

Gymnosperms

General Characteristics

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Introduction

- Once an authoritative and major classification level in the plant kingdom, the gymnosperms form today a rather heterogeneous group of seed-bearing plants that includes conifers, cycads, Ginkgo and Gnetales.
- The term "gymnosperm" comes from word gymnospermos, meaning "naked seeds", after the unenclosed condition of their seeds (called ovules in their unfertilized state).
- Their naked condition stands in contrast to the seeds or ovules of flowering plants (angiosperms) which are enclosed during pollination.
- Gymnosperm seeds develop generally on the surface of scale- or leaf-like appendages of cones.

Diversity and origin

- There are between 700 and 900 extant* or currently living species of Gymnosperms.
- It is widely accepted that the gymnosperms originated in the late Carboniferous Period. Early characteristics of seed plants were evident in fossil progymnosperms of the late Devonian period around 380 million years ago.
- It has been suggested that during the mid-Mesozoic period, pollination of some extinct groups of gymnosperms were by extinct species of scorpionflies that had specialized proboscis for feeding on pollination drops.
- The scorpionflies likely engaged in pollination mutualisms with gymnosperms, long before the similar and independent coevolution of nectar-feeding insects on angiosperms

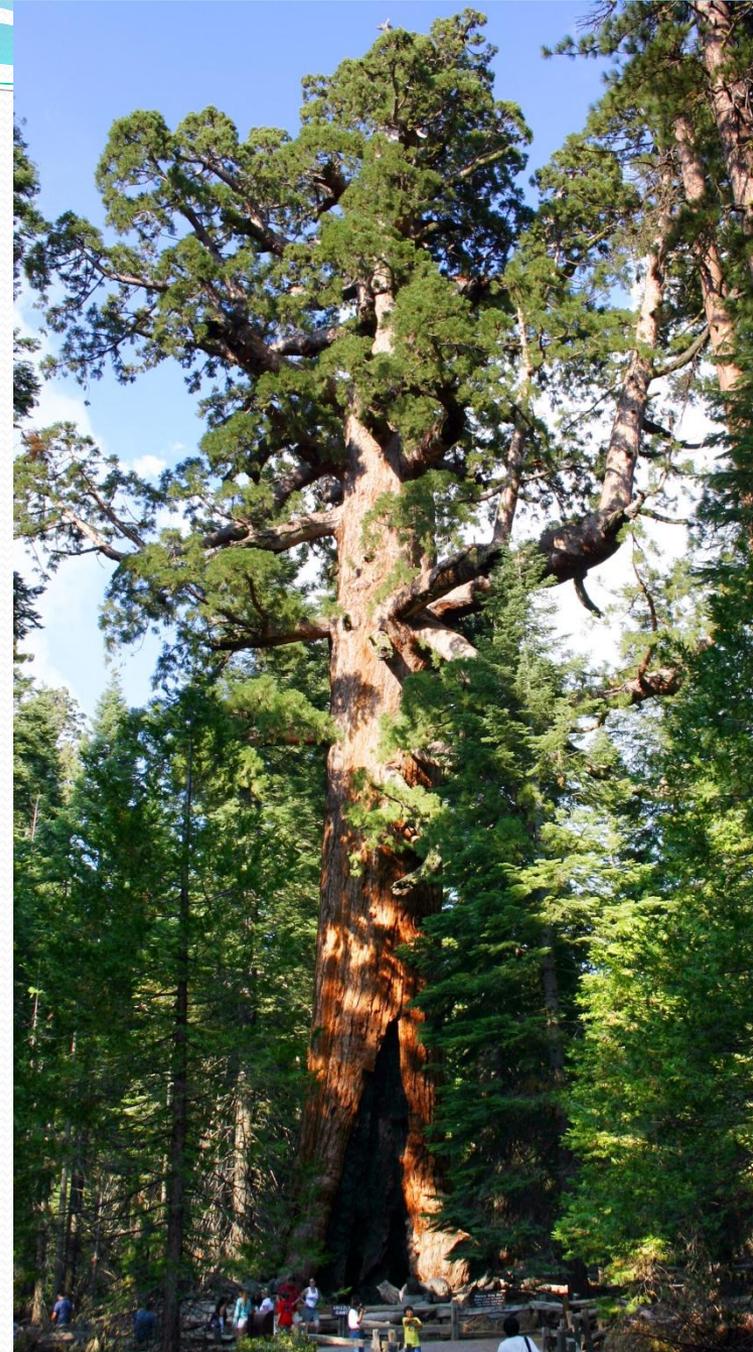
* Extant is a term commonly used in biology to refer to taxa (such as species, genera or families) that are still in existence (living). The term extant contrasts with extinct

