

VIII. Angiosperms

1. General characteristics

Angiosperms, or flowering plants (plants with ovaries), currently constitute the vast majority of terrestrial plants (200 000 to 250 000 species) grouped into 400 to 500 families, and exhibit extremely varied morphologies. Angiosperms (which bear seeds enclosed within a fruit) are organisms that are:

- Tracheophytes: vascular plants equipped with conducting vessels.
- Phanerogams: possessing visible reproductive organs.
- Adapted to terrestrial life: they have colonized virtually every terrestrial habitat.
- Cormophytes: their vegetative body (a leafy stem plus roots) is termed a cormus.
- Flowering plants (true flowers): they perform sexual reproduction via flowers.
- Spermatophytes: like gymnosperms, they produce seeds because they bear ovules.
- The female gametophyte, located in the ovule and called the embryo sac, is the site of a double fertilization; one event forms the embryo, the other forms the endosperm (the seed's storage tissue).
- Flowers may be unisexual or hermaphroditic.

Classically, angiosperms are divided into Monocotyledons and Dicotyledons; phylogenetically, they follow the APG (Angiosperm Phylogeny Group) system.

2. Class monocotyledons

Monocots differ from dicots not only by having a single cotyledon but also by a suite of anatomical and morphological traits that make them recognizable at first glance:

- Roots: the primary root arising from the radicle typically aborts soon after germination and is replaced by many thin, sparsely branched adventitious roots (a fibrous root system).
- Stems: usually an unbranched, herbaceous shoot (culm). They may also appear as rhizomes (underground stems) or bulbs (modified leafy stems); in some species the stem becomes woody (stipe).
- Leaves: generally solitary, sessile (no petiole), without stipules, with a sheathing base; blades are simple with parallel venation.
- Flowers: 3-merous (trimery); each floral whorl has three parts.
- Perianth: sepals and petals are not differentiated and are collectively called tepals.
- Seeds: possess a large endosperm (albuminous seeds).

3. Class dicotyledons

- Roots: a well-developed primary (tap) root bears lateral branches (a taproot system).

- Stems: may be herbaceous or woody and are often highly branched. Dicot stems can form trees, shrubs, vines, succulents, or xerophytes, displaying erect, creeping, or climbing habits.
- Leaves: may be sessile or petiolate, simple or compound, and come in diverse shapes (entire, serrated, lobed). Venation is typically reticulate (pinnate or palmate).
- Flowers & Inflorescences: extremely varied in eudicots. Flowers feature distinct sepals (usually green, protective) and petals; calyx and corolla are generally dissimilar. Most flowers are 5-merous (pentamerous), less often 4-merous (tetramerous).
- Seeds: often retain a persistent endosperm.

4. Floral morphology

A flower is a composite structure of specialized parts borne on a swollen axis called the floral receptacle, which itself sits atop the peduncle that attaches to the stem; at that point of attachment you often find a bract. The perianth (the non-sexual parts) consists of:

- a calyx (the sepals)
- a corolla (the petals)

