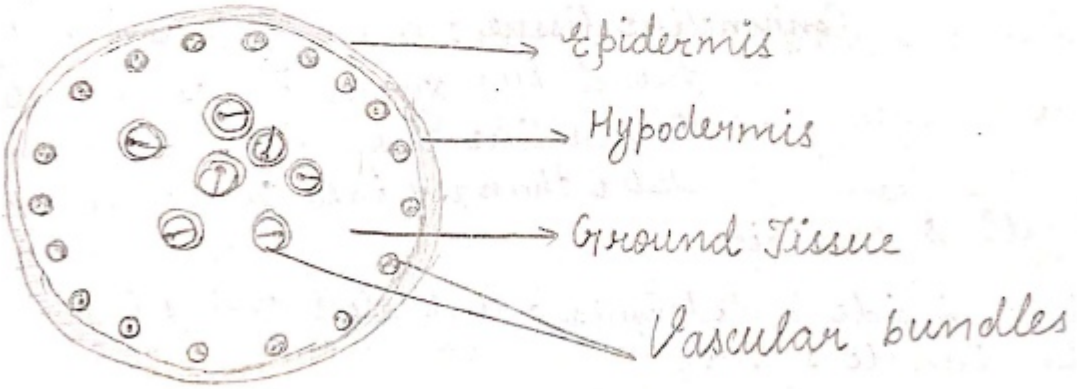
→ Peripheral vascular bundle smaller than Central vascular bundle.

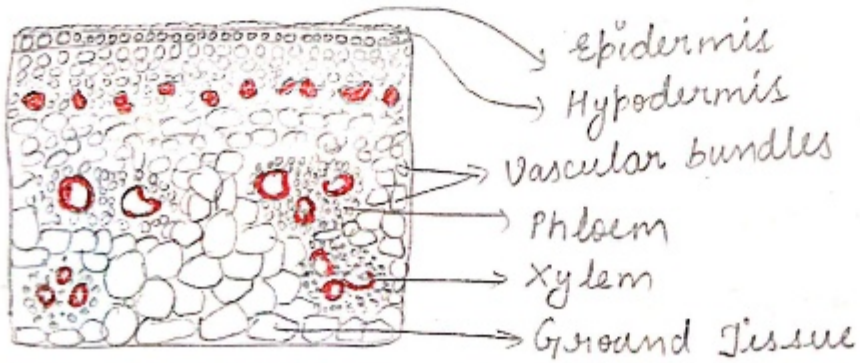
→ Conjoint, closed and scattered.

↓

(means Cambium absent i.e no, secondary growth).

⑤ Pith → x



# DICOT ROOT

(i) Epidermis or epiblema
- → cuticle absent
- → Unicellular hair, increases the absorptive surface area of water & minerals absorption.

(ii) Cortex
- → Several layer of Parenchymatous cells have intercellular space.
- → Hypodermis → absent
- → Endodermis
  - → Single layer
  - → Barrel shaped cells
  - → Tangential & radial wall have deposition of Suberin called Casparian strips.

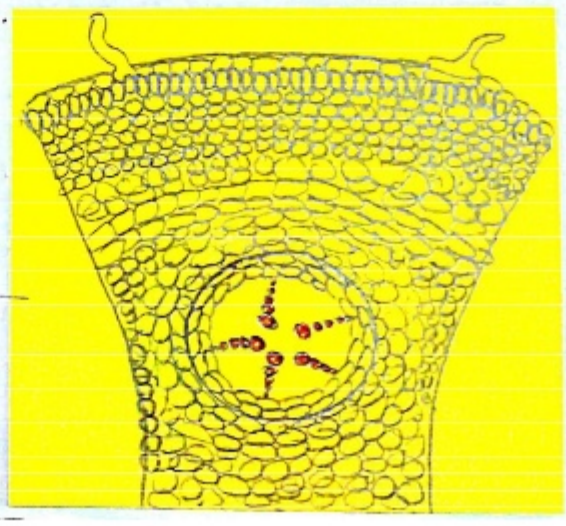
(iii) Pericycle
- → thick walled parenchymatous cells.
- → During secondary growth lateral roots & cambium are formed by Pericycle.

