# 5 POLLINATION AND FERTILIZATION

***Syllabus :*** Pollination : self and cross-pollination.
Fertilization.

*Explanation, advantages and disadvantages of self and cross-pollination, agents of pollination and the characteristic features of flowers pollinated by various agents such as insects, wind and water.*

*A brief idea as to how nature favours cross pollination.*

*Events taking place between pollination and fertilization leading to the formation of zygote in the embryo sac. A brief explanation of the terms double fertilization and triple fusion. .*

## 5.1 POLLINATION

**What is pollination ?** You have read that the stamens of a flower are the male organs. The anthers of the stamens produce powdery material called **pollen** which consists of particles called **pollen grains.** Each pollen grain contains nuclei that participate in reproduction. For initiating this process of formation of fruit and seeds the first step is that the pollen grains must reach the stigma. It may happen in three principal ways (Fig. 5.1).

1. The pollen of the ***same flower*** may fall on its stigma by itself **(autogamy)** (*auto* : self, *gamy:* marriage).
2. The pollen of ***another flower of the same plant*** may fall on the stigma **(geitonogamy)** (*geitono*: neighbouring).
3. The pollen of a flower of ***another plant of the same species*** may fall on the stigma **(allogamy)** (*allo* : other). This transference can occur through wind, insects, or other agents and the term used for this transference is cross pollination.

**Pollination is the process of transference of pollen grains from the anther to the stigma.**

**Pollination must occur between plants of the same species.** Many different kinds of flowering plants may be growing in the same vicinity. *For example*, an orchard may have trees of mango, guava, litchi, etc., and even some wild trees like neem, jamun or sheesham may also be growing in the neighbourhood. Similarly, various crops may be growing in neighbouring agricultural fields—wheat, mustard, pulses, vegetables and so on. The **wind may blow away** the pollen from all such plants together and thus the flowers of a particular plant may receive all kinds of pollen—of its own kind as well as of others. Similarly,

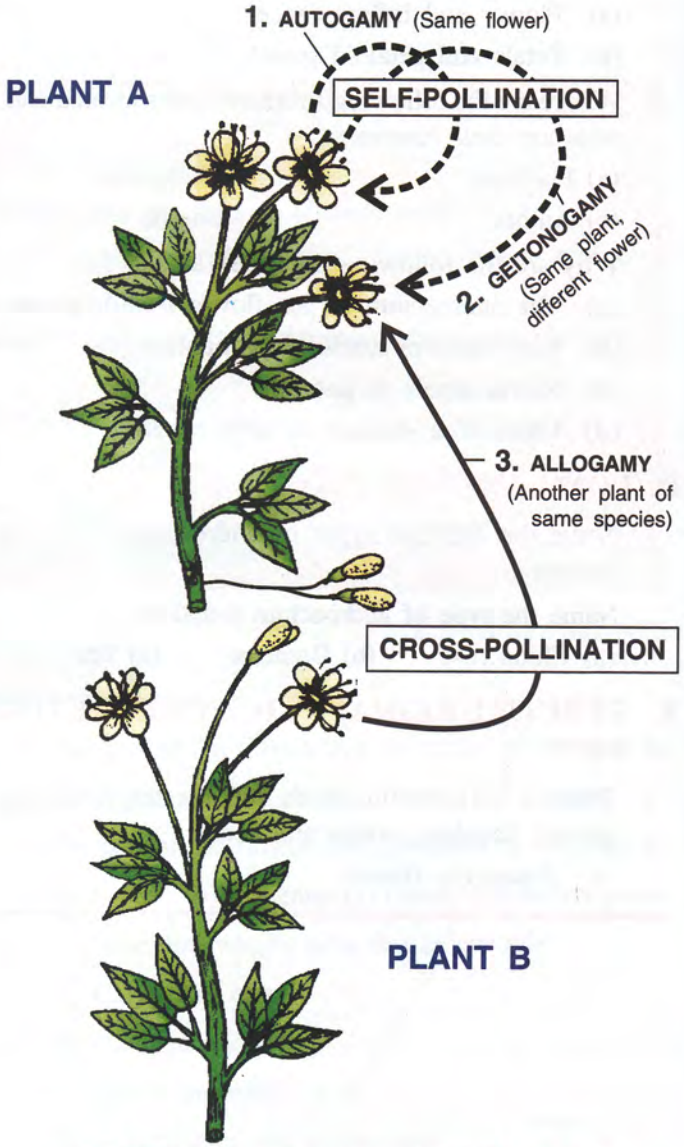



**Fig. 5.1 Diagrammatic representation of self and cross-pollination.**

**insects like bees and butterflies** generally do not discriminate between plants and collect nectar from all kinds of flowers. In the process, the insects are carrying different types of pollen on their bodies. Therefore, the stigma of a flower of any one particular plant receives pollen of its own species as well as of others. But **Nature has so designed that only the pollen of the same species of plant will survive and grow further to continue the processes for reproduction and the rest of the types of pollen will fail to germinate and perish.**