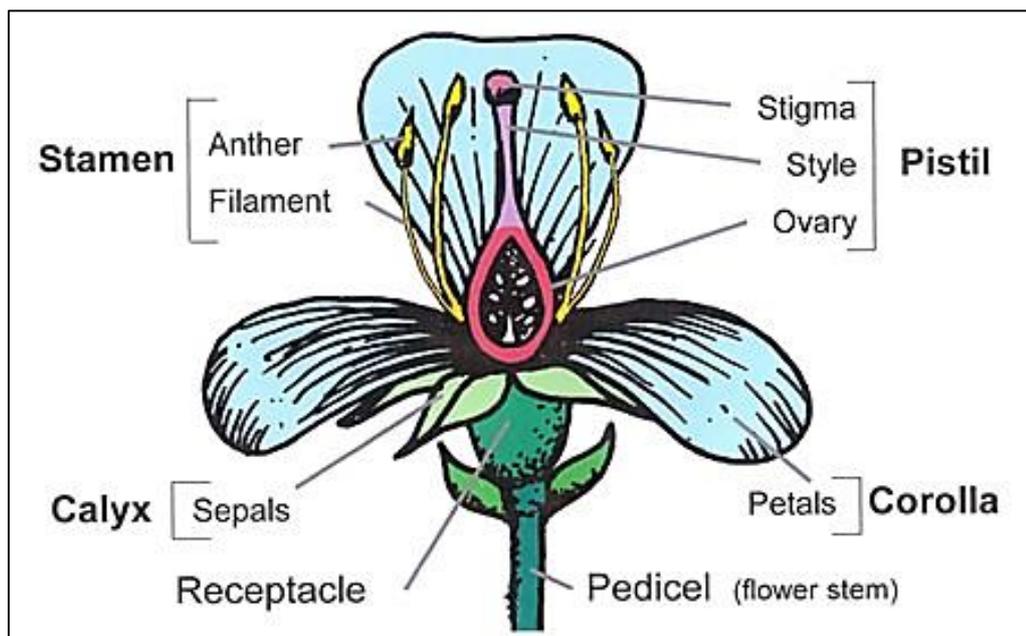


Figure : Flower structure

The fertile parts are :

- the androecium (the stamens)
- the gynoecium (the pistils or carpels)

The reproductive structures of angiosperms are these flowers. A flower is an extremely modified shoot axis bearing specialized appendages (modified leaves). The modified stem (the floral axis) is called the

receptacle, while the stalk that bears the flower is the pedicel (or peduncle). Flowers generally arise in the axil of a (sometimes modified) leaf—the bract—and smaller leaf-like structures called bracteoles often develop along the pedicel.

A flower is complete if it has all three parts (perianth, androecium and gynoecium). If one part is absent, the flower is incomplete. If either the androecium or the gynoecium is missing, the flower is unisexual: staminate (male) or pistillate (female).

When the perianth's parts are not differentiated into sepals and petals, it is simply composed of tepals. Otherwise, the perianth is differentiated into a distinct calyx and corolla, each forming one or more whorls of organs.

Flowers develop from either terminal or lateral floral buds. Each flower is borne on a peduncle inserted in the axil of a bract, and the whole is attached to a branch. The flower itself sits at the swollen tip of the peduncle (the receptacle). Although the number, shape, and arrangement of floral parts vary by species, their order of insertion on the receptacle is always the same.

5. Floral Formula

A floral formula is a concise, symbolic way to describe the structure of a flower. It uses letters, numbers, and special symbols to record. Floral formulas are useful tools for remembering characteristics of the various angiosperm families. Their construction requires careful observation of individual flowers and of variation among the flowers of the same or different individuals. A floral formula consists of five symbols indicating from left to right: Floral symmetry, number of sepals, number of petals, number of stamens, and number of carpels.

Floral Formula Symbol 1

The first symbol in a floral formula describes the symmetry of a flower.

- (*) Radial symmetry – Divisible into equal halves by two or more planes of symmetry.
- (x) Bilateral symmetry – Divisible into equal halves by only one plane of symmetry.
- (\$) Asymmetrical – Flower lacking a plane of symmetry, neither radial or bilateral.

Floral Formula Symbol 2

The second major symbol in the floral formula is the number of sepals, with “**K**” representing “calyx”.

Floral Formula Symbol 3

The third symbol is the number of petals, with “C” representing “corolla”.

Floral Formula Symbol 4

The fourth symbol in the floral formula is the number of stamens (androecial items), with “A” representing “androecium”. ∞ (the symbol for infinity) indicates numerous stamens and is used when stamens number more than **12** in a flower.

Floral Formula Symbol 5

The fifth symbol in a floral formula indicates the number of carpels, with “G” representing “gynoecium”.

More on floral formulas

- The plus symbol (+) is used to indicate differentiation among the members of any floral part. For example, a flower with five large stamens alternating with five small ones would be recorded as: **A5 + 5**.
- A line below the carpel number indicates the superior position of the ovary with respect to other floral parts. A line above the carpel number indicates the inferior position of the ovary with respect to other floral parts.
- Flowers with a perianth of tepals (no differentiation between calyx and corolla) have the second and third symbols combined into one. A hyphen(-) is placed before and after the number in this symbol.

Example: *, T-5-, A 10, G 3

- The lack of a particular floral part is indicated by placing a zero (0) in the appropriate position in the floral formula.

