Gymnosperms:

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Definition of Gymnosperms:

The term gymnosperms (gymnos = naked; sperma = seed) was introduced by Theophrastus in 300 BC to describe plants with unprotected seeds. Gymnosperms are phanerogams without ovary.

The phanerogams or Spermatophyta (sperm = seed; phyton = plant) or seed plants are those plants which reproduce by means of seeds, not spores. Gymnosperms are the vascular plants where seeds are not enclosed within an ovary (opposite to an angiosperm or flowering plants where seeds are enclosed by mature ovaries or fruits). In these plants the ovules are borne naked or the surface of the megasporophylls, which are often arranged in the cones.

Fossil records indicate that the gymnosperms must have evolved approximately 300 million years ago from non-seed producing ancestors of the extinct division of Progymnospermophyta which were fern like in appearance (form a bridge between pteridophytes and angiosperms).

Gymnosperms were dominant plants over the earth's surface during the jurassic and cretaceous periods of mesozoic era. At present about 83 genera and approximately 790 species of living gymnosperms are distributed throughout temperate, tropical and arctic regions of the world.

Characteristics of Gymnosperm:

Gymnosperms are, those seed plants in which the seeds remain exposed over the surface of the megasporophylls because the latter are not folded to form pistils.

1. Gymnosperms are a small group of seed plants which are represented by only 900 living species.
2. Gymnosperms are more ancient than the angiosperms. They formed dominant vegetation on earth some 200 million years back in mesozoic era. Today they are dominant only in cold areas, where instead of rain; snow is the source of water.

At other places they have been replaced by angiosperms. In warmer areas only a handful of gymnosperms can be observed, e.g., *Cycas* (like *C. circinalis* in South India), *Araucaria* (native of South America, New Zealand and East Australia, like *A. heterophylla*.

3. All gymnosperms are perennial and woody, forming either bushes or trees. Some of these are very large and live for thousands of years, e.g., *Sequoia sempervirens* (tallest gymnosperm of 111.6 m) *Zamia pygmia* is smallest (26 cm).
4. Flowers are absent. Two types of sporophylls, microsporophyll's and megasporophylls are usually aggregated to form distinct cones or strobili, pollen cones (male cones) and seed cones (female cones) respectively.
5. Seeds do not occur inside a fruit. They are naked.
6. A distinction of ovary, style and stigma is absent.
7. Ovules are orthotropous and sessile. Each ovule is surrounded by a 3-layered integument.
8. Female gametophyte contains archegonia.
9. Pollination is direct as a stigma is absent and the pollen grains directly reach the micropylar ends of ovules. Pollination is usually accomplished by wind (anemophily).
10. Male gametophyte produces only two male gametes or sperms. Generally one of them is functional.
11. An external water is not required for transport of male gametes. Instead, a pollen tube is formed by the male gametophyte for effecting fertilization (siphonogamy).
12. Seeds contain a food laden tissue or endosperm for future growth of embryo into seedling. The tissue represents the female gametophyte.
13. Like pteridophytes, xylem does not possess vessels except in some gneophytes. Phloem is without companion cells and sieve tubes. Sieve cells are not arranged end to end in rows.

