Sexual Reproduction in Flowering Plants

Four main events must occur in order for sexual reproduction to take place.

1. The organism must be developed and mature sexually.
2. Gametogenesis; production of sex cells involving a special type of cell division known as meiosis during which the chromosome number is halved must take place.
3. Dispersal or liberation of at least one type of gamete
4. The fusion of gametes female and male and production of the zygote by the process of fertilization

Flower structure

Sexual reproduction in flowering plants involves the flower. Within a flower are structures that produce both male gametes and female gametes.

n.b Revise the structure of a flower from the Functional approach.

Development of the ovule and female gamete

There is development of one or more **ovules** inside the ovary. Each ovule begins life as a small projection into the cavity of the ovary. As it grows and develops it begins to bend but remains attached to the ovary wall by a placenta. The ovule is the structure that gives rise to and contains the female reproductive cells. It consists of three parts: The **integument(s)** forming its outer layer(s), the **nucellus** (or megasporangium), and the megaspore-derived female gametophyte in its center. The megagametophyte (also called **embryo sac** in flowering plants) produces an egg cell (or several egg cells in some groups) for fertilization. After fertilization, the ovule develops into a seed.

At the beginning, in the ovule is a group of similar cells called the **nucellus**? As the ovule develops, the mass of cells differentiates to form an inner and an outer **integument**, surrounding and protecting the nucellus within, but leaving a small opening called the **micropyle**.The micropyle.The is generally at the lower end of the ovule and serves as a passage for the entry of the pollen tube. Within the nucellus is one megaspore mother cell or an embryo sac mother cell.The other end of the ovule where funicle joins with the nucellus and integument is called the chalaza.

Development of a megaspore mother cell

A megaspore mother cell is a large diploid cell that produces the female gametophyte. The diploid cell undergoes meiosis and gives rise to four haploid cells. One cell develops into a haploid megaspore and the rest which are three in number degenerate. As it grows,its nucleus undergoes 3 mitotic divisions and produces eight haploid nuclei.The structure formed is termed as the embryo sac.

At the centre of the ovule is an **embryo sac** containing the haploid egg cell (the female gamete).

Development of the embryo sac

An embryo sac contains eight nuclei which further undergo various developmental changes as given below.

Each end of the embryo sac has 4 nuclei.

One nucleus from each group of the 4 nuclei moves to the centre. These nuclei are known as polar nuclei and may fuse to form a single diploid nucleus in some plants. In other plants they fuse later at the time of fertilization.

There are three nuclei at the micropyle.The end and another group of three nuclei at the chalaza end. Thin cell walls form and isolate all these six nuclei.

Out of the three cells at the micropyle.The end, one enlarges and becomes the egg cell or female gamete. The cells on its either side are called synergids.

The three cells at the chalaza end are known as the antipodal cells.

N.b draw the diagrams of the Development of the embryosac, structure of a mature ovule from the biological science.

Development of the male gamete

Each anther contains 4 pollen sacs. Each pollen sac is known as microsporangium and is filled with number of large sized cells called microsporocytes or sporogenous cells. They have abundant cytoplasm and prominent nuclei. Each diploid microsporocyte divides many times by mitosis to produce diploid microspore mother cells or pollen mother cells. Each pollen mother cell undergoes meiosis to form 4 haploid pollen cells or microspores. These form a tetrad with a common wall. Each pollen cell or microspore gets separated and develops into a pollen grain.. Many pollen grains develop inside each pollen sac. In each pollen grain the wall thickens and forms an inner layer (the **intine**) and an often highly sculptured outer layer (the **exine**). The surface pattern is different on pollen grains in the different plant species. Each pollen nucleus in the mature pollen grain undergoes mitosis and forms 2 nuclei. One that is bigger is known as the generative nucleus while the smaller one is known as the tube nucleus.

When the pollen grains are mature, the anther dries out and splits open along the lines of weakness (a process called **dehiscence**) and the pollen grains are released.

N.b draw the diagrams of the Development of the male gamete, structure of a mature pollen grain and pollen germination from biological science

Pollination

Many plants favour cross-**pollination**, so pollen must be transferred to the stigma of another plant if sexual reproduction is to take place. Some flowers rely on the wind to carry the pollen grains while others rely on the insects.

Self-pollination is where the pollen is transferred to the stigmas of the same flower or the stigma of another flower on the same plant. Self-pollination is more reliable, particularly when the nearest plants are not very close.

A potential drawback to this method of pollination is that both gametes come from the same parent. If the plant is well adapted to a stable environment, the production of uniform offspring is advantageous. However, inbreeding does occur and if there are disadvantageous recessive characteristics in the parents, they are much more likely to be expressed if the plants are selfed.

