ANATOMY OF FLOWERING PLANTS

Tissue Systems in Plants

1. Epidermal Tissue System

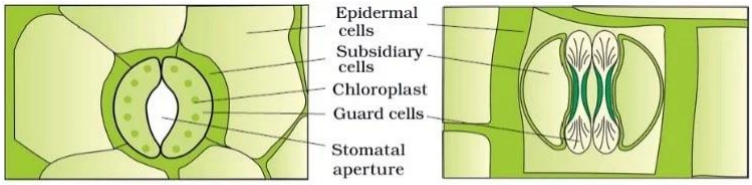
- **Definition:** Outermost protective covering of the entire plant body.
- **Composition:** Epidermal cells, stomata, epidermal appendages (trichomes & hairs).

Epidermis

- Single-layered, parenchymatous, covered by a **cuticle** (waxy layer) to prevent water loss.
- Cells usually compactly arranged, lack intercellular spaces.
- May be interrupted by **stomata** and **epidermal appendages**.

Stomata

- Present in epidermis of leaves & young stems.
- Function: **Regulate transpiration & gaseous exchange**.
- Structure:
  - **Dicots** → Bean-shaped guard cells.
  - **Monocots** → Dumbbell-shaped guard cells.
- Guard cells contain **chloroplasts** and are responsible for **stomatal movement**.
- **Subsidiary cells** surround guard cells.
- Stomatal apparatus = **Stomatal pore + Guard cells + Subsidiary cells**.



Stomata with bean-shaped guard cells

Stomata with dumb-bell shaped guard cell

Epidermal Appendages

- **Root hairs** → Unicellular outgrowths of root epidermal cells; increase water & mineral absorption.
- **Trichomes (stem hairs)** → Multicellular, branched/unbranched; may be glandular/non-glandular; protect against transpiration, grazing, and excess light.

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2. Ground Tissue System

- **Definition:** All tissues between the epidermis and vascular bundles.
- **Composition:** Mostly **simple permanent tissues** (parenchyma, collenchyma, sclerenchyma).
- **Functions:** Photosynthesis, storage, mechanical support.

Distribution

- **Stem & Roots:** Pericycle, cortex, pith, medullary rays.
- **Leaves:** Mesophyll (contains chloroplasts; site of photosynthesis).
  - **Palisade parenchyma** → Columnar cells, more chloroplasts (photosynthesis).
  - **Spongy parenchyma** → Loosely arranged, facilitates gaseous exchange.

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3. Vascular Tissue System

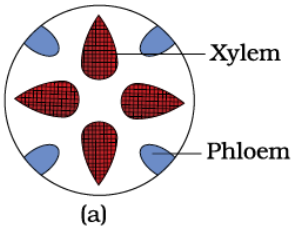
- **Definition:** Complex permanent tissue system forming **vascular bundles**.
- **Components:**
  - **Xylem** → Conducts water & minerals (tracheids, vessels, xylem parenchyma, xylem fibres).
  - **Phloem** → Conducts food (sieve tubes, companion cells, phloem parenchyma, phloem fibres).

Types of Vascular Bundles

a) Radial → Xylem & phloem arranged on different radii (roots).

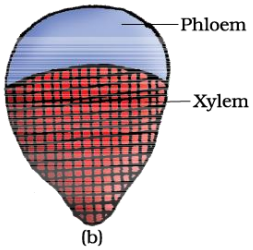
Conjoint → Xylem & phloem on the same radius (stems & leaves).

Collateral: Phloem outside, xylem inside (most common).



(a)

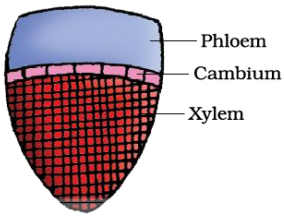
b) Conjoint Closed → Xylem & phloem on same radius, **cambium absent**, **no secondary growth**. (Monocot stems – maize)
c) Conjoint Open → Xylem & phloem on same radius, **cambium present**, allows **secondary growth**. (Dicot stems – sunflower)



(b)

Bicollateral: Phloem on both sides of xylem (e.g., Cucurbita).
Concentric: One vascular tissue surrounded by the other.