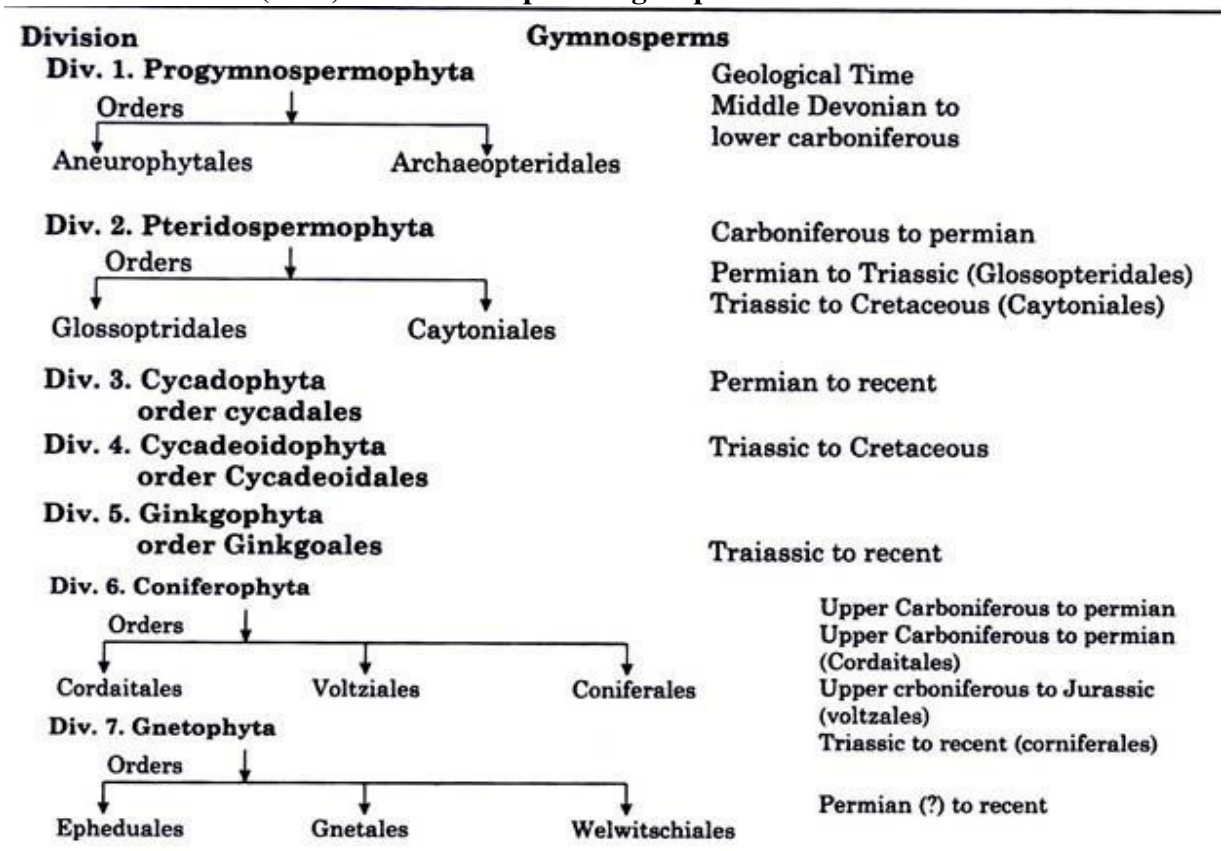
14. Vascular tissues are arranged into vascular bundles just like angiosperms. Vascular bundles of stem are open so that secondary growth is quite common.

Classification of Gymnosperms:

In older times gymnosperms were kept among angiosperms. It was Robert Brown (1827) who first of all recognised these plants due to presence of naked ovules and placed them in a distinct group called gymnosperms. Bentham and Hooker (1862-83) in their 'Genera Planterum' placed this group in between dicotyledonae and monocotyledonae.

The classification of gymnosperms is quite controversial because several genera and a few orders like the cordiatales and cycadeoidales are known only in fossil state. Attempts have, however, been made from time to time to classify them.

Gifford and Foster (1989) raised the important groups to the rank of division.



Characteristics of Cycadophyta: They comprise a group of the plants with a number of primitive characters than are possessed by any other group of living gymnosperms, and because of the retention of these primitive characters sometimes they are supposed to be 'the living fossils'.

1. All cycads are typical xerophytes.
2. The plants are low and palm-like in habit.
3. The stem is short, un-branched, columnar and covered with dense persistent leaf bases.
4. The leaves are pinnately compound and arranged in a terminal crown.
5. The plants grow very slowly but they live for ages.
6. Comparatively the pith is large and cortex is broad.
7. There is a narrow zone of conducting tissue whereas in conifers the case is reverse. The conducting strand is represented by conjoint, collateral, endarch and open vascular bundles around the pith separated from each other by medullary rays.