**Kinds of pollination.** There are two kinds of pollination : self-pollination and cross-pollination.

### 5.1.1 SELF-POLLINATION

**Self-pollination** is the transfer of pollen from the anther to the stigma of the **same flower** *(autogamy)*, or to the stigma of **another flower** of the **same plant** *(geitonogamy)*. Pollination between flowers of the same plant is considered self-pollination on account of the common genetic characters—*i.e.* the general qualities or features of any one plant are the same in the different flowers borne on it.

In some rare cases, as in **pansy**, some flowers growing close to the ground level, do not open at all (**cleistogamy,** *cleisto* : closed), the anthers and stigma lie close to each other which mature at the same time and self-pollination is assured.

**When can self-pollination occur ?**

Self-pollination can occur in bisexual flowers, *i.e.* in flowers having both male and female organs, or it can also occur in such unisexual flowers where both male and female flowers are borne on the same plant. To ensure self-pollination, it is necessary that the *anther and stigma of a flower must mature at the same time,* or if the flowers are unisexual and borne on the same plant then they must also mature at the same time.

**Advantages and disadvantages of self-pollination.**

**A. Advantages of self-pollination**

1. It is much **surer** in such bisexual flowers where stamens and carpels mature at the same time.
2. **Parental characters are preserved** indefinitely.
3. There is **no wastage** of pollen grains. Even a small quantity of pollen will suffice.
4. The flowers need not be large and showy.
5. Scent and nectar need not be produced by flowers.

All the above advantages mean **great economy** on the part of the plant. A lot of nutrient material which would otherwise be used in the production of pollen, nectar, scent and large petals, etc., is saved.

**B. Disadvantages of self-pollination**

1. Continued self-pollination, generation after generation, may lead to **weakening of the variety** or the species. The seeds produced through it are poor in quality and give rise to less vigorous offspring.
2. The weaker or defective characters of the variety or breed cannot be eliminated.
3. It **does not yield new varieties.** The genetic traits of the same plant with no change and without any intermixing are passed on to the next generation. Thus there is little chance for improvement in the next generation.

### 5.1.2 CROSS-POLLINATION

Cross-pollination is the transfer of pollen from the **anthers of flowers of one plant to the stigma of a flower of another plant of the same species.** This too has advantages and disadvantages.

**A. Advantages of cross-pollination**

1. The offspring are **healthier**.
2. The seeds produced are **abundant** and viable.
3. **New varieties** may be produced by cross-pollinating two different varieties of the same species or even two species.

**B. Disadvantages of cross-pollination**

1. The pollination is **not always certain** because some pollinating agent is always needed which may or may not be available at the proper time.
2. The pollen has to be produced in large quantity to ensure chances of pollination which means a lot of **wastage of pollen**.
3. The process is **uneconomical for the plant** because the flowers have to be large, coloured, scented and have to produce nectar—for attracting pollinating agents.

The differences between self-pollination and cross-pollination are summarised in Table 5.1.

**Nature favours cross-pollination.** The vast majority of flowering plants are cross-pollinated. Some of the various devices (contrivances) or the

**Table 5.1 : Differences between self–pollination and cross–pollination.**

| *Self-pollination* | *Cross-pollination* |
|---|---|
| 1. It is the transfer of pollen grains from the anthers to the stigma of the same flower (autogamy). | 1. It is the transfer of pollen grains from the anthers of one flower to the stigma of another flower of a different plant of the same species. (allogamy). |
| 2. No external agency or agent is required | 2. An external agent (wind, water, insect) is always required. |
| 3. Male and female parts mature at the same time. | 3. Anthers and stigma mature at different times. |
| 4. It can occur even when flower is closed. | 4. It can occur when flower is open. |
| 5. It preserves parental characters | 5. It does not preserve parental characters. |
| 6. New variations are impossible, hence young ones cannot adapt to changed environmental conditions. | 6. Offsprings are healthier to adapt to environmental changes. |
| 7. New varieties are not possible | 7. New varieties can be produced. |

conditions which favour cross-pollination are as follows :

1. **Unisexuality.** The flowers may be either male or female and they may be borne on separate plants. In this way cross-pollination is the only possibility; *e.g.* palms and papaya. (Papaya usually has separate male and female trees, but less frequently there may also be a hermaphrodite tree bearing both kinds of flowers). In cucumber, gourd, etc., the male and female flowers may be borne on the same plant.
2. **Dichogamy** (Different timings of maturation of androecium and gynoecium). In many bisexual flowers the anthers and stigma of the same flower mature at different times.
   — In some plants anthers of the flower mature earlier than the stigma (**protandry**), *e.g.* bhindi, sweet pea, salvia, sunflower.
   — In some plants, the stigma of the flower matures earlier than the anthers (**protogyny,** *protos* : first, *gyne* : female), *e.g.* custard apple, peepal.