Diversity and origin

- Conifers are by far the most abundant extant group of gymnosperms with six to eight families, with a total of 65-70 genera and 600-630 species (696 accepted names).
- Conifers are woody plants and most are evergreens
- The leaves of many conifers are long, thin and needle-like with a waxy coating, others species, including most Cupressaceae and some Podocarpaceae, have flat, triangular scale-like leaves.
- Agathis in Araucariaceae and Nageia in Podocarpaceae have broad, flat strap-shaped leaves
- Cycads are the next most abundant group of gymnosperms, with about 130 species. The other extant groups are the 75 - 80 species of Gnetales and one species of Ginkgo.

Diversity and origin

- Gymnosperms include one of the world's tallest trees - *Sequoia sempervirens* (the Giant Red Wood Tree) measuring about 125 meters in height and 30 meters in girth
- A 4000 year old red wood tree is still found in California!



Characteristics of Gymnosperms

There exist a set of standard feature or characteristics that help to identify gymnosperms. Here are some of the peculiar characteristics of gymnosperms:

- Gymnosperms do not have an outer-covering or shell around their seeds.
- Gymnosperms do not produce flowers barring a few exceptions.
- Gymnosperms are heterosporous which means that they produce different male and female spores. The microspores develop into pollen grains and the megaspores are in an ovule.

Characteristics of Gymnosperms

- Gymnosperms produce cones.
- Gymnosperms do not bear fruits.
- Gymnosperms propagate via wind pollination
- The adult plant body is a sporophyte. It is represented by a perennial, evergreen, woody plant. Most of them are trees and some are shrubs. There are no herbs.
- Pinus as well as other conifers are evergreen trees. They have monopodial growth represented by one main axis. As the axis grows taller it increases in diameter due to secondary growth. Stem branches are of two types:
 1. Long shoots or branches of unlimited growth.
 2. Dwarf shoots or branches of limited growth

Characteristics of Gymnosperms

- The plants possess well-developed tap root system. In some cases the roots are symbiotically associated with algae (coralloid roots of *Cycas*) or with fungi (mycorrhizal roots of *Pinus*).
- The stem is erect and woody, may be branched or unbranched.



Coralloid (C) and Precorallloid (PC) on a *Cycas*



Characteristics of Gymnosperms

- Gymnosperms are heterosporous, producing two kinds of spores microspores and megaspores produced by separate sporangia
- The two types of sporangia - microsporangia and megasporangia are found on special leaf like structures called sporophylls
- The microsporangia represent the pollen sacs and the megasporangia represent the ovules. Microsporangia occur on microsporophylls (stamens) and megasporangia occur on megasporophylls (carpels)



Characteristics of Gymnosperms

- The sporophylls are usually aggregated to form structures called cones or strobili. Male cones (with microsporophylls) and female cones (with megasporangia) occur on separate plants (unisexual)
- The microsporangium (pollen sac) produces numerous pollen grains which are anemophilous. The megasporangium (ovule) remains exposed on the megasporophyll
- The pollen grain which represents the male gametophyte comes in contact with the ovule, develops a pollen tube and brings about pollination