8. The cycads are strictly dioecious, i.e., micro and megasporophylls develop on separate plants. Except the female strobilus of Cycas the sporophylls are arranged in definite cones.
9. The ovules are straight and usually sessile. The pollen chamber is found for receiving the pollens.
10. Male gametes are motile.

Examples:

Cycas sp*, Zamia* sp*, Dioon* sp*, Macrozamia* sp*, Bowenia* sp*, Ceratozamia* sp.

Characteristic Features of Coniferopsida:

1. Mostly evergreen with branched stems, rarely shrubs.
2. The leaves are needle or scale-like, sometimes flattened, rarely falling in autumn, spirally arranged or whorled, entire. The leaves possess xerophytic characters.
3. Wood without vessels consisting of long tracheids which show bordered pits. Resin canals present frequently.
4. The flowers are monoecious or dioecious. The female flowers are terminal or lateral and then surrounded by supporting bracts.
5. The male flowers consist of a number of stamens arranged in strobili. The stamens are usually many, each with 2 to 20 pollen sacs, connective often produced as an appendage.
6. Pollen grains may be winged, e.g., Pinus.
7. The female flowers are arranged in cones or catkins with the exception of Taxaceae, Cephalotaxaceae and Podocarpaceae.
8. Each female flower consists of a bract (sterile) and a scale (fertile). The scale is found above the bract. The ovules develop on the upper surface of ovuliferous scales.
9. The female cone ripens in 1-3 years and is usually dry on ripening.
10. The seeds are often winged, nut like and with a leathery or woody testa.
11. The cotyledons are epigeal and 2-16 in number.
12. Polyembryony is quite common.
13. They produce non-motile sperms at the time of fertilization.

Examples: *Pinus* sp., *Picea* sp., *Juniperus* sp*., Cupressus* sp., *Podocarpus* sp*., Taxus* sp., *Abies* sp., *Sequoia* sp., *Taxodium* sp. etc.

Characteristic features of Gnetophyta:

1. These are woody plants, of which some species are trees *(Gnetum gnemon*), many are lianes or shrubs and a few. are stumpy turnip-like (e.g. *Welwitschia mirabilis).*
2. Leaves are simple elliptical or strap-shaped or sometimes reduced to minute scales. They are generally opposite or whorled.
3. Vessels are present in the secondary wood.
4. 'Flowers' are unisexual, usually dioecious and only rarely monoecious as in some species of *Gnetum.*
5. **'Flowers'** are arranged in compound strobili or 'inflorescences'.
6. The male flowers are surrounded by a perianth. Each male flower contains an antherophore with one to eight synangia.
7. A single erect orthotropous ovule is present in each female flower.
8. Nucellus of the ovule remains surrounded by two or three envelopes.
9. The micropyle of each ovule remains projected in the form of a long bristle-like tube.
10. At the time of fertilization the pollen tube contains two male nuclei.
11. A unicellular primary suspensor is present in the embryo.
12. Two cotyledons are present in the embryo.

Examples: *Gnetum* sp., *Welwitschia* sp., *Ephedra* sp.

Affinities and Relationship of Gymnosperms:

Gymnosperms occupy a place in between pteridophytes and angiosperms in the plant kingdom. Therefore, gymnosperms bear close affinities with the pteridophytes on the one hand and the angiosperms on the other. In many other characters they differ from both.

