GYMNOSPERMS, TAXONOMY OF ANGIOSPERMS AND ANATOMY (BOT 503)

BLOCK-I-GYMNOSPERMS

Unit-3: Reproductive structures of Cycadales, Ginkogoales, Conferales, Taxales and Gnetales

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INTRODUCTION

The word Gymnosperm, *"Gymnos" = necked and "Sperma" means seeds* was first used by Theophrastus, a pupil of Aristotle in his famous book *"Enquiry into Plants"*. He used this term in all those plants having unprotected (without covering) seeds. On the basis of their seeds with or without covering are grouped into two major categories namely- Angiosperms and Gymnosperms. Thus the plants or Spermatophyta is divided into two sub groups Angiosperms and Gymnosperms.

The ovules of gymnosperms have freely exposed before and after fertilization while in case of angiosperms where (*Angios* = *Vessels* and *Sperma* = *Seeds*) the ovules are enclosed within the carpel. Thus due to this, the angiosperms are considered as the most advanced type of organisms in plant kingdom. Comparatively to angiosperms, the gymnosperms are less advanced; but they have some specific characteristic features.

REPRODUCTIVE STRUCTURES OF CYCADALES

Cycadales are dioecious and hence possess male and female reproductive structures on different individuals of the same species. In some genera including Cycas sex of individual is determined by X and Y chromosomes.

Megasporophylls and Female Cones

The reproductive organs are borne in the form of compact cones in all living genera which terminate the female plant. However, in Cycas, loose and leaf-like megasporophylls are spirally arranged and alternate with the cataphylls and vegetative leaves. Megasporophylls in the female cone are spirally arranged around the cone axis. Generally only one female cone is produced at the apex but sometimes two cones may also develop due to development of another meristem. Smallest female cones (about 2-3 cm in length) of Cycadaceae develops in *Zamia pygmea*, in *Macrozamia denisonii* length of female cone is upto 60-75cm. In *Dioon spinulosum* length of female cone reaches up to 50-60 cm in length. Megasporophyll of Cycas are leafy in nature and regarded to be the most primitive one. It is believed that during evolution distal foliar part of megasporophyll of cyadales gradually reduced in the size alongwith reduction in number of the ovules. on the megasporophyll. Hence, megasporophylls of *Cycas revoluta* having leafy distal part and many pairs of ovules represent the

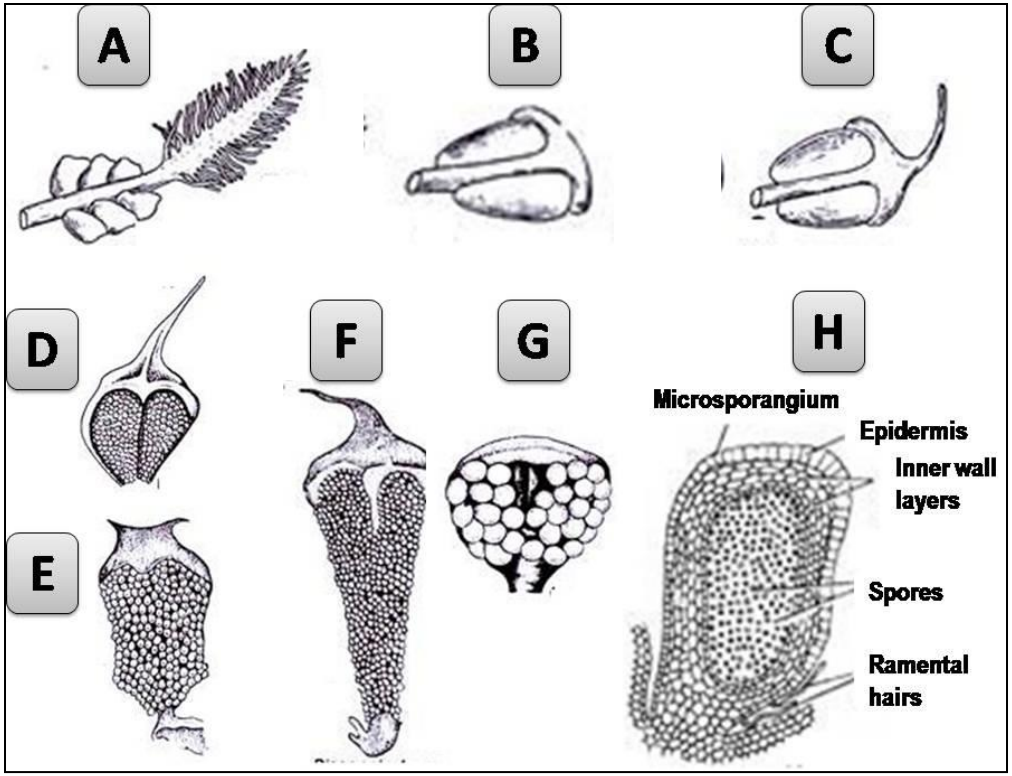
most primitive form and megasporophylls of *Macrozamia* and *Zamia* bearing only two ovules with their distal part not leaf-like represent the most advanced. Hence, ovules are foliar in origin and Cycadales are phyllospermous. Contrary to this some workers believe Cycadales to be stachyospermous. Botanists in favour of this view believe that peltate megasporophylls of *Zamia* and *Macrozamia* with two ovules are most primitive, and the entire series has progressed in an opposite direction. According to them, leaf-like megasporophylls of *Cycas revoluta* having several ovules represent the most advanced stage.

