GYMNOSPERMS

Characteristics of Living Gymnosperms:

•The word "Gymnosperm" "Gymnos"=naked and "Sperma"means seeds was used in 300 BC by Theophrastus, a pupil of Aristotle in his book "Enquiry into Plants". They originated in the Upper Devonian period of Late Palaeozoic era. They are represented by 81 genera and 947 species (approx.). Living Gymnosperms includes middle sized or tall trees and shrubs. There are no herbs and climbers.

•Generally they possess tap root but sometimes mycorrhizal and coralloid roots (*Pinus* and *Cycas* respectively)are present in some genera.

•Stem: The stem may be aerial, erect, underground (Welwitschia)

unbranched (e.g. *Cycas*, *Zamia*) or branched (e.g. *Pinus*, *Cedrus* etc.). In gymnosperms the branches may be of two types on the basis of their branching system.

They may be of two types as in *Pinus*-

i)the long shoots and

ii)the dwarf shoots that bears at their apices bundles or cluster of green leaves and collectively known as spurs.

A. *Cycas*
B. *Pinus*
C. *Welwitschia*

• Leaves: Gymnosperms bears both microphyllous (small and scaly) and megaphyllous leaves. The megaphyllous leaves are large and well-developed and their vascular supply always leaves a leaf-gap in the stem stele.

•The leaves may be simple or compound and vary in shape, size and form, as a minute scale leaf to several feet long megaphylls (e.g. in *Cycas*).

•The arrangement of leaves may be whorled (*Cedrus*), opposite and decussate (*Gnetum*, *Ephedra* etc.) or spirally arranged (*Taxus*, *Podocarpus* etc.).

• Gymnosperms show great diversity in leaf venation, it may be parallel (*Welwitschia*), reticulate (*Gnetum*) or even dichotomous (*Ginkgo*). The pinnae in *Cycas* have a single midrib and their no lateral veins. Pinnate leaves of Cycas showed circinate vernation. In ***Ceratozamia* – entire leaf.**

•The leaves mostly possess resin canals as in *Pinus*, *Cedrus* and *Abies*. The leaves of Gnetales lack resin passages but Gnetum possess latex tubes.

• Stomata may be syndetocheilic or haplocheilic. They may be distributed on both surfaces (*Ginkgo*) or on lower epidermis alone (*Cycas*).

• The leaves of conifer and Cycads possess transfusion tissue.

• The mesophyll may (*Cycas)* or may not *(Pinus)* be differentiated into palisade and spongy parenchyma. In *Pinus* wall of mesophyll are thrown into folds.

• Leaves may be triangular (*P. roxburghii*)

circular (*P. monophylla*)

semi-circular (*P. sylvestris*)

bifacial (leaflet of *Cycas*)

• Leaflet in *C. revoluta* has revolute margins.

• Secondary wood in Gymnosperms may be **manoxylic** (Cycadophyta) – porous, soft and more parenchymatous, wide medullary rays.

or **pycnoxylic** (Coniferophyta).

• Xylem lack wood vessel except *Gnetum*, *Welwitschia*, *Ephedra*.

• Phloem is devoid of companion cells.

• Xylem usually is mesarch or endarch (exarch-roots).

• Secondary vasculature may be **monoxylic** (*Pinus*) or **polyxylic** (*Cycas*).

