Kingdom Plantae - Seed Plants (Gymnosperms And Angiosperms)

Objectives

After going through this lesson, the learners will be able to understand the following:

- How seeds allow plants to reproduce without water
- Evolution of seed plants
- Classification of Gymnosperms
- Characteristics of angiosperms
- Difference between monocots and dicots
- Diversity amongst angiosperms

Content Outline

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Introduction

The kingdom plantae includes eukaryotic, photosynthetic organisms. The kingdom plantae have traditionally been classified broadly into two sub-kingdoms cryptogamae and phanerogamae. As in the previous two modules we broadly studied the classification of plants with special relevance to the sub-kingdom Cryptogammae including Thallophyta, Bryophyta & Pteridophyta in this module we will learn about the other two division in Phanerogamae i.e Gymnosperms and Angiosperms or the flowering plants. Phanerogams have the ability to produce seeds. Gymnosperms bear naked seeds directly on the surfaces of cones however angiosperms have covered seeds. Angiosperms are also called flowering plants. Gymnosperms include conifers like the pines, spruce and deodars or palm like plants belonging to cycads. Whereas, angiosperms are widely present as flowering plants in the wild and in gardens, agricultural fields as trees, shrubs, creepers and climbers.

The Gymnosperms

The gymnosperms (gymnos: naked, sperma: seeds) are plants in which the ovules are not enclosed by any ovary wall and remain exposed, both before and after fertilisation. The seeds that develop post-fertilisation, are not covered, i.e., are naked. Thus gymnosperms are plants with naked seeds.

Gymnosperms include medium-sized trees or tall trees and shrubs. One of the gymnosperms, the giant redwood tree *Sequoia* is one of the tallest tree species. The smallest gymnosperm is *Zamia pygmaea* with a height of only about 25 cm.

The plant possess vascular tissues i.e. Xylem & Phloem. However with respect to xylem, vessels are absent in gymnosperms except in Gnetales & in phloem the sieve are not well organized. The roots are generally tap roots. Roots in some genera have fungal association in the form of mycorrhiza (*Pinus*), while in some others (*Cycas*) small specialized roots called coralloid roots are associated with N2- fixing cyanobacteria.

The stems are unbranched (*Cycas*) or branched (*Pinus, Cedrus*). The leaves may be simple or compound. In *Cycas* the pinnate leaves persist for a few years. Many gymnosperms have needle-like or scale-like leaves. The leaves in gymnosperms are well-adapted to withstand extremes of temperature, humidity and wind. In conifers, the needle-like leaves reduce the surface area. Their thick cuticle and sunken stomata also help to reduce water loss.

Habitat and Distribution

Gymnosperms are a more ancient group of plants than the Angiosperms. Most of the gymnosperms have gone extinct and now there are only 1021 known surviving species on our planet out of 74 are found in India of which 8 are endemic and 7 are threatened. Gymnosperms are woody perennials, either shrubs or trees. There are 58 taxa growing in the wild under 15 genera and 8 families in India (Singh & Mudgal, 1997). Family Pinaceae is the largest followed by Cupressaceae, Ephedraceae, Gnetaceae, Cycadaceae. The genus Ephedra is the largest genus with 8 taxa followed by Pinus, Juniperus, Gnetum & Cycas. In addition, there are many gymnosperms introduced in various gardens, parks and as avenue trees across the country. Some of the popular exotics are *Cycas revoluta*, *Ginkgo biloba*, and species of *Araucaria*, *Agathis* and *Pinus*.

The conifers flora of India is dominated by the genera of Northern hemisphere, viz. *Pinus, Abies, Cedrus* and *Picea*. The species of *Cycas* are distributed widely in Eastern and Western Ghats, Northeast India and Andaman & Nicobar Islands. Majority of the species of Ephedra are distributed in higher elevations of Himalaya preferably with alkaline soils. Similarly, the species of *Gnetum* inhabit evergreen tropical rain forests of Eastern and Western Ghats, Northeast India and Andaman & Nicobar Islands.

Evolution of Seed Plants

The evidence from paleontological study reveals that the ancestors of seed plants evolved new adaptations that helped them to survive in conditions where mosses and ferns could not, especially dry conditions and extreme temperature. During the Devonian period about 300 to 400 million years ago conditions where humid and wet which helped the mosses and the ferns to flourish but with time the conditions became drier that made survival of mosses and ferns difficult many of these plants went extinct and seeded plants replaced them as they were better suited to survive in dry terrestrial environment. Further fossil studies reveal that these early seed plants evolved from extinct seed ferns and other pteridophytes. Pteridophytes were not successful as terrestrial plants as they lack seed production. Certain adaptations like presence of extensive underground root system, vascular tissue, presence of tissues for mechanical support, cambium and secondary growth, presence of water not required for fertilization and zygote within the ovule to form an embryo all such features helped seed plants to evolve and diversify.

