➢ Anatomy of Flowering Plants

1. What is Plant Anatomy?

Anatomy means the **study of the internal structure of plants**.
A plant is made up of:

- **Cells** → Smallest/basic units of a plant.
- **Tissues** → A group of similar cells working together.
- **Organs** → Different tissues working together to perform a function.
  Easy order:
  Cells → Tissues → Organs

Different organs of a plant have different internal structures.
Monocot plants and **dicot plants** also have different internal structures.
Plants can change their internal structure to **adapt to different environments**.

2. Tissue System

Plant tissues are arranged into **3 main tissue systems**:

1. **Epidermal tissue system**
2. **Ground/Fundamental tissue system**
3. **Vascular/Conducting tissue system**

3. Epidermal Tissue System

The **epidermal tissue system** is the **outer covering of the plant**.
Think of it like the **skin of our body**. It protects the plant from the outside environment.
It includes:

- **Epidermal cells** → Form the outer layer.
- **Stomata** → Small openings that help in gas exchange.
- **Trichomes** → Hair-like structures on the plant.
- **Hairs** → Protect the plant and may help reduce water loss.

Epidermis

- The **epidermis** is the **outermost layer** of the primary plant body.
- Its cells are usually **elongated**.
- The cells are **closely packed**, with very little space between them.

Epidermal Tissue System — Easy Notes
1. Epidermis

- **Epidermis** is the **outermost covering** of a plant.
- Its cells are arranged closely together and form a **continuous layer**.
- It is usually **single-layered**.
- Epidermal cells are **parenchymatous**.
- They have:
  - **Small amount of cytoplasm**
  - **Large vacuole**

Cuticle

- The outside of the epidermis is often covered by a **thick, waxy layer** called the **cuticle**.
- **Function:** Prevents excessive **water loss**.
- **Important:** Cuticle is **absent in roots**.

Remember:
Cuticle = Waxy layer = Prevents water loss

2. Stomata

- **Stomata** are small structures/openings present mainly in the **epidermis of leaves**.
- They help in:
  - **Gaseous exchange**
  - **Transpiration**

Guard Cells

Each stoma has **two guard cells**.

- In most plants, guard cells are **bean-shaped**.
- In **grasses**, guard cells are **dumb-bell shaped**.
- Guard cells surround the **stomatal pore**.

Stomatal pore = Opening between the two guard cells

Structure of Guard Cells

- Outer wall → **Thin**
- Inner wall → **Thick**
- Guard cells contain **chloroplasts**.

Function of Guard Cells

Guard cells control the **opening and closing of stomata**.

3. Subsidiary Cells

- Some epidermal cells near the guard cells become **specialised**.
- These are called **subsidiary cells**.
- They help in the functioning of the stomata.

4. Stomatal Apparatus

The following three together are called the **stomatal apparatus**:

Stomatal pore + Guard cells + Subsidiary cells

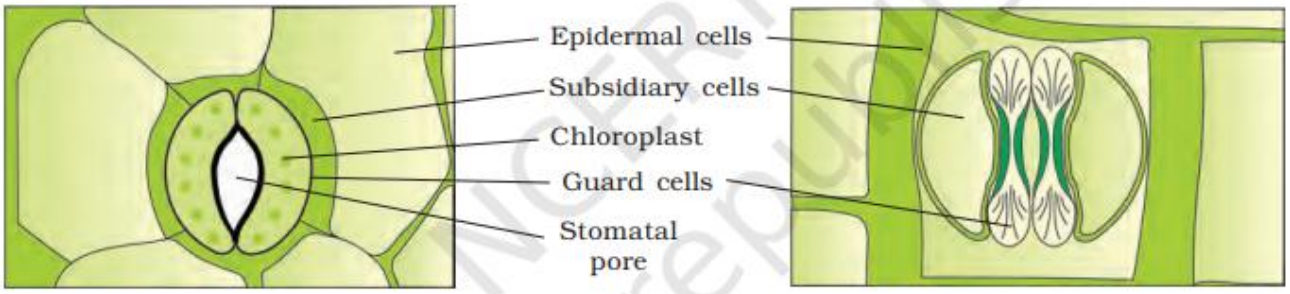


Figure 6.1 Diagrammatic representation: (a) stomata with bean-shaped guard cells (b) stomata with dumb-bell shaped guard cell

Epidermal Hairs and Trichomes

1. Root Hairs

- **Root hairs** are small, hair-like structures found on **roots**.
- They are **unicellular**, which means they are made of **one cell**.
- They are extensions of **epidermal cells**.
- Their main function is to **absorb water and minerals from the soil**.