For example, a carpellate flower (flower with a gynoecium but no functional androecium) would be described as: ***, K3, C3, A0, G2**

Example:

***, K5, C5, ∞ , G10**

- Radial symmetry (*)
- 5 sepals in the calyx (K5)

- 5 petals in the corolla (C5)
- Numerous stamens (∞) 12 or more
- 10 carpels (G10)

6. Floral diagram

Floral diagrams are stylized cross sections of flowers that represent the floral whorls as viewed from above. Rather like floral formulas, floral diagrams are used to show symmetry, numbers of parts, the relationships of the parts to one another, and degree of connation and/or adnation.

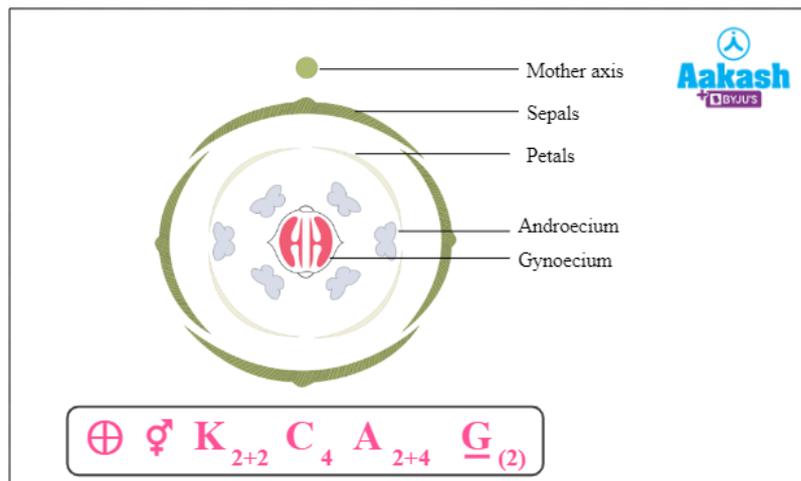
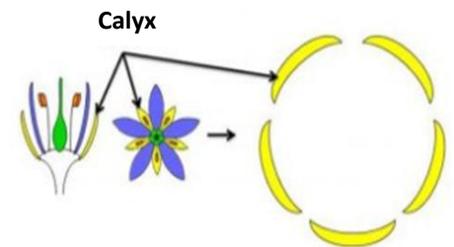
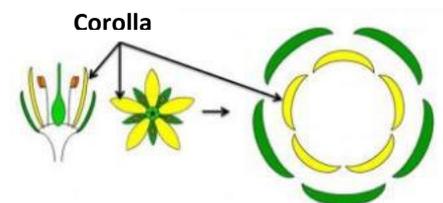


Figure : Floral diagram

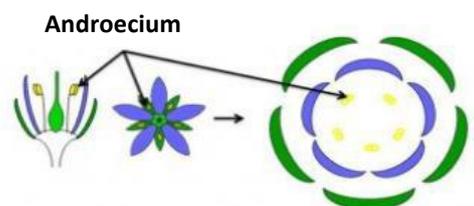
a) **The calyx:** This is the outermost whorl, the set of sepals. It is generally represented as empty, flattened crescent moons.



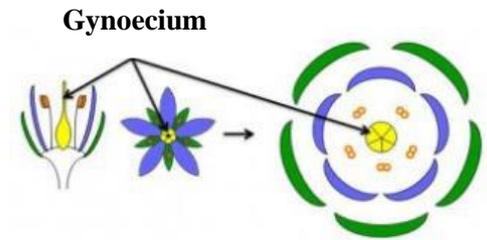
b) **The corolla:** This is the set of petals. They are also represented as crescent moons, but slightly smaller and fuller.



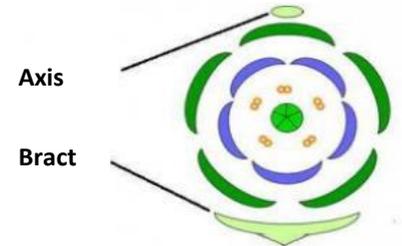
c) **The androecium:** This is the set of male organs. They are represented by an eight.



d) **The gynoecium:** This is the set of female organs. It is represented by a circle, cut into as many slices as there are carpels, that is to say compartments inside the pistil. To count these compartments, you will need to make a section of the pistil, and observe with a good magnifying glass.



