# Chapter 5: Morphology of Flowering Plants

## Exercises — Exercises

### Q1 How is a pinnately compound leaf different from a palmately compound leaf?

SOLUTION

In a compound leaf, the incisions of the lamina reach all the way to the midrib, breaking it into a number of separate leaflets. Compound leaves are of two types based on how the leaflets are arranged.

Pinnately compound leaf:
- Leaflets (pinnae) are arranged on both sides of a common central axis called the rachis.
- The rachis represents the midrib of the original leaf.
- Example: Neem (Azadirachta indica).

Palmately compound leaf:
- Leaflets are all attached at a single common point at the tip of the petiole (like fingers from a palm).
- There is no rachis; all leaflets radiate from one point.
- Example: Silk cotton (Bombax ceiba).

Key difference: In pinnate leaves, leaflets are arranged along a rachis (feather-like); in palmate leaves, all leaflets arise from a single point (hand-like).

Answer: Pinnately compound leaf: leaflets arranged along a central rachis (e.g., neem). Palmately compound leaf: all leaflets attached at one point at the tip of the petiole (e.g., silk cotton).

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### Q2 Explain with suitable examples the different types of phyllotaxy.

SOLUTION

Phyllotaxy is the pattern of arrangement of leaves on the stem or branch. There are three main types:

1. Alternate phyllotaxy:
- A single leaf arises at each node alternately.
- Successive leaves are arranged in a spiral pattern up the stem.
- Examples: China rose (Hibiscus rosa-sinensis), mustard (Brassica), sunflower (Helianthus).

2. Opposite phyllotaxy:
- A pair of leaves arises at each node, lying opposite to each other.
- The two leaves in a pair are on directly opposite sides of the stem.
- Examples: Calotropis procera, guava (Psidium guajava).

3. Whorled phyllotaxy:
- More than two leaves arise at each node and form a whorl (ring) around the stem.
- Example: Alstonia scholaris (devil's tree).

Answer: Three types: (1) Alternate — one leaf per node, e.g., china rose; (2) Opposite — two leaves per node facing each other, e.g., Calotropis, guava; (3) Whorled — more than two leaves per node forming a ring, e.g., Alstonia.

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Q3 Define the following terms:
(a) aestivation (b) placentation (c) actinomorphic (d) zygomorphic (e) superior ovary (f) perigynous flower (g) epipetalous stamen

SOLUTION

(a) Aestivation: The mode of arrangement of sepals or petals in the floral bud with respect to the other members of the same whorl. Main types are valvate, twisted, imbricate, and vexillary.

(b) Placentation: The arrangement of ovules within the ovary. Types include marginal, axile, parietal, basal, free central, and superficial.

(c) Actinomorphic (radial symmetry): A flower that can be divided into two equal halves by any radial plane passing through its centre. Examples: mustard, datura, chilli.

(d) Zygomorphic (bilateral symmetry): A flower that can be divided into two similar halves only in one particular vertical plane. Examples: pea, gulmohur, bean, Cassia.

(e) Superior ovary: The condition in a hypogynous flower where the gynoecium occupies the highest position on the thalamus and all other floral parts (calyx, corolla, androecium) are situated below it. Examples: mustard, china rose, brinjal.

(f) Perigynous flower: A flower in which the gynoecium is situated in the centre and other floral parts are located on the rim of the thalamus at almost the same level. The ovary is said to be half inferior. Examples: plum, rose, peach.

(g) Epipetalous stamen: Stamens that are attached to (fused with) the petals are called epipetalous. Example: brinjal (Solanum melongena).

Answer: (a) Arrangement of sepals/petals in bud; (b) Arrangement of ovules in ovary; (c) Radial symmetry — divisible in any plane (e.g., mustard); (d) Bilateral symmetry — divisible in one plane only (e.g., pea); (e) Ovary above all other floral parts (hypogynous flower); (f) Flower with ovary at centre, other parts on thalamus rim (half-inferior ovary); (g) Stamens fused with petals (e.g., brinjal).

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Q4 Differentiate between
(a) Racemose and cymose inflorescence
(b) Apocarpous and syncarpous ovary

SOLUTION

(a) Racemose vs. Cymose inflorescence:

Racemose inflorescence:
- The main floral axis continues to grow indefinitely (indeterminate growth).
- Flowers are borne laterally on the axis in an acropetal succession (older flowers at base, younger at apex).
- The apex does NOT terminate in a flower.
- Example: mustard, radish.

