

## Gymnosperms

- The most familiar gymnosperms are the conifers, the cone-bearing plants such as pines.
- The ovules and seeds of gymnosperms (“naked seeds” – not in fruits) develop on the surfaces of specialized leaves called **sporophylls**.
  - In contrast, ovules and seeds of angiosperms develop in enclosed chambers (ovaries).
- Gymnosperms appears in the fossil record much earlier than angiosperms.
- There are four plant phyla grouped as gymnosperms.
  - **Phylum Ginkgophyta**
  - **Phylum Cycadophyta**
  - **Phylum Gnetophyta**
  - **Phylum Coniferophyta**
- The conifers, **phylum Coniferophyta**, is the largest gymnosperm phylum.
  - The term **conifer** comes from the reproductive structure, the cone, which is a cluster of scalelike sporophylls.
- Conifers include pines, firs, spruces, larches, yews, junipers, cedars, cypresses, and redwoods.
- Most conifers are evergreen, retaining their leaves and photosynthesizing throughout the year.
- The needle-shaped leaves of some conifers, such as pines and firs, are adapted for dry conditions.
  - A thick cuticle covering the leaf and the placement of stomata in pits further reduce water loss.
- Much of our lumber and paper comes from the wood (actually xylem tissue) of conifers.
  - This tissue gives the tree structural support.
- Coniferous trees are amongst the largest and oldest organisms of Earth.
  - Redwoods from northern California can grow to heights of over 100m.
  - One bristlecone pine, also from California, is more than 4,600 years old.

## The life cycle of a pine demonstrates the key reproductive adaptations of seed plants

- The life cycle of a pine illustrates the three key adaptations to terrestrial life in seed plants:
  - increasing dominance of the sporophyte
  - seeds as a resistant, dispersal stage
  - pollen as an airborne agent bringing gametes together.
- The pine tree, a sporophyte, produces its sporangia on scalelike sporophylls that are packed densely on cones.
- Conifers, like all seed plants, are heterosporous, developing male and female gametophytes from different types of spores produced by separate cones.
  - Each tree usually has both types of cones.
  - Small pollen cones produce microspores that develop into male gametophytes, or pollen grains.
  - Larger ovulate cones make megaspores that develop into female gametophytes.
- It takes three years from the appearance of young cones on a pine tree to the formation mature seeds.
- The seeds are typically dispersed by the wind.

## Angiosperms

- Angiosperms, better known as flowering plants, are vascular seed plants that produce flowers and fruits.
- They are by far the most diverse and geographically widespread of all plants.
- There are about 250,000 known species of angiosperms.
- All angiosperms are placed in a single phylum, the **phylum Anthophyta**.
- The angiosperms are divided into two main classes, the **monocots** and the **dicots** (*more on this later*).
- The **flower** is an angiosperm structure specialized for reproduction.
  - In many species, insects and other animals transfer pollen from one flower to female sex organs of another.
  - Some species that occur in dense populations, like grasses, rely on the more random mechanism of wind pollination.
- A flower is a specialized shoot with four circles of modified leaves: sepals, petals, stamens, and carpals.
- The **sepals** at the base of the flower are modified leaves that enclose the flower before it opens.
- The **petals** lie inside the ring of sepals.
- Neither the sepals or petals are directly involved in reproduction.
- **Stamens**, the male reproductive organs, are the sporophylls that produce microspores that will give rise to gametophytes.
  - A stamen consists of a stalk (the **filament**) and a terminal sac (the **anther**) where pollen is produced.
- **Carpals** are female sporophylls that produce megaspores and their products, female gametophytes.
  - At the tip of the carpal is a sticky **stigma** that receives pollen.
  - A **style** leads to the **ovary** at the base of the carpal.
  - Ovules and, later, seeds are protected within the ovary.

### Fruits help disperse the seeds of angiosperms

- A **fruit** is a mature ovary.
  - As seeds develop from ovules after fertilization, the wall of the ovary thickens to form the fruit.
  - Fruits protect dormant seeds and aid in their dispersal.
  - The fruit develops after pollination triggers hormonal changes that cause ovarian growth.

## The life cycle of an angiosperm is a highly refined version of the alternation of generations common in plants

- All angiosperms are heterosporous, producing microspores that form male gametophytes and megaspores that form female gametophytes.
  - The immature male gametophytes are contained within **pollen grains** and develop within the anthers of stamens.
    - Each pollen grain has two haploid cells.
  - **Ovules**, which develop in the ovary, contain the female gametophyte, the **embryo sac**.
    - It consists of only a few cells, one of which is the egg.
- The life cycle of an angiosperm begins with the formation of a mature flower on a sporophyte plant and culminates in a germinating seed.
- The anthers of the flower produce microspores that form male gametophytes (pollen).
- Ovules produce megaspores that form female gametophytes (embryo sacs).
- After its release from the anther, pollen is carried to the sticky stigma of a carpel.
  - Although some flowers self-pollinate, most have mechanisms that ensure **cross-pollination**, transferring pollen from flowers of one plant to flowers of another plant of the same species.
- The pollen grain germinates (begins growing) from the stigma toward the ovary.
  - When the pollen tube reaches the micropyle, a pore in the integuments of the ovule, it discharges two sperm cells into the female gametophyte.
- In a process known as **double fertilization**, one sperm unites with the egg to form a diploid zygote and the other fuses with two nuclei in the large center cell of the female gametophyte.
- The zygote develops into a sporophyte embryo packaged with food and surrounded by a seed coat.
  - The embryo has a rudimentary root and one or two seed leaves, the **cotyledons**.
    - Monocots have one seed leaf and dicots have two.
- Monocots store most of the food for the developing embryo in **endosperm** which develops as a triploid tissue in the center of the embryo sac
  - Beans and many dicots transfer most of the nutrients from the endosperm to the developing **cotyledons**.
- The seed consists of the embryo, endosperm, sporangium, and a seed coat from the integuments.
- As the ovules develop into seeds, the ovary develops into a fruit.
- After dispersal by wind or animals, a seed germinates if environmental conditions are favorable.
  - During germination, the seed coat ruptures and the embryo emerges as a seedling.
  - It initially uses the food stored in the endosperm and cotyledons to support development.