Fertilisation is a process of sexual reproduction in plants in which male pollen gametes combine with female gametes or ovum to generate a diploid zygote or eggs that grow into seeds. Flowers are plant reproductive organs.

We acquire fruits and veggies because of seeds. Plants reproduce primarily through three steps: pollination, fertilisation, and germination.

An individual plant's life begins when an egg nucleus in the maternal organs of a flower is fertilised by a sperm nucleus, resulting in the formation of a zygote. The zygote's growth and differentiation results in the formation of an embryo within a protective structure known as a seed. Under the right conditions, the embryo within the seed will regenerate and develop into a mature plant. Fertilisation occurs in both angiosperms and gymnosperms.

Pollination, which is required for fertilisation, follows the development of male and female gametophytes. Pollination results in a thick coating of pollen grains on the stigma surface.

Fertilisation in angiosperms begins with the arrival of suitable pollens at the stigma and ends with the merging of male and female gametes in the embryo sac. The stigma stores pollens collected by the female reproductive organ, the carpel. Because the fusing within the embryo sac occurs twice, this event is known as Double fertilisation and is a distinct property of angiosperms.

Strasburger discovered fertilisation for the first time in 1884. In angiosperms, the female gametophyte (embryo sac) is located in the ovule. As a result, pollens that reach the stigma form a pollen tube, which aids the delivery of male gametes deep into the embryo sac from the stigma.

The developing pollen tube penetrates the stigmatic tissue, moves through the style, and then down the ovarian wall. The design might be hollow or solid.

**Entry of pollen tube into ovule:**

The pollen tube makes its way into the ovule after entering the ovary. The pollen tube can penetrate the ovule in three ways.

1. via the micropyle

2. via the chalazal end

3. by way of the integument or the funicle

Three names are defined based on the mechanisms of entry of the pollen tube into the ovule:

**1. Porogamy:** Porogamy occurs when the pollen tube reaches the ovule through the micropyle. This is the most typical way for pollen tubes to enter the ovule.

**2. Chalazogamy: This condition occurs when the pollen tube penetrates the ovule by the chalazal end. Casuarina, Betula, and Juglans regia were found to have this form of pollen tube entrance into the ovule.**

**3. Mesogamy: This state occurs when the pollen tube reaches the ovule through the integument or the funicle. This sort of pollen tube penetration into the ovule has been reported in Cucurbita (via integument) and Pistacia (via funicle).**

**Entry of pollen tube into the embryo sac:**

It makes no difference which way the pollen tube enters the ovule; it always enters the embryo sac by the micropylar end, implying that pollen tube entry into the embryo sac is independent of pollen tube entry into the ovule.

Again, the pollen tube may enter the embryo sac via multiple pathways after passing through the micropyle. It could be between the egg cell and one of the synergids, between the embryo sac wall and the synergid, or directly entering one of the synergids.

So, synergids not only play a vital function in determining pollen tube entry into the embryo sac, but they also influence male gamete distribution in the embryo sac.

**Discharge of male gametes from pollen tube:**

After reaching the embryo sac the tip of the pollen tube swells up and finally ruptures liberating two male gametes into the cytoplasm of the female gametophyte. Just prior to bursting of pollen tube the tube nucleus disorganizes. Immediately after release, the male gametes show amoeboid movement and one male gamete moves toward the egg while the other one moves towards the polar nuclei (or secondary nucleus).

**Syngamy- fusion of gametes:**

When a male gamete reaches an egg, it unites with it. This fusion produces a diploid zygote/oospore (2n). Syngamy, or fertilisation, is the union of male and female gametes.

This is one of the most significant discoveries made by **E. Strasburger in 1884**. He observed the actual fusion of the male gamete with the female gamete (egg) in *Monotropa.*

What happened to the second male gamete, given that the pollen tube releases two male gametes? S. Nawaschin (1898) discovered the answer while working with Fritillaria and Lilium. He demonstrated that one male gamete fuses with the egg (syngamy), while the other male gamete fuses with the two polar nuclei, resulting in the formation of a triploid nucleus (3n) known as the major endosperm nucleus.

