## Sporophyte and gametophyte generations alternate in the life cycles of plants: *a review*

- The life cycles of angiosperms and other plants are characterized by an **alternation of generations**, in which haploid (*n*) and diploid (*2n*) generations take turns producing each other.
  - The diploid plant, the **sporophyte**, produces haploid spores by meiosis.
  - These spores divide by mitosis, giving rise to multicellular male and female haploid plants - the **gametophyte**.
  - The gametophytes produce gametes - sperm and eggs.
  - Fertilization results in diploid zygotes, which divide by mitosis and form new sporophytes.
- In angiosperms, the sporophyte is the dominant generation, the conspicuous plant we sell.
- In angiosperms, the sporophyte produces a unique reproductive structure, the flower.
  - Male and female gametophytes develop within the ***anthers*** and ***ovaries***, respectively, of a sporophyte flower.
  - Pollination by wind or animals brings a male gametophyte (pollen grain) to a female gametophyte.
  - Union of gametes (fertilization) takes place within the ovary.
  - Development of the seeds containing the sporophyte embryos also occurs in the ovary, which itself develops into the fruit around the seed.

## Flowers are specialized shoots bearing the reproductive organs of the angiosperm sporophyte

- Flowers, the reproductive shoots of the angiosperm sporophyte, are typically composed of four kinds of highly modified leaves called floral organs.
- The four kinds of floral organs are the **sepals**, **petals**, **stamens**, and **carpals**.
  - Their site of attachment to the stem is the **receptacle**.
  - Sepals and petals are ***non reproductive*** organs.
- Stamens and carpels are the male and female reproductive organs, respectively.
  - A stamen consists of a stalk (the filament) and a terminal **anther** within which are pollen sacs.
    - The pollen sacs produce pollen.
  - A carpel has an **ovary** at the base and a slender neck, the style.
    - At the top of the style is a sticky structure called the stigma that serves as a landing platform for pollen.
    - Within the ovary are one or more **ovules**.
- The stamens and carpels of flowers contain sporangia, within which the spores and then gametophytes develop.
  - The male gametophytes are sperm-producing structures called **pollen grains**, which form within the pollen sacs of anthers.
  - The female gametophytes are egg-producing structures called **embryo sacs**, which form within the ovules in ovaries.
- Pollination begins the process by which the male and female gametophytes are brought together so that their gametes can unite.
  - Pollination occurs when pollen released from anthers is carried by wind or animals to land on a stigma.
  - Each pollen grain produces a pollen tube, which grows down into the ovary via the style and discharges sperm into the embryo sac, fertilizing the egg.
  - The zygote gives rise to an embryo.
  - The ovule develops into a seed and the entire ovary develops into a fruit containing one or more seeds.
  - Fruits carried by wind or by animals disperse seeds away from the source plant where the seed germinates.

## Male and female gametophytes develop within anthers and ovaries, respectively: Pollination brings them together

- The male gametophyte begins its develop within the sporangia (pollen sacs) of the anther.
- The female gametophyte begins to develop within the ovules of the ovary.
- The development of angiosperm gametophytes involves meiosis and mitosis.
- Pollination, which brings male and female gametophytes together, is the first step in the chain of events that leads to fertilization.

## Double fertilization gives rise to the zygote and endosperm

- After landing on a receptive stigma, the pollen grain absorbs moisture and germinates, producing a pollen tube that extends down the style toward the ovary.
  - The generative cells divides by mitosis to produce two sperm, the male gametophyte.
  - Directed by a chemical attractant, possibly calcium, the tip of the pollen tube enters the ovary, probes through the micropyle (a gap in the integuments of the ovule), and discharges two sperm within the embryo sac.
- Both sperm fuse with nuclei in the embryo sac.
  - One sperm fertilizes the egg to form the zygote.
  - The other sperm combines with the two polar nuclei to form a triploid nucleus in the central cell.
  - This large cell will give rise to the **endosperm**, a food-storing tissue of the seed.
- The union of two sperm cells with different nuclei of the embryo sac is termed **double fertilization**.
  - Double fertilization is also present in a few gymosperms, probably via independent evolution.
  - Double fertilization ensures that the endosperm will develop only in ovules where the egg has been fertilized.
- After double fertilization, the ovule develops into a seed, and the ovary develops into a fruit enclosing the seed(s).
  - As the embryo develops, the seed stockpiles proteins, oils, and starch.
  - Initially, these nutrients are stored in the endosperm.
- Endosperm development usually precedes (comes before) embryo development.
- The endosperm is rich in nutrients, which it provides to the developing embryo.