GYMNOSPERMS

Seeds

For the lower vascular plants the important evolutionary development was in the water and food conducting tissues of the sporophyte. As we move on through the plant kingdom the next important development was the seed. The free living gametophyte is a vulnerable phase of the life cycle. Reproduction by seeds is a less chancy procedure and has other advantages for plant survival and dispersal. Seeds can be remarkably tolerant of environmental extremes heat, cold and drought. Unlike free-living gametophytes seeds can postpone their development until conditions are right. And, of course, we find them very convenient for plant propagation.

Already in the coal-measure forests there were plants that reproduced by seeds. Some were the so-called "seed ferns". none of which survive. Others were the ancestors of the plants we now know collectively as "gymnosperms". In these plants the seeds are not enclosed in an ovary, as in the flowering plants; they grow on the surface of a modified leaf in a strobilus or cone. "Gymnosperm" means naked seed.

Alternation of generations is still involved in the reproduction of these plants. They are all heterosporous: the microspores are shed as pollen, whereas the megaspore germinates in the strobilus to produce the female gametophyte. The archegonia in this gametophyte get fertilized by sperm from the male gametophyte and the zygote grows to produce an embryo which is enclosed in a seed coat of tissue from the parent plant.

Gymnosperms were the dominant land plants in the age of dinosaurs, the Cretaceous and Jurassic periods. The surviving gymnosperms in the Coniferophyta, Cycadophyta and Ginkgophyta are similar in their woody habit and pattern of seed development but are not closely related.

Coniferophyta

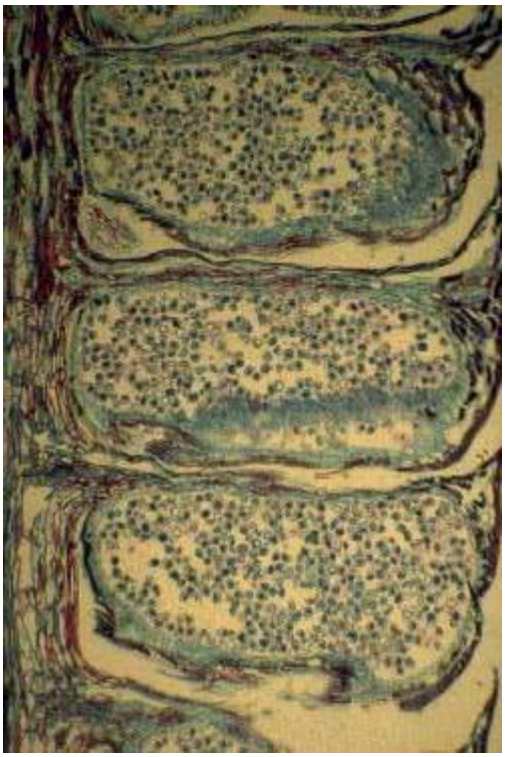
Conifer leaves are needle or scale-like. They result from the downsizing of true megaphylls

and unlike the microphylls of lower plants they are connected to the vascular system of the stem. Conifers are often large and can dominate the plant life in some ecosystems because their stems continue to expand in width as well as length throughout the life of the plant. The older parts of the stem become woody, which provides a further distinction from the seedless vascular plants of which there are no surviving woody representatives.

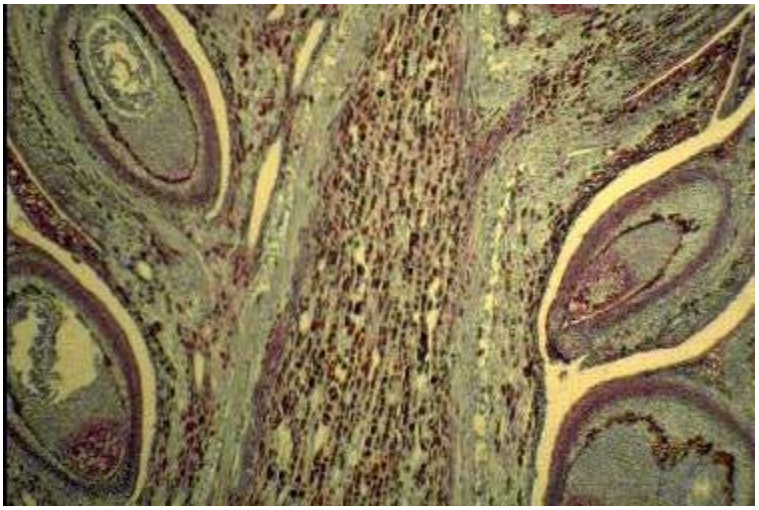
The wood of conifers is more primitive than that in angiosperm trees. It contains tracheids but no vessel elements, and there is generally less ray parenchyma in conifer wood than in dicot wood.

Conifer life cycle

Microspores and megaspores are formed on sporophylls in male and female cones respectively. Each scale in the male cone has two sporangia in which meiosis occurs to produce tetrads of spores, just as in a fern sporangium. Male gametophyte development starts in the microspore (or pollen grain) before it is shed. Mitotic divisions result in two prothallial cells, a tube cell and a generative cell. The sporangium breaks open to shed the immature gametophytes which are carried on the wind and may chance to arrive at a sporophyll on a female cone.



Old male cones of *Pinus nigra* and (right) L.S. of male cone



In the female cone each scale bears two megasporangia - ovules in which a single mother cell undergoes meiosis to produce four megaspores.

