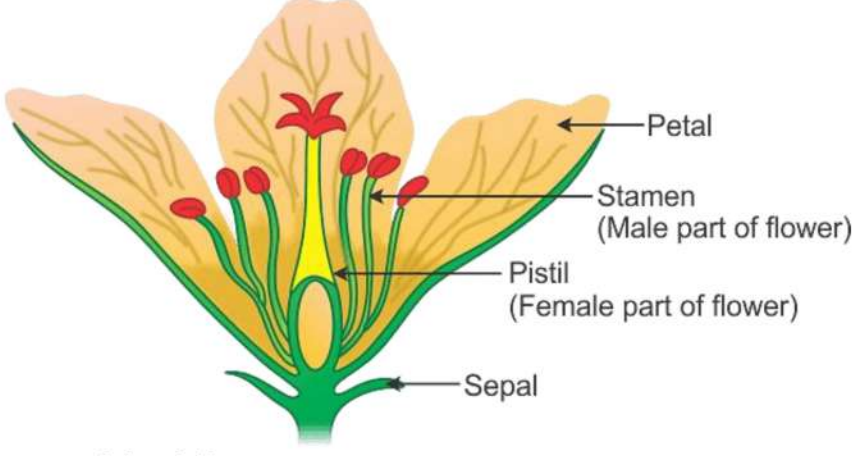
Chapter 2

Sexual Reproduction in Flowering Plants

Angiosperms & Pre-Fertilisation: Structure & Events

Introduction to Parts of a Flower

Flowering plants, also called angiosperms, use a sexual mode of reproduction. Reproduction in plants, mainly revolves around the flower, which has both the male and the female gametes. All parts of a flower aid in the process of reproduction, although some of them are sterile. Therefore, to understand the process of reproduction in flowering plants, we need to look at the different parts of the flower and their functions.



Flower comprises of the following parts:

1. **Calyx:** It is the outermost whorl of a flower. It comprises units called sepals. In the bud stage, calyx encloses the rest of the flower. They usually exhibit green colouration, at some other instances, they may be a colour like petals. This state of Calyx is termed as petaloid. Calyx can either be prominent or absent.
2. **Corolla:** It consists of many numbers of petals and it is the second whorl of the flower. These petals are sometimes fragrant. They are coloured, thin and soft that would help in the process of pollination as they would attract animals and insects.

3. **Stamen:** the male reproductive part comprises the anther and filament.
4. **Pistil:** the female reproductive part comprising three parts – stigma, style, and ovary.
5. **Sepals and Petals:** The sepals and petals together make up the perianth, or floral envelope. The sepals are usually greenish and often resemble reduced leaves, while the petals are usually colourful and showy.
6. **Pedicel:** Pedicel refers to a structure connecting a single flower to its inflorescence. In the absence of a pedicel, the flowers are described as sessile.

What are Angiosperms?

- Angiosperms are vascular plants with stems, roots, and leaves. The seeds of the angiosperm are found in a flower.
- These make up the majority of all plants on earth. The seeds develop inside the plant organs and form fruit. Hence, they are also known as flowering plants.
- Angiosperms are the most advanced and beneficial group of plants. They can grow in various habitats as trees, herbs, shrubs, and bushes.

Classification of Angiosperms

1. **Monocotyledons**
    - The seeds have a single cotyledon.
    - The leaves are simples and the veins are parallel.
    - This group contains adventitious roots.
    - Each floral whorl has three members.
    - It has closed vascular bundles and large in number.
    - For eg., banana, sugarcane, lilies, etc.
2. **Dicotyledons**
    - The seeds of these plants have two cotyledons.
    - They contain tap roots, instead of adventitious roots.
    - The leaves depict a reticulate venation.
    - The flowers are tetramerous or pentamerous and the vascular bundles are organized in rings.
    - For eg., grapes, sunflower, tomatoes, etc.