Cymose inflorescence:
- The main floral axis terminates in a flower, so growth is limited (determinate growth).
- Flowers are borne in a basipetal order (older flowers at apex, younger towards base).
- Example: Solanum (nightshade).

(b) Apocarpous vs. Syncarpous ovary:

Apocarpous ovary:
- The flower contains more than one carpel, and the carpels are free (not fused) from each other.
- Examples: lotus (Nelumbo), rose (Rosa).

Syncarpous ovary:
- The carpels are fused together into a single compound ovary.
- Examples: mustard (Brassica), tomato (Solanum lycopersicum).

Answer: (a) Racemose: main axis grows indefinitely, flowers in acropetal order (e.g., mustard); Cymose: main axis ends in a flower, flowers in basipetal order (e.g., Solanum). (b) Apocarpous: carpels free (e.g., lotus, rose); Syncarpous: carpels fused (e.g., mustard, tomato).

Q5 Draw the labelled diagram of the following:
(i) gram seed (ii) V.S. of maize seed

SOLUTION

(i) Gram seed (dicotyledonous, non-endospermous seed):

Structure description (Figure 5.14 in textbook):
- Seed coat: outermost protective covering; made of two layers — outer testa and inner tegmen.
- Hilum: scar on the seed coat, the point of attachment to the fruit wall.
- Micropyle: a small pore above the hilum through which water is absorbed during germination.
- Cotyledons (2): two large, fleshy cotyledons that store food (non-endospermic — endosperm is absent in mature seed).
- Embryonal axis: the small axis between the two cotyledons.
- Plumule: the embryonic shoot at one end of the embryonal axis (above cotyledons).
- Radicle: the embryonic root at the other end of the embryonal axis (below cotyledons).

Labels to mark on diagram: Seed coat (testa + tegmen), Hilum, Micropyle, Cotyledon (x2), Plumule, Radicle, Embryonal axis.

(ii) V.S. of maize seed (monocotyledonous, endospermous seed):

Structure description (Figure 5.15 in textbook):
- Seed coat and fruit wall: fused together as a membranous outer layer (cannot be separated).
- Endosperm: large, bulky central region that stores food (starchy); occupies most of the seed.
- Aleurone layer: a proteinaceous layer that separates the endosperm from the embryo; secretes digestive enzymes during germination.
- Embryo: small, situated in a groove at one end of the endosperm.
- Scutellum: the single, large, shield-shaped cotyledon of the embryo; lies

adjacent to the endosperm and absorbs digested food.
- Coleoptile: sheath enclosing the plumule (embryonic shoot).
- Plumule: embryonic shoot within the coleoptile.
- Radicle: embryonic root.
- Coleorhiza: sheath enclosing the radicle.

Labels to mark on diagram: Seed coat & fruit wall (fused), Endosperm, Aleurone layer, Scutellum, Coleoptile, Plumule, Embryo, Radicle, Coleorhiza.

Answer: (i) Gram seed labels: Seed coat (testa/tegmen), Hilum, Micropyle, Two cotyledons (fleshy, non-endospermic), Plumule, Radicle, Embryonal axis. (ii) Maize V.S. labels: Seed coat + fruit wall (fused), Endosperm (bulky), Aleurone layer, Scutellum (shield cotyledon), Coleoptile, Plumule, Radicle, Coleorhiza, Embryo.

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Q6 Take one flower of the family Solanaceae and write its semi-technical description. Also draw their floral diagram.

SOLUTION

Example: Solanum nigrum (makoi / black nightshade) — Family Solanaceae

Vegetative Characters:
- Habit: herb
- Stem: herbaceous, erect, branched, cylindrical, solid or hollow, hairy or glabrous
- Leaves: alternate, simple, exstipulate; venation reticulate

Floral Characters:
- Inflorescence: Solitary axillary or cymose
- Flower: bisexual, actinomorphic (radially symmetrical), bracteate or ebracteate, hypogynous
- Calyx: sepals 5, united (gamosepalous), persistent, valvate aestivation
- Corolla: petals 5, united (gamopetalous), valvate aestivation
- Androecium: stamens 5, epipetalous (attached to petals), alternipetalous
- Gynoecium: bicarpellary, syncarpous (carpels fused), obligately placed (at 45 degrees to the floral axis); ovary superior, bilocular, placenta swollen with many ovules, axile placentation
- Fruit: berry or capsule
- Seeds: many, endospermous

Floral Formula:
Bisexual, actinomorphic (⊕): K(5) C(5) A5 G(2) with superior ovary indicator

Written as: Br ⊕ (bisexual) K(5) C(5) A5 G(2)

