Chapter 6: Anatomy of Flowering Plants

Exercises — Exercises

Q1 Draw illustrations to bring out the anatomical difference between (a) Monocot root and Dicot root (b) Monocot stem and Dicot stem

SOLUTION

(a) Monocot root vs. Dicot root — key anatomical differences:

Dicot root (e.g., sunflower):
- Outermost layer: epiblema with unicellular root hairs
- Cortex: several layers of thin-walled parenchyma with intercellular spaces
- Endodermis: single layer of barrel-shaped cells with Casparian strips (suberin deposits)
- Pericycle: few layers of thick-walled parenchymatous cells
- Vascular bundles: 2–4 xylem patches alternating with 2–4 phloem patches (few, exarch, radial arrangement)
- Pith: small or inconspicuous
- Undergoes secondary growth via cambium that develops between xylem and phloem

Monocot root (e.g., maize):
- Same general layers: epiblema, cortex, endodermis, pericycle
- Vascular bundles: more than six xylem bundles (polyarch), alternating with phloem
- Pith: large and well developed
- No secondary growth

Diagram labels for Dicot root T.S.: Root hair → Epidermis (epiblema) → Cortex → Endodermis (Casparian strip) → Pericycle → Phloem → Protoxylem → Metaxylem → Pith (small)

Diagram labels for Monocot root T.S.: Root hair → Epidermis → Cortex → Endodermis → Pericycle → Phloem → Protoxylem → Metaxylem → Pith (large, well developed); note: many xylem bundles (polyarch)

(b) Monocot stem vs. Dicot stem — key anatomical differences:

Dicot stem (e.g., sunflower):
- Epidermis with cuticle; may bear trichomes and stomata
- Cortex in three sub-zones: outer hypodermis (collenchymatous), middle

parenchyma, inner endodermis (starch sheath)
- Pericycle: semi-lunar patches of sclerenchyma above each phloem group
- Vascular bundles: arranged in a ring, conjoint, open (cambium present), endarch protoxylem
- Medullary rays: radially placed parenchyma between vascular bundles
- Pith: large, parenchymatous, centrally located

Monocot stem (e.g., maize):
- Epidermis with cuticle; no distinct cortex or pericycle
- Hypodermis: sclerenchymatous (provides mechanical strength)
- Vascular bundles: numerous, scattered throughout the ground tissue, each enclosed in sclerenchymatous bundle sheath; conjoint and closed (no cambium)
- Peripheral bundles smaller than central ones
- Phloem parenchyma absent; water-containing cavities present within vascular bundles
- Ground tissue: large parenchymatous mass; no distinct cortex, pith or medullary rays

Diagram labels for Dicot stem T.S.: Epidermis → Hypodermis (collenchyma) → Cortex (parenchyma) → Endodermis (starch sheath) → Pericycle (sclerenchyma patches) → Phloem → Cambium → Metaxylem → Protoxylem → Medullary rays → Pith

Diagram labels for Monocot stem T.S.: Epidermis → Sclerenchymatous hypodermis → Ground tissue (parenchyma) → Scattered vascular bundles (each with bundle sheath) → Phloem → Xylem → Water cavity

Answer: (a) Dicot root: 2–4 xylem/phloem patches, small pith, undergoes secondary growth. Monocot root: polyarch (>6) xylem bundles, large pith, no secondary growth. (b) Dicot stem: vascular bundles in a ring, conjoint open (with cambium), collenchymatous hypodermis, distinct cortex/pith. Monocot stem: vascular bundles scattered, conjoint closed (no cambium), sclerenchymatous hypodermis, no distinct pith.

Q2 Cut a transverse section of young stem of a plant from your school garden and observe it under the microscope. How would you ascertain whether it is a monocot stem or a dicot stem? Give reasons.

SOLUTION

The following features in the T.S. allow identification:

1. Arrangement of vascular bundles:
   - Dicot stem: vascular bundles are arranged in a ring (circular arrangement) around the pith.
   - Monocot stem: vascular bundles are scattered throughout the ground tissue with no definite ring pattern.

2. Nature of vascular bundles (open vs. closed):
   - Dicot stem: each vascular bundle is open — cambium is present between xylem and phloem. This allows secondary growth.
   - Monocot stem: vascular bundles are closed — no cambium is present. No secondary growth occurs.

3. Bundle sheath:
   - Dicot stem: bundle sheath is absent (pericycle forms semi-lunar sclerenchyma patches above phloem).
   - Monocot stem: each vascular bundle is surrounded by a sclerenchymatous bundle sheath.

4. Hypodermis:
   - Dicot stem: hypodermis is collenchymatous (flexible support).
   - Monocot stem: hypodermis is sclerenchymatous (rigid support).

