FREE EDITION · NOTES + 3 SAMPLE MCQS

CUET · BIOLOGY · CLASS XI · CODE 304

Anatomy of Flowering Plants

CUET unit: Structural Organisation in Plants and Animals → Anatomy of Flowering Plants

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Anatomy is the study of the internal structure of plants; cells form tissues, tissues form organs, and different organs (root, stem, leaf) show distinctive internal organisation.
- Plant tissues fall into three tissue systems — epidermal, ground (fundamental) and vascular — each examined through transverse sections.
- Within angiosperms, monocots and dicots differ anatomically in roots, stems and leaves.
- CUET routinely tests (a) identification of T.S. images, (b) vascular-bundle classification (radial/conjoint, open/closed, endarch/exarch), and (c) one-line distinguishing features (e.g. polyarch monocot root, scattered monocot stem bundles, kranz/bulliform cells in grasses).

📖 Detailed Notes

2.1 Core concepts

- **Anatomy defined.** Study of the internal structure of plants is called anatomy. Plants have cells as the basic unit, organised into tissues, and tissues organised into organs. Different organs in a plant show differences in internal structure; within angiosperms, monocots and dicots are also anatomically different, and internal structures show adaptations to diverse environments (NCERT Ch. 6 intro, p. 71).
- **Three tissue systems.** On the basis of structure and location, plant tissues are grouped into three tissue systems — the **epidermal tissue system**, the **ground (fundamental) tissue system** and the **vascular (conducting) tissue system** (NCERT §6.1, p. 71).
- **Epidermal tissue system.** Forms the outermost covering of the whole plant body and comprises **epidermal cells, stomata** and the **epidermal appendages** — the **trichomes** and hairs. The **epidermis** is the outermost layer of the primary plant body, usually single-layered, made of elongated, compactly arranged parenchymatous cells with a small amount of cytoplasm lining the cell wall and a large vacuole (NCERT §6.1.1, pp. 71–72).
- **Cuticle, stomata, guard cells and subsidiary cells.** A **waxy thick layer called the cuticle** covers the outside of the epidermis to prevent water loss; cuticle is **absent in roots**. **Stomata** are structures in leaf epidermis that regulate

transpiration and gaseous exchange. Each stoma is composed of two **bean-shaped guard cells** enclosing a stomatal pore; in **grasses, the guard cells are dumb-bell shaped**. The outer walls of guard cells (away from the pore) are thin and the inner walls (towards the pore) are highly thickened; guard cells possess **chloroplasts** and regulate stomatal opening and closing. Surrounding epidermal cells specialised in shape and size are **subsidiary cells**. The stomatal aperture, guard cells and surrounding subsidiary cells together form the **stomatal apparatus** (NCERT §6.1.1, p. 72, Figure 6.1).

- **Trichomes and root hairs.** The cells of epidermis bear a number of hairs. **Root hairs** are unicellular elongations of the epidermal cells that absorb water and minerals from soil. On the stem the epidermal hairs are called **trichomes** — usually multicellular, branched or unbranched, soft or stiff, sometimes secretory, helping prevent water loss due to transpiration (NCERT §6.1.1, p. 72).
- **Ground tissue system.** All tissues except epidermis and vascular bundles constitute the **ground tissue**. It consists of simple tissues such as **parenchyma, collenchyma and sclerenchyma**. Parenchymatous cells are usually present in cortex, pericycle, pith and medullary rays in primary stems and roots. In leaves, the ground tissue consists of thin-walled chloroplast-containing cells and is called **mesophyll** (NCERT §6.1.2, p. 72).
- **Vascular tissue system.** Made of complex tissues — the **phloem** and the **xylem**. Together they constitute **vascular bundles**. In dicotyledonous stems, **cambium** is present between phloem and xylem, so the bundle can form secondary xylem and phloem and is called an **open vascular bundle**. In monocotyledons the bundles lack cambium and so cannot form secondary tissues; they are **closed**. When xylem and phloem are arranged in an alternate manner along **different radii**, the arrangement is **radial** (typical of roots). In **conjoint** bundles xylem and phloem are jointly situated along the **same radius** of vascular bundles; such bundles are common in stems and leaves, and the phloem is usually located only on the outer side of the xylem (NCERT §6.1.3, p. 73, Figure 6.2).
- **Dicotyledonous Root (T.S.).** Outermost layer is the **epiblema**; many of its cells protrude as unicellular root hairs. **Cortex** consists of several layers of thin-walled parenchyma with intercellular spaces. The innermost layer of cortex is the **endodermis** — a single layer of barrel-shaped cells without intercellular spaces. The tangential as well as radial walls of endodermal cells have a deposition of water-impermeable, waxy material **suberin** in the form of **casparian strips**. Next to endodermis lies the **pericycle** — a few layers of thick-walled parenchyma; initiation of lateral roots and vascular cambium during secondary growth takes place in these cells. The **pith** is small or inconspicuous. The parenchymatous cells between xylem and phloem are **conjunctive tissue**. There are usually **two to four xylem and phloem patches**. Later, a cambium ring develops between xylem and phloem. All tissues on the inner side of the endodermis (pericycle, vascular bundles and pith) together constitute the **stele** (NCERT §6.2.1, pp. 73–74, Figure 6.3a).

