SEMESTER-II

Core Course IV: Archegoniate Course Code: BOTACOR04T

Unit 6: Gymnosperms-I

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GENERAL CHARACTERS OF GYMNOSPERMS

The sporophyte is usually arborescent comprising of large or small woody trees or shrubs. Few may be lianas or climbers. Most gymnosperms are evergreen but some are deciduous such as *Larix* sp. and *Taxodium* sp. The plants are mostly xerophytes. *Gymnosperms show the following features:*

1. The plants have a long lasting tap root system. The vascular cylinder is di-to polyarch, xylem exarch. Main elements of xylem are tracheids. Phloem is composed of sieve cells and lacks companion cells. Some forms exhibit additional symbiotic relationship between roots and algae in coralloid roots (Cycas sp.) and between roots and fungi in mycorrhizic roots (Pinus sp).

2. The sporophyte shows unlimited growth of aerial trunk by means of apical and lateral meristem which produces secondary vascular tissues.

3. The aerial trunk is branched or unbranched and woody. Majority of gymnosperms have branched stem (except in Cycas sp. and Zamia sp.). In Pinus branches are of two types :- (a) long shoots or branches of unlimited growth (b) dwarf shoots or branches of limited growth bearing clusters of variable number of needle shaped leaves and collectively called as spur. Vascular bundles of stem are collateral, endarch or mesarch, open and arranged in a ring.

4. Secondary growth very pronounced. Secondary vascular tissues consist mainly of tracheids and sieve cells. Normally xylem lacks vessel elements and the phloem lacks companion cells. But both vessels and companion cells present in members of Gnetales. Mature metaxylem and secondary xylem elements have bordered pits of various types. Wood or secondary xylem of two types namely, manoxylic and pycnoxylic. In manoxylic type (as in Cycas) wood is less, porous and soft. There is a large cortex and pith and parenchymatous rays are wide. In pycnoxylic type (as in Pinus) wood is dense or compact with small xylem rays and reduced pith and cortex.

5. Leaves are diverse in form and arrangement. They are both simple and compound ranging in size from a minute scale to leaves a few meters long. Arrangements of leaves usually spiral, they may also be whorled as in *Cedrus* sp. or opposite decussate as in Cupressaceae, *Welwitschia* sp. and *Gnetum* sp. Scale leaves are microphyllous whereas larger leaves are megaphyllous and their

vascular supply always leaves a leaf gap in the stem stele. Venation may be parallel (*Agathis* sp. and *Welwitschia* sp.), reticulate (*Gnetum* sp.) or dichotomous (*Ginkgo* sp.) or as in most genera there may be a single vein. Leaves may be dorsiventral or isobilateral, amphistomatic or hypostomatic with sunken stomata. Mesophyll may be differentiated into spongy and palisade parenchyma (*Cycas* sp., *Gnetum* sp.) or undifferentiated (*Pinus* sp.). Transfusion tissue is a prominent feature. Leaf surface protected by a thick cuticle and sometimes by an additional waxy layer. Resin canals occur in all conifers (except *Taxus* sp.) and mucilage ducts in cycads and *Ginkgo* sp. and latex tubes in *Gnetum* sp. Vasculature of petiole quite variable. In *Cycas* sp., vascular bundles are arranged in a horse-shoe shaped manner or look like an inverted omega (U). They are diploxylic having both centripetal and centrifugal xylem. In *Ginkgo* sp. petiole receives two vascular bundles and each half of lamina is supplied by one bundle which later dichotomizes. In Gnetum, the petiole shows an arc-shaped arrangement.

6. Vegetative methods of reproduction are rare in gymnosperms but vegetative propagating bulbils are known in *Cycas* sp.

7. Plants are heterosporous. They may be monoecious (*Pinus* sp.) or dioecious (*Cycas* sp.). Reproductive structures are borne in cones or strobili that are either staminate (male) or ovulate (female) except in *Cycas* sp. where ovules are borne on loose megasporophylls. Sporangia are borne on fertile leaves or leaf-like structures called microsporophylls (in male cone) and megasporophylls (in female cones) which are arranged spirally around a central axis.

8. Microsporangia are borne on abaxial or lower surface of microsporophylls. They may be numerous and grouped in sori (*Cycas* sp.) or reduced to two (*Pinus* sp.). Microspores are produced in tetrads.

