**Sexual reproduction in plants:**

**Plant Reproduction**

Plant reproduction is the production of new offspring in plants, which can be accomplished by sexual or asexual reproduction.

**Sexual reproduction**

 Sexual reproduction produces offspring by the fusion of gametes, resulting in offspring genetically different from the parent or parents. Asexual reproduction produces new individuals without the fusion of gametes, genetically identical to the parent plants and each other, except when mutations occur.

**Process of Sexual Reproduction**

This fundamental process of reproduction is DNA replication. In other words, if an organism wants to continue its species, then they need to transfer their traits to the next generation by DNA (genetic information) copying which occurs during the process of reproduction.

We know asexually reproducing organisms copy their DNA and divide themselves into new cells which are their clones. Since the process of replication is not completely reliable, there are chances of variation, but they are quite limited. Organisms need to adapt themselves to the changing environment; the creation of variants needs to be hastened for this reason. This will only happen when there is a union of two different DNAs. This highlights the significance of sexual reproduction in organisms.

If two reproducing cells simply join, the chromosome number in the new organism will be doubled. But this cannot happen because the number of chromosomes in each cell of every organism is fixed – the same holds good for the reproducing cell. Thus, the reproducing cells from both parents reduce their chromosome number into the half before fusion and are called gametes (germ cells). In simple organisms, the size and shape of gametes are almost the same. But in higher organisms, a male gamete is small and mobile while female gamete is large, immobile and they stores food for the fetus. The gametes are produced in a specialized system called the reproductive system.

**Parts of a Flower in Plant Reproduction**

A bisexual flower typically contains the male and female parts in it. There are other supporting structures as well apart from the reproductive parts for sexual reproduction.

**Sexual Reproduction**

(Source: Instructables)

There are four main layers of the parts of a flower:

**Calyx**

**Corolla**

**Androecium**

**Gynoecium**

**Calyx**

It is a collection of sepals. The sepals are the green coloured small florets that are considered the first layers of the flower from the base. In some cases, the sepals have colour. They are called petaloid. Their main function is to protect the flower while it is still in the bud stage.

**Corolla**

This layer is a collection of petals. It is the second layer of the flower, superior to the calyx layer. The petals are the colourful part of a flower that helps to attract insects and birds to the flower to facilitate pollination.

Androecium

It is the third layer of the flower superior to the Corolla. This is a term given to the male parts for sexual reproduction of a plant. The androecium is made up of a collection of stamens. Each stamen has the following parts:

**Anther-** It is present at the tip of the filament. It is internally lobed. Pollen grains are inside the Anther Lobe.

Filament- It is a thin stalk-like structure that holds the anther

**Gynoecium**

A Gynoecium is a collection of carpels. It is the fourth layer of a flower. It has three parts:

**Stigma**- It is a small and sticky landing structure. The pollen grain from the same or different flower stick to it. This structure acts as a landing for the insects or birds that act as pollinating agents.

**Style-** It is a thin stalk-like structure that holds the stigma.

**Ovary-** It is the base of the style and contains the ovules which contain the female gametes.

**Pollination and Fertilization in Plant Reproduction**

The transfer of pollen grains from the anther of one flower to the stigma of the same or another flower is known as pollination. It can be caused by insects, birds, wind, water and animals including man. These are together called as pollinating agents.

**Sexual Reproduction**

**Types of Pollination**

**Self-Pollination:**

 Self-Pollination is when the pollen of one flower transfers to the stigma of the same flower. Many flowers that are hermaphrodite see this kind of pollination. However, there are many advantages and disadvantages of this type of pollination. Many flowers have various mechanisms to prevent self-pollination or promote cross-pollination.

**Cross-Pollination:**

Cross-Pollination is when the pollen of one flower transfers to the stigma of another flower. This type of pollination helps brings about genetic variation in the species and allow the plant to withstand changes in the environment better. Once the pollen has landed on the stigma of a flower, the pollen tube develops to transfer the pollen to the ovules which contain the female gamete.

