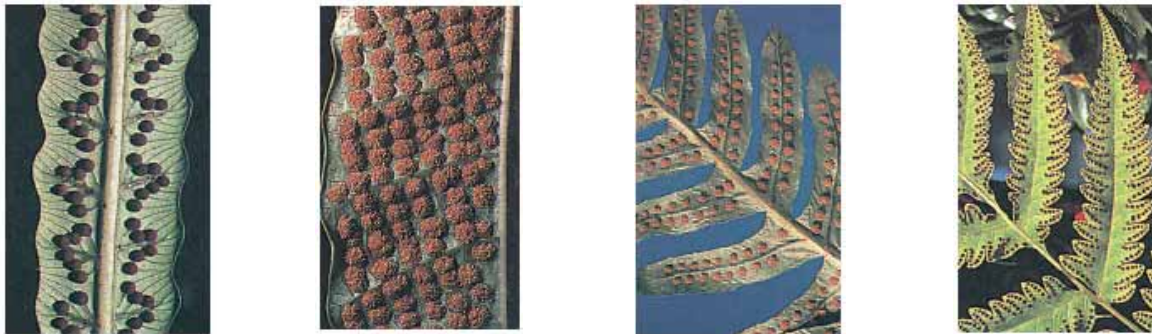


Like mosses, mature fern sperm are released from the antheridia but require moisture to help transfer them to the female sex organs, the archegonia. Following fertilization, the diploid zygote, the first cell of the sporophyte generation, grows by mitosis into an embryo that continues to grow. The tiny immature sporophyte plant produces small roots to absorb water and minerals and a tiny frond that can photosynthesize even before it has fully unfurled and reached its full size. A rhizome is also produced, which grows laterally and produces more fronds and roots. The prothallus withers and dies.

The mature sporophyte frond bears clusters of sporangia on its lower surface. One of these clusters is called a sorus (plural: sori) (**Figure 8**). In some fern species, the sporangia develop on special separate fronds with a distinctive form and colour. Many species of fern can be identified by the distinctive patterns formed by the sori. Diploid spore mother cells are produced by mitosis inside each sporangium. Each of these undergoes meiosis to form four haploid spores, the first cells of the next gametophyte generation. When the spores are mature, the sporangia use a variety of mechanisms to eject the spores. One frond alone can release many thousands of spores, which will be carried away in the wind.



(a)
Figure 8
Example of sori

(b)

(c)

(d)

Life Cycle of Gymnosperms

Gymnosperms produce unprotected, or “naked,” seeds in cone-like structures and are often referred to as conifers. The pine tree will provide a general example of a gymnosperm’s life cycle (**Figure 9**). A pine tree is the diploid sporophyte plant. In the spring, each tree produces two types of cones, neither of which looks like the woody, brown cones you have seen. The male cones, sometimes called pollen cones, are quite small and delicate and are found in clusters. Each male cone consists of many scales, each one with two sacs. In each sac, diploid microspore mother cells undergo meiosis to form four haploid microspores. Each of these develops into a haploid pollen grain, which is the male gametophyte. The female cones, sometimes called seed cones, are also quite small and somewhat sticky. They are often a pinkish-purple colour and are found singly or in groups of two or three. Each cone consists of many scales. On the upper side of each scale are two ovules. In each ovule, the megaspore mother cell undergoes meiosis but only one survives as a haploid megaspore, the female gametophyte.

