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ECONOMIC SIGNIFICANCE IN GYMNOSPERMS -A REVIEW

***Dr. Mandaloju Venkateshwarlu**

M. Sc, Ph.D., (Botany) M. Sc (Bio-tech), FSAB, FHAS, SFS, CFE and (LLB).,
Department of Botany (UASC) Kakatiya University Warangal.

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***Corresponding Author: Dr. Mandaloju Venkateshwarlu**

M. Sc, Ph.D., (Botany) M. Sc (Bio-tech), FSAB, FHAS, SFS, CFE and (LLB)., Department of Botany (UASC) Kakatiya University Warangal.

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ABSTRACT

Gymnosperms and angiosperms are two groups of seed plants. The former are naked seeded plants in which ovules are not enclosed by the ovary wall, born freely on open. whereas later, ovules are born in the closed. K.R. (Reprint 2020). Due to this reason (protected seed), angiosperms are more advanced than Gymnosperms. In Gymnosperms, ovules are either borne naked or on the surface of megasporophylls, often arranged in cones. These plants evolved approximately 300 million years ago from non-seed-producing ancestors of the extinct division. which had a fern-like appearance and acted as a bridge between pteridophytes and Angiosperms. During the Jurassic and Cretaceous periods of the Mesozoic era, Gymnosperms were the dominant plants on Earth's surface. S.P., and Moitra, A. (1996). As Gymnosperms do not possess an ovary, hence. they don't produce fruits, whereas angiosperms possess ovaries and produce fruits. Today, approximately 83 genera and around 790 species of living Gymnosperms are distributed across temperate, tropical, and arctic regions worldwide Biswas Chhaya and Johri, B.M. (1997) & Vashishta, P.C. (1990). General characters of gymnosperms 1. They are slow growers and lack vegetative means of propagation such as by cuttings, layering, etc. 2. They are unable to grow under varied habitats as they can grow in some specific habitats and conditions. 3. They have limited means of dispersal of seeds and can be dispersed only by wind, animals or human beings. 4. Most of the Gymnosperms are terrestrial and unable to grow in aquatic habitats, except a few. 5. They lack vessels in the xylem (with few exceptions) and companion cells in the phloem. 6. Most of the Gymnosperms are unisexual; thus due to the absence of bisexuality, the chances of Self-pollination are reduced. Chamberlain, C.J. (2009) & Christenhusz et al. (2011).

KEYWORDS: Economic Significance Extinct, Specific habitats.

INTRODUCTION

Gymnosperms show diversity in leaf venation, it may be parallel (Welwitschia), reticulate (*Gnetum*), or even dichotomous (*Ginkgo*). The leaves are always evergreen and mostly possess resin canals as in *Pinus*, *Cedrus*, and *Abies*. The leaves of members of Gnetales lack resin passages but *Gnetum* possesses latex tubes. The arrangement of leaves may be whorled (*Cedrus*), opposite, and decussate (*Gnetum*, *Ephedra*, etc.) or spiral (*Taxus*, *Podocarpus*, etc.). Conifers usually have sunken stomata. The shape of leaves may also vary from triangular (*Pinus roxburghii*), semi-circular (*Pinus sylvestris*), bifid or circular (*Pinus microphylla*), and bifacial leaflet of *Cycas*, *Zamia*, and *Gnetum*). The arrangement of vascular bundles also shows great variations. Singh, V.P. (2006).

Vegetative propagation is not reported in this group but reproduction by bulbils is known in *Cycas*. Chopra, G.L. (2008) Generally, the plant possesses tap roots but sometimes mycorrhizal (*Pinus*) and coralloid (Cycas) roots are also present. Govil, C.M. (2007). The stem may be aerial, erect, unbranched (e.g. *Cycas, Zamia*), or branched (e.g. Pinus, Cedrus etc.). In gymnosperms the branches may be of two types- i) the long shoots and ii) the dwarf shoots based on their branching system. Leaves are present at their apices of dwarf shoot. Dwarf shoot with leaves collectively known as a spur. Gymnosperms bears both microphyllous and megaphyllous leaves. The megaphyllous leaves are large and well-developed with their vascular supply leaving a leaf gap in the stem. 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*).

ECONOMIC SIGNIFICANCE OF GYMNOSPERMS

The period gave the name "Age of Ferns". The evidence of Cycadofilicales in the Devonian is furnished by Euspermatopteris, which finally became coal. Lyginopteris, Medullosa, Heterangium many others have become well known. It was from this vast assemblage that the Bennettitales and cycadales were developed. In the permian period, the cycadofilicales decline became very scanty in the Triassic and disappeared in the Lower Jurassic. The big trees are Lepidodendron and Sigillaria, but the fan like plants except the true ferns, Psaronius belonging to the Cycadofilicales.

The living gymnosperms Comprises of trees and shrubs, which are characterized by xeromorphic characters. Woody climbers (lians) are found in Gentiles Herbs and annuals are completely absent.Gymnosperms are found both in tropical and temperate region of the world. Some species are found ever in arctic region. In India they are mostly distributed in hill areas. Very few Gymnosperms grow in plains of India. The cycadofilicales reached their greatest development in the upper Carboniferous (pennsyluanian). The plant body is a sporophyte and is differentiated into root, stem and leaves. The roots are generally tap roots. In some genera the roots may be associated with blue green algae (Corolloid roots of Cycas), they may be with fungus (Mycorrhizal roots of Pinus) The stems are aerial, erect, branched (Pinus, Cedrus) and unbranched (Cycas, Zamia). The branches are of two types (i) the long shoots and (ii) the dwarf shoots that bear at their upices bundles (a) Clusters of green leaves and Collectively known as spur. The leaves may be small and scaly known as microphyllous and large and well developed known as megaphyllous. The foliage leaves are evergreen, simple (Pinus), (a) Compound (Cycas). The arrangement of leaves usually spiral (Cycas). The phyllotaxy may be opposite and decusate (Gnetum) (or) whorled (cedrus). The venation may be reticulate (Gnetum), Parallel (Welwitshia), (a) dichotomous (Ginkgo).