Classification of Gymnosperms

According to Gifford and Foster 1989 Gymnosperms have been divided into 7 major taxa (divisions) with about 3 divisions complexly extinct including the Progymnospermatophyta, Pteridospermatophyta and Cycadophyta. Out of the divisions with existing living species includes the Gnetophytes, Cycadophyta or cycads, Coniferophyta or conifers, and Ginkgophyta.

1. **Cycadophyta (Cycads)** – About 175 Million years ago the majority of plants were cycads. Today Cycads mainly grow in tropical and subtropical areas such as Mexico, West Indies, Florida, parts of Asia, Africa and Australia. These are palm like plants that reproduce with large cones.The plants are dioecious that is microsporophyll and megasporophyll develop on separate plants. Egs Sago Palm, *Cycas circinalis*, *Cycas revoluta*
2. **Conifers** – These are cone bearing plants, are the largest and most diverse group of Gymnosperms with about 500 known species. Most conifers are evergreen such as Junipers, Sequoias, Pines, Spruce, and Cedars. Some of these plants can survive for 4000 years such as the bristlecone pine tree. Plants are usually monoecious. Conifers are usually found in temperate areas as they are evergreen and are able to manufacture food, conifers also show xerophytic adaptation that helps them to conserve water during winters when water in the soil is frozen and unavailable.
3. **Ginkgophyta or Ginkgoes –** Ginkgoes were very common millions of years ago during the times of dinosaurs and appear in the triassic era but today only one species *Ginkgo esbiloba*. The living Ginkgoes species look similar to its fossil ancestors, so it's truly a living fossil. It probably survived because Chinese and Japanese cared for it in their gardens. Since they can tolerate pollution these trees are planted along the city streets.
4. **Gnetophytes** – There are about 70 known species of Gnetophytes placed under 3 genera. The reproductive scales are clustered into cones. These plants are mostly found in hot deserts and in tropical rainforests. *Welwitschia* grows in deserts of west Africa and can live for more than 1000 years.

Reproduction in Gymnosperms

The gymnosperms are heterosporous; they produce haploid microspores and megaspores. The two kinds of spores are produced within sporangia that are borne on sporophylls which are arranged spirally along an axis to form lax or compact strobili or cones. The strobili bearing

microsporophylls and microsporangia are called microsporangiate or male strobili. The microspores develop into a male gametophytic generation which is highly reduced and is confined to only a limited number of cells. This reduced gametophyte is called a pollen grain. The development of pollen grains takes place within the microsporangia. The cones bearing megasporophylls with ovules or megasporangia are called microsporangiate or female strobili. The male or female cones or strobili may be borne on the same tree (Pinus). However, in cycas male cones and megasporophylls are borne on different trees. The megaspore mother cell is differentiated from one of the cells of the nucellus. The nucellus is protected by envelopes and the composite structure is called an ovule. The ovules are borne on megasporophylls which may be clustered to form the female cones. The megaspore mother cell divides meiotically to form four megaspores. One of the megaspores enclosed within the megasporangium develops into a multicellular female gametophyte that bears two or more archegonia or female sex organs. The multicellular female gametophyte is also retained within megasporangium. Unlike bryophytes and pteridophytes, in gymnosperms the male and the female gametophytes do not have an independent free-living existence. They remain within the sporangia retained on the sporophytes. The pollen grain is released from the microsporangium. They are carried in air currents and come in contact with the opening of the ovules borne on megasporophylls. The pollen tube carrying the male gametes grows towards archegonia in the ovules and discharges their contents near the mouth of the archegonia. Following fertilisation, zygote develops into an embryo and the ovules into seeds. These seeds are not covered.

Economic Importance of Gymnosperms

1. **Food –** The seeds of *Pinus gerardiana* are edible and are eaten after roasting.
2. **Timber –** The softwood of gymnosperms is used in preparation of light furniture, plywood, packing cases, railway sleepers etc.
3. **Paper –** a wide range of gymnosperms are utilized in the manufacture of paper. Eg.- *Pinus*, *Abies*, *Larix* and *Picea* etc.
4. **Resins –** It is a semifluid secretion containing terpenes, resin, acids and esters which solidifies on exposure to air. It helps in sealing and is antiseptic and toxic to pets, thus preventing microbial and insect attack. Resin is commercially extracted to obtain turpentine and resin.
5. **Ephedrine –** It is a drug obtained from Ephedra and used in curing respiratory ailments, including asthma.