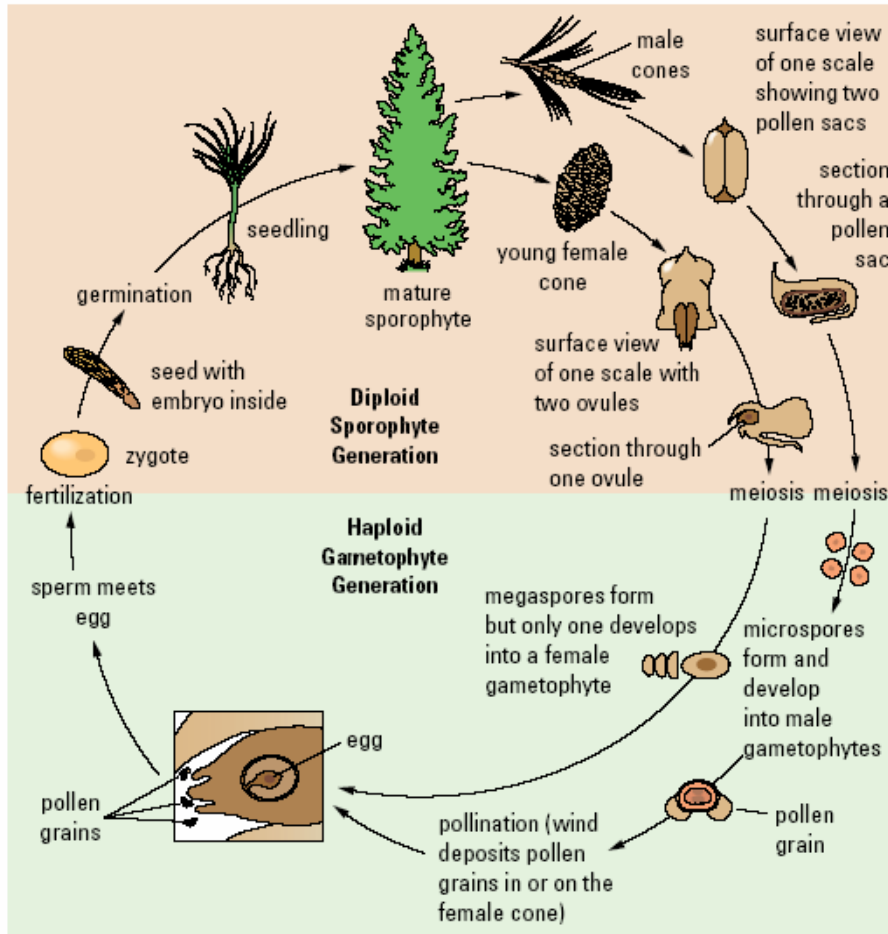


Figure 9

Alternation of generations of a pine tree. Starting with the mature diploid sporophyte tree at the top of the diagram, follow the cycle clockwise and note the labels carefully as you read the detailed description in the main text. Remember that even though the gametophyte generation is small, it is very important for maintaining diversity within the species.

When the pollen grains are mature, the tiny sacs of the male cones disintegrate and millions of dry pollen grains are released. The pollen grains have little flaps or wings that allow them to be carried easily by the wind. A parked car under a pine tree during this pollen release will accumulate a layer of yellow dust. The remnants of the male cones gradually dry up and fall off the tree.

The female cones are held by the tree such that the tip is pointing upward and the scales angle downward. When ripe, airborne pollen lands on the female cones of the same or a different pine tree, and the sticky sap and angles of the scales ensure that the pollen moves toward the ovules. After pollination, the female cones become greenish, quickly increase in size, and reorient themselves so that the tips are pointing downward. In some gymnosperms, fertilization may occur right away, but in pines, it usually takes a year before fertilization occurs.

Fertilization, the union of the microspore and megaspore nuclei, produces the diploid zygote, which is the first cell of the next sporophyte generation. The zygote grows by mitosis to produce the diploid embryo, which remains inside the ovule. Now that there is an embryo, the ovule becomes a seed. It develops a seed coat which protects the embryo until there are suitable conditions for germination. Some gymnosperm seeds may develop within a few months, but most species take two to four years to mature. During this seed development, the female cones become brown and take on a woody texture. As they dry, the scales separate and the seeds fall out. Eventually the empty female cones fall to the ground. If conditions are suitable, the seeds germinate. After germination, the tiny plant is called a seedling. Gymnosperms usually have to grow for many years before they produce male and female cones. Although the gymnosperm gametophyte generation is extremely tiny, both in size and duration, it still creates variety in the next generation of plants to ensure survival under many different circumstances.

Life Cycle of Angiosperms

Angiosperms produce seeds that are enclosed and protected inside a fruit, which is formed by various flower parts. Many can reproduce asexually by a broad variety of mechanisms, but they all reproduce by alternation of generations. The sexual phase of alternation of generations allows genetic material to be recombined as a result of fertilization. Even the young produced by the same two parents can be very different from each other.

The entire angiosperm plant, including the roots, stem, leaves, and flowers, belongs to the diploid sporophyte generation. In the appropriate season, the flower bud opens and the petals unfurl. The reproductive parts are revealed and, in a few days, they mature (**Figure 10**). The filament of the stamen elongates and the anther enlarges. Each anther consists of several chambers in which diploid microspore mother cells are located. Each of these undergoes meiosis to form four haploid microspores, or male gametophytes. Each will develop into a mature pollen grain. When the pollen grains reach maturity, the anther chambers split, and as they curl inside out, the pollen grains appear to be coating the outside of the anthers. The pollen of some species is quite sticky, while in others it is like dry powder. The pollen of some plants has tiny wings, while in others the surface has distinctive ridges and grooves. During this stamen development, the style of the pistil also elongates and the stigma enlarges slightly and secretes a sticky, sometimes scented, substance that covers its surface. At the bottom of the pistil, the ovary also enlarges. Inside are one or more ovules. Within each ovule, the diploid megaspore mother cell undergoes meiosis and forms four haploid megaspores, but only one survives as the female gametophyte.