Affinities and relationship of gymnosperms with other groups of plants are as follows:

Resemblances or Similarities with Pteridophytes:

1. Sporophytic, independent plant body is present in both the groups. It is differentiated into root, stem and leaves.
2. Sporophyte possess a well-developed vascular tissue.
3. Xylem lacks vessels and phloem companion cells.
4. Young leaves show circinate vernation.
5. Presence of megaphyllous leaves.
6. Gymnosperm and few pteridophytes e.g. *Selaginella* are heterosporous i.e. form micro- and megaspores in micro- and megosperangia, borne on the micro and megasporophylls respectively.
7. In *Cycas*, sporangia are grouped in sori like pteridophytes.
8. The female sex organ is archegonium in both the groups.
9. The male gametes of *Cycas and Ginkgo* are motile like the pteridophytes.
10. Permanent retention of megaspore within the megasporangium.
11. Gametophytes are endosporic and highly reduced.
12. Female prothallus develops before fertilization and there is free nuclear division.
13. Germination of spores is precocious in gymnosperms and hetrosporous pteridophytes.
14. Development of distinct embryo after fertilization.
15. Like the pteridophytes, gymnosperms show marked alternation of generation between gametophytic and sporophytic phase. Sporophytic generation or sporphytic phase is dominant, independent and large at maturity while the gemetophtic generation exhibits progressive reduction and dependence.

Difference between Gymnosperms and Pteridophytes:

Gymnosperms:	**Pteriodophytes:**
1. Occur in Xerophytic habitats.	1. Hygrophytes (grow in moist and shady places).
2. Have taproot.	2. Possess adventitious roots.
3. Eustelic organization.	3. Not found.
4. Secondary growth present.	4. Absent.
5. Stems are aerial.	5. Usually underground rhizomes.
6. Only microspores are shed from microsporangia.	6. Both micro- and megaspores are shed from sporangia.
7. Pollen tube is developed to carry male gametes to archegonium.	7. Pollen tube is absent in all heterosporous pteridophytes.
8. Archegonia lack neck canal and neck canal cell and archegonium is absent in Gnetum.	8. In archegoniun, neck canal and neck canal cells are present.
9. Megasporangium is protected by integument and is called ovule.	9. Ovule is absent.
10. Water is not essential for fertilization.	10. Water is essential for fertilization.
11. Gametophyte is fully dependent on sporophyte.	11. Gametophyte is green and autotrophic.
12. Presence of free nuclear divisions in earlier stages of development.	12. Absent.
13. Seeds are present.	13. Absent.

Similarities with Angiosperms:

1. Main plant body is sporophytic and is differentiated into root, stem and leaves.
2. Plants are trees or shrubs and may be erect or climbing.
3. Root system is well developed and the roots may be diarch, triarch, tetrach or polyarch.
4. The xylem is exarch in the roots.
5. Stem is eusteltic. Vascular bundles are conjoint, collateral, open and endarch.
6. Secondary growth takes place.
7. Wood may be monoxylic or polyxylic.
8. Vessels and companion cells also occur in some gymnosperms (Gnetales) like angiosperms.
9. Heterosporous and have reduced gametophytes.
10. Nucellus is surrounded by integument to form a structure called ovule.
11. Like gymnosperms many angiosperms are wind pollinated.
12. Megaspore permanently remains inside the megasporangium and develops into female gametophyte.
13. Pollen grains grow into pollen tube.
14. Male gametes are non-motile in majority of gymnosperms and angiosperms.
15. Fertilization is siphonogamous.
16. Suspensor is formed during development of embryo.
17. Formation of endosperm.
18. Formation of seeds from ovules.
19. As in gymnosperms, polyembryony is found in several angiosperms.
20. Embryogeny is endoscopic.
21. Life cycle is similar in both groups.

Difference between Gymnosperms and Angiosperms:

Gymnosperms:	**Angiosperms:**
1. Plants are mostly woody trees.	1. Plants may be herbs, shrubs or trees.
2. Unisexual, may be monoecious or dioecious.	2. Bisexual as well as unisexual, monoecious or dioecious.
3. Majority of the gymnosperms are perennial.	3. Angiosperms may be annual, biennial or perennial.
4. Rarely reproduce by vegetative means.	4. Vegetative reproduction is very common.
5. Vessels in xylem element and companion cells in phloem are completely absent.	5. Present.
6. Cones are present.	6. Absent.
7. Beautifying devices like sepals and petals are absent.	7. Flowers consist of sepals and petals.
8. Pollination is anemophilous.	8. Pollination may be anemophilous, entomophilous, hydrophilous or zoophilous.
9. Ovules are naked.	9. Ovules are enclosed within the ovary wall.
10. Presence of prothallius.	10. Absent.
11. Archegonia present.	11. Absent.
12. Endosperm is formed before fertilization.	12. Formed after fertilization.
13. Endosperm is haploid.	13. Endosperm is triploid.
14. Double fertilization absent.	14. Present.
15. Cleavage polyembryony prevalent.	15. Absent.
16. Zygote undergoes free nuclear divisions.	16. Zygote does not undergo nuclear divisions.
17. Fruit formation absent.	17. Present.