The Angiosperms

Angiosperms or the flowering plants – The angiosperms or the flowering plant first appeared during the Cretaceous period, about 135 million years ago. These are the most advanced forms of plants and are the most recent in their origin. Angiosperms are the most dominant vegetation present on the earth. Unlike the gymnosperms where the ovules are naked, in the angiosperms or flowering plants, the pollen grains and ovules are developed in specialized structures called flowers. In angiosperms, the seeds are enclosed by fruits. The angiosperms are an exceptionally large group of plants occurring in a wide range of habitats. They range in size from tiny, almost microscopic ***Wolfia*** to tall trees of ***Eucalyptus*** (over 100 metres). They provide us with food, fodder, fuel, medicines and several other commercially important products. They are divided into two classes: the dicotyledons and the monocotyledons.

General Characteristics

Angiosperms are flowering plants that occur in most environments on the earth. Plant body is sporophytic and represented by herbs, shrubs, trees, climbers, creepers and epiphytes. The plant body is differentiated into stem, roots and leaves. Xylem possess vessels and phloem possess sieve tubes and companion cells. Vascular bundles are conjoint and collateral and open in dicots, hence show secondary growth. Sporophylls are aggregated to form flowers. Both microsporophylls and megasporophylls are specialized to form stamen and carpel producing male and female gametes respectively. The female gametophytes are represented by an embryo sac. The most characteristic feature of angiosperm is double fertilization where one of the male gamete fuses with the egg cell to form zygote and the other male gamete fuses with the two polar nuclei to form the triploid endosperm, after fertilization the ovules ripen into seeds and ovaries ripens into fruits.

Distribution of Habitat

Angiosperms plants grow in almost every form of habitat. High mountains, Polar regions, Deserts, Tropical and subtropical regions, shallow seas, and freshwater angiosperms are found almost in all such habitats throughout the world.

Angiosperms in India

There are 17,527 species, 296 subspecies, 2215 varieties, 33 subvarieties altogether 20,141 taxa of angiosperms under 2991 genera and 251 families in India, representing approximately

7% of the described species in the world (Karthikeyan, 2009). However, the recent estimate accounts for a total of 17926 species of angiosperms in the country (Singh & al., 2013). Family Poaceae is the largest in India being represented by 263 genera and 1291 species followed by Orchidaceae (184/1229), Leguminosae (173/1192), Asteraceae (167/950), Rubiaceae (113/616), Cyperaceae (38/545), Euphorbiaceae (84/528), Acanthaceae (92/510), Rosaceae (40/492) and Lamiaceae (72/454). According to Rana & Ranade (2009) a total of 236 monotypic genera (84 are endemics) are found in India, of which 176 are dicotyledones and remaining 60 are monocotyledons.

About half of the world's aquatic angiosperms occur in India, and are chiefly distributed in families such as Alismataceae, Hydrocharitaceae, Najadaceae, Nymphaeaceae, Podostemaceae, Lemnaceae, Potamogetonaceae and Ceratophyllaceae, which alone collectively comprise a total of 107 aquatic species of angiosperms.

The angiospermic flora of India is further characterised by high endemism, which is next only to Australia. Nayar (1996) has identified 3 megacentres and 25 micro centres of endemic plants in the Indian subcontinent based on the diversity and distribution of endemic species.

Evolution and the Success of Angiosperms

The fossil study reveals that the first angiosperms appeared during the lower Cretaceous (around 150 million years ago). However by the upper cretaceous (around 70 Million Years ago) Angiosperms has already established itself as the dominant plant group over the planet. The origin of angiosperm remains obscure but the features of sexual reproduction suggest that the angiosperm had a single ancestor. The success of angiosperms has been attributed to the following characteristic features:

1. Sexual reproduction is rapid and time taken for seed formation is a matter of weeks in conifers it takes about an year.
2. Closed ovaries not only provide protection to the ovule but also the incompatibility mechanism that helps to exclude self-pollination increases genetic diversity of the progeny leading to evolution by natural selection.
3. The unique double fertilization ensures the parent plant invests a seed with a food store only if the ovum is fertilized.
4. Co–evolution between angiosperms and their pollinators.
5. Their leaves are relatively succulent and decay rapidly on falling which produces humus for re supplying nutrients back in the soil.