Ephedrine: Extracted from *Ephedra* species, this alkaloid treats asthma, bronchitis, and nasal congestion.

Taxol: Derived from the bark of yew trees (*Taxus*), it serves as a potent anti-cancer chemotherapy drug.

Industrial Resins and Chemicals

Turpentine and rosin: Pine tree resins are distilled to make turpentine and solid rosin, used in paints, varnishes, and soaps.

Tannins: Bark extracts from species like *Araucaria* and *Pinus* provide tannins utilized in the leather-tanning trade.

Food and Edible Products

Edible seeds: Seeds of *Pinus gerardiana* (chilgoza pine) are roasted and consumed as nutrient-rich nuts.

Sago starch: The stems and seeds of certain cycads yield starchy food products If you'd like, I can detail:

Specific species and their native regions.

Ecological roles of gymnosperms in forests.

Timber and Wood Products

Softwood source: Conifers like pine, fir, cedar, and spruce yield lightweight, durable timber used for general construction and furniture.

Paper and pulp: Vast tracts of conifers provide wood pulp utilized heavily in the global paper and newsprint manufacturing industries.

Plywood and boards: Softwoods are processed into plywood, matchsticks, and fiberboards for packing cases.

STRUCTURES DEVELOPED

Generally, in Gymnosperms, the female gametophyte has cellular tissue at its lower end while few free nuclei remain at its upper end. a. After fertilization the apical end, however, becomes cellular (the exception is *Welwitschia*). Microspores: The pollen grains or microspores are unicellular and haploid structures developed within specific structures, the microsporangia. They differ in shape and size in different groups of gymnosperms. They may be uniaperturate, tetrahedral with a definite polarity due to the thicker exine towards the base (e.g. *Cycas*) and may be almost spherical. (*Ginkgo*), maybe winged (saccate), and may have reticulate exine (*Abies pindrow, Cedrus deodara, Pinus roxburghii, P. wallichiana, Picea smithiana*etc.) (Fig -5). whereas in *Ephedra* the pollen grains are inaperturate, elongated with palcateexine surface. *E. foliate* pollen grains show parallel ridges along their long axis and possess two tiny saclike structures. These sacs are almost absent in other species. Based on studies it is suggested that there is a gradual reduction in the wings or sacs and ultimately resulting in non-winged pollen grains as found in *Ephedra*. There is also an indication of the relationship of *E. foliata* with Coniferales and

Cordaitales as there is a minute A- Cluster of male cones,
B- A single male cone.

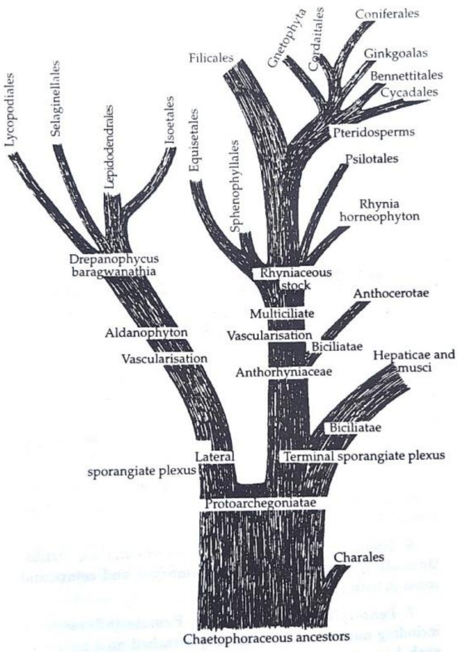

Fig -1 A. Chaetophoraceous Ancestors.

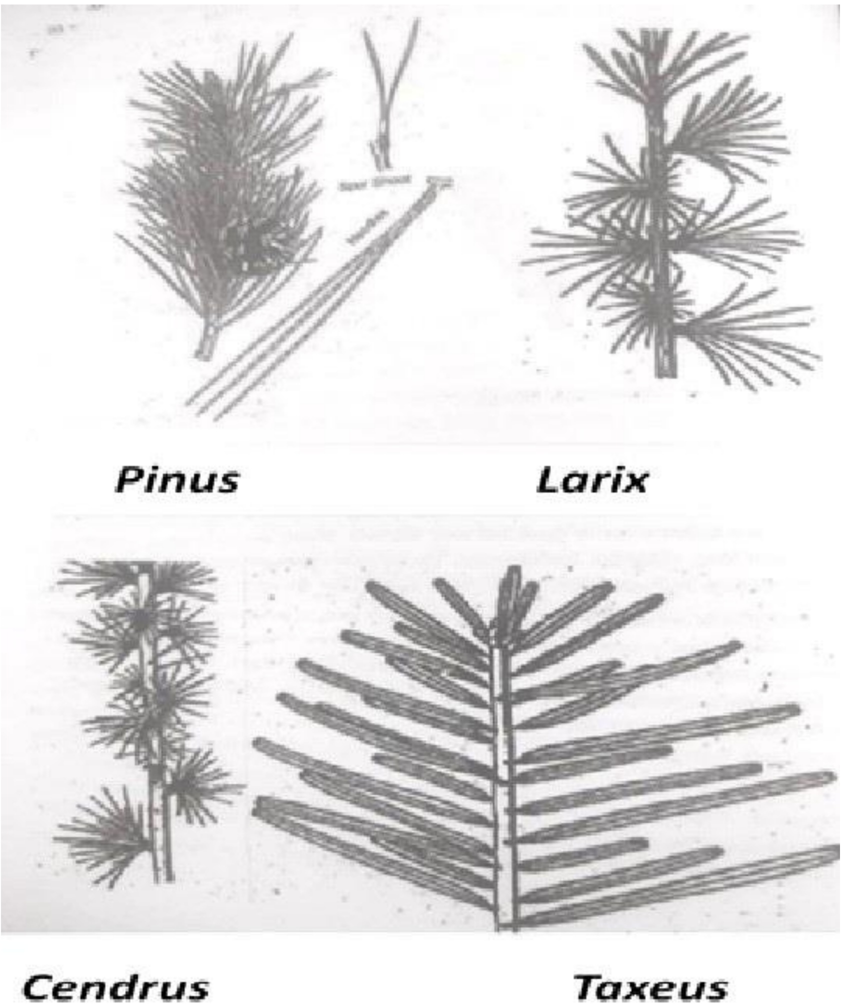

Fig -1B. Gametophytes Morphology.