- **Monocotyledonous Root (T.S.).** Anatomy of the monocot root is similar to that of the dicot root in many respects — it has epidermis, cortex, endodermis, pericycle, vascular bundles and pith. Differences: compared to dicot roots, monocot roots usually have **more than six (polyarch) xylem bundles**, a **large and well-developed pith**, and they **do not undergo secondary growth** (NCERT §6.2.2, p. 74, Figure 6.3b).
- **Dicotyledonous Stem (T.S.).** The **epidermis** is the outermost protective layer covered with a thin layer of cuticle; it may bear trichomes and a few stomata. **Cortex** lies in three sub-zones — the outer **hypodermis** of a few layers of collenchymatous cells providing mechanical strength to the young stem; the **cortical layers** of rounded, thin-walled parenchymatous cells with conspicuous intercellular spaces below the hypodermis; and the innermost cortical layer, the **endodermis**, whose cells are rich in starch grains — this layer is also referred to as the **starch sheath**. The **pericycle** is present on the inner side of endodermis and above the phloem as **semi-lunar patches of sclerenchyma**. Between vascular bundles lie a few layers of radially placed parenchymatous cells — the **medullary rays**. The vascular bundles are arranged in a **ring** — a characteristic of the dicot stem. Each vascular bundle is **conjoint, open**, with **endarch protoxylem**. A large number of rounded, parenchymatous cells with large intercellular spaces occupy the centre — the **pith** (NCERT §6.2.3, pp. 74–76, Figure 6.4a).
- **Monocotyledonous Stem (T.S.).** Sclerenchymatous **hypodermis**; a **large number of scattered vascular bundles**, each surrounded by a sclerenchymatous **bundle sheath**; a large, conspicuous parenchymatous **ground tissue**. Vascular bundles are **conjoint and closed**. Peripheral vascular bundles are generally smaller than the centrally located ones. **Phloem parenchyma is absent**, and **water-containing cavities** are present within the vascular bundles (NCERT §6.2.4, p. 76, Figure 6.4b).
- **Dorsiventral (Dicotyledonous) Leaf.** Vertical section through the lamina shows three main parts — **epidermis, mesophyll and vascular system**. The epidermis covering both the upper (**adaxial**) and lower (**abaxial**) surfaces has a conspicuous cuticle; the abaxial epidermis generally bears more stomata than the adaxial epidermis, which may even lack stomata. The tissue between the upper and the lower epidermis is the **mesophyll** — chloroplast-bearing parenchyma carrying out photosynthesis — made up of two cell types: the adaxial **palisade parenchyma** (elongated cells arranged vertically and parallel) and the **spongy parenchyma** below (oval/round cells loosely arranged with numerous large air spaces and air cavities). The **vascular system** includes vascular bundles in veins and the midrib — sizes vary with vein thickness in reticulate venation. Vascular bundles are surrounded by a layer of thick-walled **bundle sheath cells** (NCERT §6.2.5, pp. 76–77, Figure 6.5a).
- **Isobilateral (Monocotyledonous) Leaf.** Similar to the dorsiventral leaf in many ways but shows characteristic differences: **stomata are present on both surfaces** of the epidermis, and the **mesophyll is not differentiated** into palisade and spongy parenchyma. In **grasses**, certain adaxial epidermal cells along the veins

modify into large, empty, colourless cells called **bulliform cells** — when turgid (after absorbing water) the leaf surface is exposed; when **flaccid due to water stress**, they make the leaves curl inwards to minimise water loss. The parallel venation in monocot leaves is reflected in near-similar sizes of vascular bundles (except in main veins) (NCERT §6.2.6, p. 77, Figure 6.5b).

- **Tissue overview (summary).** Anatomically, plant tissues are classified into **meristematic** (apical, lateral and intercalary) and **permanent** (simple and complex). Assimilation of food and its storage, transportation of water/minerals/ photosynthates, and mechanical support are the main functions of tissues. There are three tissue systems — epidermal, ground and vascular. The ground tissue system forms the main bulk of the plant and is divided into cortex, pericycle and pith. The vascular tissue system is formed by xylem and phloem; on the basis of presence of cambium, and location of xylem and phloem, the vascular bundles are of different types. Monocot and dicot plants show marked variation in their internal structures and secondary growth occurs in most dicot roots and stems (NCERT Summary, p. 77).

