When the sperm are mature, they are released from the antheridia. The mature eggs remain in the archegonia, which now produce a very sticky material. Transfer of the sperm from the male plants to the female plants can only occur if there is water. However, the plants are usually very close together and the water required can be as little as dew drops. Once in the vicinity of the archegonia, the sperm cells are attracted to the sticky material and swim down the neck of the archegonia. Only one sperm fuses with the waiting egg. This fertilization marks the beginning of the new sporophyte generation.

The first cell of this new sporophyte generation is the diploid zygote that grows rapidly by mitosis to form the diploid embryo—still in the archegonium. The embryo continues to grow into the new sporophyte plant, remaining embedded in the archegonium, which supplies nearly all the nutrients for the growing sporophyte plant. As the embryo grows, it becomes visible as a thin, brown stalk rising out of the top of the female gametophyte plant. Sometimes the brown stalk seems to be wearing a “hat.” This “hat” is the top of the old archegonium, which was torn off and rides up as the stalk grows. The stalk’s total height is often equal to the height of the gametophyte plant supporting it. Gradually the top of the stalk, under the “hat,” enlarges into a sporangium, inside of which are many diploid spore mother cells. Each spore mother cell undergoes meiosis to form four haploid spores, which are the first cells of the next gametophyte generation. The sporangia open and eject the spores, which are carried away by air currents. The stalk height increases the efficiency of spore dispersal.

Life Cycle of Ferns

The full life cycle of ferns involves an alternation of generations. Follow **Figures 6** and **7** carefully as you read the details that follow.

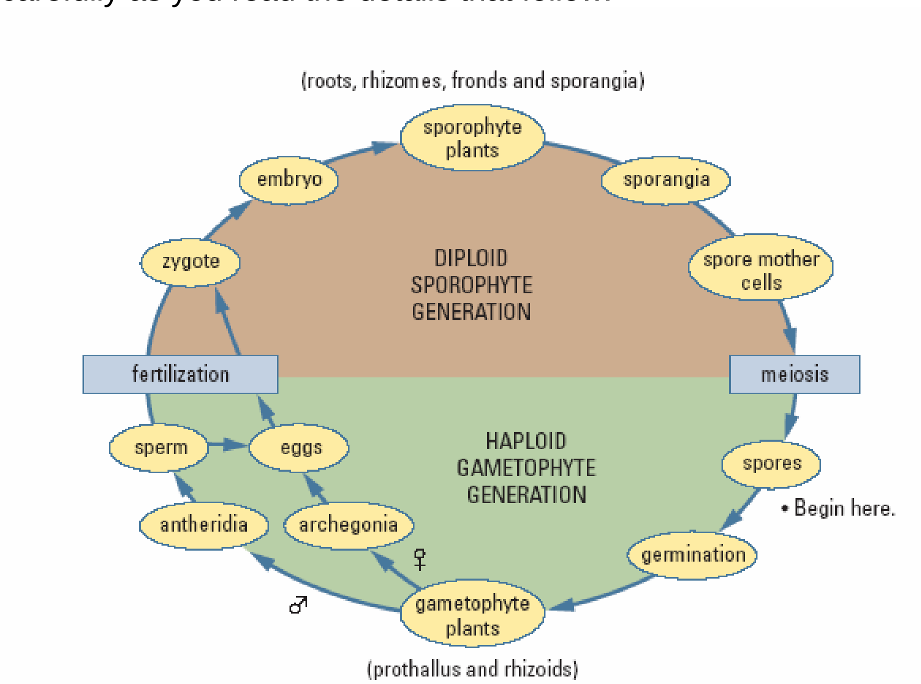


Figure 6

Alternation of generations of a fern. Starting with the spores at the right side of the diagram, follow the cycle clockwise and note the labels carefully as you read the detailed description in the main text.