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They are the pioneers or primary structures of the male and female gametophytes respectively. In Gymnosperms the gametophytes are endosporic i.e. they develop within the 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. Gymnosperms possess two different types of spores and are hence referred as heterosporous. S.P. Bhatnagar, and Alok Moitra (1996) The microspores are smaller and there may not be any difference in the size of the spore while another spore larger in size called a megaspore. These two kinds of spores on germination produce two different types of gametophytes (Fig- 1A&1B) The microspore or pollen grain produces male gametophyte, while the larger megaspore produces female gametophyte, which bears two or more archegonia or female sex organs. Faeen, K and L. van der Pijl. Yon, (1979) These spores are produced within the sporangia that are borne on sporophylls. *Hall, J. A. G. H Waiter. et al(2004)* These sporophylls are spirally arranged along an axis to form compact strobili or cones. The male or microsporangia strobili bear microsporophylls and micro sporangia while the female or megasporangiate strobili bear megasporophylls with megasporangia (ovules). The two types of cones or strobili may be borne on the same tree as in *Pinus* or on different trees like *Cycas* and *Ginkgo*. *Ginkgo biloba* along a shoot bearing dwarf shoots. *Taxus baccata*: A. Shoot bearing seeds, B. Male shoot, C. A male strobilus, D. A microsporophyll, E. A female flowering shoot, F. Median L.S. female flowering shoot, This suggests parallel evolution among these groups rather than evolution from a common ancestor. However, the Gymnosperms embryo Share some common features with other embryos- 1. Axial development of embryo. 2. Early determination of polarity. 3. A conspicuous meristematic distal pole. The microsporangium contains numerous small microspores whereas the megasporangium contains only one large megaspore. Both micro and megaspores are haploid and develop due to meiosis in the respective spore mother cells.

Vascular Tissue system

Anatomical Characters:

1. The stele in the root is diarch (or) polyarch. See growth occurs as in the case if dicotyledonous roots.
2. The stem has a ring of discrete Vascular bundles with narrow (or) broad medullary rays. The bundles are conjoint, Collateral, endarch and open.
3. See, growth occurs by the activity of a Cambium. It produces See, Phloem on the Outerside and see xylem on the inner side. The see, wood forms distinct annual rings.
4. The xylem consists of tracheids with bordered pits and xylem parenchyma. Xylem vessels are normally absent except in Gnetales.
5. The Phlem consists of seive-tubes and phloem parenchyma only. The companion cells are absent.
6. See Wood in Gymnosperms may be (i) Manoxylic and (ii) Pycnoxylic. The manoxylic wood is porous, soft with broad parenchymatous meduallary rays. It is commercially useless eg: Cyeadophyta. The pycnoxylic wood is hard, compact and densely packed with few rays. It is commercially valuable timber eg: Coniferophyta.
7. The leaves are invariably ever green, may be simple as in Pinus (a) compound as in cycas, Boweria etc., They exhibits xerophytic characters in their form of texture and covered by thick cuticle, sunken Stomata and Sclerenchymatous hypodermis. The stomata may be haplochelic (or) Syndetochelic type.
8. The presence of mesarch xylem and the transfussion tissue in the leaves of certain groups is a primitive character, establishing affinity with extinct group - Cycadofilicales and living ferns.

The leaf base remains permanently meristematic while the tip starts drying off. Due to secondary growth Gymnosperms possess primary and secondary wood. The Manoxylic secondary wood is the characteristic feature of Cycadophyta. P.C. Vashista, S. Chand (1990) This wood is porous, soft and more parenchymatous, while pycnoxylic wood is the characteristic feature of Coniferophyte as this wood is compact and hard with narrow medullary rays. Xylem lacks wood vessels except in *Ephedra*, *Gnetum*, etc. The xylem is usually endarch Gymnosperms or mesarch in stem while it is exarch in roots. The vascular bundles in the stem are conjoint, collateral, endarch, and open. *Pinus wallichiana*, Gymnosperms L.S. of *Taxus* wood showing tracheids with tertiary spiral thickening in addition to bordered pits. Life cycle of a Gymnosperm plant. Ovule and female gametophyte: 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 in the plant kingdom. Inside an ovule, there is a parenchymatous mass of cells known as nucellus surrounded by an integument. (Fig-2 & 3). The integument grows all around except the apical part leaving a small pore i.e. micropyle and this end is known as the micropylar end. The nucellus has a single megaspore mother cell at a later stage which undergoes meiosis and forms 4 haploid cells (megaspores) arranged linearly. Out of the four megaspores only one, usually the lower one remains functional, and the rest degenerates (Fig-4). The functional megaspore enlarges and undergoes free nuclear divisions resulting in many free nuclei. HKD. B. T. Osborne R CAB (2004) This transforms into a young gametophyte that has developed within the megaspore. Now centripetal wall formation starts, and it continues till the whole female gametophyte becomes cellular. The single integument of the ovule of Gymnosperms consists of three layers namely). i) The outer fleshy layer or outer sarcotesta, ii) The middle stony layer or sclerotesta, iii) The inner fleshy layer or inner sarcotesta. Thus, the integument of the ovule consists of one middle stony layer covered by inner and outer fleshy layers.