- Amphivasal: Phloem surrounded by xylem. Ex: Yucca
- Amphicribral: Xylem surrounded by phloem. Ex: Fern



(c)

Dicots (Bean shaped) Monocots (Dumb-bell shaped)

- Epidermis also contains a number of hairs. Root hairs are unicellular elongation of epidermal cells. Trichomes are present on stems, which are multicellular, branched or un-branched preventing water loss due to transpiration.

The ground Tissue System

- All the tissue between epidermis and vascular bundle forms the ground tissues. It consists of simple permanent tissues. Parenchyma is present in pericycle, cortex, pith and medullary rays in stem and roots.
- In leaves the mesophyll, chloroplast containing cell, forms the ground tissues.

Dicotyledonous (Dicot) Root – Primary Root (Ex- Sunflower)

- **Epidermis (Epiblema)**: Single outer layer with unicellular root hairs; no cuticle or stomata.
- **Cortex**: Many layers of thin-walled parenchyma with intercellular spaces; stores food.
- **Endodermis**: Single innermost layer of cortex with **barrel-shaped cells** -tangential and radial walls- **Casparian strips** (suberin deposition-impervious to water) are present, especially opposite protoxylem.

Stele: All tissues inside the endodermis, including:

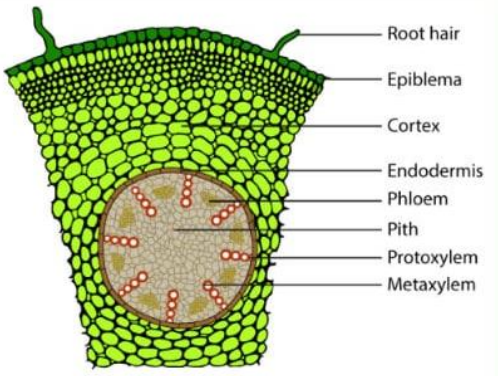
- **Pericycle**: consisting of a few layers of thick-walled parenchymatous cells located below the endodermis, gives rise to lateral roots and, opposite the protoxylem, forms interfascicular cambium that joins to complete the cambial ring responsible for secondary growth.
- **Vascular bundles**: Few 2-4 (diarch to tetrarch, rarely polyarch), radially arranged; **xylem and phloem alternate**.

Cambium: is **not present in primary structure**.

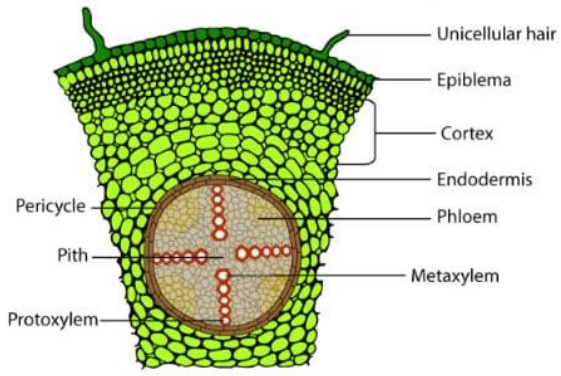
Conjunctive tissue

During **secondary growth**, **cambium originates secondarily** from: **Conjunctive tissue** (between xylem and phloem**)** → (forms **fascicular cambium** & secondary xylem and phloem) → increases girth.

- **Pith**: Innermost region, small or inconspicuous.