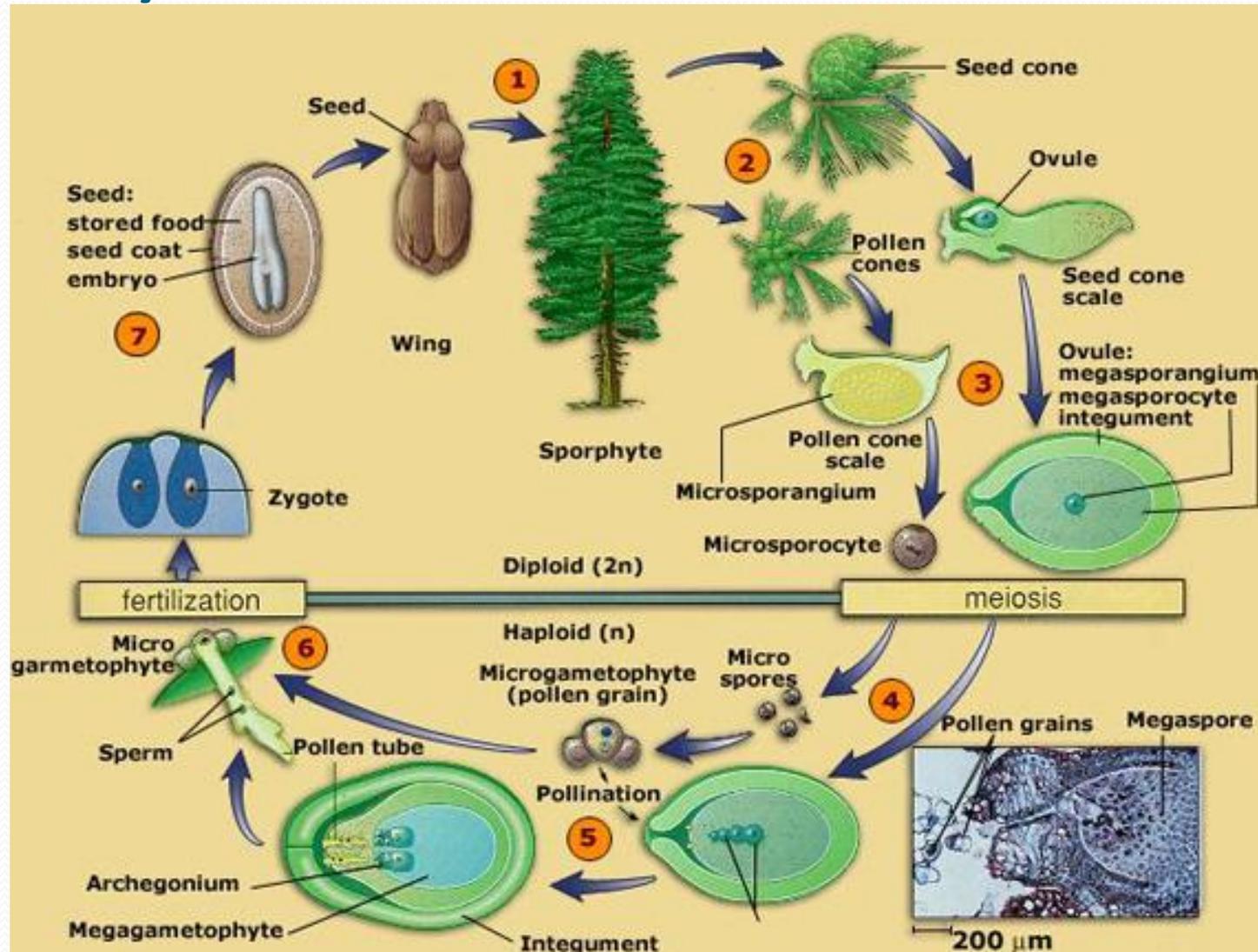


Male Cones and
Female cone of Pinus

Characteristics of Gymnosperms

- The generative cell present in the pollen tube produces two male gametes. One of them unites with the egg cell in the ovule to form a zygote.
- The diploid zygote develops into an embryo which remains enclosed within the ovule. The ovule then transforms itself into a seed
- The seed remains attached to the megasporophyll and is not enclosed by a fruit
- The ripe and dry seeds are shed. Under suitable conditions the seeds germinate and develop into new plants

Life Cycle



Classification

- Gymnosperms are grouped into seven divisions of which four divisions include examples which have become extinct.
- Among the existing forms the most familiar ones are the Cycads. (E.g., *Cycas*) and the Conifers (E.g., *Pinus*).
- Some examples like *Gnetum* and *Ephedra* show certain characteristics close to angiosperms.