Microsporogenesis results in the formation of Male Gametes and Megasporogenesis results in the formation of Female Gametes.

**Microsporogenesis**

The anthers contain the pollen mother cell (2n-diploid) that undergoes meiosis to form microspores.

Tetrad is the result of the microspore mother cell diving and the formation of 4 microspores.

The Anther releases the microspores/pollen grains when it is mature.

**Megasporogenesis**

Megasporangium are the Ovules. They are in the ovary and contain the female gametes. Megasporogenesis is the formation of megaspores from the megaspore mother cell (diploid). The resultant of the meiosis fo the megaspore mother cell is 4 haploid megaspores. Of the four cells that form, only one is functional while the other degenerate.

Double Fertilization happens in angiosperms. This is because the male gamete that enters the ovule has two nuclei. One of the male gametes fuses with the female gamete to form a diploid zygote whereas the other one forms a triploid endosperm by fusing with the diploid polar nuclei. The zygote divides to form the future plant whereas the endosperm provides nutrition to the developing embryo.

**Sexual Reproduction**

(Source: jagranjosh)

**Events after Fertilization in Plant Reproduction**

After fertilization, the ovary becomes the fruit and the ovules become the seeds. The other structures like the calyx, corolla and the remaining parts of the androecium and gynoecium degenerate or fall off.

Sexual reproduction involves two fundamental processes: [meiosis](https://en.m.wikipedia.org/wiki/Meiosis), which rearranges the [genes](https://en.m.wikipedia.org/wiki/Gene) and reduces the number of [chromosomes](https://en.m.wikipedia.org/wiki/Chromosome), and [fertilization](https://en.m.wikipedia.org/wiki/Fertilisation), which restores the chromosome to a complete [diploid](https://en.m.wikipedia.org/wiki/Diploid) number. In between these two processes, different types of [plants](https://en.m.wikipedia.org/wiki/Plant) and [algae](https://en.m.wikipedia.org/wiki/Algae) vary, but many of them, including all [land plants](https://en.m.wikipedia.org/wiki/Embryophyte), undergo [alternation of generations](https://en.m.wikipedia.org/wiki/Alternation_of_generations), with two different multicellular structures (phases), a gametophyte and a sporophyte. The evolutionary origin and adaptive significance of sexual reproduction are discussed in the pages “[Evolution of sexual reproduction](https://en.m.wikipedia.org/wiki/Evolution_of_sexual_reproduction)” and “[Origin and function of meiosis](https://en.m.wikipedia.org/wiki/Origin_and_function_of_meiosis).”

The gametophyte is the multicellular structure (plant) that is [haploid](https://en.m.wikipedia.org/wiki/Haploid), containing a single set of [chromosomes](https://en.m.wikipedia.org/wiki/Chromosome) in each cell. The gametophyte produces male or female [gametes](https://en.m.wikipedia.org/wiki/Gamete) (or both), by a process of cell division, called [mitosis](https://en.m.wikipedia.org/wiki/Mitosis). In vascular plants with separate gametophytes, female gametophytes are known as mega gametophytes (mega=large, they produce the large egg cells) and the male gametophytes are called micro gametophytes (micro=small, they produce the small sperm cells).

The fusion of male and female gametes (fertilization) produces a [diploid](https://en.m.wikipedia.org/wiki/Diploid) [zygote](https://en.m.wikipedia.org/wiki/Zygote), which develops by mitotic cell divisions into a multicellular [sporophyte](https://en.m.wikipedia.org/wiki/Sporophyte%22%20%5Co%20%22Sporophyte).

The mature sporophyte produces [spores](https://en.m.wikipedia.org/wiki/Spore) by [meiosis](https://en.m.wikipedia.org/wiki/Meiosis), sometimes referred to as "[reduction division](https://en.m.wikipedia.org/wiki/Reduction_division)" because the chromosome pairs are separated once again to form single sets.