   In either case, cross-pollination is the only possibility.
3. **Self-sterility.** This is a condition in which even if the stigma receives pollen from the anthers of the same flower, the pollen fails to undergo further growth. In such cases, only the pollen from another plant of the same species, can effectively complete the process of setting of the seeds *e.g.*– ray florets of sunflower, orchids, etc.
4. **Herkogamy** (Mechanical or Structural barriers) (*herkos* : barrier). In some flowers the pollen of a flower cannot reach the stigma of the same flower. *For example*, a hood covering the stigma acts as a mechanical barrier in Pansy flowers, Iris, etc.

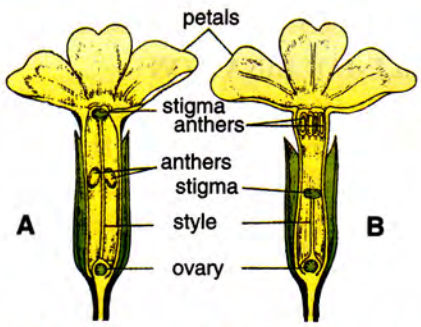



**Fig. 5.2. Heterostyly : A–long styled flower B–short styled flower**

5. **Heterostyly** — In such flowers the stigma and anthers grow at different heights which does not favour self-pollination. *e.g.* prim rose, oxalis (Fig. 5.2).

### 5.1.3 AGENTS OF CROSS-POLLINATION

The two commonest agents of cross-pollination are insects and wind. But, some flowers are also pollinated by certain animals and birds, like squirrels, bats, *etc.*, or even by water in the case of some aquatic plants. Each category has some special features to promote chances of pollination.

**Insect-pollinated** (or **entomophilous;** *entomon*: insect, *phile* : affinity) flowers usually have the following characteristics :

1. The flowers are *large*.
2. They are usually *brightly coloured* to attract insects.
3. They usually emit *scent* for attracting insects.
4. They produce *nectar* which is food for the insects.
5. The pollen grains are *sticky* or spiny to enable them to be carried by the insects easily.
6. The stigma is *sticky* and does not generally hang out from the flower.

7. The flowers tend to be in *clusters* to make them conspicuous, especially in the cases where individual flowers are small, e.g. Dahlia.

**Wind-pollinated** (or **anemophilous,** *anemo* : wind; *phile* : affinity) flowers usually possess the following special features. (*Example : Maize*)

1. The flowers are *small.*
2. They are usually *not brightly coloured* and often dull green.
3. They *do not produce scent* or nectar.
4. The stamens are *long and hang out* of the flower to be exposed to wind.
5. The anthers are *large and loosely attached* to the filaments so that the slightest wind may move them (versatile).
6. Pollen is produced in *very large quantities.*
7. Pollen grains are *light, dry and smooth* so that they can easily be carried away by wind.
8. The stigmas are *feathery and hang out* of the flower to trap the pollen grains.