Floral Diagram description:
- Outermost whorl: 5 united sepals (calyx)
- Second whorl: 5 united petals (corolla) alternating with sepals
- Third whorl: 5 stamens attached to petals (epipetalous)
- Centre: gynoecium of 2 fused carpels (bicarpellary syncarpous), superior ovary
- Mother axis dot at top of diagram

Economic Importance of Solanaceae:
- Food: tomato (Solanum lycopersicum), brinjal (S. melongena), potato (S. tuberosum)
- Spice: chilli (Capsicum annuum)
- Medicine: belladonna (Atropa belladonna), ashwagandha (Withania somnifera)
- Fumigatory: tobacco (Nicotiana tabacum)
- Ornamentals: petunia (Petunia hybrida)

Answer: Solanum nigrum: bisexual, actinomorphic; K(5) C(5) A5 G(2); 5 united sepals, 5 united petals (valvate), 5 epipetalous stamens, bicarpellary syncarpous superior ovary, axile placentation; fruit berry/capsule; many endospermous seeds.

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Q7 Describe the various types of placentations found in flowering plants.

SOLUTION

Placentation is the arrangement of ovules within the ovary. The following types are found in flowering plants:

1. Marginal placentation:
- The placenta forms a ridge along the ventral suture of the ovary.
- Ovules are borne on this ridge in two rows.
- Ovary is unilocular.
- Example: pea (Pisum sativum).

2. Axile placentation:
- The placenta is axial (central column) in a multilocular ovary.
- Ovules are attached to the central axis where the septa meet.
- Examples: china rose (Hibiscus), tomato (Solanum lycopersicum), lemon (Citrus).

3. Parietal placentation:
- Ovules develop on the inner wall of the ovary or on peripheral parts.

- Ovary is basically one-chambered but may become two-chambered due to formation of a false septum.
- Examples: mustard (Brassica), Argemone (prickly poppy).

4. Free central placentation:
- Ovules are borne on a central axis that arises from the base of the ovary.
- Septa are absent; the axis is free, not attached to the ovary wall.
- Examples: Dianthus (carnation), Primrose (Primula).

5. Basal placentation:
- The placenta develops at the base of the ovary.
- A single ovule is attached to it.
- Examples: sunflower (Helianthus), marigold (Tagetes).

6. Superficial placentation (mentioned in some references):
- Ovules are attached all over the inner surface of the locule.
- Found in water lily (Nymphaea); not discussed separately in this chapter.

Answer: Five main types: (1) Marginal — ovules on ventral ridge, e.g., pea; (2) Axile — ovules on central axis in multilocular ovary, e.g., china rose, tomato; (3) Parietal — ovules on ovary wall/false septum, e.g., mustard; (4) Free central — ovules on free central axis, septa absent, e.g., Dianthus; (5) Basal — single ovule at ovary base, e.g., sunflower.

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Q8 What is a flower? Describe the parts of a typical angiosperm flower.

SOLUTION

A flower is the reproductive unit of angiosperms, meant for sexual reproduction. It is a modified shoot in which the shoot apical meristem changes to floral meristem. The internodes do not elongate and the axis (thalamus/receptacle) is condensed. The apex produces different kinds of floral appendages laterally at successive nodes instead of leaves.

A typical angiosperm flower has four whorls arranged on the swollen end of the stalk (pedicel) called the thalamus or receptacle:

1. Calyx (outermost whorl):
- Members are called sepals; usually green and leaf-like.
- Function: protect the flower in the bud stage.
- May be gamosepalous (sepals united) or polysepalous (sepals free).

2. Corolla:
- Members are called petals; usually brightly coloured.
- Function: attract pollinators (insects).
- May be gamopetalous (petals united) or polypetalous (petals free).
- Corolla shape varies: tubular, bell-shaped, funnel-shaped, wheel-shaped.
- Calyx and corolla together are accessory organs.
- When calyx and corolla are indistinguishable (as in lily), they are called perianth.

3. Androecium:
- The male reproductive whorl; composed of stamens.
- Each stamen has a filament (stalk) and a bilobed anther.
- Each anther lobe has two pollen sacs that produce pollen grains.
- A sterile stamen is called a staminode.
- Stamens may be free (polyandrous) or united: monoadelphous (one bundle, e.g., china rose), diadelphous (two bundles, e.g., pea), polyadelphous (>2 bundles, e.g., citrus).
- When attached to petals: epipetalous (e.g., brinjal); when attached to perianth: epiphyllous (e.g., lily).