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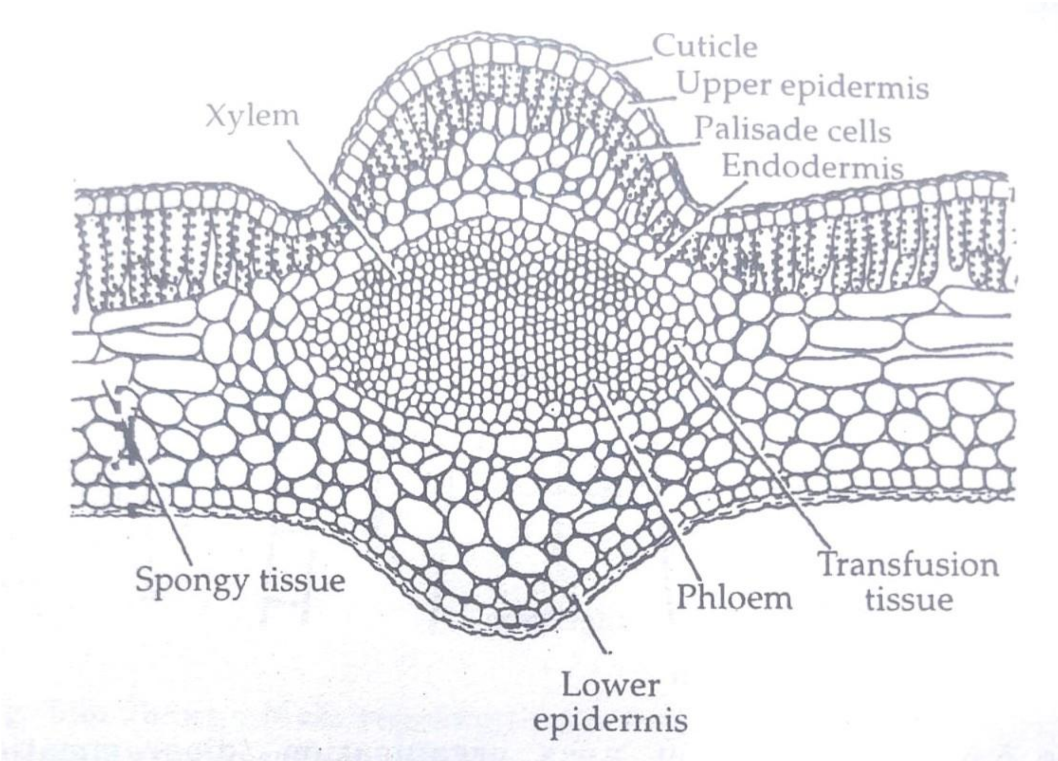

Fig-2 ***TAXUS LEAF VS.***

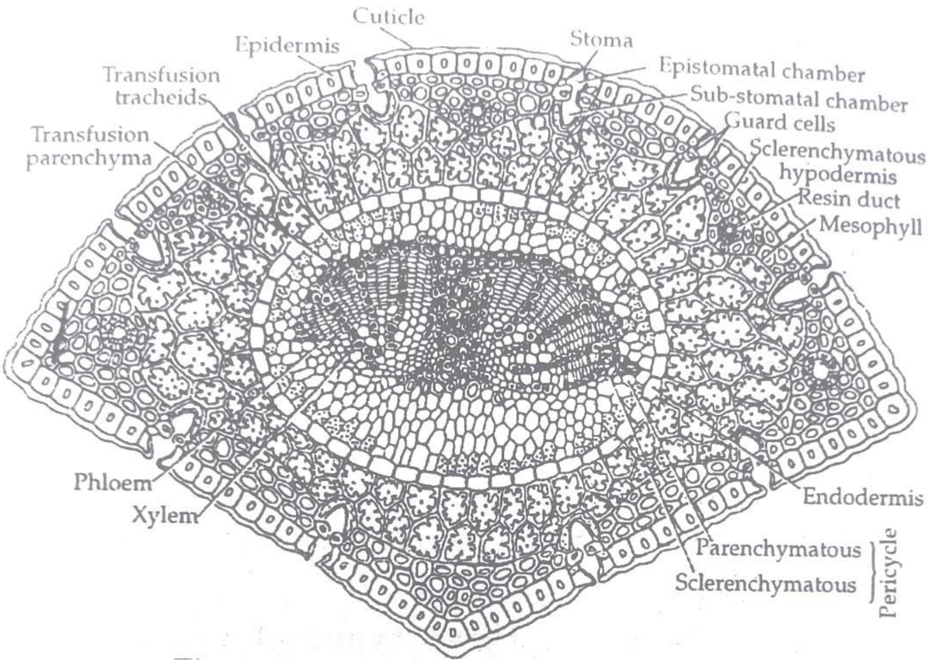

Fig-3 ***PINUS LEAF VS.***

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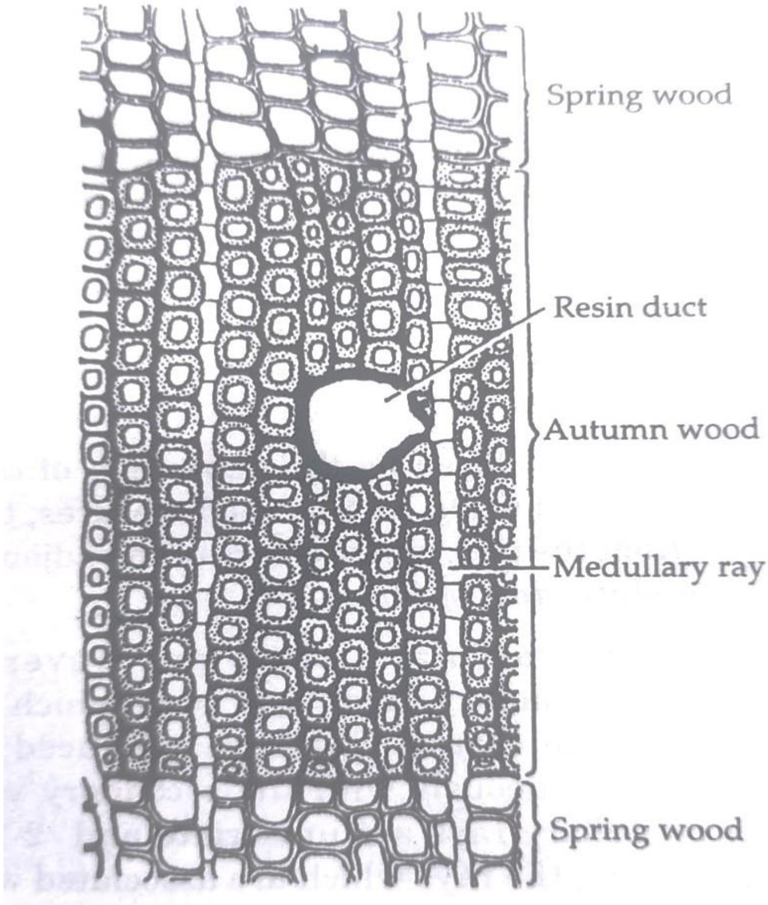

Fig-4 FINUS SECONDARY XYLEM.

