Bio Factsheet

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# Fertilisation and Seed Production in Flowering Plants

This Factsheet describes the events following pollination in dicotyledonous plants up to the formation of seeds. Pollination was described in Factsheet 96.

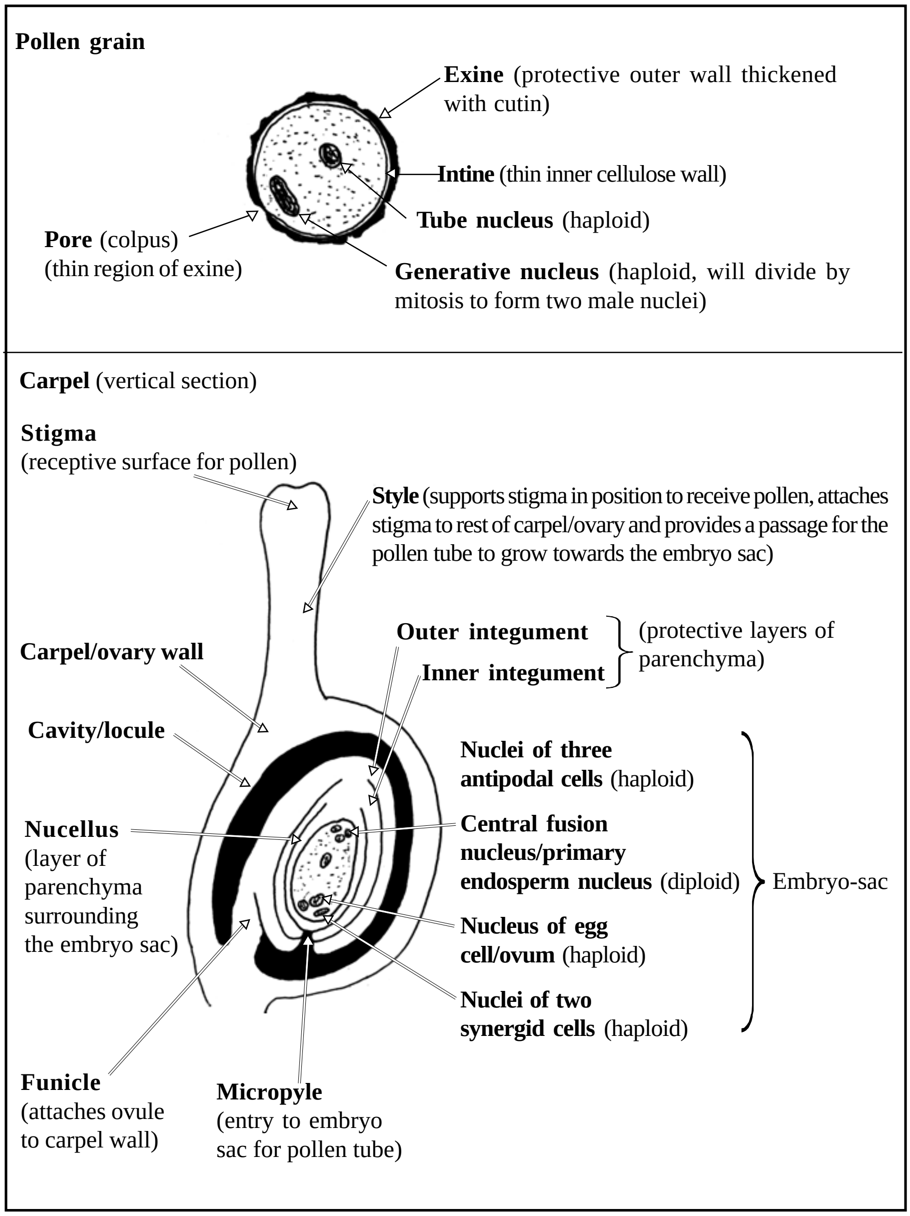
***Remember*** *– the female part of the flower is the ovary. Depending on the species it may consist of many separate carpels (eg. Buttercups), or a number of carpels fused together into one structure (eg. Tomatoes).*

## Introduction

Following pollination, the pollen grains which contain the male nuclei are stuck to the stigmas of the ovary. The ovary contains the embryo-sacs which contains the female nuclei. Fig 1 illustrates the structure of a pollen grain and the structure of a single carpel of an ovary.