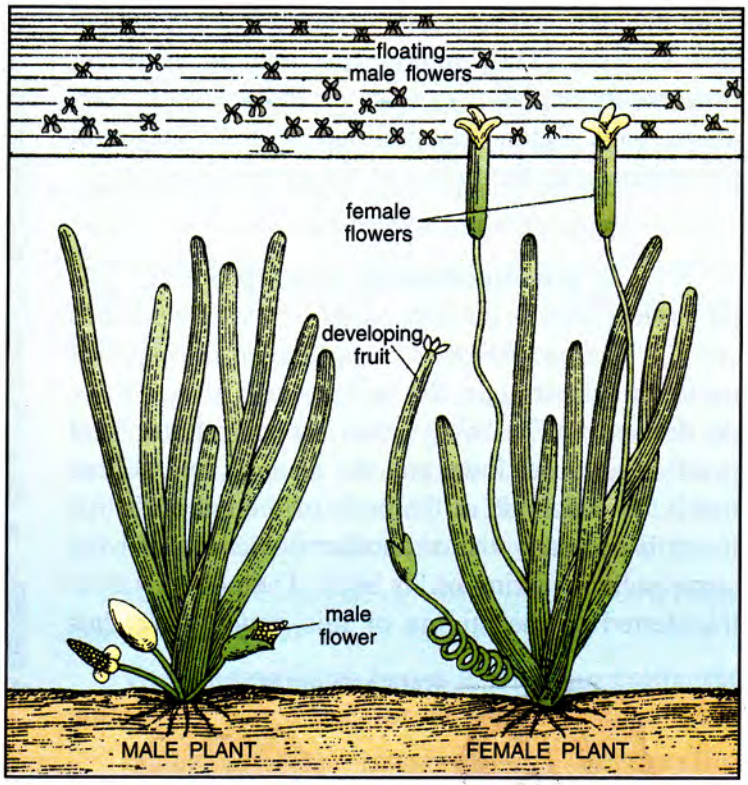



Fig. 5.3. *Vallisneria* showing male and female plants; note the free floating male flowers.

**Water-pollinated** (or **hydrophilous,** *hydro* : water, *phile* : affinity) flowers are found only in aquatic plants. They have the following characteristics :

1. Pollen grains are produced in *large numbers.*
2. In some plants the pollen grains have a specific gravity almost equal to that of water so that they *remain floating* below the surface of water.
3. In some special cases male flowers are such that they float on the surface of water till they meet female flowers (Fig. 5.3) *e.g. Vallisneria.*

Some flowers are pollinated by birds (**ornithophily,** *ornitho* : bird), e.g. *Bignonia, canna.* Elephophily is the pollination affected by elephants. Elephophily is found in *Rafflesia* whose flowers are very large and are found at ground level. The pollen grains of one flower get attached to the feet of elephants and may be carried to the stigma of another flower when trampled by those feet.

**Artificial pollination.** When man himself transfers pollen to the stigma it is called artificial pollination. In the ancient civilization of Babylonia, it was a common practice to sprinkle "male flowers" of palms on the "female" flowers; of course, at that time they neither knew the sexuality of palm flowers nor anything about pollination.

In modern times, artificial pollination (also called artificial crossing) is a standard practice adopted by

**Table 5.2 : Differences between wind-pollinated and insect-pollinated flowers**

| *Wind-pollinated flowers* | *Insect-pollinated flowers* |
|---|---|
| 1. Flowers are unisexual, dull coloured, without scent and nectar. | 1. Flowers are brightly coloured, scented and secrete nectar. |
| 2. Pollen grains are produced in large number, some go waste. | 2. Less pollen grains are produced because they are transported mechanically by insects. |
| 3. Pollen grains are small, light and smooth. | 3. Pollen grains are larger, sticky and spiny. |
| 4. Stigma long and hangs out of the petals, feathery or sticky | 4. Stigma often deep in corolla and small. |
| 5. Stamens long and protrude above petals. *e.g.* Maize, grass, rice, wheat. | 5. Stamens may be within corolla tube. *e.g* China rose, Salvia, pea, sunflower |

plant breeders and scientists in their efforts to evolve new varieties. They remove the anthers in young flowers (emasculation) and cover these flowers with plastic bags. Later, they pollinate such flowers with the pollen from the plants of the desired variety.

## 5.2 SOME EXAMPLES OF POLLINATION

(1) In **insect-pollinated sweet pea** (Fig. 5.4) the insects such as the bee, alight on the conspicuous corolla. The bee thrusts its long tongue in search of nectar. In this struggle, the 'wing petals' of the flower are depressed. The 'wing petals' along with the 'keel petal' are forced down and the stamens and stigma touch the underside of the body of the insect. If this insect has already visited another flower it may have some pollen sticking on its body. The pollen is now transferred to the stigma of this new flower thus affecting pollination. When the insect flies away, it may, in turn, carry some pollen of this flower to other similar flowers. However, if cross-pollination does not take place, there is every chance of self-pollination in this case, since both the stamens and the carpels are enclosed within the keel and are more or less at the same level.