Reproductive Methods

Male Gametophyte:(Fig-7) The male gametophytes in gymnosperms are endosporic in nature and show variations regarding their release from sporangia, the number of prothallial cells (they complete their development partly in the microsporangium and partly in the pollen chamber in the ovule), size and motility of male gametes and their time of formation and discharge. In lower gymnosperms- Cycadophytes male gametophyte is with one male prothallial cell and a large sterile cell or stalk cell. Stalk cell divides to Gymnosperms form a body cell or a spermatogenous cell and a tube nucleus. They are arranged in a linear row. The body cell again divides into two multiciliate male gametes. In all Cycads, the pollen tube is formed and is more haustoria in nature than a sperm carrier. In Microcycas, the stalk cell divides into 10 or 11 body cells or Spermatogenous cells. These cells divide to produce 20 or 22 spermatozoa. Contrary to this in Ceratozamia there are 4 spermatozoids. Generally, in Gymnosperms, the generative cell divides transversely into stalk cell and body cell except in *Cycas revoluta*, where it divides anticlinal. In case of *Ginkgo biloba*, the male gametophyte contains two male prothallial cells, a stalk cell, a body cell and a tube nucleus. Here the generative cell divides anticlinally into stalk and body cell. Later the stalk cell surrounds the second male prothallial cell. The male gametes are multifllagellate. In case of different families of Coniferales, slight variations are noticed in the sequence of development of male gametophyte, although major events show similarities. In Pinaceae the nucleus of microspore divides twice by periclinal walls and cuts off three cells- two male prothallus cells and one antheridial cell. The latter divides periclinally and forms a tube cell and a generative cell.

The grains are liberated at this four-celled stage (two prothallus cells, one tube cell, and one generative cell). The generative cell then undergoes periclinal division forming a stalk cell and a body cell. All these cells lie in an axial row. The semi-germinated pollen grains may germinate immediately or after a month. The pollen tube may start branching on entering the nucellus, then the tube nucleus migrates into one of the branches of pollen grain and moves to the tip while the generative cell remains within the spore wall and divides into stalk cell and body cell between the pollination period of the year or in the following spring these two moves into the pollen tube. Simultaneously about a week before fertilization, the body cell divides into two non-motile, unequal-sized male gametes. There is a difference of opinion regarding the male gamete. According to some workers, the two male gametes are two nuclei of binucleate sperm cells, whereas others regard them as two sperm cells. Sometimes the generative cell divides before pollination in some genera e.g. *Abies, Cedrus, Picea, and Larix* etc. In *Abies,* the cell sometimes divides

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into two male gametes before pollination or shortly after pollination. However, Chowdhury (1960) reported equal male gametes in *Cedrus*. The period between pollination and fertilization varies in Gymnosperms different members of Pinaceae. It is longest in *Pinus* ranging up to one year, up to nine months in Cedrus, 4-5 weeks in Abies and a few days in *Picea*. Similarly, the number of prothallial cells also varies in different plants of Gymnosperms.