9. Megasporangium or ovule is borne on adaxial or upper surface of megasporophyll or ovuliferous scale and are generally orthotropous. Young megasporangium consists of a nucellus which is surrounded by a sheath or integument and inside the nucellus is single functional megaspore. A narrow passage above the nucellus in the integument is the micropyle.

10. Microspore and megaspore germination in situ, producing micro-and mega-gametophytes which are not autotrophic. Microspores have partly developed endosporic male gametophytes when they are transferred to micropyle of ovule. The microspore or pollen grain at the time of shedding may have only one prothallial cell (*Cycas* sp.) or two prothallial cells (*Pinus* sp.), the former being liberated at three-celled stage and latter at four-celled stage.

11. The microspores or pollen grains are borne by wind and enter the ovule directly through the micropylar canal. The micropyle in almost all gymnosperms secretes a sugary exudate called the "pollination drop" which not only receives the pollen grains but also transports them to nucellus of ovule.

12. The development of female gametophyte is monosporic (except in *Welwitschia* sp. and *Gnetum* sp. where it is tetrasporic). It is permanently retained inside the megaspore wall and dependent on parent sporophyte for its nutrition. The archegonia in female gametophyte may be two (in *Ginkgo* sp.) to many (as in many conifers). Archegonia are quite large and elongated and lack neck canal cells. Often the ventral canal cell too, is eliminated. Gametophytic cells around the archegonia develop into a nutritive layer or jacket. However, the nutritive layer and archegonia are absent in *Welwitschia* sp. and *Gnetum* sp.

13. Fertilization is effected by means of a pollen tube (siphonogamy). The multi-flagellate spermatozoids or male cells within the pollen tube have no specialized means of locomotion and occur within the ovule. The pollen tube bursts liberating two large flagellated sperms into the cavity (archegonial chamber) directly above female gametophyte. One sperm fertilizes the large egg cell giving rise to a zygote (2n).

14. At the beginning of embryogeny, zygote shows free nuclear division in all except *Welwitschia*, *Gnetum* and *Sequoia sempervirens*. Later embryo becomes cellular after wall formation and gradually differentiates into a suspensor, shoot apex, cotyledons, hypocotyl and radicle. Polarity is endoscopic with the shoot end directed away from the micropyle. Embryo remains contained within the seed developed from the ovule. Mature embryo is differentiated into root, stem and leaves.

15. In most gymnosperms a common feature in embryogeny is polyembryony with young seeds having more than one embryo. It may be simple polyembryony when more than one archegonium is fertilized producing several zygotes or cleavage polyembryony when single zygote gives rise to multiple embryos due to cleavage or splitting of embryonic layer. The mature seed normally has only one embryo.

16. The young embryo draws its nutrition from the endosperm which develops before fertilization and is haploid (n). Endosperm develops from female gametophyte that has absorbed the food from nucellus.

17. During last phases of embryogeny, the nucellar tissue of ovule becomes disorganized and frequently persists only as a paper-like cap of dry tissue at micropylar end of the seed.

18. Gymnosperm ovules and seeds are unprotected and not surrounded by an ovarian wall, hence, true fruits like that of angiosperms are not formed.

19. Histological maturation of various layers of integument continues and the stony layer becomes an extremely hard, resistant shell which effectively encloses and mechanically protects the female gametophyte and the embryo.

20. The detached seeds of all gymnosperms (except for cycads and *Ginkgo* sp.) remain dormant for sometime undergoing a resting period.

21. Gymnosperms being mostly temperate plants (except for cycads, *Gnetum* sp. and *Ephedra* sp.) growing in tropics and subtropics show very little activity in the development of reproductive structures during winter. The activity is renewed in the spring. Under favorable conditions the embryo resumes growth and after rupturing the seed coat develops into a new sporophyte plant.

22. Polyploidy is rare in gymnosperms, except in *Juniperus* sp. (partly) *Sequoia* sp. and *Ephedra* sp. (partly) where gametic number is multiple of the basic number of the families. *Sequoia* sp. is the solitary gymnosperm which is hexaploid. *Ephedra* sp. is the only genus where polyploidy is common.