Classification

Cycadophyta

- The 220 species of cycads are widely distributed through the tropical and subtropical regions. Most of them superficially resemble ferns, having a cluster of long pinnate (rarely bipinnate) fronds growing from a central stalk, but they differ in developing distinctive male and female cones.
- Cycads are woody, long-lived, unisexual plants. All species have coralloid roots, which support symbiotic cyanobacteria that can fix atmospheric nitrogen.
- The cycads and ginkgo are unique among seed plants in having motile sperm; this is often taken as evidence of their evolutionary primitiveness.

Cycadophyta

- Cycads appeared in the fossil record about 230 million years ago and attained their greatest ecological importance during the Jurassic period, about 193 million to 136 million years ago, when they formed extensive forests.
- This division includes palm-like gymnosperms, not to mention the surviving order *Cycadales* and other extinct orders. The cycads are slow growing palm-like plants. These plants also have another characteristic feature that the leaves of these plants are borne together on the top of the trunk. The seeds of these plants are present on the surface of the scales of cones



Classification

Coniferophyta

- With approximately 588 living species, this is the most diverse and by far the most ecologically and economically important gymnosperm group
- Conifers grow in all climate zones and on all continents except Antarctica
- They all bear their seeds within a cone or a structure superficially resembling a berry (true berries only exist among angiosperms)
- Most conifers are trees
- Conifers appeared in the fossil record about 290 million years ago and have been an ecologically important, widespread group ever since then.



Pinus sylvestris



Coniferophyta

- This is the largest division of gymnosperms, which includes Pines, Yews, Spruces, Junipers, Cedars and many more plants
- These conifers are found in the high latitudes of the northern hemisphere
- There are several families of the *Coniferophyta* division as well
- These are cone-bearing gymnosperms, which date back to the carboniferous period.



Classification

Gingkophyta

There is one surviving species of Ginkgo. It is a tree, sometimes attaining large size, native to China but widely planted around the world. Ginkgo is often referred to as a "living fossil" because nearly identical plants are known from fossils nearly 200 million years old. The fossil record shows that they were formerly a widespread, abundant, and diverse group.

This group of the gymnosperms is relatively limited since it contains only one member. The single living species of the Ginkgophyta division is the *Ginkgo biloba* from China.



Classification

Gnetophyta

The gnetophytes are one of the most peculiar plant groups.

They include three highly distinct groups totaling 68 species. One group, the genus *Ephedra*, is composed of shrubs native to deserts and semiarid areas. The second group, the genus *Gnetum*, is composed of climbing vines (and one tree species) native to tropical rainforests. The third group contains a single species, *Welwitschia mirabilis*. It lives in the desert of Southwest Africa, produces two leaves that grow throughout the life of plant, and lives an estimated two thousand years.

Gnetophyta

- Although the fossil record is virtually nonexistent, studies suggest that the Gnetales are a relatively young group that evolved from the angiosperms and thus are unrelated to the other gymnosperms.
- These are gymnosperms, which are truly unique due to the fact that they bear flowers- a property that is exclusively attributed to the angiosperms

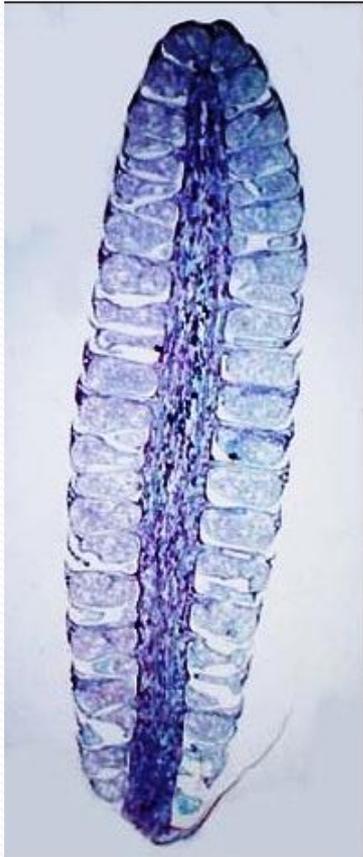


Gnetophyta

- In addition to this, the xylem of these plants contain vessels and pollen-producing structures, which resemble the stamens in angiosperms. Owing to this, these plants are considered as a link between gymnosperms and angiosperms.
- The plants included in this division are tropical lianas, joint-firs and also several other plants