5. Pith and cortex:
   - Dicot stem: distinct cortex and large central pith separated by the ring of vascular bundles.
   - Monocot stem: no distinct cortex, pith or medullary rays; the entire interior is ground tissue.

6. Phloem parenchyma:
   - Dicot stem: phloem parenchyma is present.
   - Monocot stem: phloem parenchyma is absent.

Conclusion: If the section shows scattered vascular bundles with sclerenchymatous bundle sheaths, closed bundles, and sclerenchymatous hypodermis → monocot stem. If vascular bundles are arranged in a ring, open

(with cambium), and there is a distinct collenchymatous hypodermis and pith → dicot stem.

Answer: Monocot stem: scattered vascular bundles, closed (no cambium), sclerenchymatous bundle sheaths and hypodermis, no distinct pith/cortex. Dicot stem: vascular bundles in a ring, open (cambium present), collenchymatous hypodermis, distinct cortex and pith.

Q3 The transverse section of a plant material shows the following anatomical features - (a) the vascular bundles are conjoint, scattered and surrounded by a sclerenchymatous bundle sheaths. (b) phloem parenchyma is absent. What will you identify it as?

SOLUTION

The given anatomical features — conjoint vascular bundles that are scattered (not in a ring) and enclosed by sclerenchymatous bundle sheaths, combined with the absence of phloem parenchyma — are the defining characteristics of a monocotyledonous stem.

Reasoning:
- Conjoint vascular bundles (xylem and phloem on the same radius) are found in stems and leaves, not roots.
- Scattered arrangement (as opposed to a ring) is exclusive to monocot stems.
- Sclerenchymatous bundle sheath surrounding each vascular bundle is a hallmark of monocot stems.
- Absence of phloem parenchyma is a specific characteristic of monocot stems.

Therefore, the plant material is a monocotyledonous stem (e.g., maize/Zea mays stem).

Answer: It is a monocotyledonous stem. The scattered conjoint vascular bundles with sclerenchymatous bundle sheaths and absent phloem parenchyma are the diagnostic features of a monocot stem.

Q4 What is stomatal apparatus? Explain the structure of stomata with a labelled diagram.

SOLUTION

Stomatal apparatus:

The stomatal aperture (pore), the guard cells surrounding it, and the neighbouring subsidiary cells together constitute the stomatal apparatus.

Structure of stomata:

1. Guard cells:
   - Each stoma is bounded by two guard cells.
   - In most dicots: guard cells are bean-shaped (kidney-shaped).
   - In grasses (monocots): guard cells are dumb-bell shaped.
   - The inner walls of guard cells (facing the stomatal pore) are heavily thickened; the outer walls (away from the pore) are thin. This differential thickening is key to the opening/closing mechanism.
   - Guard cells contain chloroplasts and can perform photosynthesis.
   - Guard cells regulate the opening and closing of stomata in response to light, CO_2 concentration, and water availability.

2. Stomatal pore:
   - The aperture enclosed by the two guard cells.
   - Regulates transpiration and gaseous exchange (CO_2 in, O_2 out during photosynthesis; vice versa during respiration).

3. Subsidiary cells (accessory cells):
   - Certain epidermal cells in the vicinity of guard cells become specialised in shape and size.
   - They surround the guard cells and assist in the opening/closing movements.

4. Epidermal cells:
   - The general epidermal cells form the backdrop; they lack chloroplasts (unlike guard cells).

Diagram labels (T.S./surface view of stomata):
- Epidermal cells (outer layer, no chloroplasts)
- Subsidiary cells (flanking the guard cells)
- Guard cells (bean-shaped or dumb-bell shaped, with chloroplasts)
- Stomatal pore (aperture between the guard cells)
- Chloroplast (within guard cells)

- Thickened inner wall of guard cell (towards pore)
- Thin outer wall of guard cell (away from pore)

Answer: The stomatal apparatus consists of the stomatal pore, the two guard cells (bean-shaped in dicots, dumb-bell shaped in grasses) and the surrounding subsidiary cells. Guard cells have thickened inner walls, contain chloroplasts, and control pore opening/closing to regulate transpiration and gaseous exchange.

Q5 Name the three basic tissue systems in the flowering plants. Give the tissue names under each system.

SOLUTION

The three basic tissue systems in flowering plants are:

1. Epidermal Tissue System:
   - Epidermis (epidermal cells)
   - Stomata (guard cells and subsidiary cells)
   - Epidermal appendages: trichomes (on shoot) and root hairs (on root)

2. Ground (Fundamental) Tissue System:
   - Parenchyma (in cortex, pith, pericycle, medullary rays; as mesophyll in leaves)
   - Collenchyma (in hypodermis of dicot stems)
   - Sclerenchyma (in hypodermis of monocot stems, bundle sheaths, etc.)