(iv) Vascular Bundle → 2 to 4 xylem & Phloem patches

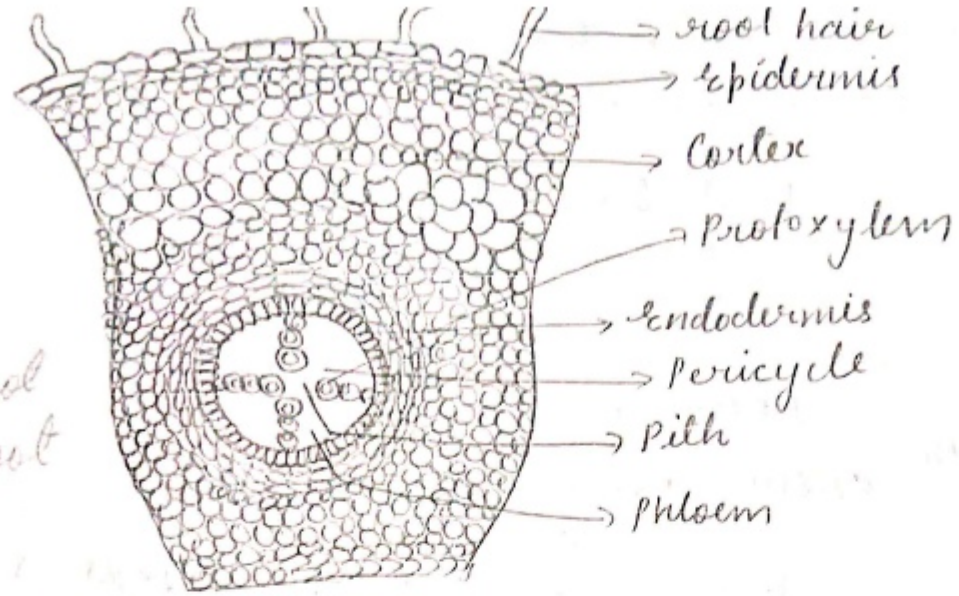
Conjunctive tissue : Parenchymatous cell found b/w xylem & Phloem called Conjunctive tissue. This tissue later changed into Cambium.

(v) Pith → Small & Incospicuous

NOTE:
Steel → all tissue inside endodermis called steel Pericycle, vascular bundle & Pith.



Monocot root ←




MONOCOT ROOT

→ Anatomically dicot & Monocot roots are similar

→ but, vascular bundle of xylem → more than 6,
& Pith → large and well develop.

NOTE:
For better study of root, stem and leaves perform transverse section.

Leaf → anatomically dicot & monocot leaf are similar, but

In dicot leaf: Mesophyll cells or Parenchyma are two types:

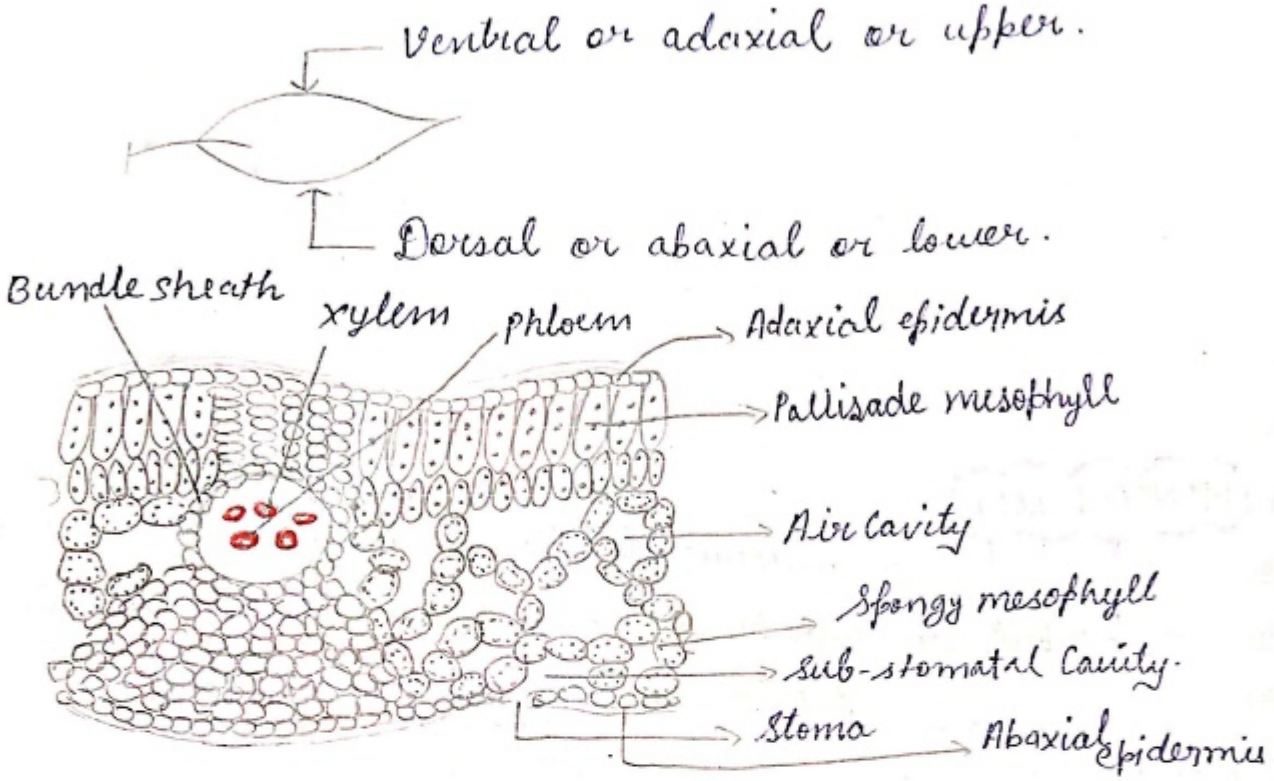
- Pallisade Parenchyma
  - → elongated, vertical arranged & Parallel to each other.
- Spongy Parenchyma
  - → Present below of pallisade Parenchyma.
  - have air cavity