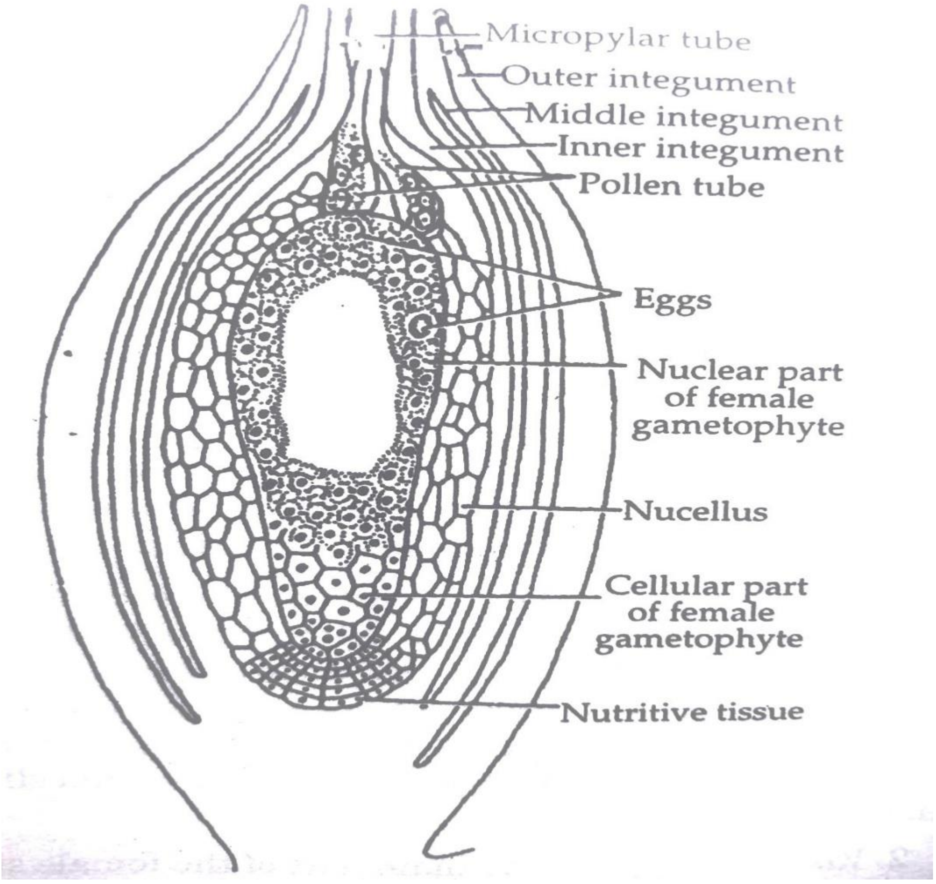

Fig -5 *Ginkgo biloba ovule.*

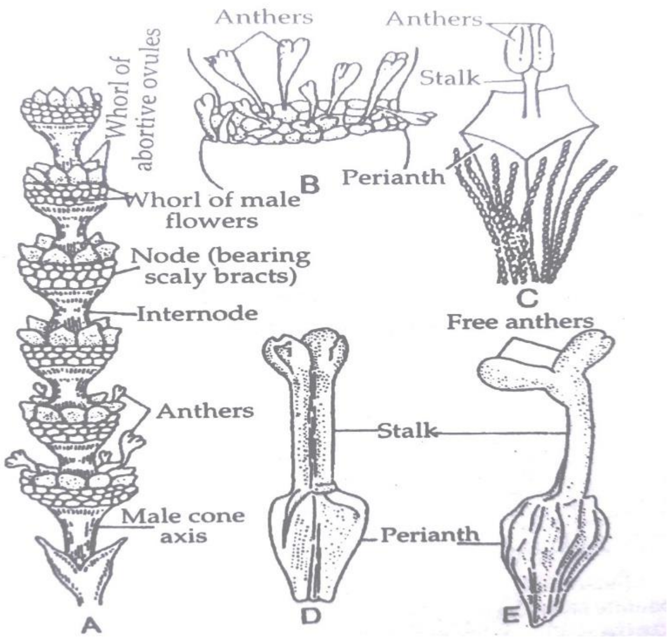

Fig -6 *Gnetum ovule.*

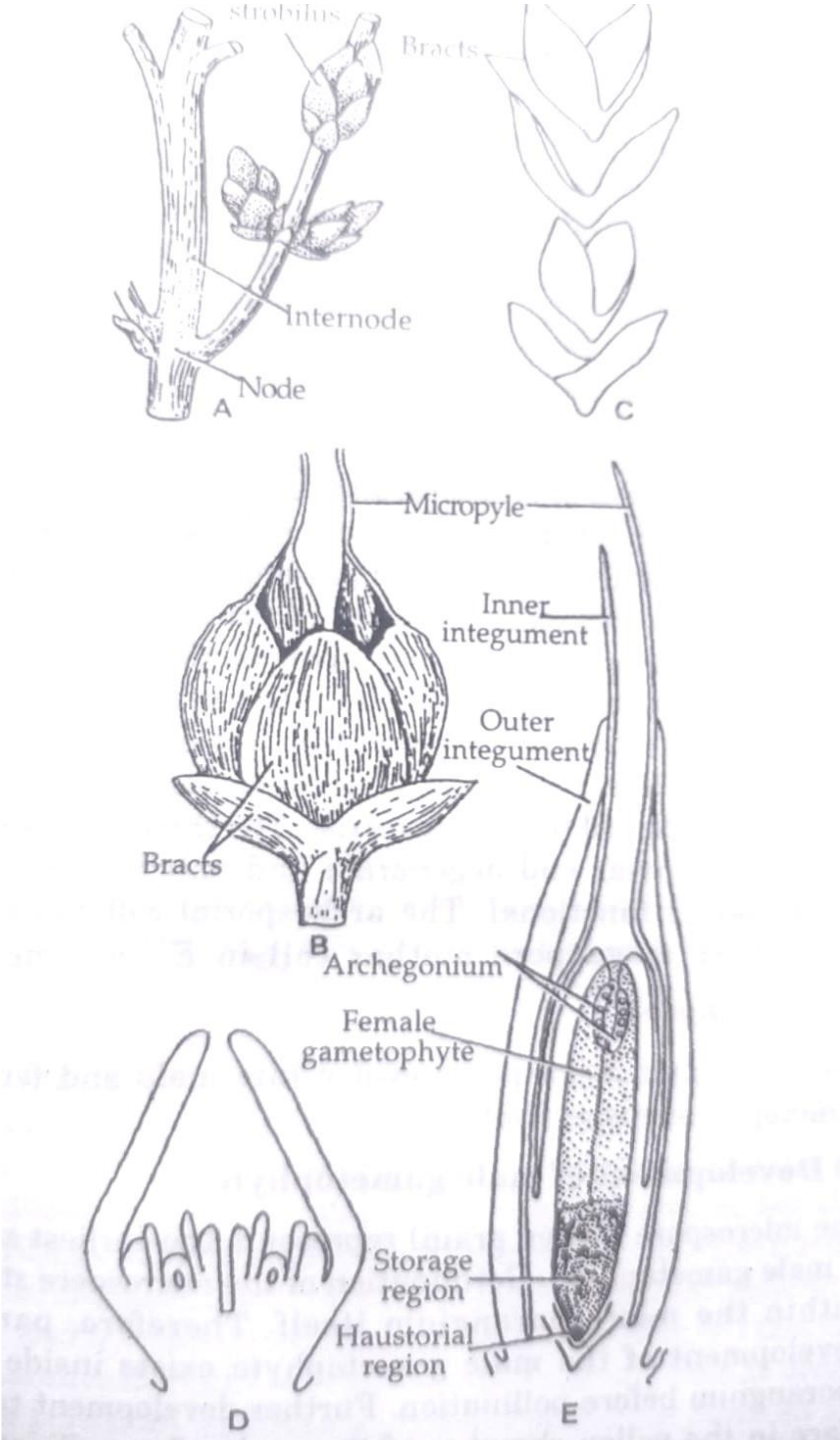

Fig -7 *E. foliate* Male Gametophyte.