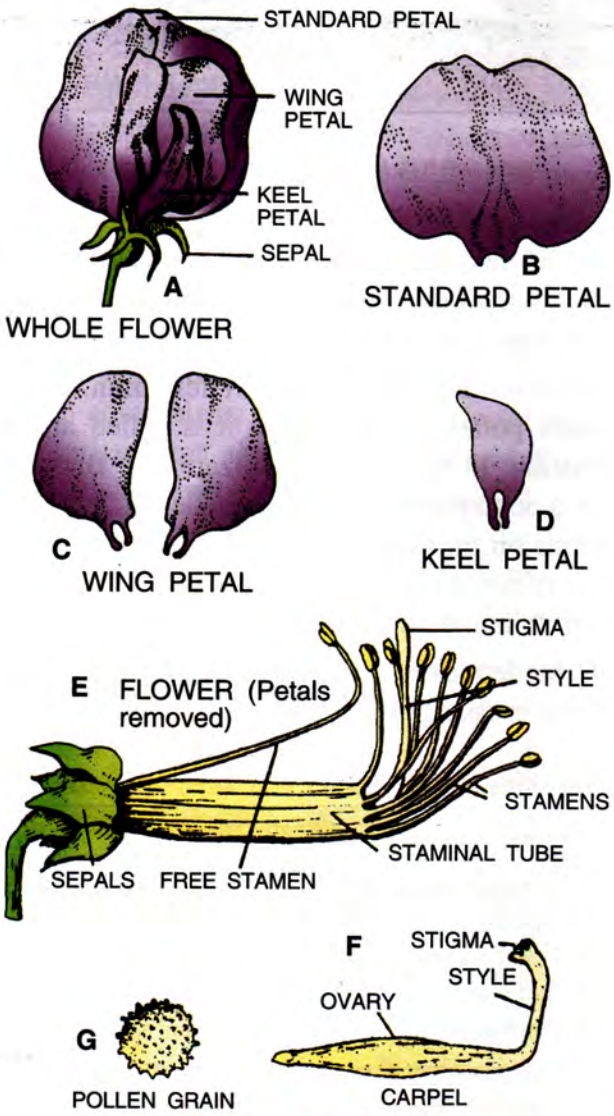



Fig. 5.4. Floral parts of sweet pea.

(2) In **wind-pollinated maize** (Fig. 5.5) pollination is brought about by wind. As the wind blows, the pollen from the outwardly hanging anthers (in the tassel) is blown away easily because the anthers are so loosely attached to the filament that the slightest wind will shake them. The pollen blown away by the wind may fall on the feathery stigmas of the female flowers which have a large surface for this purpose. The male flowers mature earlier than the female ones, so that there are less chances for self-pollination.

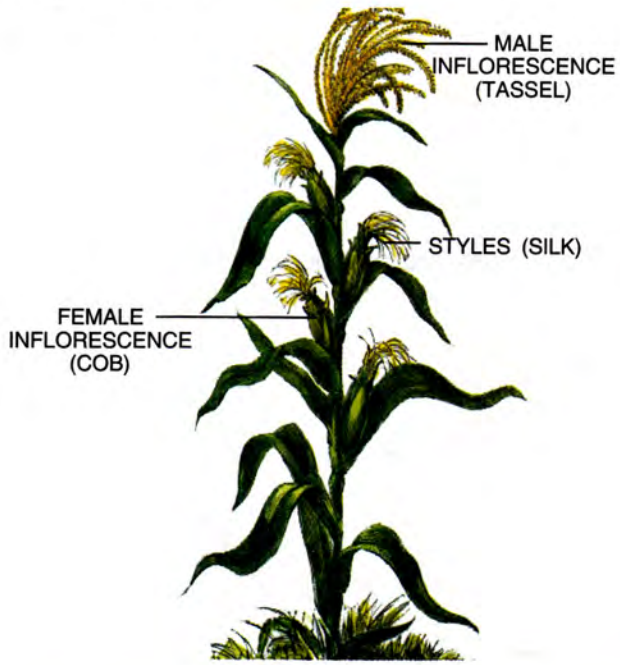



Fig. 5.5 Maize plant

### PROGRESS CHECK

1. Match the items in Column I with those in Column II

| Column I | Column II |
|---|---|
| (i) Feathery stigma hanging out | Rafflesia |
| (ii) Different timings for maturation of anthers and stigma | Entomophilous |
| (iii) Pollination by elephant | Wind-pollination |
| (iv) Flowers produce nectar | Dichogamy |

2. Complete the following statements :

(i) Pollination is the process of transference of _____

(ii) The two kinds of pollination are _____ and _____

(iii) For self-pollination the flowers need not be _____ and showy.

(iv) For self-pollnation, _____ and _____ must mature at the same time.

(v) Self-pollination does not yield _____ varieties.

(vi) In _____ pollination there is much wastage of _____.

## 5.3 FERTILIZATION (FIG. 5.6)

Fertilisation is the **union/fusion** of the nuclei of male and female **gamete**.

### In flowering plants

- The pollen grain is the **male gamete**.
- The ovule inside the ovary is the **female gamete**.

### The Pollen Grain

The mature pollen grain (Fig. 5.6 B) is a cell with a double wall — the outer **exine** and the inner **intine**. Its nucleus has already divided into a **tube nucleus** and a **generative** (male) **nucleus**. At this stage, the pollen is transferred to stigma (pollination). Further changes in pollen grain occur only if it has fallen on the stigma of a plant of the same species.