Characteristics of Angiosperms

- Most of the important Angiospermic characters are found in Capsella so that for the study of Angiosperms, it is considered as a **"Typical Angiosperm"**.
- It is an annual plant and grows like a weed during the winter season in the field.
- The main plant of the Capsella is a **sporophyte,** which is diploid and it is differentiated into root, stem and leaves.
- Capsella is a heterosporous plant it means there are two different types of spores are formed in the life cycle which is classified into two categories in which male spores are called **Microspores** and female spores are called **Megaspores**.
- The process of reproduction takes place in this plant through a special structure, called a **flower**.
- Calyx, Corolla, Androecium and Gynoecium are present in the typical or complete flower.
- The **calyx** and **corolla** are termed accessory whorls of the flower because these structures do not participate in the process of reproduction, they only help.
- The **androecium** and **gynoecium** are known as essential whorls because they are directly related to reproduction.

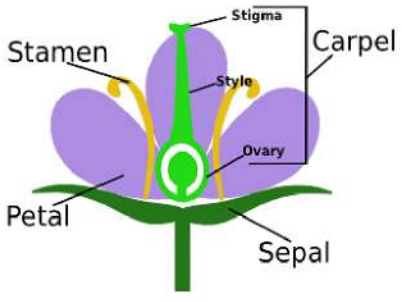
Angiosperms - Points to Remember

- Angiosperm originated in the **Mesozoic era**. Angiosperm originated either in the beginning of the Cretaceous period or in the ending of the Jurassic period of the Mesozoic era. It means they are originated between the Cretaceous and the Jurassic period on the earth.
- Angiosperm dominated over the earth in the **Cenozoic era**. So this era is known as the **"Golden Period of Angiosperms"**.
- First of all, **N.Grew** realized the fact, Stamens are male sex organ of flower (Anatomy of plants).
- Sexuality in plant first of all reported by **Jacob Camerarius**.
- He reported Anthers are the male sex organ and Ovary with style and stigma are female sex organ, and for the formation of seed, interaction is essential in between both the sex organs.
- The significance of pollination and the role of insects in pollination was recognized by **Joseph Kolreuter**.
- **Prof. P. Maheshwari -** Father of Indian plant Embryology. He wrote a book – 'An Introduction to Embryology of Angiosperms'.

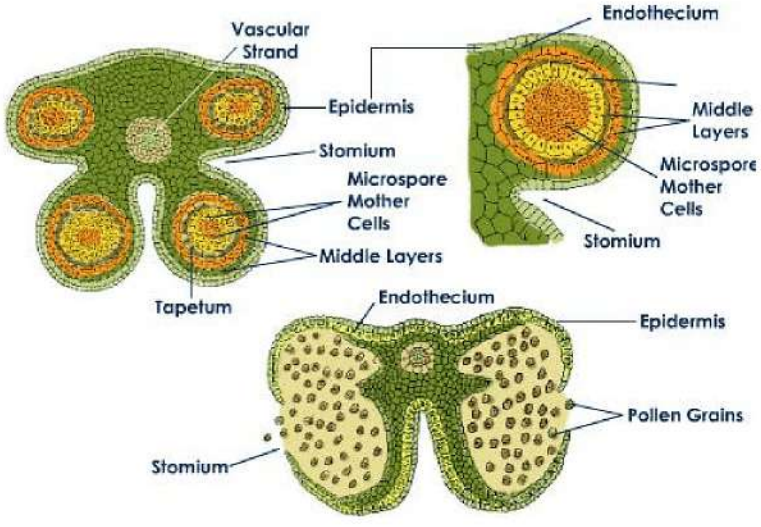
Sexual Reproduction in Flowering Plants

- In Angiosperms, male and female gametes are formed in male and female sex organs by the process of **meiosis**.
- Both the gametes fuse together to form a diploid zygote which gives rise to the embryo. The process in which an embryo is formed by meiosis and fertilization is called **Amphimixis**.