In mosses and liverworts, the gametophyte is relatively large, and the sporophyte is a much smaller structure that is never separated from the gametophyte. In [ferns](https://en.m.wikipedia.org/wiki/Fern), [gymnosperms](https://en.m.wikipedia.org/wiki/Gymnosperm), and [flowering plants](https://en.m.wikipedia.org/wiki/Flowering_plant) (angiosperms), the gametophytes are relatively small and the sporophyte is much larger. In gymnosperms and flowering plants the megagametophyte is contained within the [ovule](https://en.m.wikipedia.org/wiki/Ovule) (that may develop into a seed) and the micro gametophyte is contained within a [pollen](https://en.m.wikipedia.org/wiki/Pollen) grain. It is known as fertilization.

## **History of sexual reproduction of plants**

Unlike animals, plants are immobile, and cannot seek out sexual partners for reproduction. In the evolution of early plants, abiotic means, including water and wind, transported [sperm](https://en.m.wikipedia.org/wiki/Sperm) for reproduction. The first plants were [aquatic](https://en.m.wikipedia.org/wiki/Aquatic_ecosystem), as described in the page "[Evolutionary history of plants](https://en.m.wikipedia.org/wiki/Evolutionary_history_of_plants)", and released sperm freely into the water to be carried with the currents. Primitive land plants like liverworts and mosses had motile sperm that swam in a thin film of water or were splashed in water droplets from the male reproduction organs onto the female organs. As taller and more complex plants evolved, modifications in the [alternation of generations](https://en.m.wikipedia.org/wiki/Alternation_of_generations) evolved; in the [Paleozoic](https://en.m.wikipedia.org/wiki/Paleozoic) era [progymnosperms](https://en.m.wikipedia.org/wiki/Progymnosperm%22%20%5Co%20%22Progymnosperm) reproduced by using spores dispersed on the wind. The seed plants including [seed ferns](https://en.m.wikipedia.org/wiki/Seed_fern), [conifers](https://en.m.wikipedia.org/wiki/Conifer) and [cordaites](https://en.m.wikipedia.org/wiki/Cordaites%22%20%5Co%20%22Cordaites), which were all [gymnosperms](https://en.m.wikipedia.org/wiki/Gymnosperm), evolved 350 million years ago; they had pollen grains that contained the male [gametes](https://en.m.wikipedia.org/wiki/Gametes) for protection of the sperm during the process of transfer from the male to female parts. It is believed that insects fed on the pollen, and plants thus evolved to use [insects](https://en.m.wikipedia.org/wiki/Insect) to actively carry pollen from one plant to the next. Seed producing plants, which include the angiosperms and the gymnosperms, have a heteromorphic alternation of generations with large sporophytes containing much-reduced gametophytes. Angiosperms have distinctive reproductive organs called flowers, with [carpels](https://en.m.wikipedia.org/wiki/Carpel%22%20%5Co%20%22Carpel), and the female gametophyte is greatly reduced to a female embryo sac, with as few as eight cells. The male gametophyte consists of the pollen grains. The sperm of seed plants are non-motile, except for two older groups of plants, the [Cycadophyta](https://en.m.wikipedia.org/wiki/Cycadophyta%22%20%5Co%20%22Cycadophyta) and the [Ginkgophyta](https://en.m.wikipedia.org/wiki/Ginkgophyta%22%20%5Co%20%22Ginkgophyta), which have flagellated sperm.