### The Ovule

Ovule is the inner part of ovary. **Ovule** is destined to become the **seed** and the **ovary** to become the **fruit** containing the seed inside. There may be

- a single ovule producing single seeded fruit, or
- many ovules producing a many-seeded fruit.

Each ovule has one or two protective coverings, the **integuments**.

The integuments leave a small opening the **micropyle** at one end (for the entry of pollen tube).

Enclosed by the integuments is the **nucellus** (a mass of food laden cells), and further inside the nucellus is the **embryo sac**.

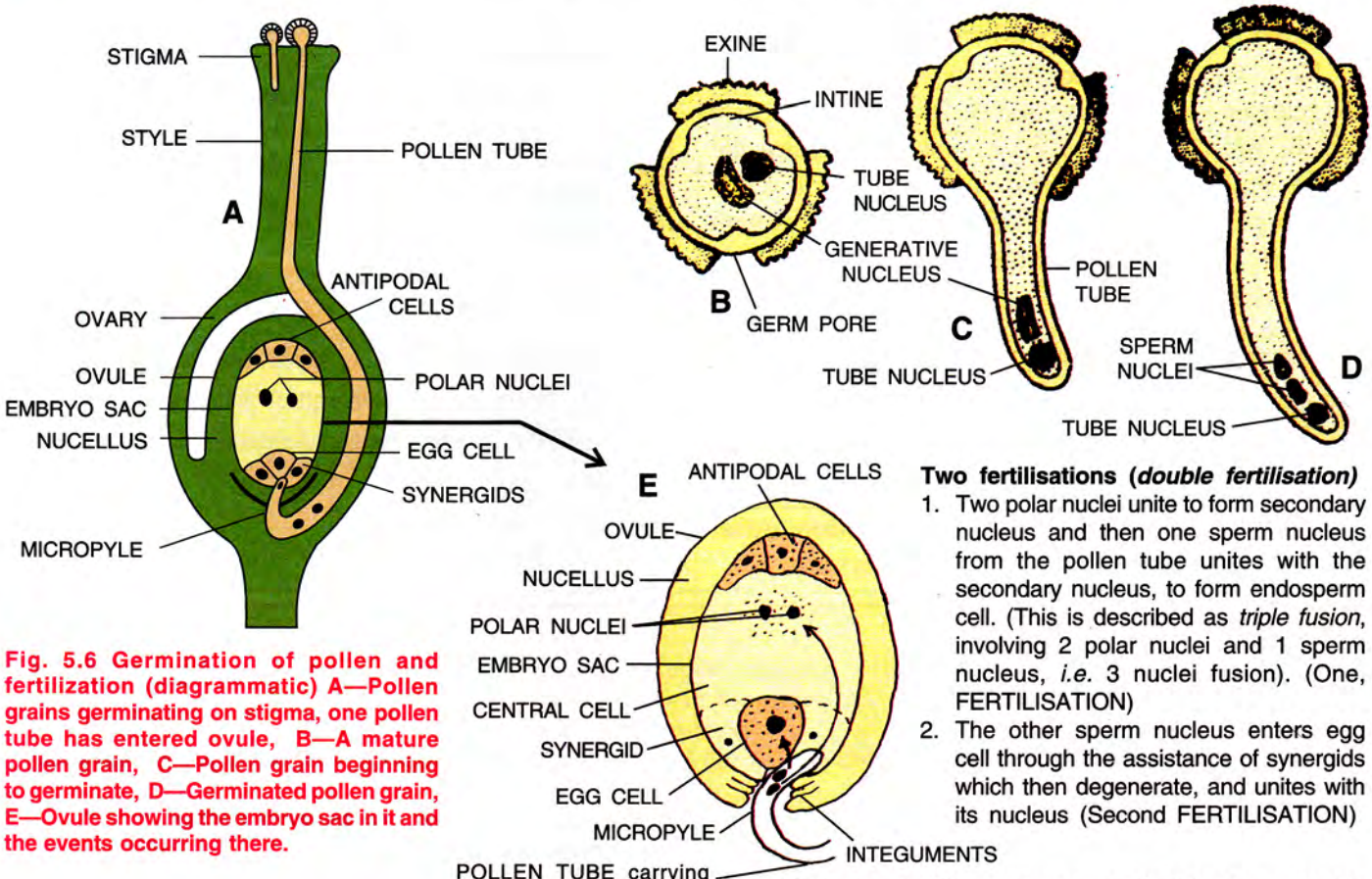



**Fig. 5.6 Germination of pollen and fertilization (diagrammatic) A—Pollen grains germinating on stigma, one pollen tube has entered ovule, B—A mature pollen grain, C—Pollen grain beginning to germinate, D—Germinated pollen grain, E—Ovule showing the embryo sac in it and the events occurring there.**