Male Reproductive Organ: Androecium



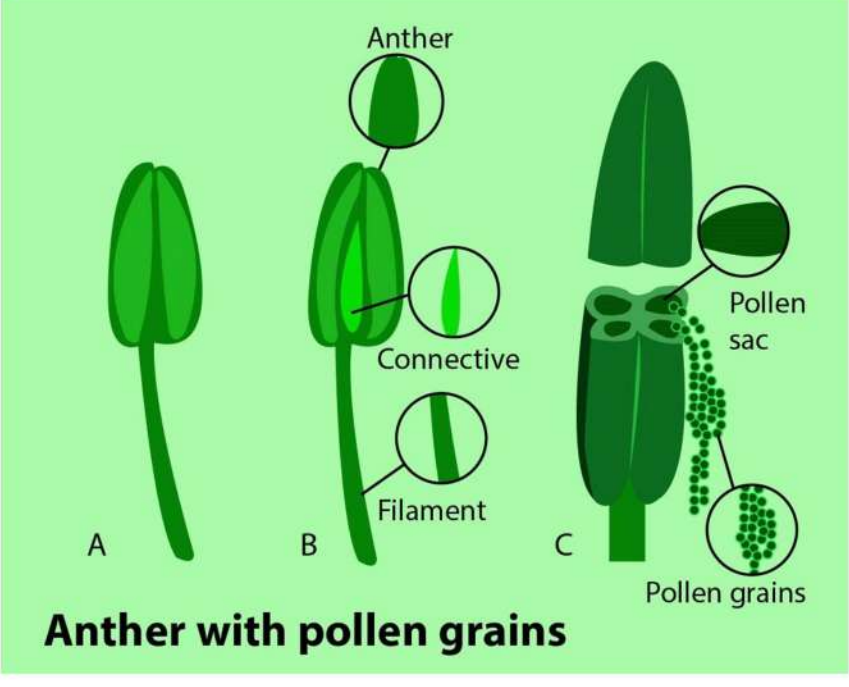
- Stamen is also known as microsporophyll. There are 6 stamens in Capsella.
- A typical stamen is differentiated into three parts:
  I. The thin structure is called filament which joins the stamen to the thalamus.
  II. The free end of the filament, a swollen spore-bearing structure is called the anther.
  III. Anther and filament are attached together with help of a small region, called connective. Connective contains vascular tissues.
- The main part of the stamen is anther. Each anther generally bilobed structure i.e., anther has two other lobes, called dithecous. Each lobe of anther has two chambers which are called pollen sacs or pollen chambers.
- Therefore, a typical anther has four pollen sacs called tetrasporangiate.



- Pollen grains are formed inside the pollen sac through the meiotic division in pollen mother cells.
- At the maturity of the pollen grains, sterile tissue degenerate which is present in between the pollen sacs. Both the pollen sac fused together. Because of this reason, only one chamber appears in each anther lobe at maturity. So two chambers are seen in the mature anther at the time of dehiscence.
- In Capsella, which is a member of the **Cruciferae** or **Brassicaceae**, anther is dithecous and tetrasporangiate type.
- But in Malvaceae, the anther of stamen has only one anther lobe. This is called **monothecous** and it contains only two pollen sacs called **Bisporangiate**.
- Monothecous anther is also found in Moringa, Wolffia plants.
- In Arceuthobium where there is only one microsporangium per anther. This condition is called **Monosporangiate**.

Types of Structure in Anther

- The development of anther in origin is the **Eusporangiate** type i.e. it is developed from more than one archesporial cells.
- In the transverse section of an anther, it is seen as almost spherical.



Anther with pollen grains

1) Epidermis

It is the outermost layer of the anther. It is a single-celled thick and continuous layer but not archesporial in origin. It forms the outermost protective layer

In **Arceuthobium** (Smallest Parasitic Angiosperm) fibrous thickening present in the epidermis so it is called **exothecium**.

2) Endothecium

This layer is present below the epidermis. It is a single-celled thick layer. During the maturation of anther, various changes take place in different walls of cells of endothecium. The outer wall of these cells remains thin-walled, but inner walls and radial walls become thick due to the thickening of cellulose fibres.
Callose bands are also present along the radial walls. At some places callose bands and fibrous thickening are absent. These places are called **stomium**. The dehiscence of anther takes place only from these places. Endothecium becomes hygroscopic in nature due to the presence of fibrous thickening. So it helps in dehiscence of the anther.
Note: In the Hydrocharitaceae family, fibrous thickening is absent in endothecium.