Cedrus

Gnetum

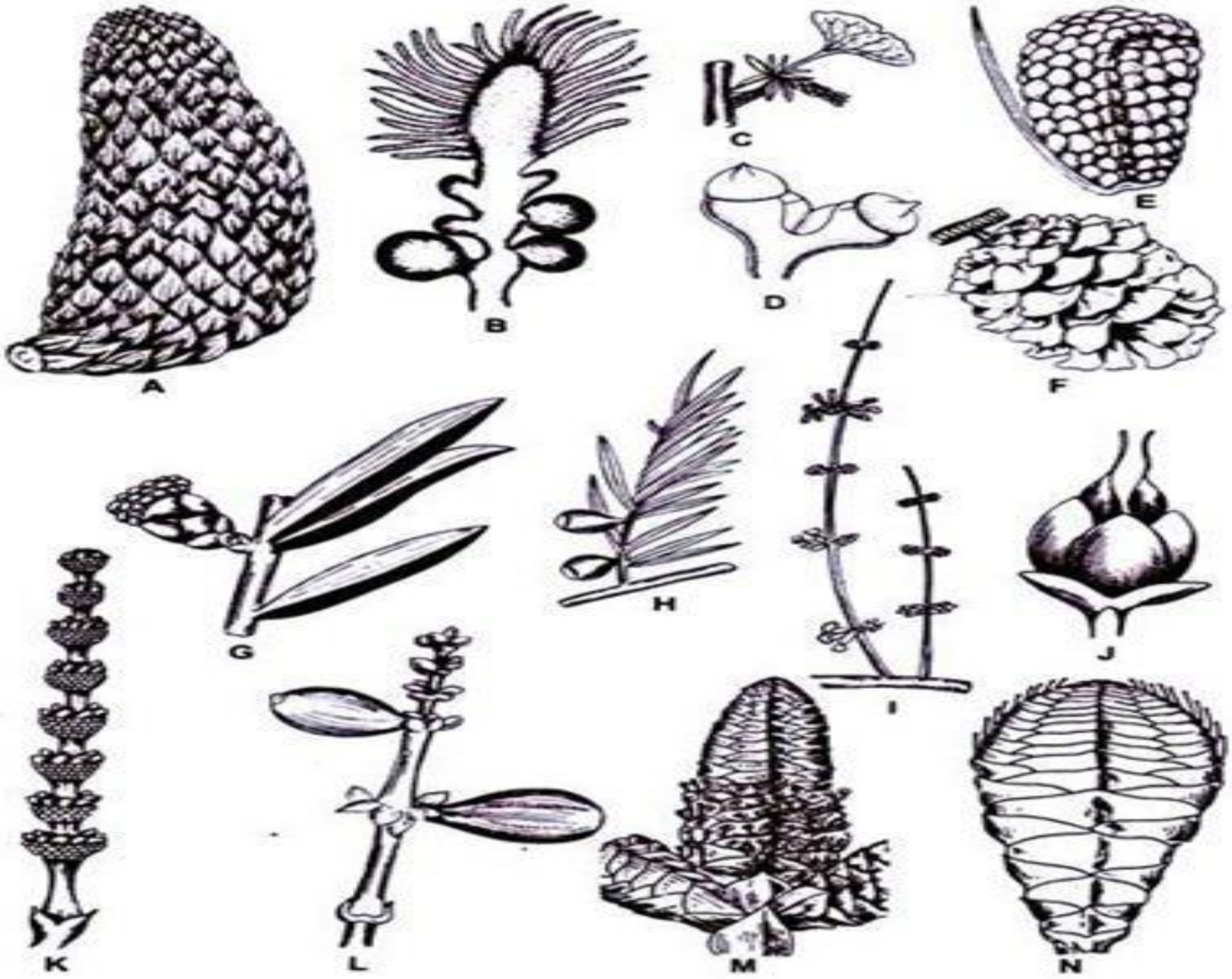
Taxus

• **Reproduction:** Gymnosperms possess two different types of spores and hence refers as heterosporous. The microspores are smaller while another spore larger in size called megaspore. These two kinds of spores on germination produce two different kinds of gametophytes. The microspore or pollen grains produce male gametophyte, while the larger megaspore produces female gametophyte.

•These spores are produced within the leafy structures or sporangia that borne on sporophyll, spirally arranged along an axis to form compact strobili or cones.

•The microsporangiate or male strobili bear microsporophyll and microsporangia while the megasporangiate or female strobili bear megasporophylls with ovules or megasporangia.

•The two types of cones or strobili may be borne on same tree as in ***Pinus*** or on different trees like in ***Cycas*** **and** ***Ginkgo***. The microsporangium contains numerous small microspores whereas the megasporangium contains only one larger megaspore. Both the spores i.e. microspore and megaspores are haploid and develop as a result of meiosis or reduction division in the respective spore mother cells. They are the primary structures of the male and female gametophytes respectively.



Male and female cones/strobili of *Cycas(A,B)*, *Ginkgo(C,D)*, *Pinus* (E,F), *Taxus(G,H)*, *Ephedra(I,J)*, *Gnetum(K,L)* and *Welwitschia (M,N)*

•In gymnosperms the gametophytes are *endosporic* i.e. They develop within or inside the respective spore wall.

•In general the strobili or cones are of varying shapes and sizes in different species. Their position also varies from plant to plant.

•Among gymnosperms, In *Cycas* the microsporangiate or male cones are largest and arise singly at the apex of male plant.