***Exam Hint*** – It is important that biological terms are spelt correctly so that they cannot be confused with other terms. For example, do not lose exam marks by spelling 'carpel' incorrectly as 'carpal'. (Carpals are bones in the wrist). Do not confuse the terms 'ovary' and 'ovule'. The ovule is the structure which contains the embryo-sac. Ovules are found inside the ovary.

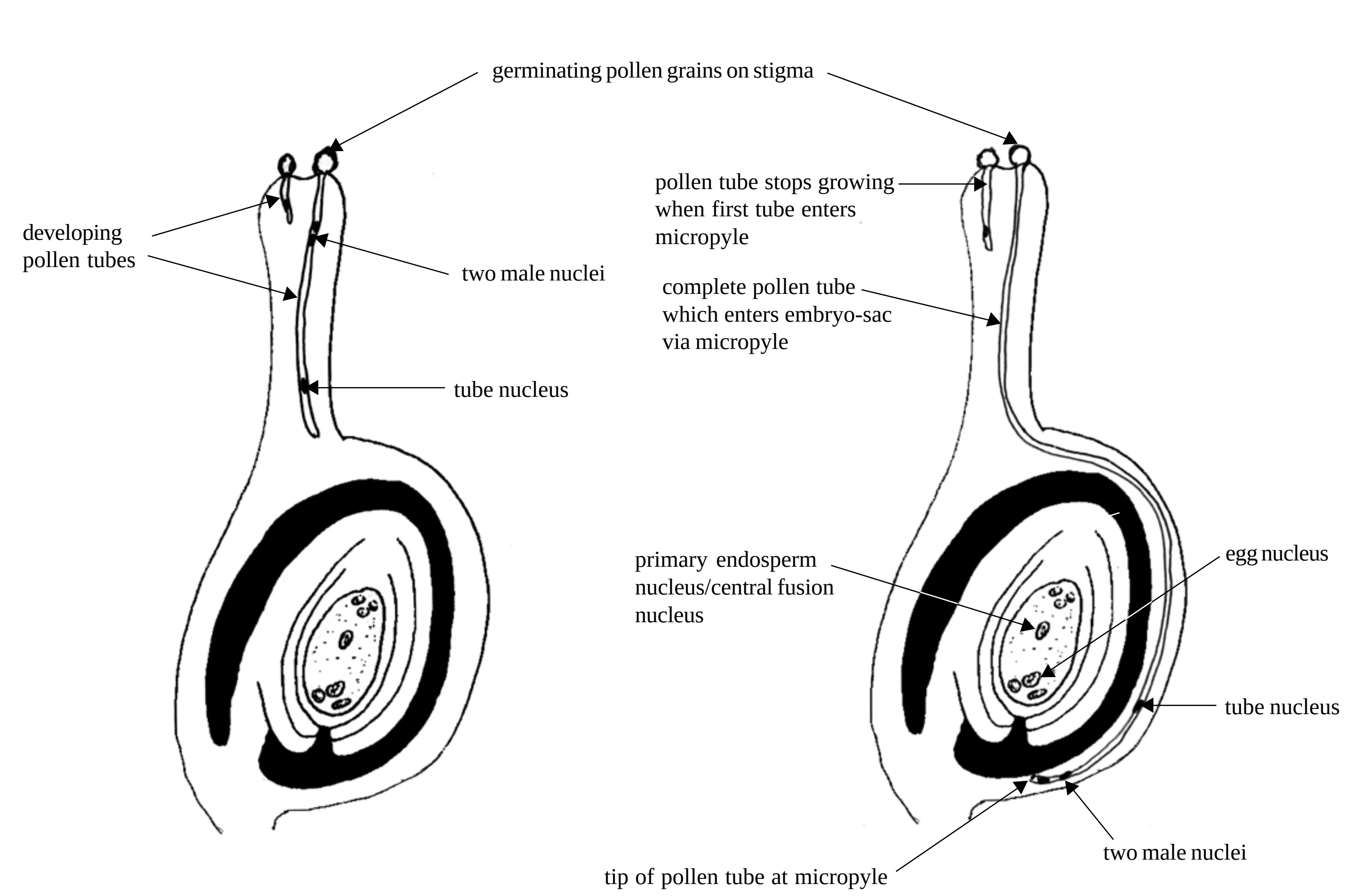
**Fig 1. Structure of a pollen grain and a single carpel of an ovary**