2.2 Definitions to memorise

Term	Definition	Page
Anatomy	Study of the internal structure of plants.	71
Epidermis	Outermost, usually single-layered, parenchymatous covering of the primary plant body.	71–72
Cuticle	Waxy thick layer outside the epidermis that prevents water loss; absent in roots.	72
Stomata	Pores in leaf epidermis bounded by guard cells; regulate transpiration and gaseous exchange.	72
Guard cells	Two bean-shaped (dumb-bell in grasses) chloroplast-bearing cells with thin outer and thickened inner walls that enclose the stomatal pore.	72
Subsidiary cells	Specialised epidermal cells around the guard cells.	72
Stomatal apparatus	Stomatal aperture + guard cells + subsidiary cells.	72
Root hair	Unicellular elongation of an epidermal cell that absorbs water and minerals.	72
Trichome	Multicellular epidermal hair on the shoot; prevents transpiration loss.	72
Ground tissue	All tissues except epidermis and vascular bundles; includes parenchyma, collenchyma, sclerenchyma.	72
Mesophyll	Chloroplast-containing parenchymatous ground tissue of the leaf.	72

Term	Definition	Page
Vascular bundle	Xylem + phloem (with/without cambium) forming the conducting unit.	73
Open vascular bundle	Bundle with cambium between xylem and phloem; can form secondary tissues (dicot stem).	73
Closed vascular bundle	Bundle without cambium; no secondary growth (monocot).	73
Radial bundle	Xylem and phloem on alternate radii (typical of roots).	73
Conjoint bundle	Xylem and phloem on the same radius, phloem usually outside xylem (stems, leaves).	73
Casparian strips	Deposition of waxy suberin on tangential and radial walls of endodermal cells.	74
Pericycle	Layer of thick-walled parenchyma inside endodermis; initiates lateral roots and vascular cambium.	74
Conjunctive tissue	Parenchymatous cells lying between xylem and phloem in dicot root.	74
Stele	All tissues inside the endodermis — pericycle, vascular bundles and pith.	74
Polyarch	Condition of having more than six xylem bundles (monocot root).	74
Starch sheath	Starch-rich endodermis of the dicot stem.	75
Endarch protoxylem	Protoxylem lying towards the centre (dicot stem).	76
Bundle sheath	Sclerenchymatous (stem) or thick-walled (leaf) cells surrounding a vascular bundle.	76–77
Bulliform cells	Large, empty, colourless adaxial epidermal cells in grasses that curl the leaf under water stress.	77

2.3 Diagrams / processes to remember

- **Figure 6.1 (p. 72)** — Stomatal apparatus: (a) bean-shaped guard cells, (b) dumb-bell shaped guard cells (grasses). Note labels: epidermal cells, subsidiary cells, guard cells, stomatal pore, chloroplast.
- **Figure 6.2 (p. 73)** — Types of vascular bundles: (a) radial, (b) conjoint closed (no cambium), (c) conjoint open (cambium between xylem and phloem).
- **Figure 6.3 (p. 74)** — T.S. of (a) Dicot root showing 2–4 xylem patches, small pith; (b) Monocot root showing polyarch xylem (>6 bundles) and large pith.
- **Figure 6.4 (p. 75)** — T.S. of stems: (a) Dicot — ring of vascular bundles, collenchymatous hypodermis, medullary rays, cambium visible in each bundle; (b) Monocot — scattered vascular bundles in parenchymatous ground tissue.

- **Figure 6.5 (p. 76)** — T.S. of leaves: (a) Dorsiventral (dicot) — palisade above spongy mesophyll, bundle sheath, sub-stomatal cavity; (b) Isobilateral (monocot) — undifferentiated mesophyll, stomata on both surfaces.

2.4 Common confusions / NTA trap points

- **Open vs closed** refers to the presence/absence of **cambium**, not to whether the bundle is exposed; "open" = cambium present (dicot stem), "closed" = cambium absent (monocot).
- **Radial vs conjoint** is about the geometric arrangement (alternate radii vs same radius), not about open/closed. Roots are radial; stems and leaves are conjoint.
- **Polyarch** is specific to **monocot roots** (>6 xylem bundles). Dicot roots typically have only 2–4 xylem patches.
- **Starch sheath** is the dicot **stem** endodermis (rich in starch grains); the dicot **root** endodermis is characterised by **casparian strips**, not starch.
- **Bulliform cells** are restricted to grasses (monocot leaves) and aid leaf curling — students often confuse them with subsidiary cells or guard cells.
- **Phloem parenchyma is absent** in monocot stems — a favourite NTA distractor when the question lists features of a T.S. specimen.
- **Endarch protoxylem** in the dicot stem versus **exarch** condition in roots (NCERT mentions endarch in the dicot stem specifically; the root has alternate xylem/phloem).
- **Cuticle is absent in roots** — distractors often add a cuticle to root epidermis.
- **Guard cells in grasses are dumb-bell shaped**, NOT bean-shaped — chapter explicitly contrasts the two.
- **Medullary rays vs conjunctive tissue** — medullary rays are between vascular bundles in dicot stem; conjunctive tissue lies between xylem and phloem in dicot root.