In Abies balsamea formation of 3 or 4 prothallial cells. While in Taxodiaceae the male gametophyte lacks prothallial cell and divides into a generative cell and a tube cell before pollination. Further, the generative cell divides into stalk cell and body cell after pollination. The male gametes are non-motile and equal in size. In family Cupressaceae also prothallial cells are absent, here the pollen grains directly act as an antheridial cell and may divide into generative cells and tube cells before pollination. Based on studies, in Cupressus semipervirens the body cells divide into 4- 20 male gametes, contrary to this in *C. fusiberus* only two male gametes are produced. Gymnosperms show variations in the production of prothallial cells. Among them the Araucariaceae are unique in producing many prothallial cells, the two non-motile male gametes are equalin size. In the members of Podocarpaceae the number of male prothallial cells may be 1-8 in Podocarpus, 3-6in Dacrydium and 1-3 in Phyllocladus while in Pherosphaera the male prothallial cell is absent. The

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male gametes also vary in size they may be equal (Phyllocladus) or unequal (Podocarpus) in size. In Cephalotaxaceae there is no prothallial cell in any species of Cephalotaxsus, whereas in *Taxus* there is no male prothallial cell. The male gametes are unequal in size. In Ephedra the cells of male gametophyte are arranged in a single axial row including two prothallial cells, a stalk cell, a body cell, and a tube cell. Out of the two prothallial cells one is without a cell wall and is thus called prothallial nucleus. After pollination the body cell divides into two male gametes. Contrary to this in *Gnetum*(Fig-6) there is only one prothallial cell, a tube nucleus and a generative nucleus. Further division takes place after pollination while at that time the pollen grain contains only three nuclei. The generative nucleus divides into two male gametes. In *Welwitschia* there is no prothallial cell and the released pollen grain contains a tube nucleus and a generative nucleus. Based on above the general characteristics of male gametophyte in gymnosperms following points emerges. 1. The Cycadales, Ginkgoales, Coniferales, and *Ephedra*(Gnetales) all have the same cellular organization of the male gametophytes including the tube cell, the stalk cell, and the male gamete except one difference in the formation of prothallial cell Gymnosperms 2. In case of Araucariaceae and Podocarpaceae formation of a very large number of prothallial cells which develop secondarily at the base of the microspore may be considered as a later evolutionary development. This condition is neither reported in any living or fossil gymnosperms or nor among lower heterosporous tracheophytes. 3. Another specific ontogenic feature is the orientation of the division of spermatogenous cell which produces the stalk cell and the body cell, (e.g. *Ginkgo*, Auricuriaceae, Podocapeceae and *Cycas revolute* and in some species of *Ephedra*) the division is anticlinal while in Cycads and Pinaceae the division is periclinal and the two cells are superimposed. 4. Beside this in Microcycas the stalk cell which is sterile divides and gives rise to additional spermatogenous cells or body cells. 5. While in some other gymnosperms i.e. *Cupressus* and sometimes in Juniperus more than two male gametes are produced. It is assumed that this condition may have arrived as the gametes are formed from the sub- division of a single spermatogenous cell. This feature may be related with the presence of large number of archegonial complexes. Pollination and Fertilization: In gymnosperms the medium of pollination is wind; it results in the transfer of semi-germinated pollen grains on the micropyle of the ovule. In most gymnosperms, the pollen grains are caught in a pollination drop secreted at the micropylar end of the ovule. After drying of the pollination drop, the microspores in the semigerminated stage are drawn into the ovule. Just after the drawing of the microspores in the micro gametophyte, the micropyle closes. A distinct pollen chamber is formed at the apex of the nucellus which receives the micro-gametophytes as in some gymnosperms (*Cycas*, *Ginkgo*, *Ephedra*, etc.) In Conifers and other gymnosperms, the semi-germinated pollen grains come in direct contact with the nucellar beak. Contrary to this in the paleozoic gymnosperms (now extinct), the pollen chamber contained liquidfilled cavities in which the motile sperms were liberated due to the dehiscence of the microspore wall. In general, in all the living gymnosperms, the microspores produce a pollen tube as a tubular outgrowth that grows through the nucellar tissue. In *Cycads* and *Ginkgo*, the pollen tubes mainly act as the haustorial organ and grow for a long time (several months) into the nucellar tissue absorb food and supply it to the micro gametophyte Gymnosperms The pollen tube bursts during fertilization and liberates of multiciliate male gametes along with some liquid in the cavity above the megagametophyte. At that time the sperms swim to the archegonial neck and enter the archegonia and only one of them fuses with the egg or oosphere and form the diploid zygote or oospore. In the conifers, the pollen tube plays an important role of a sperm carrier. The male gamete along with the stalk and tube nucleus migrates to the tip of the pollen tube. The tube grows through the nucellar tissue, reaches the archegonial neck, enters through it, and after bursting liberates the male gametes. Among them, one fuse with the egg to form a diploid zygote. This specific process of fertilization is termed as Siphonogamy.

Embryogeny

The Embryo has two cotyledons. In most conifers, the zygote develops four free nuclei and later because of further divisions and wall formation results in forming a “Proembryo” with a four-celled distal embryonal tier, middle suspensor tier, and upper rosette tier (*Pinus*, *Cycas*, *Tsuga*, etc.). (Fig-8) While in other Gymnosperms as in *Abies*, *Picea*, and *Larix* the rosette tier disappears at a later stage. In further developmental stages, the lower embryo tier develops into all the organs at a later stage. The suspensor tier develops into additional embryos. While the uppermost tier ends are in open contact with the egg cytoplasm. This end is active in transmission of nutrients to the growing embryos. The number of cotyledons varies in different species and even in the same species. It is 10 in *Pinus*roxburghii, 3-6 in *P. banksiana*, 2-8 in *P.contorta*, 7-8 in *P. sabiniana*. Cleavage Polyembryony is not reported in *Araucaria angustifoli*a, a member of Araucariaceae. In this species, 32-45 free nuclei are formed. Later after polar elongation, wall formation takes place. The cells at the distal end develop into enlarged cap cells. The central cells develop into embryo and those situated towards the micropylar end give rise to suspensor. There is complete absence of “Cleavage Polyembryony.