- The embryo-sac, surrounding nucellus, inner and outer integuments make up the **ovule**. The ovule is attached to the carpel/ovary wall by a stalk called the funicle. Entry to the embryo-sac within the ovule is via a pore through the integuments called the micropyle.
- The pollen grains are formed in the pollen sacs of the anthers from **pollen mother cells** with dense cytoplasm and large diploid nuclei. Each pollen mother cell gives rise to four pollen grains each with a single haploid nucleus formed by meiosis of the pollen mother cell nucleus. The single haploid pollen nucleus soon divides, by mitosis, to form a haploid generative nucleus and a haploid tube nucleus. The outer wall of each pollen grain differentiates into the exine and intine.
  **At this stage the pollen grains are mature and can be transferred to the stigmas when the anthers rupture.**
- When the embryo-sac is formed within the nucellus it is a single large cell which has a single diploid nucleus. This nucleus divides by meiosis to form four haploid nuclei. These divide by mitosis resulting in eight haploid nuclei within the embryo-sac. Four nuclei migrate to each end of the embryo-sac. Then a nucleus from each end of the embryo-sac migrates to the centre of the sac. When these nuclei meet they fuse together resulting in the diploid central fusion nucleus (primary endosperm nucleus). The three nuclei left at the end of the embryo-sac distant from the micropyle become surrounded by thin cell walls and are called the antipodal cells. In some species these have a nutritive role in the seed. The three nuclei left near the micropyle are also surrounded by cell walls. One cell becomes the egg cell (ovum) and the other two cells are called synergids. These may produce enzymes which enable passage of the pollen tube end into the embryo-sac.
  **At this stage the embryo-sac is ready to be fertilised, and can be, provided a mature pollen grain of the same species has been deposited on the stigma.**

**Fertilization**

**Fig. 2. Vertical sections of an ovule showing formation of the pollen tube**




- The pollen grains germinate on the surface of the stigma where there is usually a sugary liquid secretion, which may also contain other substances, for example, malic acid in the case of heathers. During germination the thin inner wall (intine) of the pollen grain grows out through one of the pores in the thick exine.

- This produces a cylindrical **pollen tube** into which the tube nucleus and generative nucleus pass. The pollen tube, which tends to grow towards chemical substances produced by the embryo-sac, towards moisture and away from oxygen, enters the stigma and begins to grow down the style. In some species, (eg. Violets), there is an open canal in the centre of the style leading down to the ovary wall through which the pollen tube grows. In other species, (eg. Rhododendrons) the style canal is filled with mucilage through which the pollen tube passes, The pollen tube is thought to gain nutrients from the mucilage and style tissues, enabling it to grow.

- Having grown down the style, the pollen tube either grows in the tissues of the ovary wall until the tip reaches the micropyle of the ovule, or it enters the top of the ovary cavity (locule) and grows through the cavity to the micropyle. The tip of the pollen tube enters the micropyle of the ovule, possibly attracted by a fluid secreted by the synergids. These cells may also secrete the enzymes which break down the tissues of the nucellus, enabling the pollen tube to come into contact with the embryo-sac, in the vicinity of the egg cell.

- During the growth of the pollen tube the generative cell divides mitotically to form the two male nuclei. These move to the the tip of the tube.

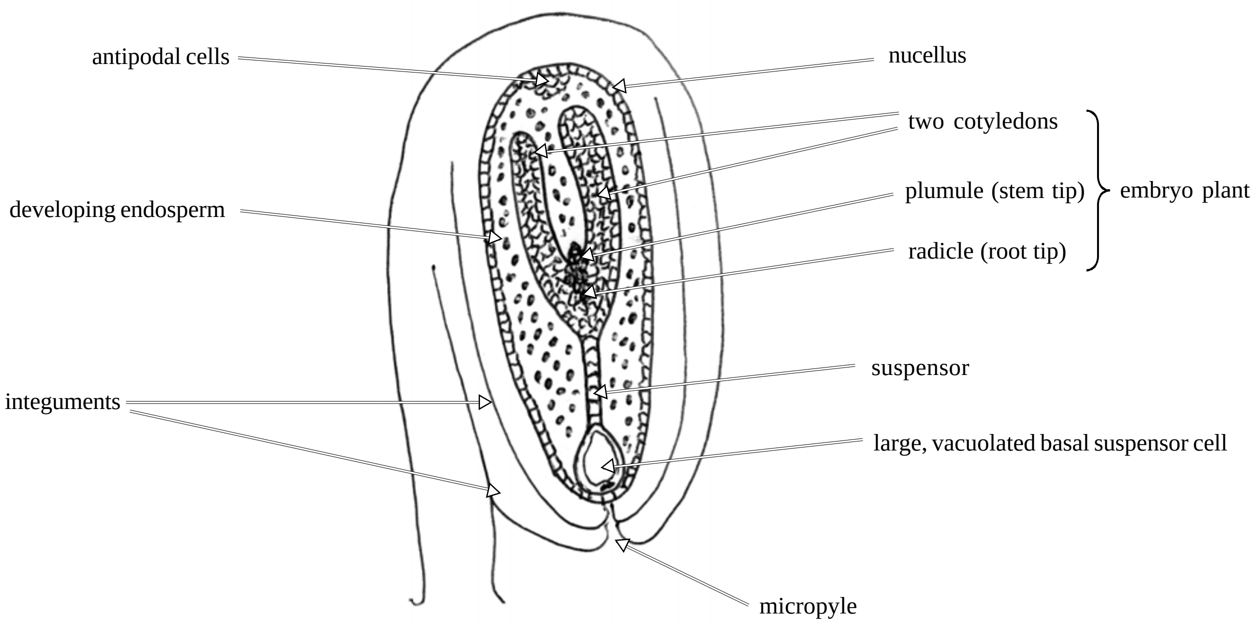
- The tip of the pollen tube becomes ruptured and the two male nuclei (gametes), now spirally coiled, thread-like shapes, enter the embryo-sac. One male nucleus enters the egg and fuses with the female nucleus forming a zygote (diploid). It is from this that the embryo plant will develop.