### **Flowering plants**

[Flowering plants](https://en.m.wikipedia.org/wiki/Flowering_plant) are the dominant plant form on land and they reproduce by sexual and asexual means. Often their most distinguishing feature is their reproductive organs, commonly called flowers. Sexual reproduction in flowering plants involves the production of male and female [gametes](https://en.m.wikipedia.org/wiki/Gamete), the transfer of the male gametes to the female ovules in a process called [pollination](https://en.m.wikipedia.org/wiki/Pollination). After pollination occurs, [fertilization](https://en.m.wikipedia.org/wiki/Fertilization) happens and the ovules grow into seeds within a [fruit](https://en.m.wikipedia.org/wiki/Fruit). After the seeds are ready to for [dispersal](https://en.m.wikipedia.org/wiki/Biological_dispersal), the fruit ripens and by various means, the seeds are freed from the fruit and after varying amounts of time and under specific conditions the seeds [germinate](https://en.m.wikipedia.org/wiki/Germinate) and grow into the next generation.

The [anther](https://en.m.wikipedia.org/wiki/Stamen) produces male [gametophytes](https://en.m.wikipedia.org/wiki/Gametophyte) which are [pollen grains](https://en.m.wikipedia.org/wiki/Pollen), which attach to the stigma on top of a [carpel](https://en.m.wikipedia.org/wiki/Carpel), in which the female gametophytes (inside ovules) are located. After the pollen tube grows through the carpel's style, the sperm from the pollen grain migrates into the ovule to fertilize the egg cell and central cell within the female gametophyte in a process termed [double fertilization](https://en.m.wikipedia.org/wiki/Double_fertilization). The resulting zygote develops into an embryo, while the triploid endosperm (one sperm cell plus a binucleate female cell) and female tissues of the ovule give rise to the surrounding tissues in the developing seed. The ovary, which produced the female gametophyte(s), then grows into a [fruit](https://en.m.wikipedia.org/wiki/Fruit), which surrounds the seed(s). Plants may either [self-pollinate](https://en.m.wikipedia.org/wiki/Self-pollination) or [cross-pollinate](https://en.m.wikipedia.org/wiki/Pollination).

#### Pollination



An orchid flower

In plants that use insects or other animals to move pollen from one flower to the next, plants have developed greatly modified flower parts to attract pollinators and to facilitate the movement of pollen from one flower to the insect and from the insect back to the next flower. Flowers of wind-pollinated plants tend to lack petals and or sepals; typically large amounts of pollen are produced and pollination often occurs early in the growing season before leaves can interfere with the dispersal of the pollen. Many trees and all grasses and sedges are wind-pollinated, as such they have no need for any flowers.

Plants have a number of different means to attract pollinators including color, scent, heat, nectar glands, edible pollen and flower shape. Along with modifications involving the above structures two other conditions play a very important role in the sexual reproduction of flowering plants, the first is the timing of flowering and the other is the size or number of flowers produced. Often plant species have a few large, very showy flowers while others produce many small flowers, often flowers are collected together into large inflorescences to maximize their visual effect, becoming more noticeable to passing pollinators. Flowers are attraction strategies and sexual expressions are functional strategies used to produce the next generation of plants, with pollinators and plants having co-evolved, often to some extraordinary degrees, very often rendering mutual benefit.



Flower heads showing disk and ray florets.

The largest family of flowering plants is the orchids ([Orchidaceae](https://en.m.wikipedia.org/wiki/Orchidaceae%22%20%5Co%20%22Orchidaceae)), estimated by some specialists to include up to 35,000 species, which often have highly specialized flowers that attract particular insects for pollination. The stamens are modified to produce pollen in clusters called [pollinia](https://en.m.wikipedia.org/wiki/Pollinium%22%20%5Co%20%22Pollinium), which become attached to insects that crawl into the flower. The flower shapes may force insects to pass by the pollen, which is "glued" to the insect. Some orchids are even more highly specialized, with flower shapes that mimic the shape of insects to attract them to attempt to 'mate' with the flowers, a few even have scents that mimic insect [pheromones](https://en.m.wikipedia.org/wiki/Pheromone).