Double fertilisation:

The fusion of an embryo sac occurs twice, once through syngamy and once through triple fusion, and so the occurrence is known as twofold fertilisation.

The zygote or oospore cell is created as a result of initial fusion, and it is the first cell of the sporophyte (embryo). The triploid or 3n nucleus of the triple fusion result is known as the primary endosperm nucleus and gives rise to the endosperm.

S.G. Nawaschin (1898) identified double fertilisation in Lilium and Fritillaria species for the first time.

**Post Fertilization Developments**

Following fertilisation, the embryo and endosperm grow concurrently within the embryo sac. The embryo grows from the oospore (zygote), while the endosperm develops from the primary endosperm nucleus. Other nuclei or cells within the embryo sac (synergids, antipodal cells) eventually disorganize.

Because the primary endosperm nucleus is the result of triple fusion, it has both maternal and paternal chromosomes, indicating that growing endosperm has hybrid vigour.

Some angiosperms have reduced endosperm production or do not form endosperm at all. Members of the Orchidaceae, Podostemaceae, and Trapaceae families are examples of angiosperms.

[When it comes to the importance of endosperm for humans, it is an edible part of cereals and coconut, as well as a source of industrial castor-oil in castor-bean. Endosperm provides the majority of human calories, making it the most essential plant product on the planet for man.

Endosperm is found in cereals such as wheat, rice, maize, millets, barley, and oats, as well as their various commercial derivatives such as cornflakes, popcorn, and bear. Similarly, cooking oils such as coconut oil and corn oil, as well as industrial oils such as palm oil, castor bean oil, and Jatropha oil, are endosperm-derived.

**4.5 ENDOSPERM DEVELOPMENT**

Endosperm is a tissue which provides the essential food materials utilized in the growth of the embryo and in many cases, the young seedling. So endosperm, a fundamental component in the evolutionary success of angiosperms (Stebbins 1974), is not only the important source of food for the developing embryo but also an important source of food, feed and industrial raw materials for mankind.

As describe earlier, the primary endosperm nucleus is formed either by the fusion of one haploid male gamete and one diploid secondary nucleus (fusion product of two haploid polar nuclei) or by the fusion of three haploid nuclei (one male gamete belongs to male gametophyte and two polar nuclei belong to the female gametophyte).

Generally the endosperm nucleus divides after the division of the oospore, but in many cases the endosperm is formed even before the first division of the oospore.

In triple fusion process there is fusion of only the male nucleus with the polar nuclei, male cytoplasm does not take part in the process while the membrane of the primary endosperm nucleus is formed by both the secondary nucleus and the male nucleus.

After fertilization, metabolic activity increase in the central cell and protein –synthesis machinery organized for the differentiation of primary endosperm cell (Bhatnagar and Sawhney 1980).

What is Fertilization?

We know during the pollination process, the pollen gets transferred to the female reproductive organs and slips inside the ovary after which the pollen tube opens into the ovule and bursts into the embryo sac here the male nucleus unites with the eggs nucleus inside the ovule where a zygote is formed.

Pollination is not enough for reproduction of a new plant. It has to be followed

by a process in which there is fusion of pollen grains with the ovule and this process is known as fertilization. So, pollination followed by fertilization brings about reproduction in a plant. Now, pollination ensures that the pollen grains fall on the stigma of the carpel.

The pollen grain has an outer exine and an internal intine. Now, after pollination the pollen grain reaches the stigma, what happens is the inner intine bulges out. It breaks open the outer exine and it forms a tube like structure.

Now, we know about two nucleus that were present in the pollen grain, the tube

nucleus and the generative nucleus. Now, the tube nucleus leads this tube formation towards the ovule and hence, it is known as the tube nucleus. Another function of the tube nucleus is that it gives direction to the generative nucleus. So, it gives direction to the generative nucleus towards the ovule.