- The second male nucleus moves deeper into the embryo-sac and fuses with the central fusion nucleus. The triploid cell resulting from this second fusion will eventually divide by mitosis to produce a nutritive tissue, known as the endosperm; food stored in this is used by the developing embryo. The time elapsing between pollination and the completion of fertilization varies considerably. In rye it is seven hours; in maize, twenty-four hours, in many trees it may be year or more.

> ***Exam Hint*** *– questions are often asked about* ***double-fertilization*** *which occurs in flowering plants. Double fertilization refers to the fact that one male nucleus fuses with the egg nucleus to form a zygote and the other male nucleus fuses with the central fusion nucleus (primary endosperm nucleus) to form the triploid endosperm nucleus.*

**Embryo and seed formation**

**Fig 3. Vertical section of ovule showing development of the embryonic plant and seed**




After fertilization the ovule develops to form the seed. The following changes occur:

- The fertilized egg cell (zygote) divides mitotically to form a short chain of cells called a **pro-embryo**. The cell of the pro-embryo nearest to the micropyle becomes very large and develops a vacuole. This large basal cell anchors the developing pro-embryo to the wall of the embryo-sac. The cell of the pro-embryo furthest from the micropyle divides many times by mitosis, in various planes, and forms the embryo plant. The chain of cells between the embryo plant and the large basal cell form the **suspensor**. This has the function of pushing the developing embryo into the developing nutritive tissue (endosperm) of the seed.

- The embryo cells continue to undergo mitosis and differentiate into the **plumule** (embryonic stem tip), **radicle** (embryonic root tip) and **cotyledons** (embryonic seed leaves). Dicotyledonous plant embryos possess two cotyledons, monocotyledonous plant embryos have only one cotyledon. The radicle always points towards the micropyle.

- The triploid endosperm nucleus divides many times by mitosis, filling the remaining space in the seed with parenchymatous endosperm tissue. These cells become filled with food reserves, for example, starch, proteins and lipids (oils). These reserves will be used to support seedling growth during germination until the seedling can support itself by photosynthesis. In some species the antipodal cells also divide and form ‘endosperm-like’ tissue.

- As the embryo-sac enlarges due to the development of the embryo and endosperm the tissues of the nucellus become crushed and destroyed. However, in some plants the nucellus persists as a nutritive tissue called the **perisperm**, for example, reeds, sedges, campions, stitchworts.

- After enlargement the integuments develop to form the protective seed coat or testa. This usually becomes fibrous and woody (lignified).

- The seeds are contained within the fruit. The fruit is formed from the ovary, the wall of which develops to form the pericarp or fruit wall. The exact nature of the **pericarp**, whether dry and woody or succulent, depends on the type of fruit and its specific dispersal mechanism.

- Stigmas, styles, stamens and petals whither away and fall off during seed development. In most species sepals fall, off but can be retained to provide extra protection for the fruit.

- Once seed development is complete, water is removed so that the seed becomes dormant and dry. At this stage the seeds can be dispersed away from the parent plant.