The bract and **the branch** (the **axis** of the stem) are added to orient the flower. By convention, the branch (or stem) is always at the top, and the bract, shaped like a hook, is at the bottom.



7. Reproduction in angiosperms

Sporophyte ($2n$) is the dominant (familiar plant body) produces spores (n) by meiosis, which develop into the tiny, multicellular gametophytes (male and female).

Formation of the male gametophyte (Pollen)

1. **Microsporogenesis** : In each anther locule, diploid microspore mother cells (microsporocytes) undergo meiosis produce four haploid microspores in a tetrad.
2. **Microgametogenesis** : Each microspore develops into a pollen grain. Most angiosperm pollen is tricellular at dispersal: 02 sperm cells (from generative cell mitosis) + 01 tube cell.

Formation of the female gametophyte (Embryo Sac)

1. **Megasporogenesis**: In the ovule's megasporangium, a diploid megaspore mother cell undergoes meiosis produce four megaspores; three degenerate, one survives.
2. **Megagametogenesis**: The functional megaspore undergoes three rounds of mitosis give an eight-nucleate, seven-celled embryo sac:
 - Egg cell + two synergids at micropylar end
 - Three antipodal cells at chalazal end
 - Two polar nuclei in central cell

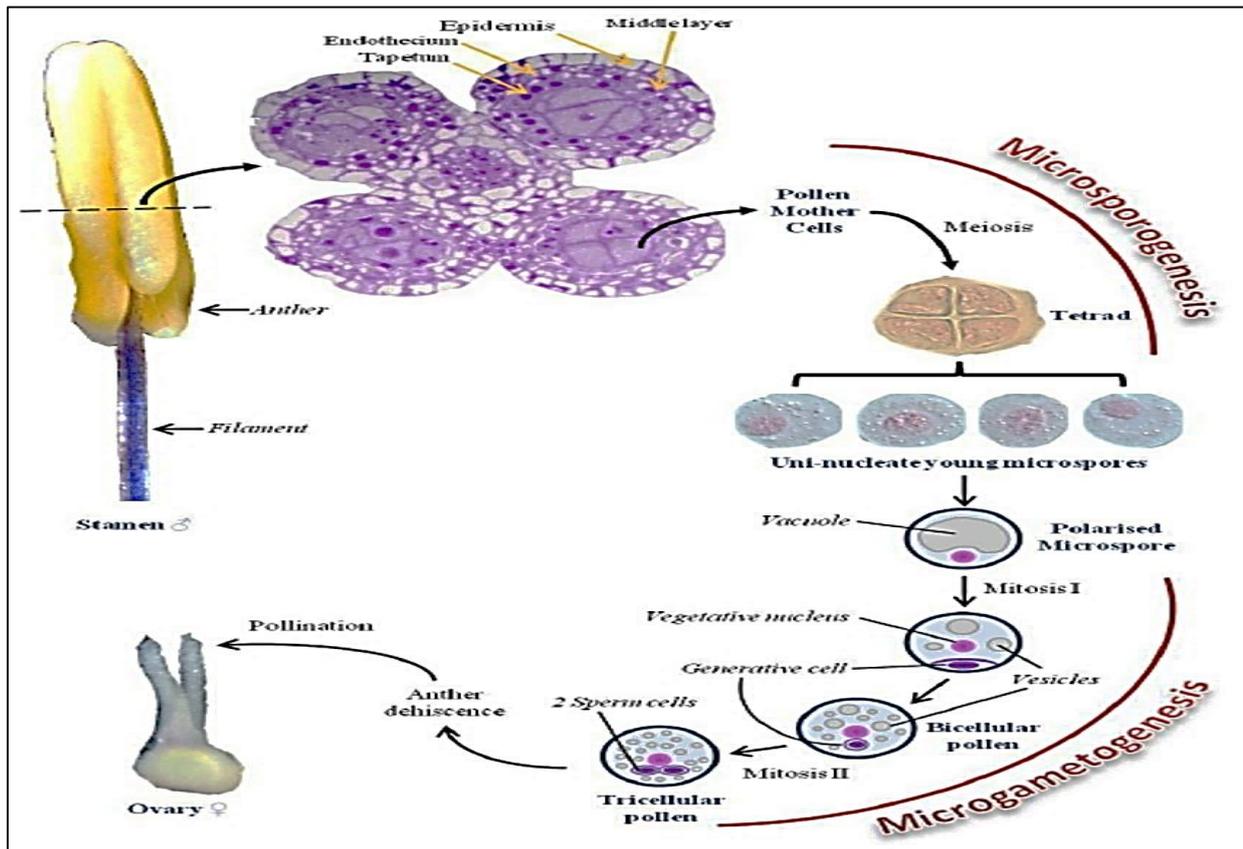


Figure: Formation of the male gametophyte (Pollen)