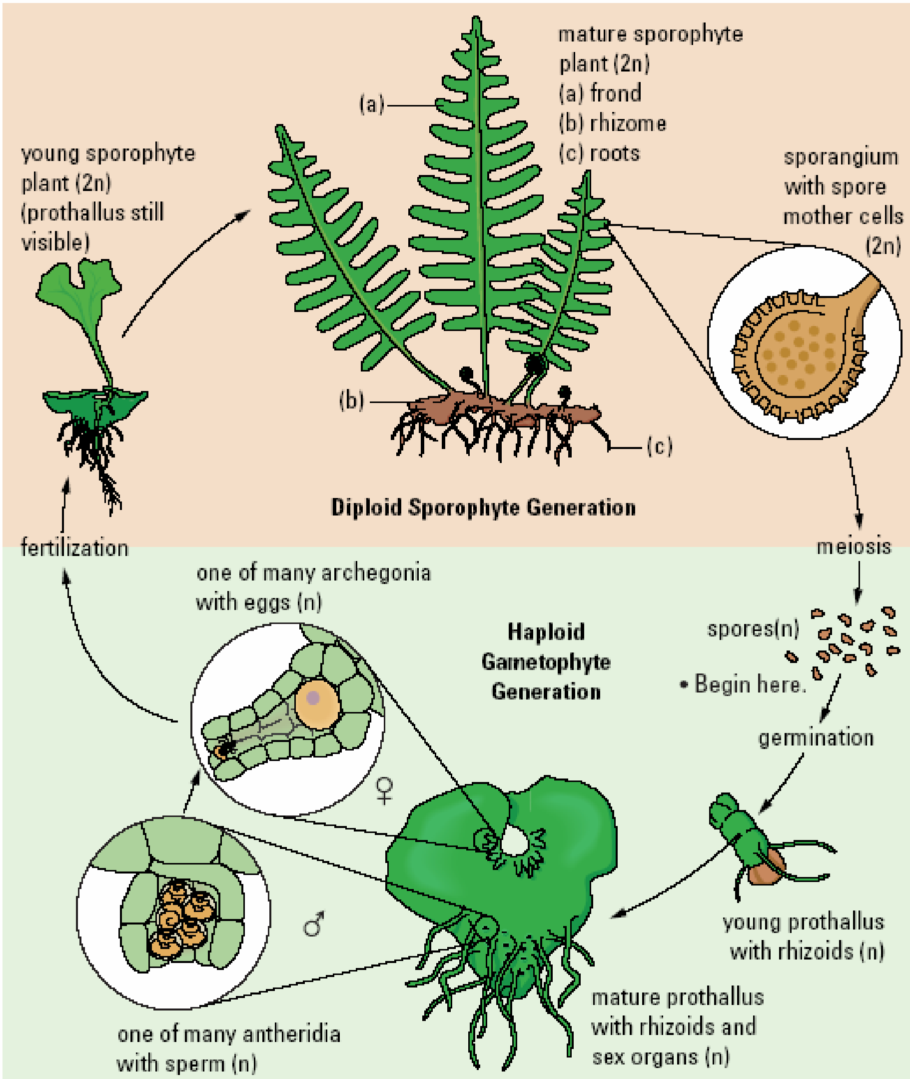
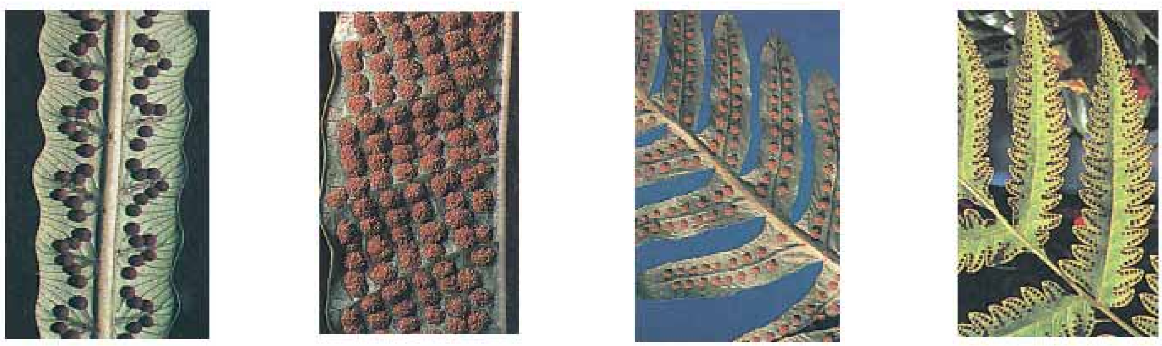


Figure 7
Alternation of generations of a fern. Starting with the spores at the right side of the diagram, follow the cycle clockwise and note the labels carefully as you read the detailed description in the main text and review the simpler diagram in **Figure 6**.

The tiny haploid spores that have been produced by meiosis are the first cells of the gametophyte generation.As they are released, they are usually carried by the wind. If a spore lands in an environment suitable for its growth, the protective covering splits and the spore germinates. The single cell divides rapidly by mitosis. The resulting haploid plant is called a prothallus (or prothallium). This thin, green, heart-shaped gametophyte is about the size of the fingernail on your baby finger. A cluster of rhizoids grow from the underside of the prothallus. Also on the underside of the prothallus are found spherical antheridia, in which sperm are produced by mitosis, or flask-shaped archegonia, in which eggs are produced by mitosis. Whether the male and female sex organs are on the same or separate gametophyte plants depends on the fern species.

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) **(b)** **(c)** **(d)**

Figure 8
Example of sori

Life Cycle of Gymnosperms

Gymnosperms produce unprotected, or “naked,” seeds in conelike 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.