Introduction

Angiosperms (flowering plants) are the dominant plants on Earth. A flower is composed of four parts: sepals, petals, stamens, and carpel. Although the sepals and petals can play an indirect role in reproduction, this tutorial focuses on the stamens and carpel—the parts directly involved in reproduction.

Learning Objectives

- Know the general structure of a flower and the parts that are directly involved in reproduction.
- Understand how pollen grains and egg cells are formed in flowering plants.
- Understand the process by which a zygote develops into an embryo in flowering plants.
Narration

Pollen Development
The dominant plants on Earth are the angiosperms, the flowering plants. Flowers, the reproductive structures of angiosperms, produce fruits, which enclose the seeds.

A flower is generally composed of four parts—sepals, petals, stamens, and one or more carpels. Although the sepals and petals can play an indirect role in reproduction (for example, attracting pollinators), here we'll concentrate on the stamens and carpel—the parts directly involved in reproduction.

The stamen, the pollen-containing structure, is composed of two parts: a stalk-like filament and an enlarged anther. Inside the anther are chambers containing diploid cells called microsporocytes. Each microsporocyte undergoes meiosis to produce four haploid microspores. These microspores divide by mitosis to form male gametophytes, or pollen grains. The immature pollen grain consists of a small generative cell enclosed within a large vegetative cell called the tube cell. The generative cell will later divide to form sperm.

When conditions are right, the anther opens to release the pollen grains. Pollen is produced in large quantities because most of it will not reach a receptive flower. Some falls to the ground, some is eaten by insects, and so on.

Ovule Development
The carpel is made up of three parts: the stigma, the style, and the ovary. A carpel may contain more than one ovary. The stigma, at the top of the carpel, is specialized for receiving pollen. The stalk-like style supports the stigma. At the base of the carpel is the enlarged ovary. The ovary contains developing ovules. After fertilization, the ovary becomes the fruit.

Each ovule contains a single diploid megasporocyte and is surrounded by a continuous covering—except for a narrow canal at one end, called the micropyle. The megasporocyte undergoes meiosis to produce four haploid megaspores. Three of the megaspores degenerate, leaving a single functional megaspore in each ovule. The megaspore divides by mitosis three times, producing a total of eight nuclei, which segregate to form seven cells. The most important elements of the female gametophyte are the egg, located at the micropyle, and a large “central cell” that is unusual in that it has two nuclei.

Pollination and Fertilization
Sexual reproduction in angiosperms involves the transfer of pollen from an anther to a stigma, a process called pollination. In self-compatible flowers, the stigma is receptive to pollen from the same flower. Self-incompatible flowers require pollen
from a different plant. In both cases, pollen can be dispersed by living vectors (such as insects) or nonliving vectors (such as the wind).

In this example, pollen from the anther of one flower is transferred to the stigma of another flower. After the pollen grain lands on a receptive stigma, it germinates, producing a pollen tube.

The pollen tube grows down through the tissue of the style. At some point during its journey, the generative cell of the pollen grain divides by mitosis to form two sperm nuclei, or male gametes.

The pollen tube continues to grow until it reaches the ovary. It then enters an ovule through the micropyle. It ruptures one of the cells next to the egg and discharges the two sperm nuclei.

In most plant groups, fertilization is straightforward: One sperm nucleus fuses with the egg to form a diploid zygote. In angiosperms, however, an unusual event called double fertilization takes place. The other sperm nucleus fuses with the two nuclei of the central cell to form a large triploid cell. The cell resulting from this second fertilization begins a series of mitotic divisions that forms a tissue called the endosperm. The function of the endosperm is to store nutrients.

**Embryo and Endosperm Development**

The zygote divides by mitosis to form two cells. The bottom cell divides to form a row of single cells. This structure provides a route for nutrient transfer from the parent to the developing embryo. The top cell divides many times in all directions, forming a globular mass of cells that eventually becomes the embryo.

Further divisions are restricted to particular regions of the embryo, producing two swellings at the end of the embryo away from the row of single cells. These swellings eventually become the cotyledons, the seed leaves of the embryonic plant.

The cotyledons continue to develop, and the embryo grows longer. Eventually, the seed is mature. The continuous covering around the ovule has formed a hardened seed coat around the seed for protection. The endosperm, which will provide nutrition for the embryo, is now fully developed. The embryo itself has two cotyledons flanking the shoot apical meristem.

When the mature seed is exposed to the necessary conditions of warmth and moisture, it germinates, or sprouts.
You should now be able to...

• Describe the role of microsporocytes and megasporocytes in angiosperm reproduction.
• Discuss the structure and function of the stamen and the carpel.
• Describe the events of pollination and fertilization in flowering plants.
• Explain the importance of double fertilization in flowering plants.
• Describe the formation and structure of a seed.