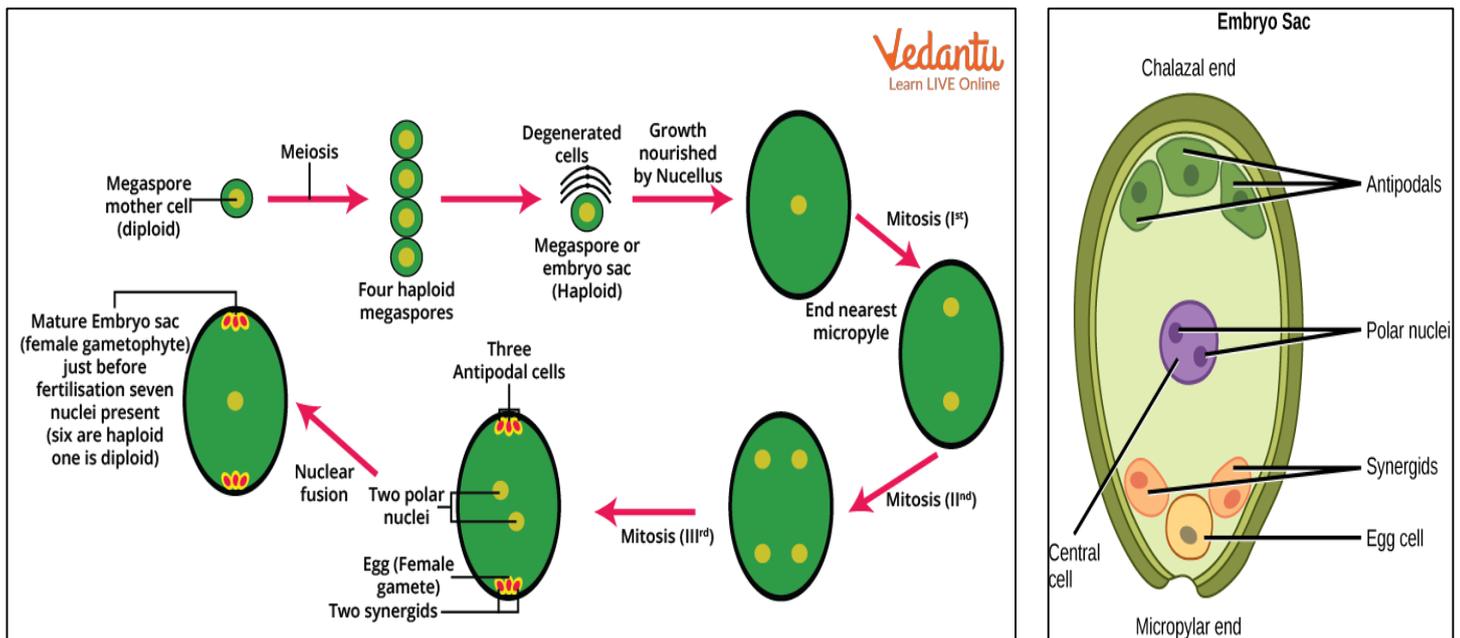


Figure: Formation of the female gametophyte (Embryo Sac)

Pollination & double fertilization

Transfer of pollen from anther to stigma by: biotic agents (insects, birds, bats) or abiotic agents (wind, water). On a compatible stigma, the pollen grain hydrates and the tube cell produces a pollen tube. The tube

grows through the style toward the ovule, guided by chemical signals. The pollen tube enters the embryo sac via the micropyle and releases its two sperm:

- Sperm 1 + egg cell → zygote (2n) → future embryo
- Sperm 2 + two polar nuclei → primary endosperm nucleus (3n) → endosperm (nutritive tissue)

Seed & fruit development

- Zygote divides → multicellular embryo with basic organs (radicle, cotyledons).
- Endosperm proliferates → feeds the embryo.
- Ovule integuments harden → seed coat.
- Ovary walls develop → fruit, enclosing and protecting the seeds.