3) Middle layer

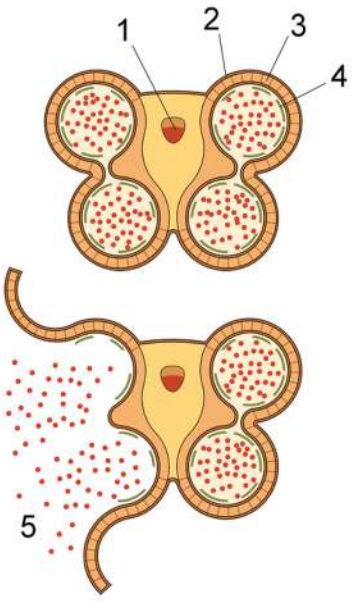
Middle layer consists of **parenchymatous** cells. This layer is one to three celled thick structure. Food is stored by parenchymatous cells in this layer. The middle layer is ephemeral in nature and absent in a mature anther.

Note

- In Holoptelia plant 3 to 4 celled thick middle layer is present.
- In Najadaceae & Lemnaceae families middle layer is absent.
- In Wolffia middle layer is absent.

- **4) Tapetum**
- It is the innermost layer that acts as a **nutritive layer**. Pollen sacs are surrounded by tapetum. This is also a single-celled thick layer. The cells of the tapetum initially diploid but they become polyploid and multinucleate due to endomitosis, free nuclear division and polyteny. It means these cells contain many chromosomes. Tapetum absorbs food from the middle layer and provides nutrition to the microspore mother cells or microspores. The cells of the tapetum secrete **hormones** and **enzymes**. The tapetum layer disappears in the mature anther.

- **Note:**
  In Nicodia and Costum plants, tapetum is multilayered.



Two Types of Tapetum

(a) Amoeboid Tapetum/Invasive Tapetum/Periplasmodial Tapetum

- It is found in primitive Angiosperm. Such type of tapetum absorbs all foods from the middle layer. So the middle layer immediately degenerates. In the beginning, all food materials stored by tapetum.
- Tapetal cells convert absorbed food into special food granules called **protoplast bodies**. The innermost layer of the tapetum dissolves and release its protoplast into the cavity of the microsporangium. Now inside the pollen sacs, protoplast bodies are known as **periplasmodium.**
- Microspore mother cells are surrounded by periplasmodium and provide nourishment to the developing microspores. This type of tapetum provides nutrition to the microspores after degeneration.
  Example: Typha, Alisma and Tradescantia.

(b) Glandular Or Secretory Tapetum

- It is an advanced type of tapetum. It does not degenerate quickly. It absorbs nutrients from the middle layer and secretes them into the cavity of the microsporangia (Pollen sacs) and does not store it e.g. Usually it is found in most of the Flowering plants(Capsella).
- Before degeneration of cells of the tapetum, they form special granules called **Proubisch bodies** in the cytoplasm. Proubisch bodies transfer between the cell wall and cell membrane of tapetal cells. Here they are

surrounded by sporopollenin. Now they are called **Ubisch bodies** or **orbicules**.

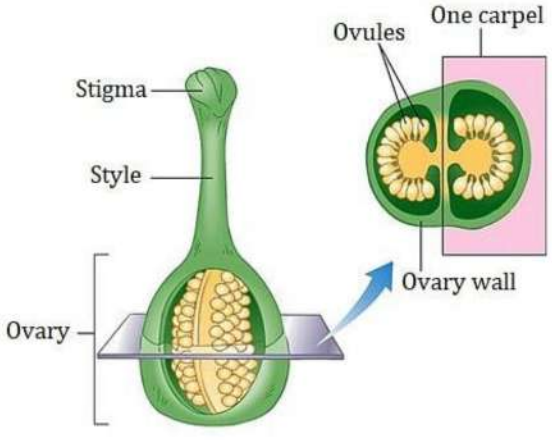
- At last tapetum degenerates and ubisch bodies released into pollen sacs. Generally, sporopollenin participates in the formation of outer covering (Exine) of Pollen grains.