Another large group of flowering plants is the [Asteraceae](https://en.m.wikipedia.org/wiki/Asteraceae%22%20%5Co%20%22Asteraceae) or sunflower family with close to 22,000 species, which also have highly modified inflorescences that are flowers collected together in heads composed of a composite of individual flowers called florets. Heads with florets of one sex, when the flowers are pistillate or functionally staminate or made up of all bisexual florets, are called homogamous and can include discoid and liguliflorous type heads. Some radiate heads may be homogamous too. Plants with heads that have florets of two or more sexual forms are called heterogamous and include radiate and disciform head forms, though some radiate heads may be heterogamous too.

### **Ferns**

Ferns typically produce large diploids with stem, roots, and leaves; and on fertile leaves called [sporangium](https://en.m.wikipedia.org/wiki/Sporangium), [spores](https://en.m.wikipedia.org/wiki/Spore) are produced. The spores are released and germinate to produce short, thin gametophytes that are typically heart-shaped, small and green in color. The gametophytes or [thallus](https://en.m.wikipedia.org/wiki/Thallus%22%20%5Co%20%22Thallus), produce both motile sperm in the [antheridia](https://en.m.wikipedia.org/wiki/Antheridia) and egg cells in separate [archegonia](https://en.m.wikipedia.org/wiki/Archegonia). After rains or when dew deposits a film of water, the motile sperm are splashed away from the antheridia, which are normally produced on the top side of the thallus, and swim in the film of water to the antheridia where they fertilize the egg. To promote out crossing or cross-fertilization the sperm is released before the eggs are receptive of the sperm, making it more likely that the sperm will fertilize the eggs of the different thallus. A [zygote](https://en.m.wikipedia.org/wiki/Zygote) is formed after fertilization, which grows into a new sporophytic plant. The condition of having separate sporophyte and gametophyte plants is called [alternation of the generations](https://en.m.wikipedia.org/w/index.php?title=Alternation_of_the_generation&action=edit&redlink=1). Other plants with similar reproductive means include the *[Psilotum](https://en.m.wikipedia.org/wiki/Psilotum%22%20%5Co%20%22Psilotum)*, *[Lycopodium](https://en.m.wikipedia.org/wiki/Lycopodium%22%20%5Co%20%22Lycopodium)*, *[Selaginella](https://en.m.wikipedia.org/wiki/Selaginella%22%20%5Co%20%22Selaginella)* and [*Equisetum*](https://en.m.wikipedia.org/wiki/Equisetum).

### **Bryophytes**

The [bryophytes](https://en.m.wikipedia.org/wiki/Bryophyte), which include [liverworts](https://en.m.wikipedia.org/wiki/Marchantiophyta), [hornworts](https://en.m.wikipedia.org/wiki/Hornwort) and [mosses](https://en.m.wikipedia.org/wiki/Moss), reproduce both sexually and [vegetatively](https://en.m.wikipedia.org/wiki/Vegetative_reproduction%22%20%5Co%20%22Vegetative%20reproduction). The gametophyte is the most commonly known phase of the plant. All are small plants found growing in moist locations and like ferns, have motile sperm with [flagella](https://en.m.wikipedia.org/wiki/Flagella) and need water to facilitate sexual reproduction. These plants start as a haploid spore that grows into the dominant form, which is a multicellular haploid body with leaf-like structures that [photosynthesize](https://en.m.wikipedia.org/wiki/Photosynthesis). Haploid gametes are produced in antheridia and archegonia by mitosis. The sperm released from the antheridia respond to chemicals released by ripe archegonia and swim to them in a film of water and fertilize the egg cells, thus producing zygotes that are diploid. The zygote divides by mitotic division and grows into a sporophyte that is diploid. The multicellular diploid sporophyte produces structures called [spore capsules](https://en.m.wikipedia.org/wiki/Sporangium). The spore capsules produce spores by meiosis, and when ripe, the capsules burst open and the spores are released. Bryophytes show considerable variation in their breeding structures and the above is a basic outline. In some species each gametophyte is one sex while other species produce both antheridia and archegonia on the same gametophyte which is thus hermaphrodite.