Seed dispersal & germination

Fruits and seeds employ various dispersal strategies: wind, water, animals. Upon landing in a suitable site, environmental cues (water, temperature, light) trigger germination of the embryo, restarting the sporophyte generation.

Asexual reproduction

- Apomixis: clonal seed production without fertilization.
- Vegetative propagation: runners, tubers, bulbs.

This coordinated process; flower morphogenesis, gametophyte development, pollination, double fertilization, and seed/fruit formation underlies the remarkable success and diversity of angiosperms.

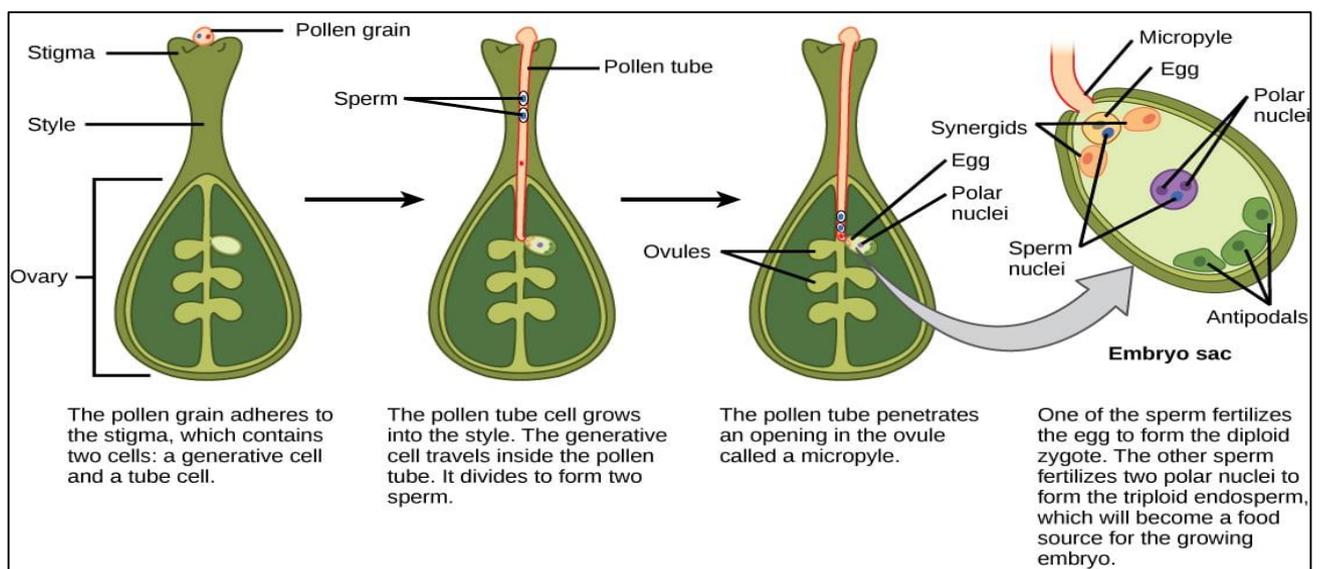


Figure : Double fertilization in angiosperms

Most important families of angiosperms

1. Monocotyledonous families:

Family: Grasses (Gramineae, Poaceae)

Approximately 650 genera (around 9,000 species) are distributed worldwide across all climates. They form vast plant communities such as prairies, savannas, steppes, etc.

Most grasses are perennial, growing from branched sympodial rhizomes that each year produce upright aerial stems. The leaves are distichously arranged (each successive leaf is set at a 180° angle from the previous one) and consist of a sheath and a blade (lamina). The flowers are grouped into spikelets, whose structure is characteristic of the family. The flower of grasses is bisexual and naked (lacking perianth), and is reduced to three stamens and three carpels.

Important plants:

Cereals:

Wheat is the most important food plant in the world (about 2000 varieties), including *Triticum sativum*, *T. dicoccum*, and *T. monococcum*.

- Soft wheats are rich in starch and valued for bread-making.
- Hard wheats are rich in gluten and used for making pasta.