Monocot Root



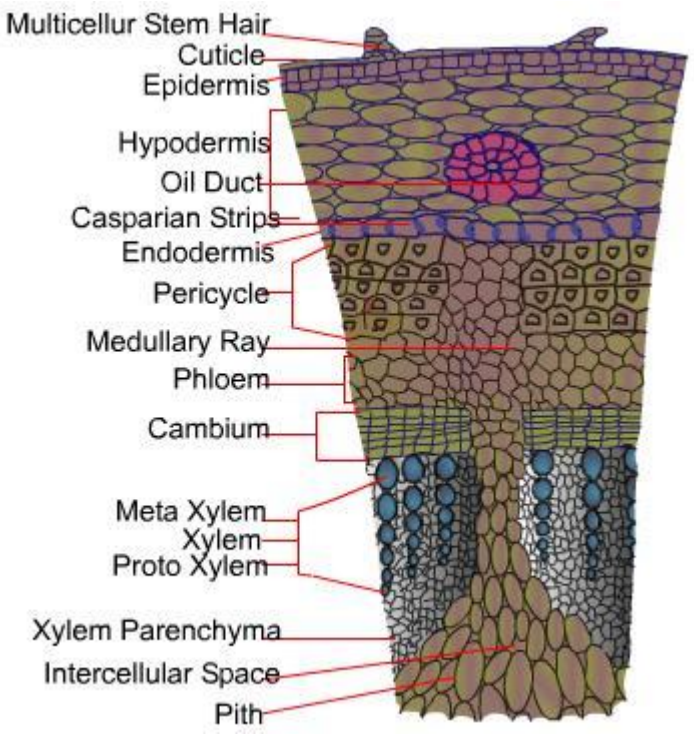
Dicot Root

Monocotyledonous (Monocot) Root (e.g., Maize)

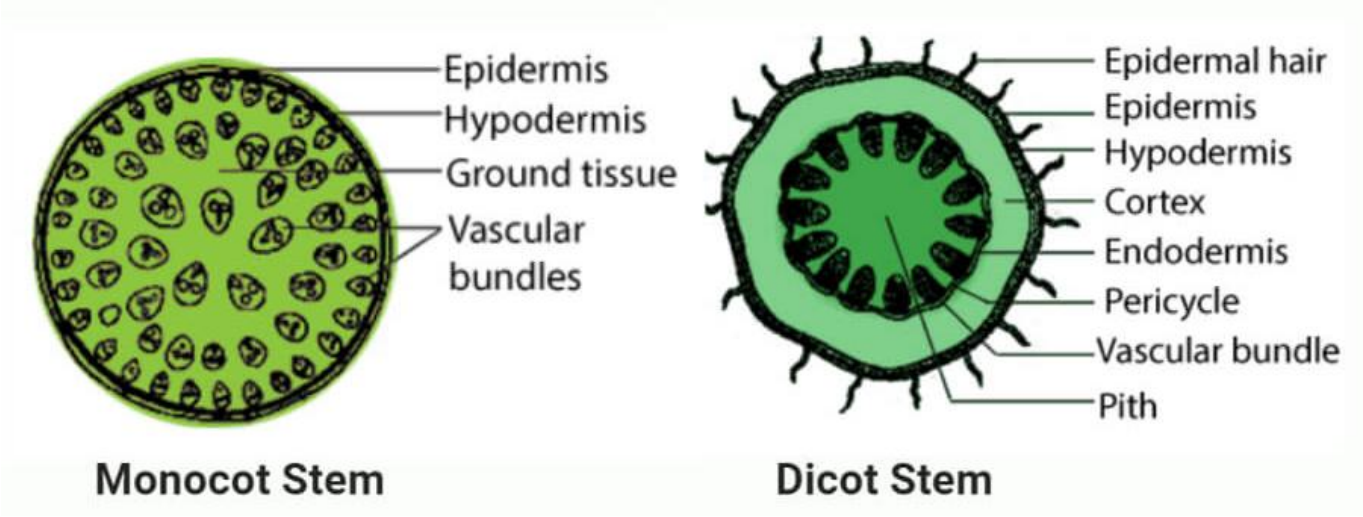
- **Epidermis (Epiblema):** Single outer layer with root hairs.
- **Cortex:** Many layers of parenchyma with intercellular spaces.
- **Endodermis** also has barrel-shaped cells with **Casparian strips**. Passage cells are present here as well.
- **Pericycle:** Single-layered, lies beneath endodermis; gives rise to lateral roots but **not cambium**.
- **Vascular tissue:** Radially arranged
    - Xylem: **Polyarch** (more than six).
    - Phloem: Alternates with xylem.
- Pith is large and well-developed.
- Cambium is **absent** → **no secondary growth** (in normal monocots), so endodermis remains intact (clearly visible).
- Exception: Some monocots (e.g., *Dracaena, Yucca*) show **anomalous secondary growth**, but it is due to a **secondary thickening meristem**, not typical cambium.