Flower and Fruits

Angiosperms develop unique reproductive organs known as flowers. The flower contains the ovaries which surround and protect the seeds. The presence of an ovary gives angiosperms their name "Enclosed Seeds". The male sex organ in a flower is the **stamen**. Each stamen consists of a slender filament with an **anther** at the tip. The anthers, following meiosis, produce **pollen grains**. The female sex organ in a flower is the **pistil** or the **carpel**. Pistil consists of an ovary enclosing one to many ovules. Within ovules are present highly reduced female gametophytes termed **embryo sacs**. The embryo-sac formation is preceded by meiosis. Hence, each of the cells of an embryo-sac is haploid. Each embryo-sac has a three-celled egg apparatus – one **egg cell** and two **synergids**, three **antipodal cells** and two **polar nuclei**. The polar nuclei eventually fuse to produce a diploid secondary nucleus. Pollen grain, after dispersal from the anthers, are carried by wind or various other agencies to the stigma of a pistil. This is termed as **pollination**. The pollen grains germinate on the stigma and the resulting **pollen tubes** grow through the tissues of stigma and style and reach the ovule. The pollen tubes enter the embryo-sac where two male gametes are discharged. One of the male gametes fuses with the egg cell to form a **zygote (syngamy)**. The other male gamete fuses with the diploid secondary nucleus to produce the **triploid primary endosperm nucleus (PEN)**. Because of the involvement of two fusions, this event is termed as **double fertilisation**, an event unique to angiosperms. The zygote develops into an embryo (with one or two cotyledons) and the PEN develops into an endosperm which provides nourishment to the developing embryo. The synergids and antipodals degenerate after **fertilisation**. During these events the ovules develop into seeds and the ovaries develop into fruit.

Diversity of Angiosperms

Angiosperms can be categorized into two classes Monocotyledonae or **Monocots** and the Dicotyledonae or **Dicots**. The cotyledons are the first seed leaves produced by the embryo of a seed plants.Monocots have single cotyledon and dicots have two cotyledons, Monocots show parallel venation on its leaves whereas dicots show reticulate venation, floral parts grow in multiple of three in monocots and in multiple of five in dicots. In monocots have vascular bundles scattered throughout the stem and in dicots vascular bundles arranged in a ring. Roots in monocots are fibrous and in dicots roots are tap roots.

According to the characteristics of stems flowering plants can be subdivided into woody and herbaceous plants and with respect to plants life spans angiosperms can be classified.

- **Annuals -** These are plants that grow from seed to maturity, produce seeds and die in the course of one growing season or we can say that they complete their life cycle in one growing season. Egs Petunia, Marigold, Pansies etc.
- **Biennials** - These angiosperms complete their life-cycle in two years. In the first year biennials germinate and grow roots, very short stems and sometimes leaves and then during the second year stem produce flowers and seeds. Once the flower produces seed, the plant dies. Eg. Evening Primrose, Foxglove etc.
- **Perennials** - These plants live for many years. Most of the perennials have woody stems, e.g. Palm trees, Maple trees etc.

Economic Importance of Angiosperms

1. **Food -** Flowering plants are the major sources of food. They produce cereals, pulses, fruits, vegetables and nuts.
2. **Edible oil -** Flowering plants are the main source of vegetable oil used for cooking. These are obtained from groundnut, mustard, sunflower and coconut.
3. **Spices -** Common spices such coriander, Cinnamon, chilies, fennel etc.
4. **Beverages -** Tea, Coffee and Cocoa.
5. **Medicines -** Many medicinal plants such as *Aconitum*, *Atropa*, *Cinchona*, *Withania somnifera* are some popular plant species to produce ayurvedic medicines.
6. **Timber -** Many angiosperm trees yield valuable hardwood.
7. **Fibers -** fiber of different qualities are obtained from various species of flowering plants. Such as flax, cotton, Husk of coconut. Etc.

Summary

The gymnosperms are the plants in which ovules are not enclosed by any ovary wall. After fertilisation the seeds remain exposed and therefore these plants are called naked-seeded plants. The gymnosperms produce microspores and megaspores which are produced in microsporangia and megasporangia borne on the sporophylls. The sporophylls – microsporophylls and megasporophylls – are arranged spirally on the axis to form male and female cones, respectively. The pollen grain germinates and the pollen tube releases the male gamete into the ovule, where it fuses with the egg cell in archegonia. Following fertilisation, the zygote develops into embryo and the ovules into seeds. In angiosperms, the male sex organs (stamen) and female sex organs (pistil) are borne in a flower. Each stamen consists of a filament and an anther. The anther produces pollen grains (male gametophyte) after

meiosis. The pistil consists of an ovary enclosing one to many ovules. Within the ovule is the female gametophyte or embryo sac which contains the egg cell. The pollen tube enters the embryo-sac where two male gametes are discharged. One male gamete fuses with egg cell (syngamy) and the other fuses with diploid secondary nucleus (triple fusion). This phenomenon of two fusions is called double fertilisation and is unique to angiosperms. The angiosperms are divided into two classes – the dicotyledons and the monocotyledons.