Cross-pollination is less reliable and more wasteful than self-pollination, but it is genetically more favourable because genes are transferred and thus more variation is ensured.

Adaptations to promote cross pollination:

- **Dioecious plants**: Some plants have flowers that are only male - they have only **stamens**. Other plants of the same species have flowers that are only female - they have only **carpels**.e.g pawpaw
- **Monoecious plants**: Some flowers on a plant are only male; other flowers on the same plant are only female. So, self pollination is avoided by a difference in the timing of their development.e.g maize
- **Protandry**: Anthers on some plants mature first. Pollination of immature stigma on the same plant is therefore not possible.
- **Protogyny**: The stigmas mature first.
- **Self-incompatibility**: Pollination can occur but the pollen tube doesn't grow well, if at all, so no fertilisation takes place.

For those plants that cross-pollinate, some are wind pollinated, others are insect pollinated. Here are some of the differences:

Feature:	**Wind pollinated flowers:**	**Insect pollinated flowers:**
Petals:	Small inconspicuous, sometimes absent. If present, not brightly	Large, brightly coloured, conspicuous and attractive to insects.

	coloured.	
Scent:	None.	Often scented.
Nectary:	Absent.	Present.
Pollen:	Produced in large quantities, light, smooth pollen grains.	Less produced pollen grains larger, sculptured walls for attachment to insects and to stigma.
Anthers:	Move freely because stamens are pendulous, so pollen is easily dispersed.	Fixed to filaments and positioned to come into contact with visiting insects.
Stigma:	Large often branched and feathery, hanging outside the flower to trap pollen.	Small, sticky enclosed within the flower, positioned to come into contact with visiting insects.

Fertilisation

If the pollen grain lands on a compatible stigma, it absorbs water by osmosis and swells. A **pollen tube** develops out of the swelling and grows through an aperture in the outer coat of the pollen grain. A sugar solution secreted by the stigma provides nourishment for the germinating pollen grain, a **pollen tube** grows so that eventually the egg cell in the embryo sac is fertilised. A pollen tube emerges from the pollen grain and its growth is controlled by the pollen tube nucleus at the tip of the pollen tube. The pollen tube grows downwards digesting its path through the style by secreting hydrolytic enzymes at its tip.It is directed towards the ovary in response to chemicals secreted by the synergids in the ovule in the ovary (a response known as positive chemotropism).

During the growth and extension of the pollen tube, the haploid **generative nucleus**, behind the pollen tube nucleus, divides by mitosis to produce **2 male haploid gametes**. The pollen tube enters the ovule through the micropyle.The the pollen tube penetrates the embryo sac wall. The tip of the pollen tube bursts open, the tube nucleus degenerates and what follows is called **double fertilisation**. It involves the following:

1 male gamete fuses with the egg cell to produce a **diploid zygote**.

1 male gamete fuses with both the polar nuclei to produce the **triploid primary endosperm nucleus**.

After fertilisation

The following happens:

1. The zygote divides many times by mitosis to produce an embryo. It differentiates to become a plumule (embryonic shoot), radicle (embryonic root) and either 1 or 2 cotyledons. It is attached to the wall of the embryo sac by a suspensor.

2. The primary endosperm nucleus divides many times by mitosis to produce endosperm tissue. In some seeds this endosperm is a food store for later use by the seed. In others it may gradually disappear as the cotyledons develop.
3. To accommodate all this growth the embryo sac expands and the nucellus is crushed out of existence, and its nutrients are taken up by the embryo and endosperm.
4. The integuments surrounding the embryo sac become the tough and protective seed coat. Outer integument forms the testa; while the inner integument forms the tegmen .The micropyle remains though so that oxygen and water can be taken in at germination.
5. The water content of the seed decreases drastically so that the seed is prepared for dormancy.
6. The ovule develops into a seed .The ovary wall develops into the **pericarp** - the fruit wall, the whole ovary develops into the fruit. The function of the fruit is to protect the seeds and to aid in their dispersal, e.g. by an animal. That is why they can be brightly coloured and sweet; animals will eat them and disperse the seeds either at the time of eating them or when they are passed out of the gut in defecation, undigested.

Germination

When conditions are conducive, the seed takes up water through the micropyle by imbibition. This triggers the beginning of the growth of the seed.

The cell swells and the testa splits. With the addition of water, large molecules of carbohydrate, protein and fat can be hydrolysed (broken down) to produce substances for respiration.

The water activates such enzymes as a-amylase to catalyse this digestion.

The growing embryo releases a hormone called **gibberellic acid** and some enzymes are produced and released in response to this.

The soluble products of digestion are delivered to the cotyledons, root and shoot. They respire aerobically and grow in size.

By the time the food store has been used up, the shoot has grown enough have the first leaves exposed to the sunlight. Photosynthesis then starts.