Root hairs = Absorb water + minerals

2. Trichomes

- The hairs found on the **stem/shoot system** are called **trichomes**.
- Trichomes are usually **multicellular**, meaning they are made of **many cells**.
- They can be:
  - **Branched or unbranched**
  - **Soft or stiff**
  - Sometimes **secretory** (they can produce/secrete substances).

Function of Trichomes

- Trichomes help **reduce water loss** from the plant through **transpiration**.

Trichomes = Protect plant + Reduce water loss

❖ Root Hairs vs Trichomes

Feature	Root Hairs	Trichomes
Found on	**Roots**	**Stem/shoot**
Made of	**One cell**	Usually **many cells**
Main function	Absorb **water & minerals**	Reduce **water loss**
Shape	Hair-like	Branched/unbranched

❖ Ground Tissue System

What is Ground Tissue?

- **Ground tissue** includes **all tissues except**:
  - Epidermis
  - Vascular bundles
- It is mainly made up of **simple tissues**:

1. **Parenchyma**
2. **Collenchyma**
3. **Sclerenchyma**

➢ Where is Parenchyma Found?

In the primary stem and root, parenchymatous cells are commonly found in:

- **Cortex**
- **Pericycle**
- **Pith**
- **Medullary rays**

Ground Tissue in Leaves

- In leaves, the ground tissue contains **thin-walled cells**.
- These cells contain **chloroplasts**.
- This ground tissue is called **mesophyll**.

Leaf ground tissue = Mesophyll
Mesophyll = Thin-walled cells + Chloroplasts

❖ Vascular Tissue System

The vascular tissue system is made up of two **complex tissues**:

- **Xylem**
- **Phloem**

Vascular Bundle
Xylem + Phloem = Vascular bundle

Think of vascular bundles as the **transport system of the plant**.

- **Xylem** mainly transports **water and minerals**.
- **Phloem** mainly transports **food**.

❖ Open and Closed Vascular Bundles

1. Open Vascular Bundle

Found in **dicot stems**.

- **Cambium is present** between xylem and phloem.
- Because cambium is present, the bundle can form:
  - Secondary xylem
  - Secondary phloem
- Therefore, it is called an **open vascular bundle**.

Dicot = Cambium present = Open

2. Closed Vascular Bundle
Found in **monocots**.

- **Cambium is absent**.
- Therefore, secondary tissues are **not formed**.
- Hence, they are called **closed vascular bundles**.

Monocot = Cambium absent = Closed
DICOT → OPEN
MONOCOT → CLOSED

❖ Radial and Conjoint Vascular Bundles

1. Radial Vascular Bundle

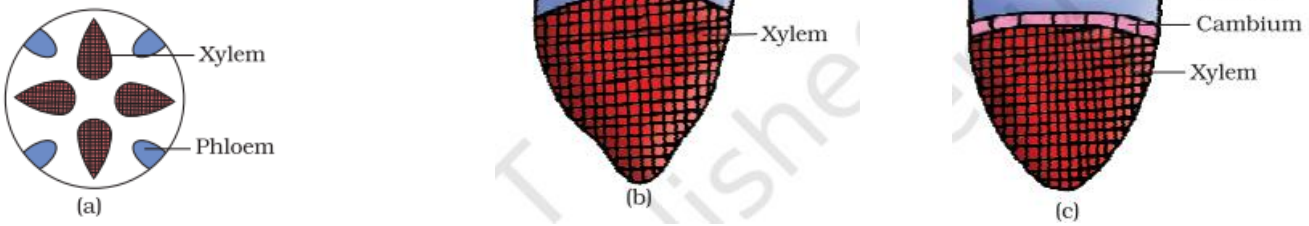
- In a radial vascular bundle, **xylem and phloem are arranged alternately** on different radii.
- It is commonly found in **roots**.

Radial → Root

2. Conjoint Vascular Bundle

- In a conjoint vascular bundle, **xylem and phloem are present together on the same radius**.
- It is commonly found in:
  - **Stems**
  - **Leaves**
- Usually, the **phloem is present on the outer side of the xylem**.

Conjoint → Stem + Leaf



Various types of vascular bundles : (a) radial (b) conjoint closed (c) conjoint open

❖ Anatomy of Dicotyledonous and Monocotyledonous Plants

To understand the internal structure of **roots, stems and leaves**, we study their **transverse section (T.S.)**.

T.S. = Transverse Section = Cross-section

Dicotyledonous Root
Example: **Sunflower root**
The main parts of a dicot root are:

Epiblema → Cortex → Endodermis → Pericycle → Vascular tissue → Pith

- **Epiblema**

➢ It is the **outermost layer** of the root.
➢ Some epiblema cells form **root hairs**.
➢ Root hairs are **unicellular**.
➢ They help absorb **water and minerals**.