• The female or megasporangiate cone in *Cycas* consist of spirally arranged megasporophylls that do not form compact strobilus but are loosely arranged in between successive crown of foliage leaves. In all other genera of *Cycads* the megasporophylls are compactly arranged to form a distinct cone or strobilus.

• In *Dioon spinulosum* the mature female cone weigh upto 60 pounds and is about two feet long.

• In some species of *Macrozamia* the female cone are axillary. In all other except *Cycas* they are terminal in position.

• **Ovules and female gametophyte:** As per discoveries the ovules of gymnosperms are without any covering or naked and are borne on usually spirally arranged megasporophylls around a central axis. The ovules are generally sessile. Among gymnosperms, ovules of Cycas are the largest among the plant kingdom.

• The ovule consist of a parenchymatous mass of cells called the nucellus.

• The nucellus encloses a single diploid megaspore mother cell that undergoes meiosis and formed 4 haploid cells arranged in linear tetrad form. Out of these 4 only one, usually the lower one remains functional and the rest ones degenerates. The functional megaspore enlarges and undergoes free nuclear division and resulted into large number of free nuclei. This transforms into young gametophyte that has developed within the megaspore.

• The ovules are orthotropous and unitegmic.

• The single integument consist of three layers – Sarcotesta or the outer fleshy layer, Sclerotesta or the middle stony layer and the inner sarcotesta or the inner fleshy layer.

• In *Podocarpus* the ovuliferous scale is folded around the ovule and encloses it completely or partially. It forms an extra envelope called epimatium. In *Phyllocladus* the integument is enveloped by true aril.

• The nucellus is usually crassinucellate (nucellus-massive, sporogenous cell deeply embedded).

• The apical region of nucellus degenerate to form a pollen chamber in which semi-germinated pollen grains remains till further growth.

• Towards the micropylar end the female prothallus develop two or more archegonia. The archegonia have short stalk and long neck. The venter canal cells are present in *Ginkgo* and *Pinus* whereas it is absent in *Cycas* and *Ephedra* which have only venter canal nucleus.

• The venter has a large egg or oosphere.

• There is no archegonium in *Gnetum*.

• **Microspores:** They are haploid structure produced within microsporangia. In *Cycas* They are tetrahedral in shape and uniaperturate. In *Ginkgo* they are spherical and uniaperturate. In some gymnosperms pollen grains are winged (saccate) for e.g. *Pinus*, *Cedrus*, *Picea* etc.

• The microspores are liberated in various stages of the development of male gametophyte. For e.g. 3 celled stage (*Cycas*), 4-celled stage (*Pinus*) and 5 celled stage (*Ephedra*).

• **Pollination:** Pollination in Gymnosperms takes place by means of wind and result in transfer of semi-germinated pollen grains on the micropyle of ovule.

• Pollen grains in most of the Gymnosperms are caught into a pollination drop secreted by the micropylar end of the ovule. The semi-germinated pollens are drawn into the ovule by the drying of pollen drop. Pollination drop is usually secreted at night and not during day. It contain sucrose, glucose and fructose. In *Abies* no pollination drop is secreted.

• After pollination fertilization takes place. The period between pollination and fertilization varies among Gymnosperm. For e.g. *Pinus-1yr*. *Abies-few* days.

• **Fertilization is siphonogamic** and the pollen tube may function as haustorial (*Cycas)* or sperm carrier (*Pinus*). Spermatozoid of *Zamia floridiana* are largest in the plant kingdom (332 µm long).

• **Zygote -** is the mother cell of next sporophytic generation.

• The development of embryo is meroblastic i.e. embryo develops only from a part (basal) of the zygote.

• Development of endosperm takes place before fertilization and hence it is haploid.

• With a few exceptions (*for e.g. Gnetum)* there are free nuclear divisions in the early stage of embryo development. The embryo is **endoscopic** i.e. Shoot apex is directed opposite to micropyle.

• There is a marked tendency for polyembryony and several embryos develop in female gametophyte.

• The polyembryony may arise by the fertilization of more than one eggs or by the division of zygote (**cleavage polyembryony).** But due to physiological competition only one embryo attains maturity.

• The naked ovule develop into seed and integuments form seed coat.

• The number of cotyledons various for e.g. one or two (*Cycas)* many (*Pinus).*

• The seed usually have long or short dormant period and then it germinate to form a new sporophytic body.

• The seeds represents 3 generation seed coat – old sporophytic generation.

Young embryo- new sporophytic generation.