Economic Importance of Gymnosperms:

From the point of their utility, Gymnosperms are very important.

1. Ornamental value:

A number of gymnosperms are grown as ornamental plants, e.g., *Cycas, Araucaria, Thuja* etc.

2. Food Value:

i. 'Sago' starch obtained from pith and cortex of stem of *C. revoluta, C. rumphi* etc.

ii. 'Seed starch' obtained from seeds of *Cycas rumphii, Dioon edule* etc. It is prepared into flour and cooked before eating.

iii. Seeds of *Pinus gerardiana* (chilgoza) are edible.

iv. 'Kaffir bread' prepared from the stem pith of *Encephalartos.*

v. Young leaves of *Cycas* cooked as vegetables.

3. Medicinal value:

i. Ephedrine (alkaloid) extracted from *Ephedra* used in treating asthma, cough, cold, bronchitis etc.

ii. Tincture of *Ephedra* is a cardiac stimulant.

iii. The juice extracted from young leaves of *Cycas revoluta* is used for curing blood vomiting and flatulence.

4. Industrial Use:

i. Gum-*Cycas* gum used as adhesive, antidote for snake bites and using malignant ulcers.

ii. Tannins – Tannins extracted from bark of *Araucaria, Pinus, Sequoia* etc. used in leather industry.

iii. Canada balsam – It is turpentine obtained from *Abies balsamea* and used as a mounting medium in biological preparations.

iv. Amber (fossil resin) – obtained from *Pinus succinifera*. Wood of *Pinu*s is used for doors, poles, beams, railway wagon flooring etc.

v. Plywood prepared from *Podocarpus*. Needles of *Pinus* and other conifers are used in making fibre boards that are used in making packing cases.

vi. Papers like newsprints, writing and printing papers are being prepared from the wood pulp of *Pinus, Picea,Abeis, Gnetum* etc.

vii. The leaves of cycads are used for preparing baskets, mats, hats, brooms etc.

viii. The fibres obtained from the leaves of *Cycas and Macrozamia* are used for stuffing pillows and making mattresses.

ix. Timber**:** Gymnosperms possess softwood. The same is used in preparation of light furniture, plywood, packing cases, match sticks, railway sleepers, etc.

x. Linoleum: Saw dust is employed in making linoleum and plastics.

6. Resin: Resin is a semifluid secreted by special tubes which contains terpenes, resin acids and esters. It solidifies on exposure to air. Therefore, it plugs the places of injury. It helps in sealing female cones after pollination, scale leaves around leaf bases and apical buds. Resin retains water. It is antiseptic and toxic to pests.

Therefore, it prevents microbial and insect attack. Resin is commercially extracted and distilled to obtain turpentine and rosin. Rosin is used in water proofing, sealing joints and preparation of writing paper. Turpentine is used as solvent in paints, polishes and wax. It is employed medicinally in removing pains, curing bronchitis and expelling worms.

5. Source of oils:

i. Oils extracted from seeds of *C. revoluta, Macrozamia reidlei, Pinus cembra and Cephalotaxus drupacea* are used as edible oils.

ii. Red cedar wood oil extracted from the heart wood of J*uniperus virginiana* is used for cleaning microscopic preparations and for oil immersion lenses.

iii. Oils obtained from *Cedrus deodara, Ciyptomeria japonica and Cupressus semperivirens* are used in preparations of perfumes.