4. Gynoecium (innermost whorl):
- The female reproductive part; made of one or more carpels.
- Each carpel consists of: stigma (pollen-receiving surface at tip) + style (connecting tube) + ovary (enlarged basal part containing ovules).
- Ovules after fertilisation develop into seeds; ovary matures into fruit.
- Carpels may be free (apocarpous, e.g., lotus, rose) or fused (syncarpous, e.g., mustard, tomato).

Based on sex of flower:
- Bisexual: both androecium and gynoecium present.
- Unisexual: only stamens (staminate) or only carpels (pistillate).

Based on symmetry:
- Actinomorphic: radially symmetrical (e.g., mustard, chilli).
- Zygomorphic: bilaterally symmetrical (e.g., pea, bean).
- Asymmetric: no symmetry (e.g., canna).

Answer: A flower is the reproductive unit of angiosperms. It has four whorls on the thalamus: (1) Calyx — sepals, protective; (2) Corolla — petals, attract pollinators; (3) Androecium — stamens (filament + bilobed anther), male organ; (4) Gynoecium — carpels (stigma + style + ovary), female organ. Calyx and corolla are accessory; androecium and gynoecium are reproductive.

Q9 Define the term inflorescence. Explain the basis for the different types of inflorescence in flowering plants.

SOLUTION

Inflorescence: The arrangement of flowers on the floral axis is termed as inflorescence. When the shoot tip transforms into a flower, it is always solitary. But when the shoot produces an axis bearing flowers, the arrangement is called inflorescence.

A flower is a modified shoot in which the shoot apical meristem changes to floral meristem. The internodes do not elongate and the axis gets condensed, bearing floral appendages laterally at successive nodes instead of leaves.

Basis for classification:
Inflorescences are classified primarily on the basis of whether the apex (tip of the main axis) terminates in a flower or continues to grow indefinitely.

1. Racemose inflorescence (indefinite / indeterminate):
- The main axis continues to grow indefinitely and does NOT end in a flower.
- Flowers are borne laterally on the axis in an acropetal succession — older (more mature) flowers at the base and younger flowers towards the apex.
- The axis has theoretically unlimited growth.
- Examples: raceme (mustard, radish), spike, catkin, spadix, corymb, umbel, capitulum (head).

2. Cymose inflorescence (definite / determinate):
- The main axis terminates in a flower, so its growth is limited.
- Subsequent flowers develop from lateral branches, each also ending in a flower.
- Flowers are borne in a basipetal order — older (more mature) flowers at the apex and younger flowers towards the base.
- Examples: Solanum (nightshade), Datura.

Answer: Inflorescence is the arrangement of flowers on the floral axis. Two main types based on apex behaviour: (1) Racemose — main axis grows indefinitely, flowers in acropetal succession (e.g., mustard); (2) Cymose — main axis ends in a flower (limited growth), flowers in basipetal order (e.g., Solanum).

Q10 Describe the arrangement of floral members in relation to their insertion on thalamus.

SOLUTION

Based on the position of calyx, corolla and androecium relative to the ovary on the thalamus, flowers are classified into three types:

1. Hypogynous flower:
- The gynoecium (ovary) occupies the highest position on the thalamus.
- All other floral parts — calyx, corolla and androecium — are situated below the ovary and arise from the thalamus beneath it.
- The ovary is said to be superior.
- Examples: mustard (Brassica juncea), china rose (Hibiscus rosa-sinensis), brinjal (Solanum melongena).

2. Perigynous flower:
- The gynoecium is situated in the centre of the floral cup (hypanthium).
- The thalamus grows up around the ovary forming a cup-like structure.
- Other floral parts (calyx, corolla, androecium) are located on the rim of the thalamus (hypanthium) at almost the same level as the ovary.
- The ovary is said to be half inferior (or semi-inferior).
- Examples: plum (Prunus domestica), rose (Rosa), peach (Prunus persica).

3. Epigynous flower:
- The margin of the thalamus grows upward, completely enclosing the ovary and getting fused with it.
- The other floral parts (calyx, corolla, androecium) arise from above the ovary.
- The ovary is said to be inferior.
- Examples: guava (Psidium guajava), cucumber (Cucumis sativus), ray florets of sunflower (Helianthus annuus).

Answer: Three types based on ovary position: (1) Hypogynous — ovary superior, all other parts below it (e.g., mustard, china rose); (2) Perigynous — ovary half-inferior, thalamus cup-shaped with other parts on its rim (e.g., rose, plum); (3) Epigynous — ovary inferior, thalamus fused with and encloses ovary, other parts arise above (e.g., guava, cucumber).