

GYMNOSPERMS

Gymnosperm means 'Naked seed'. However, when you look at a pine-cone you cannot actually see any naked seeds, so what does this term imply? The seeds are technically naked, because pollen must land on the micropyle of the ovule, the micropyle exudes a drop of fluid, the **pollination droplet** in most Gymnosperms. – in flowering plants (**Angiosperm** means 'hidden seed') the pollen lands on a **stigma**, grows a pollen-tube down a style and then meets the ovule. The term **Conifer** must also be understood to simply mean a cone-bearing plant – and it can likewise be difficult to see how the fruit of a Podocarp, Ephedra, Ginkgo or Yew (each with a single seed) can be called a cone – but it is! The Cones of pines, firs, spruces, and cycads on the other hand are self evident.

Gametophyte generation wholly enclosed by Sporophyte generation: does not exist independently. Megasporangia is contained in an 'Ovule' (An ovule comprises 2 layers [integuments] surrounding a nucellus [merely a name for the mass of tissue] in which the spore grows into the embryo sac [=Megasporangia or Female gametophyte]). After fertilisation, the Embryo develops within an endosperm (haploid in Gymnosperms), and this in turn is enclosed within a seed.

Gymnosperms are the most primitive of the seed plants. A seed comprises two parts: an **endosperm**, which nourishes the embryo, and the **embryo** itself, which is fed by the endosperm. In gymnosperms the endosperm grows from a **spore** (a cell with half the number of chromosomes – n). Pollination may occur when the cone is small, but the endosperm continues to grow to completion before fertilisation occurs. When fully grown the endosperm develops **archegonia** in which single large nuclei act as egg cells. Only now does fertilisation occur, sometimes 12 months or more after pollination.

Flowering plants have made several important evolutionary advances over gymnosperms, which is part of the reason there are 350,000 of them and just 900 gymnosperms. The **flower** is the most obvious: It is bisexual, with a carpel & stigma; unlike a gymnosperm, the endosperm and embryo develop in parallel by double fertilisation. The **leaves** are larger, broad and deciduous, reflecting an improved water supply, which is due to the evolution of **vessels** – xylem elements that are about 30 times the diameter of tracheids and 100 times as long.

Four **divisions** of Gymnosperms are recognised:

CYCADOPHYTA Cycads: 3 families: Cycadaceae, Stangeriaceae, Zamiaceae 160 spp.

Rarely branched trunks with soft pithy wood. Dioecious. Leaves compound. male gametes multi-ciliated. Microsporangia (Male gametophyte) grows within the ovule, motile sperm released after several months, sometimes after the seed has fallen.

GINKGOPHYTA 1 species: Maidenhair tree *Ginkgo biloba*

Well branched, deciduous, dioecious tree. Leaves alternate, simple, fan-shaped with dichotomous venation. Female gametophyte large, photosynthetic; male gametophyte producing 2 large swimming sperm (multiflagellate) within the pollen tube. A "living fossil" with no close relatives (more diverse in the Jurassic). Only species *Ginkgo biloba*, probably native to China; widely cultivated in temperate areas.

GNETOPHYTA 3 orders each with one genus: *Ephedra*, *Gnetum*, *Welwitschia* 70 spp.

Plants of very diverse growth forms: classified in 3 orders. All have vessels in the xylem, but this has probably evolved independently of Angiosperms. Pollen tubes with non-motile gametes are formed.

PINOPHYTA 3 orders: Pinales, Cupressales, Taxales ca. 700 spp.

Branched, woody trees, mostly monoecious. Resin canals in wood. Tracheids only, no vessels. Pollination occurs 12 months prior to fertilisation. Pollen tube, and non-motile gamete.