Dicotyledonous (Dicot) Stem

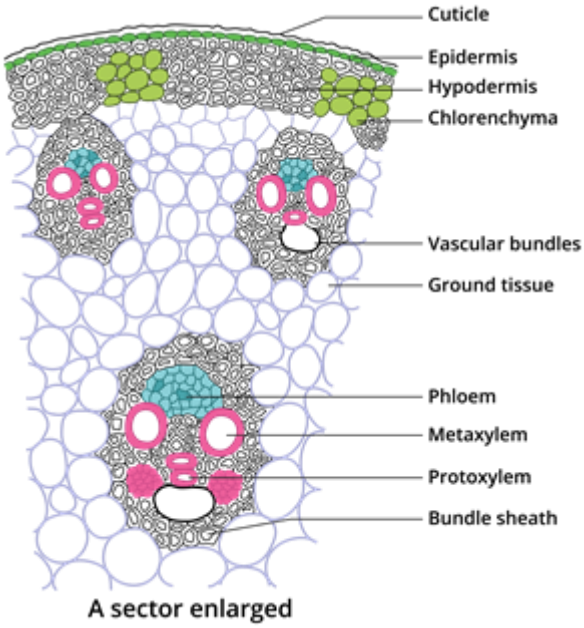
- **Epidermis**: Outermost protective layer, covered with a thin cuticle, may bear trichomes and few stomata.
- **Cortex**: Multiple cell layers between epidermis and pericycle, consisting of 3 sub-zones:
    1. **Hypodermis**: Outer zone just below epidermis, few layers of collenchyma, provides mechanical.
    2. **Cortical layers**: Below hypodermis, rounded thin-walled parenchyma cells with conspicuous intercellular spaces.
    3. **Endodermis**: Innermost layer, cells rich in starch grains, hence also called **starch sheath**.



- **Stele**: Consists of pericycle, vascular bundles, medullary rays, and pith.
    1. **Pericycle**: Inner to endodermis, above phloem, in semi-lunar patches of sclerenchyma.
    2. **Medullary rays**: Few layers of radially placed parenchyma cells between vascular bundles.
    3. **Vascular bundles**: Numerous, arranged in a ring (dicot stem-feature). Each is conjoint and open. with endarch protoxylem.
       Cambium: **Present** between xylem and phloem (*fascicular cambium*); later **interfascicular cambium** arises, forming a continuous **cambial ring** → secondary growth.
    4. **Pith**: Central portion, many rounded, parenchymatous cells with large intercellular spaces.