2.5 Comparative anatomical features (NCERT-cited)

Feature	Dicot root	Monocot root	Dicot stem	Monocot stem	Dorsiventral leaf	Isobila leaf
Outer covering	Epiblema with unicellular root hairs	Epiblema with root hairs	Epidermis with cuticle, trichomes, few stomata	Epidermis	Adaxial + abaxial epidermis with cuticle	Both surface with cu
Hypodermis	—	—	Collenchymatous	Sclerenchymatous	—	—
Endodermis	Single-layered,	Single-layered,	Starch sheath (starch-rich)	—	—	—

Feature	Dicot root	Monocot root	Dicot stem	Monocot stem	Dorsiventral leaf	Isobila leaf
	casparian strips	casparian strips				
Pericycle	Thick-walled parenchyma → lateral roots, cambium	Present	Semi-lunar sclerenchyma patches	—	—	—
Vascular bundle type	Radial	Radial	Conjoint, open (cambium)	Conjoint, closed (no cambium)	Conjoint with bundle sheath	Conjoi bundle sheath
Xylem bundles	2–4 patches	>6 (polyarch)	Endarch protoxylem; ring of bundles	Scattered bundles	In veins	In veins
Cambium ring	Develops later for secondary growth	Absent (no secondary growth)	Present in each bundle	Absent	—	—
Pith	Small, inconspicuous	Large, well-developed	Large parenchymatous with intercellular spaces	Replaced by scattered bundles + ground tissue	—	—
Bundle sheath	—	—	—	Sclerenchymatous	Thick-walled around bundles	Around bundles
Phloem parenchyma	Present	Present	Present	Absent	Present	Present
Water-containing cavities	—	—	—	Within vascular bundles	—	—
Mesophyll	—	—	—	—	Differentiated into palisade + spongy	Not differer
Stomata distribution	—	—	—	—	Mostly abaxial (adaxial may lack)	On bot surface
Bulliform cells	—	—	—	—	Absent	Present grasses leaves water s

Feature	Dicot root	Monocot root	Dicot stem	Monocot stem	Dorsiventral leaf	Isobila leaf
Secondary growth	Occurs	Does not occur	Occurs	Does not occur	—	—
Venation reflection	—	—	—	—	Reticulate (varying bundle sizes)	Parallel (near-s bundle

🎯 Practice MCQs

Q1. Which of the following correctly defines an "open" vascular bundle as used in this chapter?

A. A vascular bundle in which xylem and phloem lie on alternate radii

B. A vascular bundle that possesses cambium between xylem and phloem and can form secondary tissues

C. A vascular bundle surrounded by a sclerenchymatous bundle sheath

D. A vascular bundle in which phloem parenchyma is absent

Q2. Match the tissue/structure in Column I with its correct description in Column II. | Column I | Column II | |---|---| | P. Casparian strips | 1. Large, empty, colourless adaxial cells in grasses | | Q. Conjunctive tissue | 2. Suberin deposition on tangential and radial walls of endodermis | | R. Bulliform cells | 3. Parenchyma lying between xylem and phloem in dicot root | | S. Starch sheath | 4. Endodermis of dicot stem |

A. P-2, Q-3, R-1, S-4

B. P-3, Q-2, R-4, S-1

C. P-2, Q-4, R-1, S-3

D. P-1, Q-3, R-2, S-4

Q3. A transverse section of a plant organ shows: vascular bundles conjoint, scattered throughout the ground tissue, each surrounded by a sclerenchymatous bundle sheath, phloem parenchyma absent, and water-containing cavities inside the bundles. The organ is best identified as a:

A. Dicot root

B. Dicot stem

C. Monocot stem

D. Monocot root

📊 PYQ Alignment

CUET (UG) Biology routinely sets 1–2 questions per year from this chapter, typically image/T.S.-identification ("which features point to a monocot stem?"), one-line definition recall (casparian strips, bulliform cells, stomatal apparatus, conjunctive tissue, endarch protoxylem), and assertion–reason items contrasting dicot vs monocot anatomy. Across CUET 2023–25 this topic has averaged roughly the target ~8-question cycle when bundled with related units, so mastery of the labelled diagrams of Figs. 6.3, 6.4 and 6.5 yields direct mark return.