**Two fertilisations (*double fertilisation*)**

1. Two polar nuclei unite to form secondary nucleus and then one sperm nucleus from the pollen tube unites with the secondary nucleus, to form endosperm cell. (This is described as *triple fusion*, involving 2 polar nuclei and 1 sperm nucleus, *i.e.* 3 nuclei fusion). (One, FERTILISATION)
2. The other sperm nucleus enters egg cell through the assistance of synergids which then degenerate, and unites with its nucleus (Second FERTILISATION)

[Can you justify when we say that there is double fertilisation in flowering plants ?]

The embryo sac contains seven (3+3+1) **cells** :

- 3 cells at micropylar end — one **egg cell** and two **synergids**,
- 3 cells at opposite end, called **antipodal cells**, and
- 1 large **central cell**. The central cell is different containing two nuclei called **polar nuclei**.

### Germination of pollen grain

Pollen grain germinates only if it falls on the stigma of the same plant species, otherwise, it disintegrates.

The pollen grain on falling on the stigma is stimulated to germinate due to the secretion of sugars by the stigma. Through a point in the exine a pollen tube grows out of the pollen grain, carrying at its tip the generative nucleus and the tube nucleus generative nucleus divides into two nuclei (**male gamete nuclei** also called **sperm nuclei**). Thus there are three nuclei which are not separated by cell walls, they share a common cytoplasm.

The pollen tube grows through the stigma and style by dissolving the tissues with the help of enzymes and reaches the ovary. There, it pushes through the micropyle and reaches the embryo sac. The **tube nucleus** which had **directed the growth of pollen tube** all the way down, now disintegrates.

Now, the pollen tube enters one of the synergids and releases its two sperm nuclei. Of these, one sperm nucleus fuses with the egg cell nucleus to form the zygote while the other sperm nucleus moves towards the two polar nuclei in the central cell and fuses with them (thus 3 nuclei fuse together/triple fusion to produce the endosperm nucleus). All together two fertilizations have occurred and hence termed **double fertilization**.

**Double fertilisation**

1. One sperm nucleus fuses with egg cell nucleus
2. The other sperm nucleus fuses with two polar nuclei together

**Fate of floral parts after fertilization.** After fertilization the flower has served its purpose.

— The petals, stamens, style and stigma wither and generally fall off.

— The calyx may either fall off or may remain intact in a dried and shrivelled form. Apple and guava show such dried sepals very clearly, in brinjal it remains.

— The ovary enlarges to form fruit, the ovarian wall forming the fruit wall. The ovary wall may either form a dry and hard fruit wall or a fleshy fruit wall.

— Ovules become the seeds.

The fruit contains one or more seeds which are developed from one or more ovules attached to the ovary by means of placenta(e). When the fruit is ripe the seeds contained inside are released by one or the other method and grow into new plants in suitable conditions.

The fate of various parts of the ovary after fertilization during the formation of fruit is as follows:

| PART | | WHAT IT BECOMES | |
|---|---|---|---|
| *Ovary* | → | *Fruit* | |
| Ovary wall | → | Pericarp | |
| Ovule | → | Seed | |
| Placenta | → | Stalk of the seed | |
| Outer integument | → | Testa | Seed coat. |
| Inner integument | → | Tegmen | Seed coat. |
| Secondary nucleus | → | Endosperm | |
| Egg cell, Synergids & | → | Embryo | |
| Antipodal cells | → | Disorganised | |

### PROGRESS CHECK

1. Mention if the following statements are **true**
   (i) Intine is the outer wall of pollen grain.
   (ii) Pollen tube enters ovule through micropyle.
   (iii) Zygote gives rise to embryo.
   (iv) Ovule becomes fruit.
   (v) Dry sepals may persist in some fruit.

### POINTS TO REMEMBER

- ***Self-pollination is surer and it preserves parental characters (same variety), but it leads to weaker generations.***
- ***Cross-pollination produces healthier offspring and new varieties.***
- ***Plants have evolved several methods to favour cross-pollination.***
- ***Insect-pollinated flowers are large, brightly coloured, have scent and nectar-bearing with sticky pollen and sticky stigma***
- ***Wind-pollinated flowers are small, dull, nectarless with light and dry pollen and feathery stigma.***
- ***Pollen grain germinates on stigma and the pollen tube penetrates ovule.***
- ***After fertilization most other floral parts dry and fall off while the ovary enlarges to form fruit with ovules becoming seeds.***