3. Vascular (Conducting) Tissue System:
   - Xylem (tracheids, vessels, xylem parenchyma, xylem fibres)
   - Phloem (sieve tube elements, companion cells, phloem parenchyma, phloem fibres)

Answer: 1. Epidermal tissue system — epidermis, stomata, trichomes/root hairs. 2. Ground tissue system — parenchyma, collenchyma, sclerenchyma. 3. Vascular tissue system — xylem and phloem.

Q6 How is the study of plant anatomy useful to us?

SOLUTION

The study of plant anatomy (the internal structure of plants) is useful in several ways:

1. Understanding plant function: Knowledge of internal tissue organisation helps explain physiological processes such as water conduction (xylem), food

translocation (phloem), gas exchange (stomata), and support (collenchyma, sclerenchyma).

2. Identifying plant groups: Anatomical features reliably distinguish monocots from dicots (e.g., arrangement of vascular bundles, type of bundle sheaths, secondary growth), and primary from secondary structures. This aids systematic classification.

3. Understanding adaptations: Internal anatomy reveals how plants adapt to their environment — e.g., thick cuticle and sunken stomata in xerophytes, aerenchyma in hydrophytes.

4. Commercial and economic applications: Knowledge of wood anatomy (secondary xylem) is essential for timber identification, quality assessment, and industrial use. Fibre-yielding plants (jute, cotton) are understood better through anatomical study.

5. Agriculture and horticulture: Understanding vascular anatomy guides grafting compatibility between rootstock and scion (both must have open vascular bundles for the cambium to fuse). Anatomical knowledge also aids in developing disease-resistant varieties.

6. Forensic botany and palaeobotany: Anatomy helps identify plant fragments in forensic investigations and fossil plant material in palaeobotanical studies.

7. Pharmacognosy: Identification and quality control of crude drugs (plant-based medicines) relies heavily on anatomical features of stems, roots, and leaves.

Answer: Plant anatomy helps us understand physiological functions (conduction, support, gas exchange), classify plants (monocot vs. dicot), understand environmental adaptations, identify timber and drug-yielding plants, and guide practices like grafting in agriculture.

Q7 Describe the internal structure of a dorsiventral leaf with the help of labelled diagrams.

SOLUTION

A dorsiventral leaf is a dicotyledonous leaf with two distinct surfaces — the adaxial (upper/dorsal) and abaxial (lower/ventral) surfaces — differing in anatomy.

The vertical (transverse) section through the lamina shows three main regions:

1. Epidermis:

- Adaxial epidermis (upper surface): single layer of compactly arranged cells covered by a thick cuticle; fewer stomata or no stomata.
- Abaxial epidermis (lower surface): single layer; thinner cuticle; bears more stomata than the adaxial surface.
- Stomata are of the usual type with bean-shaped guard cells.

2. Mesophyll (ground tissue between the two epidermal layers):

a. Palisade parenchyma:

- Located just below the adaxial epidermis.
- Cells are elongated and cylindrical, arranged vertically and parallel to each other (like a palisade fence).
- Rich in chloroplasts; primary site of photosynthesis.

b. Spongy parenchyma:

- Located below the palisade parenchyma and extends to the abaxial epidermis.
- Cells are oval or round, loosely arranged with numerous large air spaces and air cavities.
- Fewer chloroplasts than palisade cells; important for gaseous exchange.

3. Vascular System (veins and midrib):

- Vascular bundles run through the mesophyll and are of varying sizes depending on vein size (reticulate venation in dicots produces veins of different thickness).
- Each vascular bundle consists of xylem (adaxial side — upper) and phloem (abaxial side — lower).
- Vascular bundles are surrounded by a layer of thick-walled bundle sheath cells.
- The midrib has the largest vascular bundle.

Diagram labels for T.S. of dorsiventral leaf:

- Cuticle
- Adaxial epidermis (upper epidermis)
- Palisade parenchyma (elongated cells with many chloroplasts)
- Spongy parenchyma (loosely arranged cells with air spaces)
- Air cavity / intercellular space
- Sub-stomatal cavity
- Stoma (with guard cells)

- Abaxial epidermis (lower epidermis)
- Vascular bundle (in the vein / midrib):
  - Xylem (towards adaxial/upper side)
  - Phloem (towards abaxial/lower side)
- Bundle sheath (around the vascular bundle)

Answer: A dorsiventral leaf has: (1) Adaxial epidermis (thick cuticle, fewer stomata) and abaxial epidermis (more stomata); (2) Mesophyll differentiated into palisade parenchyma (elongated, chloroplast-rich cells, adaxial side) and spongy parenchyma (loosely packed with air spaces, abaxial side); (3) Vascular bundles of varying size (reticulate venation) with xylem adaxially and phloem abaxially, each surrounded by bundle sheath cells.