Note:
Tapetum helps in transfer of food, storage of food, formation of sporopollenin and pollen kit materials.

5) Pollen sacs
Four Pollen sacs are present in the anther. Pollen sacs are also known as **microsporangia**. Inside the pollen sacs, microspores are formed by the meiotic division of microspore mother cells.

Female Reproductive Organ: Gynoecium

- The gynoecium is the female reproductive organ. The free unit of gynoecium is called **pistil or carpel.** The carpel is also known as **megasporophyll**.
- The carpel is differentiated into three distinct regions:
  (i) Stigma
  (ii) Style
  (iii) Ovary



- The free end of the carpel which receives pollen grains is called **stigma**.
- A long, narrow tubular structure is present in between the stigma and ovary called **style**. The basal swollen part of the carpel is called the **ovary**.

- The ovules are also known as **megasporongia** which are borne on a cushion-like tissue called the **placenta** in the ovary. One or more than one ovules are present inside the ovary.
- The gynoecium of the *Capsella* is **bicarpellary, syncarpous, unilocular and superior.** It becomes bilocular due to the formation of false septum or replum at maturity.

Difference between male and female gametophyte

S. No.	Male Gametophyte	Female Gametophyte
1	It is developed from microspore or pollen grain.	It is developed form megaspore.
2	It does not remain embedded permanently in microsporangium.	It remains embedded permanently in megasporangium.
3	Male gametes come out of pollen grain due to the formation of pollen tube.	Female gamete always remains inside, cove red by membrane of megasporangium.
4	There are two phases of growth: pre-pollination and post pollination.	Only single phase of growth.
5	It is three celled structure in mature stage.	It has seven cells in mature stage.
6	It will disintegrate after fertilization.	Two new structures are formed after fertilization, that is endosperm and oospore.

Flower as a Modified Shoot

- According to **Goethe**, Flower is a modified shoot that shows favourable adaptation for reproduction through a special method.
- The flower has a small or long stalk-like structure called a **pedicel**. The free end of the pedicel is flattened or dome-shaped is called the **thalamus**. The thalamus is a type of modified stem, on which nodes and internodes are present.
- Nodes are present very close to each other and internodes are small highly reduced in the thalamus.

- The whorls present in the flower are the modifications of leaves and arranged in four circles on the thalamus.
- The four nodes are present on the thalamus, in which the first modified leaves are attached on the first lower node are called the calyx.
- The corolla born on the second node. The androecium is present on the third node and gynoecium on the fourth node in the uppermost position.
- In some of the plants, the length of internode increases which is present in between Calyx and Corolla is called Anthophore.
  Example: Silene plant, Dianthus.
- The length of inter-node between the corolla and androecium increases. It is called androphore.
  Example: Passiflora
- If the internode between androecium and gynoecium increases then it is called gynophore.
  Example: Capparis

Capparis

- Both androphore and gynophore are present in the same flower are called **gynandrophore** or **androgynophore**.
  Example: Gynandropsis, pentaphylla and Cleome gynandra.
- The calyx is also a modified vegetative leaf. Such as in the Mussaenda flower, one sepal of calyx modified into a leaf-like bright and attractive yellow colour structure called **"Advertising flag"**. It helps in pollination.

- In some flowers; the thalamus that grows inside the ovary is called **carpophore.**
  Example: Coriandrum and Foeniculum.
- In Nymphaea Petals like stamens are present.
- On the basis of above examples, we can prove **"Flower is modified shoot"**.

Monocarpic Plants

- The plants in which **flowering** and **fruiting** take place **only once** in the whole life cycle are called **monocarpic.**
  Example: Annual & Biennial plants.

Monocarpic Plant

Polycarpic Plants

- The plants in which **flowering** and **fruiting** take place **many times** in the entire life cycle are known as **polycarpic.**
  Example: Perennial plant.
  Exception: Bamboo, Palms, Banana, Century plant (Agave americana) are perennial plants but they are the example of monocarpic plants.