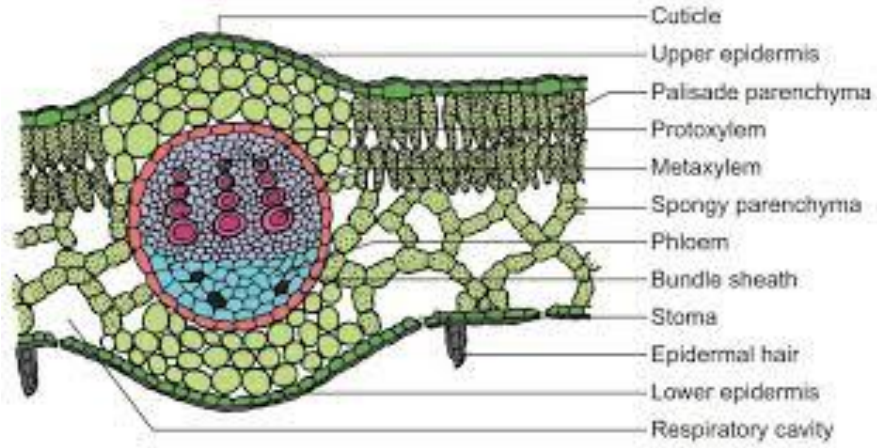


Monocotyledonous (Monocot) Stem



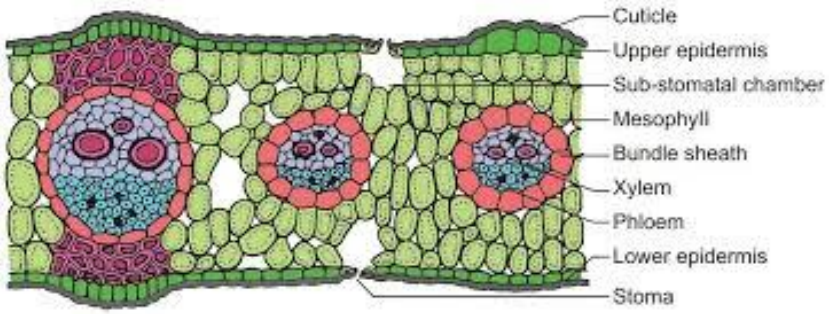
- **Epidermis**: Single outer protective layer with cuticle.
- **Hypodermis**: Sclerenchymatous, gives mechanical strength.
- **Ground tissue**: Large, undifferentiated, parenchymatous, occupies most of the stem.
- **Vascular bundles**: Numerous, scattered (atactostele), each surrounded by sclerenchymatous bundle sheath.
- Peripheral bundles smaller, central ones larger.
- Bundles are conjoint, collateral, **closed** (no cambium).
- Protoxylem is endarch; water-filled cavities present in vascular bundles due to lysed protoxylem.
- **Phloem parenchyma**: Absent.
- **Cambium**: Absent in vascular bundles (closed bundles) → no secondary growth.
- **Secondary growth**: Absent (except anomalous cases like *Dracaena*, *Yucca* due to secondary thickening meristem).

Dicotyledonous (Dorsiventral) Leaf



• **Epidermis**: Covers adaxial (upper) and abaxial (lower) surfaces; conspicuous cuticle present; abaxial side with more stomata, adaxial with fewer or none.
- **Mesophyll**: Parenchymatous tissue with chloroplasts, two types –
  - **Palisade parenchyma**: Adaxial, elongated, vertically arranged cells.
  - **Spongy parenchyma**: Below palisade, oval/round, loosely arranged with large air spaces, extends to lower epidermis.
- **Vascular system**: Veins and veinlets show reticulate venation; midrib prominent; vascular bundles surrounded by large, thick-walled bundle sheath of parenchymatous cells. **Conjoint, collateral, and closed**.
- **Leaf shape**: Broad, wide, with reticulate venation.

Monocotyledonous (Isobilateral) Leaf



- Its Anatomy is almost same as dicot leaf except as follow:
- **Epidermis**: Has stomata on both surfaces -adaxial (upper) and abaxial (lower).
- **Mesophyll**: Not differentiated into palisade and spongy parenchyma.
- The **bundle sheath**, which is prominent around the vein, is made up of parenchymatous cells, and often has sclerenchymatous cells on the outer side for support; Kranz anatomy is commonly seen in C4 monocot plants.
- In grasses, adaxial epidermal cells along the veins modify into large, empty, colourless cells called **Bulliform cells**. When they absorb water- become turgid, & the leaf surface is exposed. When they lose water- become flaccid, causing the leaves to curl inwards to minimize water loss.
- **Vascular bundles**: Similar in size, except for the main veins. Conjoint, collateral, and closed.
- Leaves are usually long & narrow with parallel venation & have nearly similar sizes of vascular bundles.