In Monocot leaf:

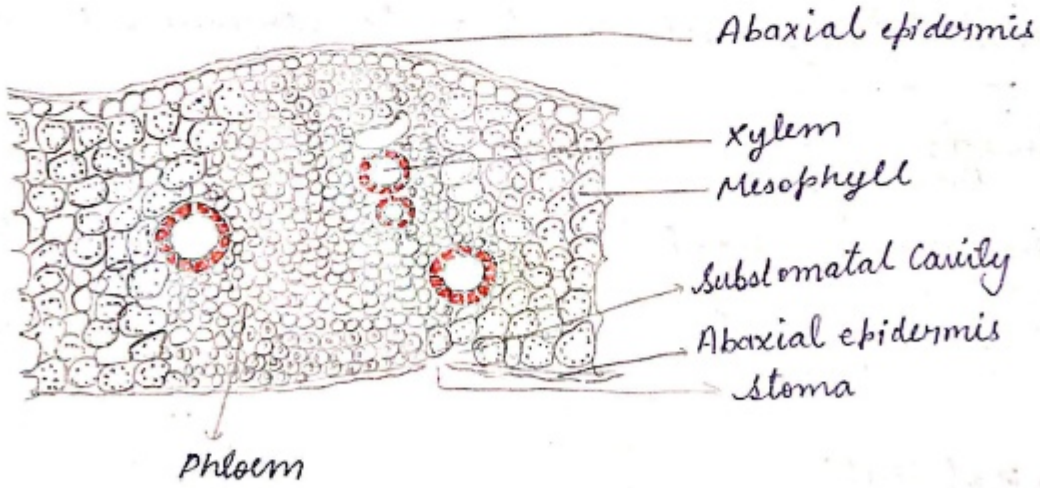
↓

Parenchyma are not divided into pallisade parenchyma & spongy Parenchyma.

* Dicot leaf called Dorsiventral leaf have more stomata on Dorsal or abaxial or lower side.




* Monocot leaf called Isobilateral have equal stomata on both side.




Monocot Leaf

→ Vertical Section of leaf:

- → Epidermis → have thick cuticle on both side.
- → mesophyll cell or Parenchyma
- → Vascular bundle in vein and midrib.

## Extra

* SECONDARY GROWTH

- → Many dicotyledenous plants increase in girth aside.
- → secondary growth or radial growth.
- → The two lateral or secondary meristems which involved in secondary growth are vascular cambium and cork cambium
- → secondary growth occurs in stem, root of dicots (like teak), as well as gymnosperm (like pine).
- → secondary growth is not seen in monocots (because vascular cambium is not present. (grasses and Hydrophytes).

* VASCULAR CAMBIUM

- → Two types of meristem
  - fascicular or intrafascicular Cambium
  - Interfascicular Cambium.
- → The meristematic layer responsible for cutting off vascular tissue Xylem & Phloem → referred to vascular tissue.
- → forms a complete ring of Cambium of both intrafascicular Cambium and interfascicular Cambium.
- → Vascular Cambium of stem is found to be partly primary (Intraf.) and partly secondary (Interf.).

* Formation of Cambial ring:-

- → Intrafascicular Cambium, the cells of medullary rays become meristematic & form the interfascicular Cambium.
- → a continuous ring of Cambium is created.
- → Interfascicular Cambium is secondary meristem, Originates from the medullary rays.

* Activity of Cambial ring

→ Cambial ring becomes active and begins to cut off new cells, in both outer and inner sides.

→ The cells are cut off towards the pith, develop into secondary xylem & the cells are cut off towards periphery mature into secondary phloem.