Other major cereals include:

- Rye (*Secale cereale*)
- Barley (*Hordeum vulgare*)
- Oats (*Avena sativa*)
- Maize (*Zea mays*)
- Rice (*Oryza sativa*)

Forage grasses in temperate regions:

- Wild oats (*Avena pratensis*)
- Quaking grass (*Briza media*)
- Bromes (*Bromus mollis*)
- Orchard grass (*Dactylis glomerata*)



Figure : Poaceae

Industrial Grasses:

- Sugarcane (*Saccharum officinarum*)
- Bamboos, widely used in tropical countries for construction, furniture, and other purposes.

Family : Liliaceae

- These are mostly herbaceous plants, most of which are perennial by means of rhizomes or bulbs.
- Flowers are hermaphroditic, though a few species are dioecious.

The Liliaceae family includes about 250 genera and around 4000 species. It is a cosmopolitan family, represented in nearly all climates.

Important plants

- *Allium cepa* L. – Onion
- *Allium porrum* L. – Leek
- *Allium sativum* L. – Garlic
- *Asparagus officinalis* L. – Asparagus

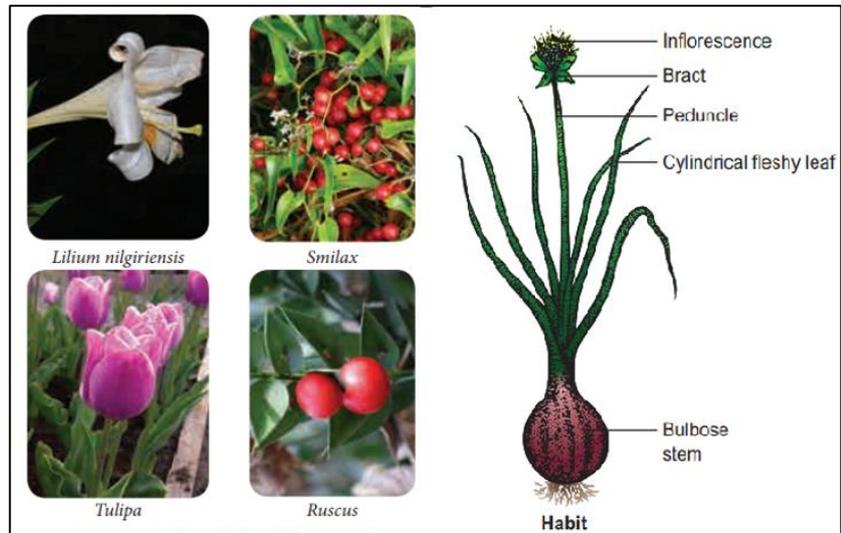


Figure : Liliaceae

2. Dicotyledonous families :

Family: Rosaceae

This family includes most of our fruit trees. Rosaceae are herbaceous or woody plants, with alternate leaves, sometimes with stipules (which may be deciduous or persistent). The flowers are generally actinomorphic and perigynous, or sometimes even epigynous. The stamens are usually arranged in three whorls, though this varies greatly. The carpels are variable in number (one or several). The fruit is highly variable (drupe, berry, aggregate fruit, etc.); it may be naked or enclosed within the cup formed by the perianth and stamens. The nature of the fruit is used to define various tribes within the family. The seeds lack endosperm (albumen). The Rosaceae family includes more than 200 genera and about 2500 species. These are mainly plants of temperate regions in the Northern Hemisphere.

Important plants

These are generally fruit trees:

- *Prunus domestica* L. – Plum tree
- *Prunus cerasus* L. – Sour cherry tree

- *Prunus amygdalus* Batsch (*Amygdalus communis* L.) – Almond tree
- *Prunus persica* Batsch – Peach tree
- *Prunus armeniaca* L. – Apricot tree
- *Prunus avium* L. – Sweet cherry tree (wild cherry)
- *Pyrus communis* L. – Pear tree
- *Pyrus malus* L. – Apple tree (*Note: now commonly referred to as Malus domestica*)
- *Fragaria vesca* L. – Wild strawberry



Figure : Rosaceae

Family : Leguminosae (Fabaceae)

The family of Leguminosae is often elevated to the rank of an order. It contains more than 700 genera and 17000 species.