- **Epiblema = Outer layer of root**

Cortex

- Cortex is made up of **many layers** of thin-walled parenchyma cells.
- There are **intercellular spaces** between the cells.

- **Cortex = Many layers of parenchyma**

Endodermis

- It is the **innermost layer of the cortex**.
- It is made up of **one layer of barrel-shaped cells**.
- There are **no intercellular spaces**.
- Its walls contain a waxy, water-resistant substance called **suberin**.
- Suberin forms **Casparian strips**.
- **Endodermis = Inner layer of cortex**
- **Casparian strips = Made of suberin**

Pericycle

- Pericycle is present **just inside the endodermis**.
- It consists of a few layers of thick-walled parenchymatous cells.
- It helps in the formation of:
  - **Lateral roots**
  - **Vascular cambium** during secondary growth.
- **Pericycle → Lateral roots + Vascular cambium**

Pith

- The pith of a dicot root is **small or inconspicuous**.
- **Dicot root → Small pith**

Conjunctive Tissue

- The parenchymatous tissue present **between xylem and phloem** is called **conjunctive tissue**.

Xylem and Phloem

- Dicot roots usually have **2–4 xylem and phloem patches**.
- Later, a **cambium ring** develops between xylem and phloem.

Stele

- All the tissues **inside the endodermis** together form the **stele**.
- Stele includes:

Pericycle + Vascular bundles + Pith

Inside Endodermis = Stele

❖ Monocotyledonous Root

The monocot root is similar to the dicot root in many ways.
It has:

- Epidermis
- Cortex
- Endodermis
- Pericycle
- Vascular bundles
- Pith

Important Differences

Dicot Root	Monocot Root
I. Usually **2–4 xylem bundles**	I. Usually **more than 6 xylem bundles**

Dicot Root	Monocot Root
II. Pith is **small**	II. Pith is **large and well-developed**
III. Secondary growth occurs	III. **No secondary growth**
IV. Xylem bundles are fewer	IV. Xylem bundles are **polyarch**

What is Polyarch?
Polyarch = More than 6 xylem bundles

Monocot root = Polyarch + Large pith + No secondary growth

Dicotyledonous Stem

A typical young dicot stem has an **epidermis** as its outermost layer.

1. Epidermis

- It is the **outermost protective layer**.
- It is covered by a **thin cuticle**.
- It may have:
  - **Trichomes**
  - A few **stomata**

Epidermis = Protection

2. Cortex

The tissue between the **epidermis and pericycle** forms the cortex.
The cortex has **3 parts**:

A. Hypodermis

- It is present **just below the epidermis**.
- It consists of a few layers of **collenchymatous cells**.
- It provides **mechanical strength** to the young stem.

Hypodermis = Collenchyma = Strength

B. Middle Cortical Layers

- These layers contain **rounded, thin-walled parenchyma cells**.
- They have noticeable **intercellular spaces**.

C. Endodermis

- It is the **innermost layer of the cortex**.
- Its cells contain many **starch grains**.
- Therefore, it is also called the **starch sheath**.

Endodermis of dicot stem = Starch sheath

❖ Monocotyledonous Stem

The main features of a monocot stem are:

- **Hypodermis:** Made of sclerenchyma Tous cells and provides strength.
- **Ground tissue:** Large and well developed.
- **Vascular bundles:** Numerous and **scattered** throughout the ground tissue.
- Each vascular bundle is surrounded by a **sclerenchymatous bundle sheath**.
- Vascular bundles are **conjoint and closed**.
- Peripheral vascular bundles are generally **smaller** than central ones.
- **Phloem parenchyma is absent.**
- **Water-containing cavities** are present inside vascular bundles.
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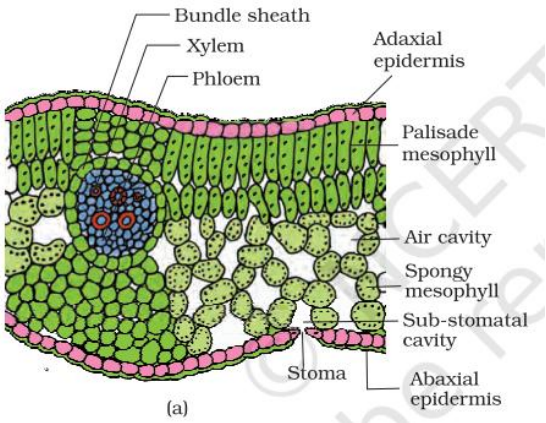


(a)