PINALES

Pinaceae: Monoecious resinous trees with opposite or whorl branches; lvs linear, needle-like, spirally arranged, borne in bundles of 2, 3 or 5, these in fact specialised branches; male cones borne terminally on side branches, microsporangia 2; female cones usually woody with spirally arranged scales bearing 2 seeds per scale; cotyledons several. 10 genera, 194 species. Mainly north temperate regions to Malesia and Central America. The bristlecone pine *Pinus longaeva* 4000 year old. *Abies* (fir), *Cedrus*, *Keteleeria*, *Larix* (larch), *Nothotsuga*, *Picea* (spruce), *Pinus*, *Pseudolarix* (golden larch), *Pseudotsuga* (Douglas-fir), *Tsuga* (hemlock).

CUPRESSALES

Cupressaceae: Monoecious or dioecious; lvs decussate or in whorls, often needle-like in juvenile vegetation, scale-like in mature; cones small, on short shoots, woody, leathery or berry-like, the cone-scales opposite or in whorls of 3s; microsporangia 3-6; the ovules 2-many per scale; cotyledons usually 2. 28 genera, 129 species. Distinguished from Pinaceae by opp. or whorled scale-like leaves. Cosmopolitan. (*Callitris*, *Chamaecyparis* [*C. lawsoniana* a v. important hedge plant], *Cupressus*, *Juniperus*, *Thuja*, *Xanthocyparis*). The hybrid X *Cupressocyparis leylandii* [now X *Cuprocyparis* (*Xanthocyparis nootkatensis* (pollen) X *Cupressus macrocarpa* (cone))] is a fast growing hedge plant.

Taxodiaceae: Monoecious resinous evergreen or deciduous trees. Leaves spirally arranged though apparently sometimes opposite. Cones woody, globose; each scale with 2-9 sometimes winged seeds; microsporangia 2-9. Formerly a widespread family, now a classic relic distribution in N.America and China, 10 genera, 14 spp., monotypic save 3. *Taxodium* (Swamp cypress), *Sequoia* (*S. sempervirens*, tallest tree), *Sequoiadendron* (*S. giganteum* largest tree), *Metasequoia* (Dawn redwood - described from fossils, living plant discovered in 1940s in China), *Cryptomeria*, *Arthrotaxis*, *Cunninghamia*, *Glyptostrobus*, *Sciadopitys*, Taiwania.

Podocarpaceae Dioecious, resinous trees. Leaves linear to scale-like. Female cones with few bracts, each with only one seed at maturity; microsporangia 2. Seed seated on or surrounded by an aril-like fleshy outgrowth, hence the name; cotyledons 2. 12 genera 155 species; S. Hemisphere, Japan to C.America, and African mountains. *Parasitaxus ustus* (New Caledonia) only parasitic gymnosperm known, parasitic by root graft. *Afrocarpus*, *Dacrycarpus*, *Podocarpus*, *Prumnopitys* (Plum fruited yew), *Saxegothaea* (prince albert's yew).

Phyllocladaceae: Celery pines. Similar to Podocarpaceae, but with complex lateral branch systems, possibly similar to those of earliest gymnosperms. *Phyllocladus* with 4 species, Borneo to New Guinea..

Cephalotaxaceae Plum Yews. Dioecious trees with 2-ranked or whorled leaves. Female cones on short secondary fertile shoots, 2 ovules per bract, but only 1 ovule developing per cone, forming a large olive-like seed, the outer layer fleshy around a stony layer; microsporangia 3-8; . *Cephalotaxus* only with 4 species - Himalayas to Japan.

Araucariaceae Monkey puzzle trees. Monoecious or ioecious with broad to needle leaves. Female cone large, globose, disintegrating when seeds mature; 1 median ovule per scale; microsporangia 5-20. 3 genera 33 species, S.America & S.E.Asia & Australia, NZ. *Araucaria*, *Agathis*, A third living genus was discovered in Australia 1994, having foliage similar to Jurassic fossil. The tree has been named *Wollemia nobilis*.

TAXALES

Taxaceae Monoecious or dioecious; lvs linear, needle-like, spirally arranged; microsporangia 2-8; fleshy "cones" with decussate bracts and a single ovule, arillate; cotyledons 2. 5 genera, 17 species. Northern hemisphere south to Malesia and New Caledonia.. *Austrotaxus*, *Taxus*, *Torreya*.