- Leaves: Simple or compound, with stipules.
- Calyx: Often gamosepalous (sepals fused).
- Corolla: Either regular or zygomorphic.
- Androecium: Diplostemonous, with stamens that are either free or fused.
- Ovary: Free, composed of a single carpel, which at maturity forms a two-valved pod (legume), a characteristic that is most consistent across the family.
- Seeds: without endosperm or with reduced endosperm.

Important plants :

Food Papilionaceae (Legumes) :

- *Pisum sativum* L. – Pea

- *Lens culinaris* Med. – Lentil
- *Phaseolus vulgaris* L. – Common bean
- *Cicer arietinum* L. – Chickpea

Forage Papilionaceae :

Clover (*Trifolium*)

-
- Alfalfa (*Medicago*)
- Lotus (*Lotus*)
- Sainfoin (*Onobrychis*)
- Vetch (*Vicia*)
- Grass pea (*Lathyrus*)



Figure : Fabaceae

Legumes are considered soil-enriching plants as their roots form nodules containing nitrogen-fixing bacteria (*Azotobacter*), which help fix atmospheric nitrogen.

Family : Solanaceae

- Trees, shrubs, or herbaceous plants, generally foul-smelling, pubescent, or viscous.
- Leaves: Isolated, with inflorescences in cymes.
- Calyx: Pentamerous, more or less long and tubular.
- Corolla: Colored or not, very variable in size, with 5 tubular lobes, either regular or slightly zygomorphic.
- Androecium: Composed of 5 stamens inserted on the corolla.
- Ovary: Composed of two locules, multiovulate.
- Fruit: Either capsular or berry-like.
- Seeds: With endosperm, and a curved or straight embryo.

This family consists of about 90 genera and around 3000 species, of which over 1000 are of the genus *Solanum*. Most Solanaceae are tropical plants.

Important plants :

- *Solanum tuberosum* L. – Potato
- *Solanum lycopersicum* L. – Tomato
- *Solanum melongena* L. – Eggplant (Aubergine)
- *Capsicum annum* L. – Bell pepper (Sweet pepper)



Figure : Solanaceae

Family: Lamiaceae (formerly Labiatae)

- Shrubs, sub-shrubs, or herbaceous plants, generally aromatic.
- Leaves usually opposite-decussate, without stipules.
- Flowers are pentamerous, generally hermaphroditic.
- Calyx has 5 lobes, often bilabiate (two-lipped), and persistent.
- Corolla typically bilabiate, with a long tubular base, sometimes with 4–5 nearly equal lobes or a single lip.
- Androecium consists of 4 stamens arranged in two unequal pairs (*didynamous*); the fifth stamen is usually absent or rudimentary.
- Gynoecium formed by 2 carpels, each with 2 ovules.
- Fruit consists of 4 nutlets (achenes), often partially fused on their inner face.

The Lamiaceae family includes many aromatic plants widely used in perfumery, pharmacy, and culinary preparations as condiments. These properties are due to essential oils located in glandular hairs.

Examples :

- *Thymus vulgaris* L. – Thyme
- *Lavandula vera* D.C. – True lavender
- *Salvia officinalis* L. – Sage
- *Origanum majorana* L. – Marjoram



Figure : Lamiaceae

Family: Asteraceae

Asteraceae, the aster, daisy, or composite family of the flowering-plant order Asterales. With more than 1620 genera and 23600 species of herbs, shrubs, and trees distributed throughout the world, Asteraceae is one of the largest plant families.

Members of the family have flower heads composed of many small flowers, called florets, that are surrounded by bracts (leaflike structures). Bell-shaped disk florets form the centre of each head. The sepals have been reduced to a ring of hairs, scales, or bristles that is called the pappus on the mature fruit. The one-seeded fruit (an achene) has a hard outer covering. The leaves of Asteraceae are simple or occasionally compound, and their arrangement along the stem may be opposite, alternate, or, less commonly, whorled; not infrequently they are opposite toward the base of the stem and alternate above.

Examples of species:

- *Taraxacum officinale* (dandelion)
- *Bellis perennis* (daisy)
- *Centaurea jacea* (knapweed)
- *Helianthus annuus* (sunflower)



Figure : Asteraceae