❖ Dorsiventral (Dicotyledonous) Leaf

A typical dicot leaf has **three main parts**:

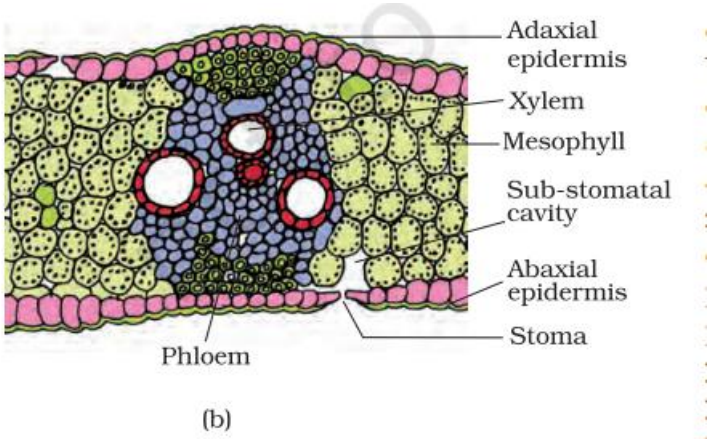
1. **Epidermis**
2. **Mesophyll**
3. **Vascular system**

Epidermis

- Covers both upper and lower surfaces of the leaf.
- Has a **cuticle** that reduces water loss.
- The lower surface usually has **more stomata**.
- The upper surface may have fewer stomata or even lack them.

Mesophyll

The tissue between the upper and lower epidermis is called **mesophyll**.
It contains chloroplasts and performs **photosynthesis**.
It has two types of cells:



(b)

A. Palisade Parenchyma

- Present below the **upper epidermis**.
- Cells are **long and elongated**.
- Cells are arranged closely and vertically.
- Rich in chloroplasts.
- Main site of photosynthesis.

B. Spongy Parenchyma

- Present below the palisade tissue.
- Cells are **round or oval**.
- Cells are loosely arranged.
- Large **intercellular spaces and air cavities** are present.
- Helps in gaseous exchange.

Vascular System

- Vascular bundles are present in the **veins and midrib**.
- Larger veins have larger vascular bundles.
- Dicot leaves generally show **reticulate venation**.
- Vascular bundles are surrounded by a **bundle sheath** made of thick-walled cells.

Position of Xylem in a Dicot Leaf

In the vascular bundle of a typical dicot leaf:

❖ Isobilateral (Monocotyledonous) Leaf

Important Features

1. Epidermis

- The leaf has **upper (adaxial) and lower (abaxial) epidermis**.
- **Stomata are present on both surfaces** of the leaf.
- This is an important difference from a typical dorsiventral dicot leaf.

2. Mesophyll

- The mesophyll contains chloroplasts and performs **photosynthesis**.
- Unlike a dicot leaf, it is **not differentiated into palisade and spongy parenchyma**.
- The mesophyll is therefore relatively uniform.

3. Bulliform Cells

- Bulliform cells are found especially in the leaves of **grasses**.
- They are **large, empty, colourless cells** present in the adaxial (upper) epidermis, usually along the veins.
- They help the leaf in **rolling or curling during water stress**.

When water is sufficient:

- Bulliform cells become **turgid**.
- The leaf remains **open/expanded**.

During water stress:

- Bulliform cells become **flaccid**.
- The leaf **curls inward**.
- This reduces the exposed surface and helps **minimise water loss**.

4. Vascular Bundles

- Monocot leaves generally have **parallel venation**.
- Vascular bundles are therefore arranged in a pattern corresponding to the parallel veins.
- Most vascular bundles are **nearly similar in size**, except those associated with the main veins.

❖ **Dicot Leaf vs Monocot Leaf**

Feature		Dicot Leaf	Monocot Leaf
I.	**Type**	Dorsiventral	Isobilateral
II.	**Stomata**	Usually more on lower surface	Present on both surfaces
III.	**Mesophyll**	Differentiated into palisade and spongy	Not differentiated
IV.	**Bulliform cells**	Generally absent	Present, especially in grasses
V.	**Venation**	Reticulate	Parallel
VI.	**Leaf curling**	Not a typical bulliform-cell mechanism	Bulliform cells help in curling

Q1. How is the study of plant anatomy useful to us?

Ans: The study of plant anatomy is useful because:

- It helps us understand the **internal structure of plants**.
- It helps in the **identification and classification of plants**.
- It helps us understand the **functions of different tissues and organs**.
- It helps in understanding **plant growth and development**.
- It helps us study the **adaptation of plants to different environments**.
- It is useful in **agriculture and crop improvement**.
- It provides useful information for **plant breeding and biotechnology**.