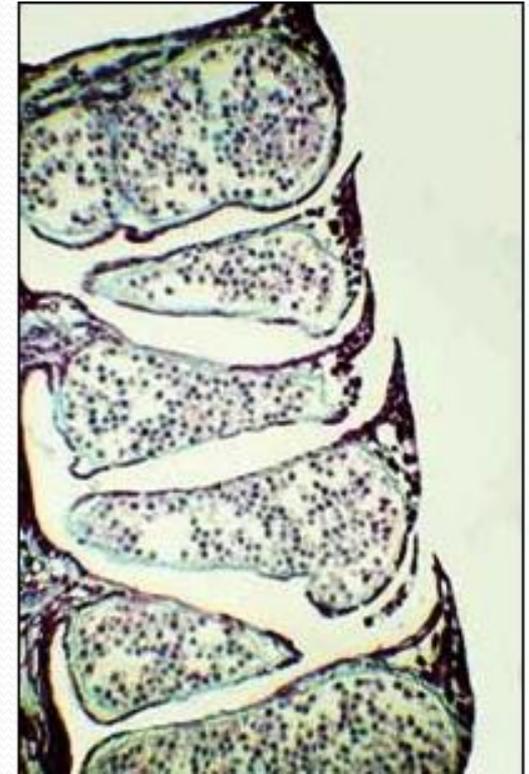
Anatomical Features – Reproductive (Male)



**Staminate cone
longitudinal
section at 35X**



Winged Pollen at 400X

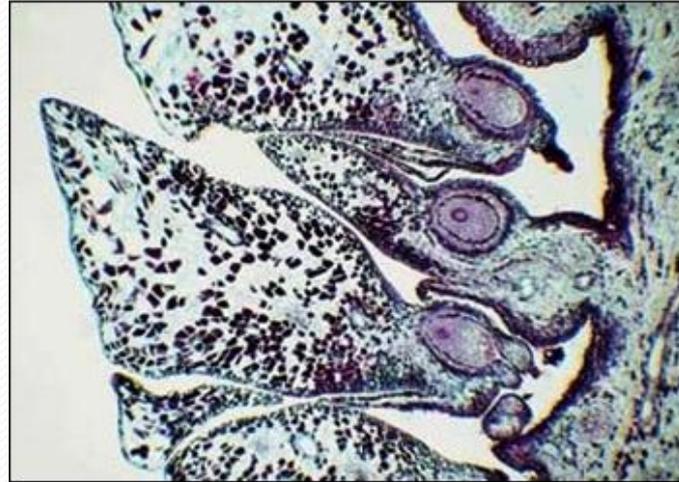


**Longitudinal section
of staminate
cone at 100X**

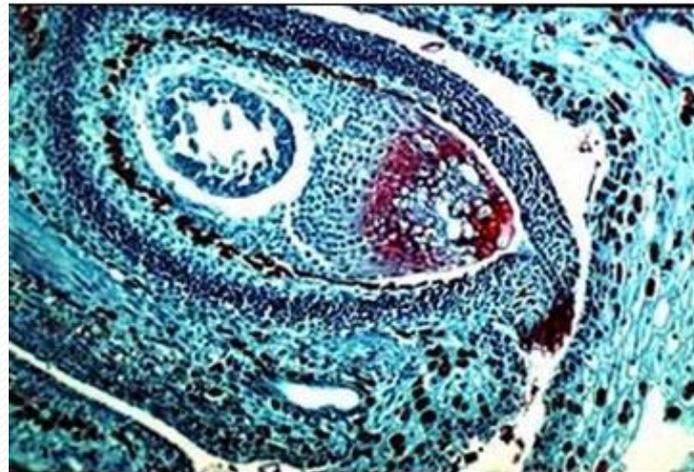
Anatomical Features – Reproductive (Female)



**Longitudinal section
of ovulate cone at
35X**



Ovulate cone section at 100X



Nucellus in ovulate cone