→ Differential action of hormones, vascular Cambium form xylem on the inner side and phloem on the outer side.

→ inner side is usually more active than the one on the outer side.

→ The amount of secondary xylem created is more than secondary phloem

→ accumulation of secondary xylem, the primary and secondary phloems will slowly be crushed.

→ In some places the cambium forms a thin band of parenchyma that passes in the radial directions through the secondary xylem & secondary phloem. These are secondary medullary rays.

## 2° Growth (Plants in temperature region)

### SPRING SEASON

↓

Cambium is very active

↓

Spring wood / early wood

↓

1. wider vessels
2. lower density
3. lighter in colour

### WINTER SEASON

↓

Cambium is less active

↓

Autumn wood / Late wood.

↓

1. Narrow vessels
2. Higher density
3. Darker in colour.

NOTE:

→ Determination of age of tree by counting the number of annual the ring in the main stem (or base of stem) is called Dendrochronology.

→ Annual rings are distinct in temperature regions (Lucknow & Shimla)
Indistinct in tropical areas & sea coast or sea shore trees (Goa & Mumbai)

→ a cut trunk shows 70 concentric rings of spring wood and autumn wood in alternate rows. The age of trunk would be 35 years.

## SAPWOOD (Alburnum)

- It is physiologically functional part of the secondary xylem.
- It is the outer wood of an old stem.
- It is light coloured
- Living cells are formed
- The tracheary elements are not plugged by tyloses.
- It is less durable because it is susceptible to attack by pathogens & insects.

## HEARTWOOD (Duramen)

It is mechanically functional part of the secondary xylem.

It is the central part of an old stem.

It is dark coloured.

Living cells are lacking.

They are plugged by tylosses

It is more durable due to its little susceptibility to the attack of pathogens & insects.

## CORK CAMBIUM

→ extra-stellar cambium or cork cambium.
→ stem begins to increase in girth
→ Cork cambium or phellogen forms, usually in the region of cortex.
↓
Composed of small, thin-walled & almost rectangular cells.
↓
Cut off all the cells on the both sides.

→ outer cells differentiate in cork or phellem while the inner cells differentiate in secondary cortex or phellodern because, of the deposition of suberin in the cell wall, the cork cam. is impervious to water.

→ Secondary cortex are parenchymatous.

→ Phellogens, Phellem, and phellodrm collectively referred to as Periderm.

→ Bark is a non-technical term, refers to all tissues exterior to vascular cambium, thus including secondary phloems.

Bark refers to different types of tissue i.e periderm & secondary phloem.

→ EARLY or soft bark → formed early in season.
LATE or hard bark → formed towards end of season.

→ LENTICELS or Parenchyma or Lens-shaped allows the gaseous exchange of gases b/w the outside atmosphere & the stem inner's tissue. "occurs mainly in woody trees" Lenticels are made with loosely organized cells.
Called Complementary cells.

→ SECONDARY GROWTH in roots:-

→ vascular cambium in dicot roots is entirely secondary in origin → located just below phloem bundles.
↓
a pericycle tissue above the protoxylem forming a complete & continuous wavy ring that becomes circular later.

→ Cells that are present just below the primary phloem are called conjunctive tissue.

→ Cork cambium is derived from Pericycle in dicot roots.

## Points to be Remembered :-

→ Hypodermis not present in roots.
→ Phloem parenchyma absent in monocot stem.
→ Pith large & well developed in monocot root
→ More than 6 xylem bundle present in monocot roots.
→ Casparian strips present in endodermis of Dicot root.
→ radially placed parenchyma present in vascular bundle of dicot stem
→ Hypodermis is collenchymatous in dicot stem.
→ Hypodermis is sclerenchymatous in Monocot stem.
→ Scattered vascular bundle in monocot stem.
→ ring vascular bundle in Dicot stem.
→ root vascular bundle ⟶ Radial, exarch or scattered.
{Centripetal}
→ Dicot stem vascular bundle
↳ Conjoint, collateral, open & endarch
{Centrifugal}
→ Monocot stem ⟶ Conjoint & closed.
→ Medullary rays — Primary, Secondary — Parenchyma
→ Dicot stem — Pericycle is sclerenchymatous
→ Barrel shaped cell — Dicot ⟶ Endodermis
→ Barrel shaped or dumb-bell shaped guard cell in monocot stem.
→ Kidney shaped or bean shaped or raniform shaped in dicot stomata.

* bulliform cell
↳ large adaxial epidermal cell
↳ Colorless
↳ empty
↳ found in monocot plant leaf
↳ fns : become curled and reduce transpiration or water loss.