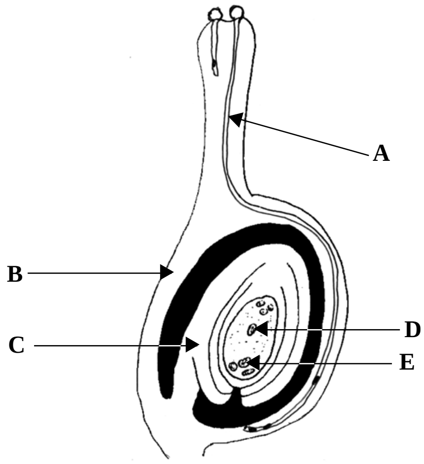
In a **non-endospermic** seed the embryo grows rapidly and uses up all the endosperm to obtain the food material required for its growth. Thus the ripe seed has little or no endosperm left. (For example, seeds of apple, sunflower, peas and beans.) In non-endospermic seeds, some of the food materials from the endosperm are stored in the cotyledons which, as a result, become fleshy and swollen. The food stored in the cotyledons is then available to support germination.

In an **endospermic** seed the embryo stops growth before the endosperm is all used and so the ripe seed contains endosperm for use during germination. (For example, seeds of castor oil, wheat and coconut.)

***Remember*** *- in some plants, for example, banana, the fruit can develop without fertilisation taking place. This is called* ***parthenocarpy*** *and results in the formation of seedless fruits. Parthenocarpy can be induced in many plants by spraying the flowers with auxins and/or gibberellins to commercially produce seedless fruit.*

**Practice Questions**

1. The drawing below shows a vertical section of a pollinated carpel of a dicotyledonous plant with a haploid chromosome number of 14.




(a) (i) Name structures A, B, C, D and E. **5**
(ii) Name the nuclei found in the fertilized embryo sac and state their chromosome numbers. **4**

(b) Flowering plants undergo 'double fertilization'. What does this term mean? **3**

(c) When does meiosis occur in the life cycle of a flowering plant? **2**
**Total 14**

2. The diploid chromosome number of the raspberry, *Rubus idaeus*, is 14. How many chromosomes would be present in the following structures of the raspberry? In each case, explain your answer.
(a) The tube nucleus of a pollen grain. **2**

(b) A nucleus of the endosperm. **2**

(c) The primary endosperm nucleus. **2**

(d) The egg nucleus. **2**

(e) A xylem vessel supplying the ovule with water. **2**
**Total 4**

3. The following table refers to characteristics of seed or fruit structure in different species. Complete the table by writing relevant information in the empty boxes.

| Characteristic | Wheat seed | Broad bean seed | Castor-oil seed | Sunflower fruit |
|---|---|---|---|---|
| Number of cotyledons | | | | |
| Nature of cotyledons (leafy, fleshy starch storing or fleshy oil storing) | | | | |
| Endosperm (present or absent) | | | | |
| Number of scars | | | | |

**Total 4**

**Answers**

1. (a) (i) A = pollen tube; B = carpel/ovary wall; C = outer integument;
D = central fusion nucleus/primary endosperm nucleus;
E = ovum/egg cell nucleus; **5**
(ii) antipodal nuclei + 14;
synergid nuclei + 14;
zygote/fertilized egg nucleus + 28;
triploid endosperm nucleus + 42; **4**

(b) two nuclear fusions occur;
fusion of one male nucleus with the egg cell nucleus to form a zygote;
fusion of a second male nucleus with the primary endosperm nucleus/central fusion nucleus to form a triploid endosperm nucleus; **3**

(c) the initial embryo-sac cell formed in the developing ovule divides by meiosis;
the pollen mother cell nuclei in the anthers undergo meiosis; 2
**Total 14**

2. (a) 7;
formed by meiosis of pollen mother cell in anther; **2**

(b) 21;
formed by fusion of three haploid nuclei; **2**

(c) 14;
formed by fusion of two haploid female nuclei in the embryo-sac before fertilisation; **2**

(d) 7;
formed by meiosis of embryo-sac mother cell. **2**

(e) 0;
xylem vessels are dead water-conducting tubes that have lost their cell contents; **2**
**Total 10**

3.

| Characteristic | Wheat seed | Broad bean seed | Castor-oil seed | Sunflower fruit |
|---|---|---|---|---|
| Number of cotyledons | one | two | two | two ; |
| Nature of cotyledons (leafy, fleshy starch storing or fleshy oil storing) | leafy | fleshy starch storing | fleshy oil storing | fleshy oil storing ; |
| Endosperm (present or absent) | present | absent | present | absent ; |
| Number of scars | one | one | one | two ; |

**Total 4**

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