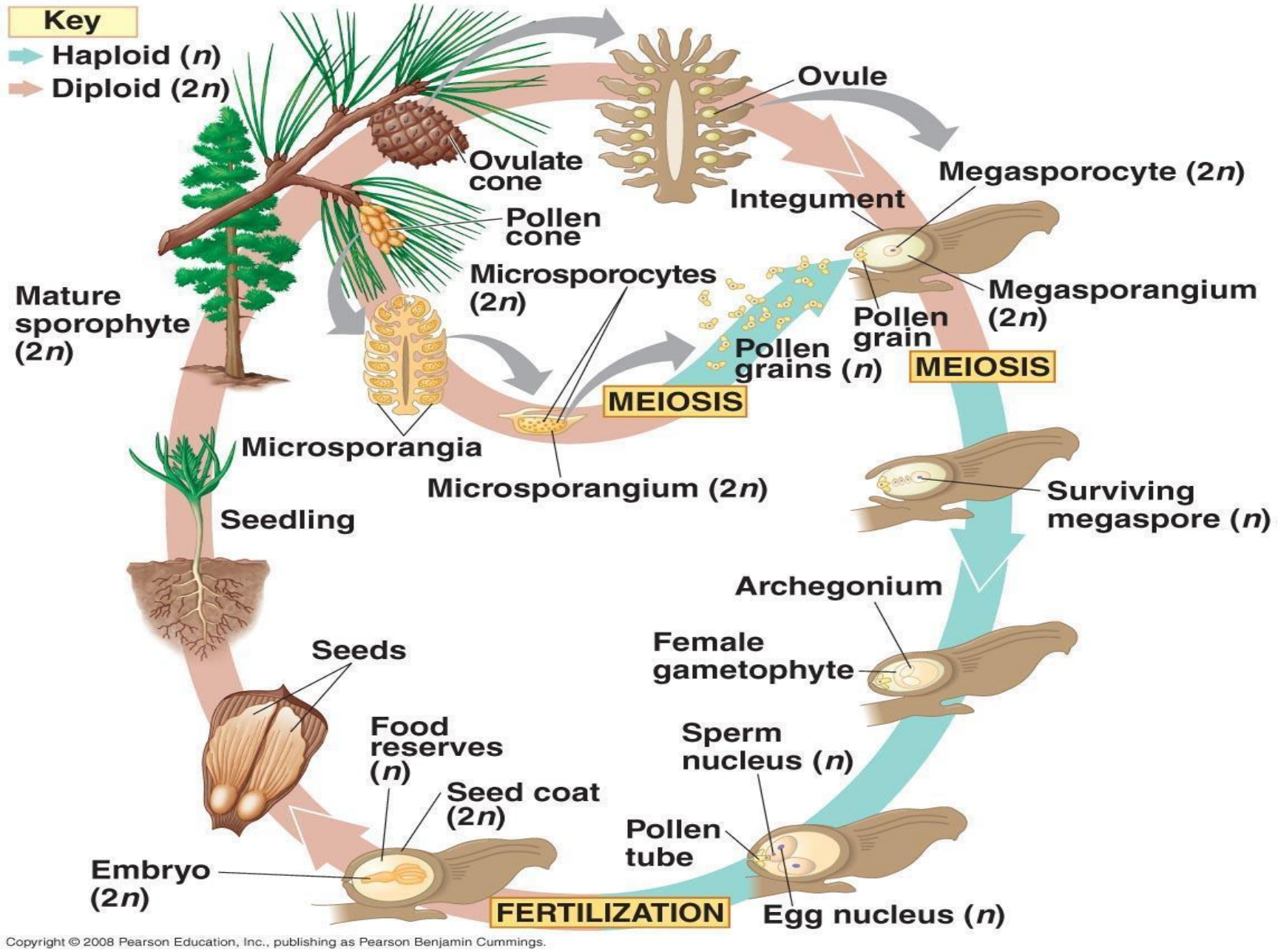
endosperm – gametophytic generation.

• Germination of seed is epigeal – cotyledons comes above the ground in most genera except *Ginkgo*.

• Vivipary – *Ephedra trifurcata*.

• There is a distinct alternation of generation. The diploid sporophytic phase is dominant, whereas the haploid gametophytic phase is reduced. The gametophytic phase is dependent on sporophytic phase.

- Key
  - Haploid (*n*)
  - Diploid (2*n*)



THANKS