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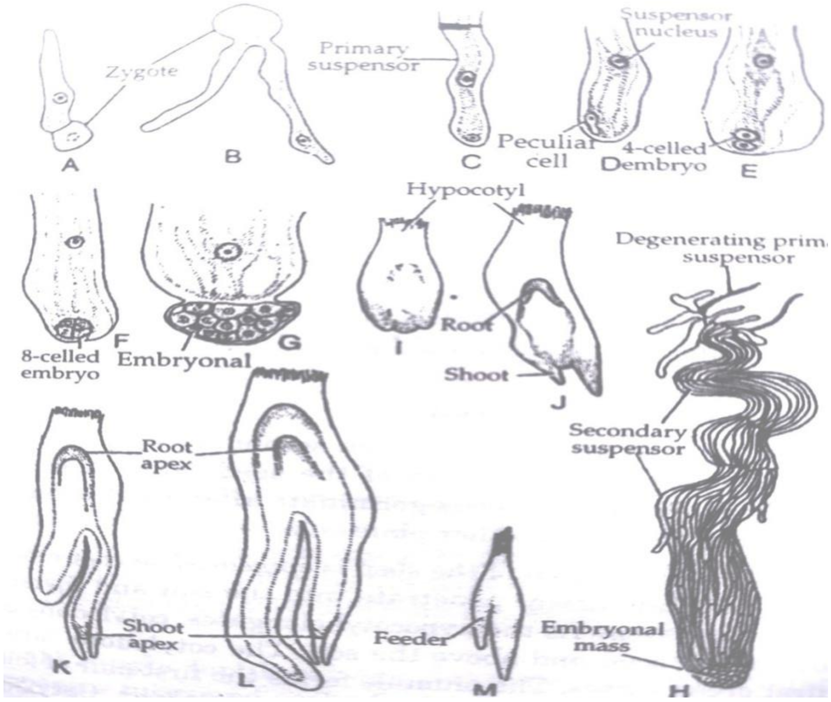

Fig- 8 *Pinus* Embryogenystages.

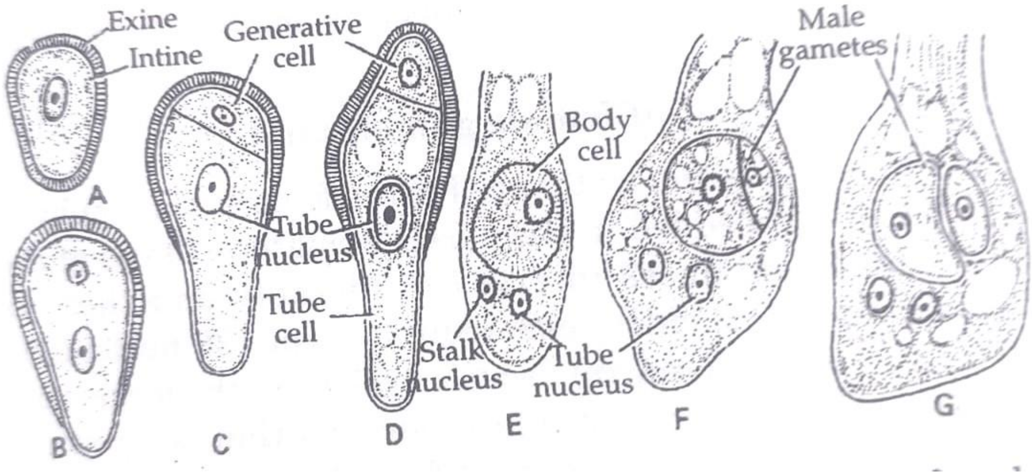

Fig -9 *Podocarpus spicatus*pro- suspensor cells.

In the case of Cupressaceae, the genus Actinostrobus shows Cleavage Polyembryony and shows a somewhat different pattern of development. Here 4 free nuclei are formed. Wall formation results in the forming of 4 cells among which two vertically placed cells below the archegonial neck and two transversally placed cells below. The lower cells divide once to form four embryonic initials while the upper cells do not divide further. The lower ones are polarized in a transverse plane and each of them forms a small distal initial cell and a large suspensor cell and forms four small embryonal cells and four large suspensor cells that elongate considerably. Hence shows cleavage polyembryony. The rosette tier and upper tier are not formed in this case. The embryo has two cotyledons. The embryonal cells are binucleate in Podocarpaceae. While the number of binucleate Gymnosperms cells and the pro- suspensor cells varies with species and genera.(Fig -9) The maximum and minimum number of the embryonal cell are 9-12 in *Podocarpus spicatus* and 1-2 in P. *toterra, P. nivalis* and *P. macrophyllus. Podocarpus spicatus* has 9-12 and P. macrophyllus has 14-15 prosuspensor cells. The embryo has two cotyledons. Development of embryos in the members of Gnetales is different than in the abovementioned cases. In Ephedra trifurcate the zygote nucleus divides into eight free nuclei of unequal sizes distributed unevenly in the protoplasm. Three to five of these nuclei become enclosed individually by irregular walls which become globular later. All these globular cells are proembryos, an example of polyembryony. Later the globular pro-embryo develops into an embryo with a massive embryonal mass at the distal end and several suspensors. In *Ephedra foliata* exceptionally there is only one suspensor tube. In Welwitschia embryo develops differently. In this case, the zygote elongates and divides into different parts- an upper elongated primary suspensor and a distal embryonal cell, later it divides to form an apical wall. The outer mass of this apical mass is called the inner cortical ring and is situated adjacent to the primary suspensor. The outer cortical ring is formed later which elongate around the suspensor. Thus, the primary suspensor cell is now surrounded by two layers of 8- 16 cells. Later by division of these cells, more layers are added around these. At the distal end, the cells form cap cells while those in the middle develop into embryos.

CONCLUSION

Comparatively to this embryo development in *Gnetum* is quite different. In this case, free nuclear division is not found and the zygote divides and develops into a two-celled body that gives out elongated and tube-like suspensors. These suspensor cells may branch, and all have a distal, densely granulose embryonal cell. Further these terminal cells develop into an embryo out of which only one reaches maturity. In *Gnetum* embryo development is completed after the detachment of the seed. Based on comparative studies of embryonal development in Gymnosperm, it is concluded that there is no close relationship or resemblances between the embryogenic of pteridophytes, Gymnosperms, and Angiosperms. The female gametophyte or prothallus gets differentiated into an upper reproductive region, middle storage region, and lower basal haustorial region.

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