Ovule:

The ovule contains the egg cell. Fusion of egg cell with the generative nucleus

forms a new plant life. Now, the ovule is connected to the ovary, by this pipe like structure which is known as the Funiculus. Now the tube formation of the

pollen grain reaches the ovule near the funiculus and enters into the ovule through a pore like structure which is known as the Micropyle. So, micropyle, which is this opening allows the entry of the tube, this pollen tube into the ovule.

Now, you might have also noticed that there are two adjacent cell beside the

egg cell. Now these two cells, they work together and help in the fusion of a generative nucleus to the egg cell. So, these two cells work together and they are known as Synergid.

Synergid means to work together and these three cells that are present on the opposite side of this opening is known as the Antipodal cells.

Antipodal means opposite side. Antipodal cells have no role in fertilization. After fertilization this ovary converts into the fruit and the ovule inside the ovary

turns into the seed of a fruit. So, after fertilization ovary becomes the fruit, and the ovules that were present inside the ovary, they turn into the seed. So, this is a

converted ovule.

So, hence it is proved that after fertilization ovule converts into a seed and the ovary converts into the fruit. Now, a seed may be stored for many years before being planted. Like all living beings, that need food to survive, even seed needs food to survive.

Well, before fertilization all the nourishment that the cells of the ovule requires is provided by this structure that surrounds the ovule and is known as the Nucellus.

After fertilization, the ovule turns into the seed. So, the seed stores food for itself in the central cell. So after fertilization, the central cell stores the food.

Because seeds are severely dehydrated, any metabolic reactions take place so slowly they are scarcely detectable. Seeds are thus **quiescent**, or resting, organs that represent a normal hiatus in the life cycle of a plant. The embryo appears to be in a state of suspended animation, capable in some cases of surviving adverse conditions for long periods of time. Resumption of embryo growth, called **germination**, is dependent upon a number of factors, but three are especially important: adequate water to re-hydrate the tissues, the presence of oxygen to support aerobic respiration, and a ‘‘physiological’’ temperature.

The initial step in germination of seeds is the uptake of water and rehydration of the seed tissues by the process of imbibition. Like osmosis, imbibition involves the movement of water down a water potential gradient.

Cell inside the ovule:

Since it is centrally located inside the ovule, it is known as the central cell. Now, the central cell contains two polar nuclei at the centre. Now, a generative nucleus fuses with this central cell to form endosperm which supplies the seed with food. Generative nucleus fuses with the egg cell to form the future plant.

In the tube formed by the pollen grain the generative nucleus divides to form two male gametes. One male gamete fuses with the egg cell to form the future plant and another male gamete fuses with the central cell to form the endosperm and this process is known as Double fertilization.

One of the male gametes fuses with the egg cell. Now the fusion of this egg cell with the male gamete gives rise to embryo. This embryo will grow into a new plant in the future. Another male gamete fuses with the central cell to form the endosperm. This endosperm stores food to support the embryo.

Double fertilization:

There are two polar nuclei inside the central cell. So this fusion of a male gamete with two polar nuclei inside the central cell is known as Triple fusion. So, this was double fertilization and this fusion within the central cell is known as triple fusion.

The cell wall of the generative cell breaks down and the generative nucleus divides once to form two sperm nuclei that follow the tube nucleus down the tube as it elongates.

In the final stage, the elongating pollen tube enters the ovule by growing through the micropyle (the space between the ends of the surrounding integuments) and releases the two sperm nuclei into the embryo sac. Ultimately, one of the two sperm nuclei enters the egg cell and fertilizes the egg cell nucleus to form the zygote. The second sperm nucleus enters the large central cell and fuses with the two polar nuclei to form a triploid endosperm nucleus. The endosperm nucleus will go on to form the primary nutritive tissue, or endosperm, for the developing embryo. The involvement of two sperm nuclei in this way is called double fertilization, a characteristic unique to the flowering plants or angiosperms.