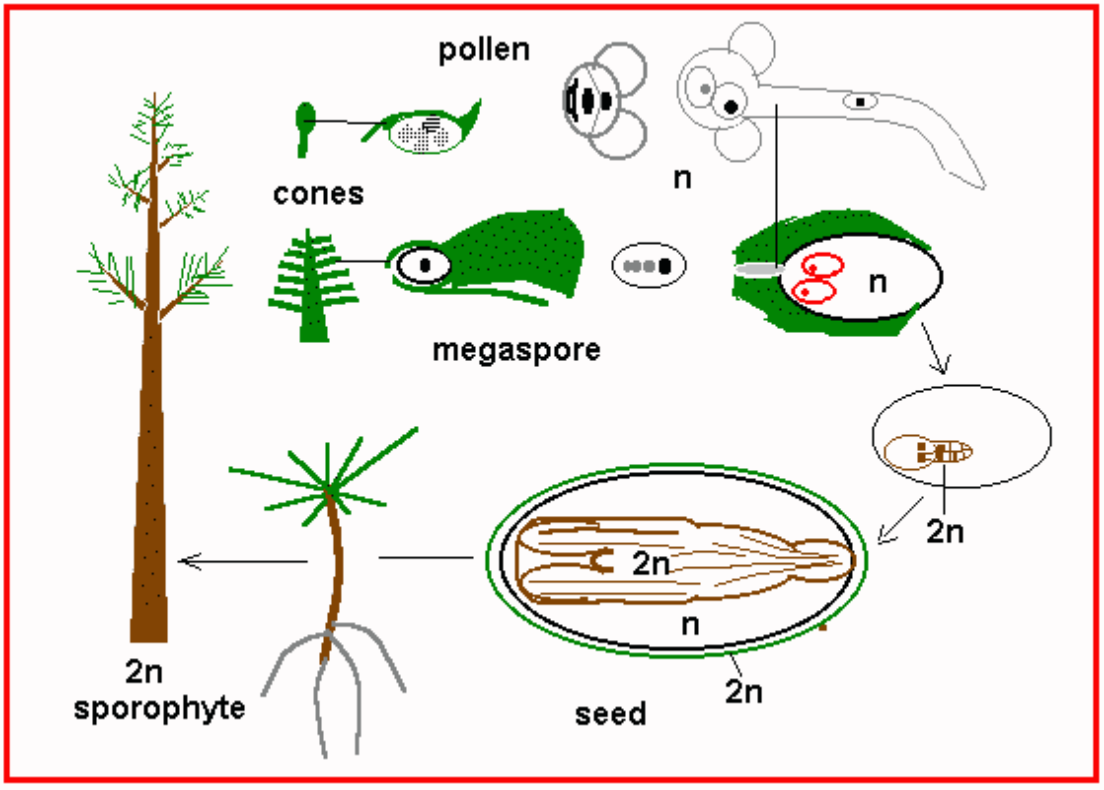
One megaspore develops into the female gametophyte which contains thousands of cells and is considerably larger than the male gametophyte.

Male gametophyte development has to wait up to a year for the female gametophyte to mature and produce two or three archegonia with egg cells.

The pollen tube grows slowly through a pore in the integument of the megasporangium and eventually the generative cell divides to produce two sperm cells. One of these fertilizes an egg cell to produce a zygote. Usually only one archegonium will produce a zygote in each megagametophyte so that there is only one embryo per seed.

The mature seed consists of three generations of tissues: maternal sporophyte tissue (seed coat and nucellus), gametophyte and daughter sporophyte (embryo) - After about two years the mature seeds are shed. Conifer seedlings have several needle-like cotyledons in a whorl and the seedlings produce scattered leaves until adult foliage develops.

Because seed development takes such a long time it is often possible to find three years' cones on pine trees



Unlike the seedless vascular plants, conifers are more prevalent in cooler regions and in xeric habitats. Because of their leaf and stem anatomy they are better adapted to drought than most broadleaved trees. In addition many conifers have evolved cold hardiness so that above ground structures can persist even in harsh environments. The bristlecone pines that grow on

mountain ridges in California are an extreme example.

Of course conifers are also important economically as a tree crop for pulp and timber. Their ability to grow in areas that are unsuitable for other crop production is an asset for this purpose. Similarly, since most (though not all) conifers are evergreen they are valued as landscape plants, particularly in areas like Ohio where few broadleaved evergreens can withstand the winter. The evergreen habit does have its disadvantages since premature leaf death caused by pollution, disease or insect attack can be more damaging than in plants which produce a complete new flush of leaves each spring.

Cycadophyta

Cycads or similar plants were the food of herbivorous dinosaurs and the fate of both of these groups of organisms was probably closely linked. They survive as a few species of tropical palm-like trees, including one which is native to the USA, *Zamia pumila* the cardboard palm. This is found on sandy soils in Florida and is sometimes grown as a foliage plant. *Cycas* species are larger and are often used as ornamentals in tropical areas. The cycads can be viewed as beneficial as they form symbiotic associations with nitrogen fixing bacteria, but they have also been the subject of extermination programs since they are highly toxic to livestock. Their life cycle is rather similar to the conifers' but they have free-swimming sperm (a primitive feature) and sometimes they are pollinated by insects (an advanced feature)

Cycas revoluta with male cones

Zamia pumila with female cone

Ginkgophyta

This is a monotypic division, a single species of a single genus, *Ginkgo biloba* the maidenhair tree. Several relatives are known as fossils dating back to Pennsylvanian times. *Ginkgo biloba* was preserved in the gardens of Buddhist monasteries in China and Japan where it was encountered by Westerners in the eighteenth century. It has turned out to be a valuable street tree because of its unusual foliage and tolerance of pollution.

Ginkgo biloba with mature female strobili

QUIZ

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