## REVIEW QUESTIONS

### A. MULTIPLE CHOICE TYPE

1. **Which one** of the following is one of the characteristics of self-pollinated flowers ?
   (a) Flowers are large and showy
   (b) Flowers remain closed and do not open
   (c) Stigma and anthers mature at the same time
   (d) Pollen is produced in very large quantities
2. Exine and intine are the parts of
   (a) Embryo sac (b) Pollen grain
   (c) Stigma (d) Seed

### B. VERY SHORT ANSWER TYPE

1. **Match the items** in Column A with those in Column B.

| Column A | Column B |
|---|---|
| (a) Generative nucleus | (i) Pollen tube |
| (b) Germ pore | (ii) Endosperm nucleus |
| (c) Exine | (iii) Testa |
| (d) Secondary nucleus | (iv) Fertilization |
| (e) Integument | (v) Male nuclei |
| (f) Egg nucleus | (vi) Rough |

2. **State the name** of the chief pollinating agent against the corresponding plant by choosing from those given in brackets.
   (a) Dahlia _____ (Crow, butterflies, mosquito).
   (b) Maize _____ (Bees, locusts, rain, wind).
   (c) Vallisneria ____ (Wind, water, ants, rabbits).
3. Fill in the **blanks** with suitable words.
   (a) Transference of pollen grains from anthers to stigma of the same flower is called _____
   (b) Different timings for maturation of gynoecium and androecium, is called ____.
   (c) _____ is a water-pollinated flower.
4. **Name the parts** of the ovary which give rise to:
   (a) Seed _____ (b) Fruit _____
   (c) Fruit wall _____
5. Give **one word/term** for the following :
   (a) A flower containing both male and female parts
   (b) Arrangement of flowers on a twig/stem
   (c) When pollen grains of a flower reach the stigma of the same flower.
   (d) When maturation time of reproductive parts in a flower is different.
   (e) When stigma and anthers do not grow up to same height, which favours only cross-pollination ?
   (f) Pollination of flowers by insects.
   (g) Pollination of flowers by birds.

### C. SHORT ANSWER TYPE

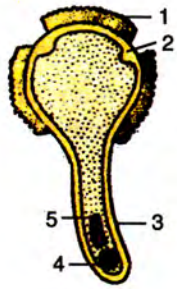
1. **Explain** the following terms :
   (a) Ornithophily.
   (b) Elephophily.
   (c) Artificial pollination.
2. **What happens** to the following after fertilization?
   (a) Ovules (b) Calyx
   (c) Petals (d) Stamens
3. **Mention** any *two* contrivances in flowers which favour cross-pollination.

### D. LONG ANSWER TYPE

1. **What are the advantages** of the following in the flower to the plant concerned ?
   (a) Long and feathery stigma
   (b) Brightly coloured petals
   (c) Smooth and light pollen
   (d) Protruding and easily movable anthers
   (e) Fragrant nectar
2. **Describe** the advantages and **disadvantages** of cross-pollination to the plant.

### E. STRUCTURED/APPLICATION/SKILL TYPE

1. What is the **function** of the pollen tube ? **Explain** it with the help of a diagram.
2. Given ahead is a diagrammatic sketch of the sectional view of a germinating pollen grain. Study the same and then answer the questions that follow :
   (a) Name the parts labelled 1, 2, 3, 4,and 5
   (b) Where does the germination of the pollen grain takes place and how ?



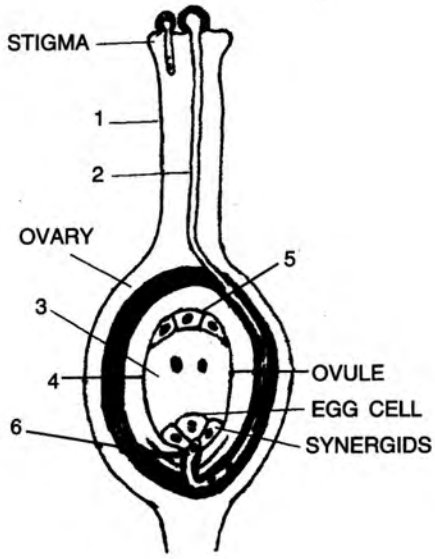

(c) What is the function of the part labelled '4' ?

(d) What happens to the part labelled '5' during the process ?

3. Given ahead is a diagrammatic representation of the process of fertilization. Study the same and then answer the questions that follow :

(a) Name the parts labelled 1, 2, 3, 4, 5 and 6.

(b) What happens to (i) Ovary (ii) Ovule after fertilization ?




(c) What is the function of the synergids ?

(d) What part does the stigma play in the process of fertilization ?