Microsporophylls and Male Cones

The male cones are compact structures which consists of a central cone axis which is covered by several microsporophylls. Microsporophyll are spirally arranged, with the exception of *Macrozamia moorei*, in which male cones are terminally located. The microsporophylls, are triangular or conical structures which bears definite sterile and fertile portions. The sterile portion is distal in position and produced into a single spinous projection as in *Macrozamia Dioon* and *Cycas*. Most of the genera contain thousands of microsporangia located in lower or abaxial surface of the microsporophyll. However number of sporangia ranges from 20-50 in *Zamia*.

The development of microsporangium in all Cycadaceae is eusporangiate.

Mature microsporangium is surrounded by a massive sporangial wall which is made up of several layers. Cells of the outermost layer are thick and functions as epidermis. The sporangial wall encloses sporogenous tissue, outermost cells of this function as single-layered tapetum. The sporogenous tissue metamorphoses to form diploid microspore mother cells. Each microspore mother cells forms four haploid microspores (pollen grains) through meiosis.



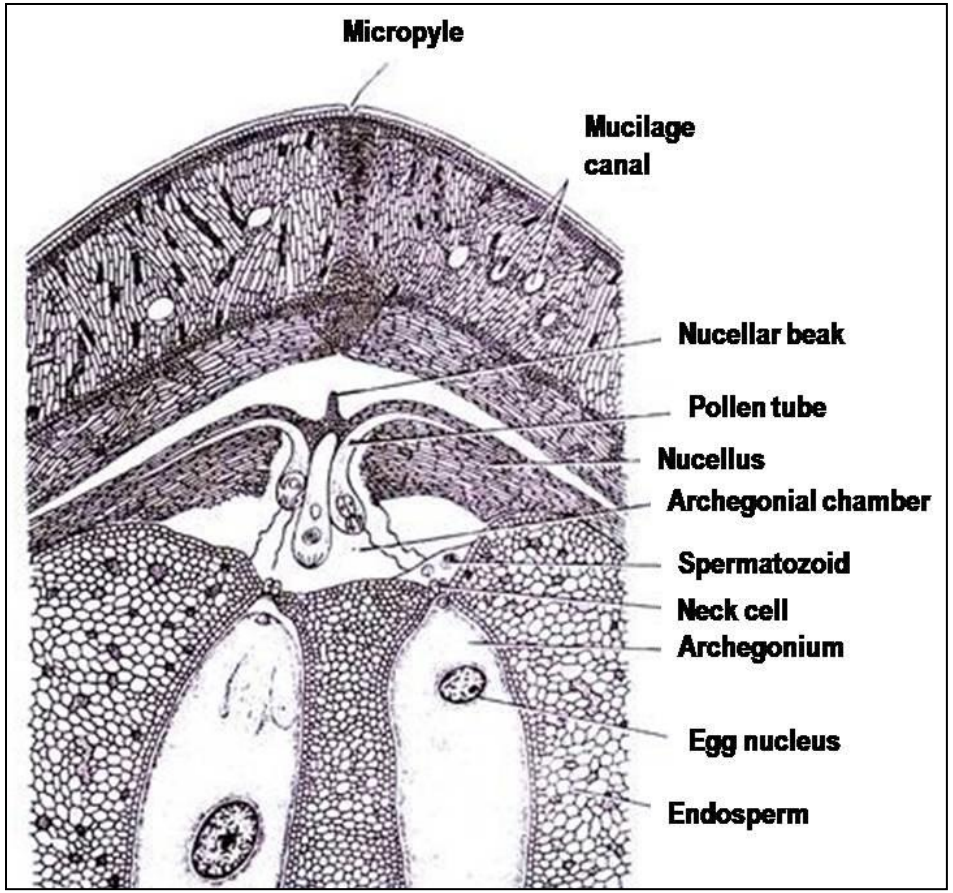
Megasporophyll: A-*Cycus revoluta*, B- *Zamia*, C- *Macrozamia*; Microsporophyll: D- *Macrozamia*, E- *Creatozamia*, F-*Dioon*, G-*Zamia*, H- Sporangium of *Stangeria*

Ovule and Female Gametophyte

Cycadaceous ovule is a sessile structure and is surrounded by a single integument. The integument consists of three layers, among which outer and inner layers are fleshy and middle one is stony in nature. A distinct micropyle is present at the distal end. The nucellus consists of parenchymatous cells, when young. A megaspore mother cell gets distinguished in the nucellus. This mother cell undergoes meiosis to form 4 haploid megaspores. Out of these 4 megaspores three gets degenerated and one megaspore remains functional. This functional megaspore undergoes free-nuclear divisions which is followed by wall formation and develops into cellular female gametophyte.

A vascular strand enters through the basal part of the ovule and constitutes its vascular supply. In some members the vascular strand divides before it enters the ovule. Two concentric vascular systems (outer and inner) are found at the base of the ovule. The outer vascular system consists of twelve vascular strands which traverse upwards through the outer fleshy layer from chalazal end to micropylar end of the ovule. The strands of the inner vascular system also moves upwards through the part of ovule where the inner fleshy layer is in close contact with the nucellus. Stomata-like structures (with guard and subsidiary cells) have been reported to be present on outer surface of the nucellus in ovules of *Ceratozamia, Cycas, Encephalartos* and *Zamia*. Female gametophyte contains a cavity which represents the pollen chamber.

One or more archegonial initials appear at the micropylar end of the female gametophyte. Each of these initials develops into an archegonium.



VS of ovule (Dioon edule)

Seed

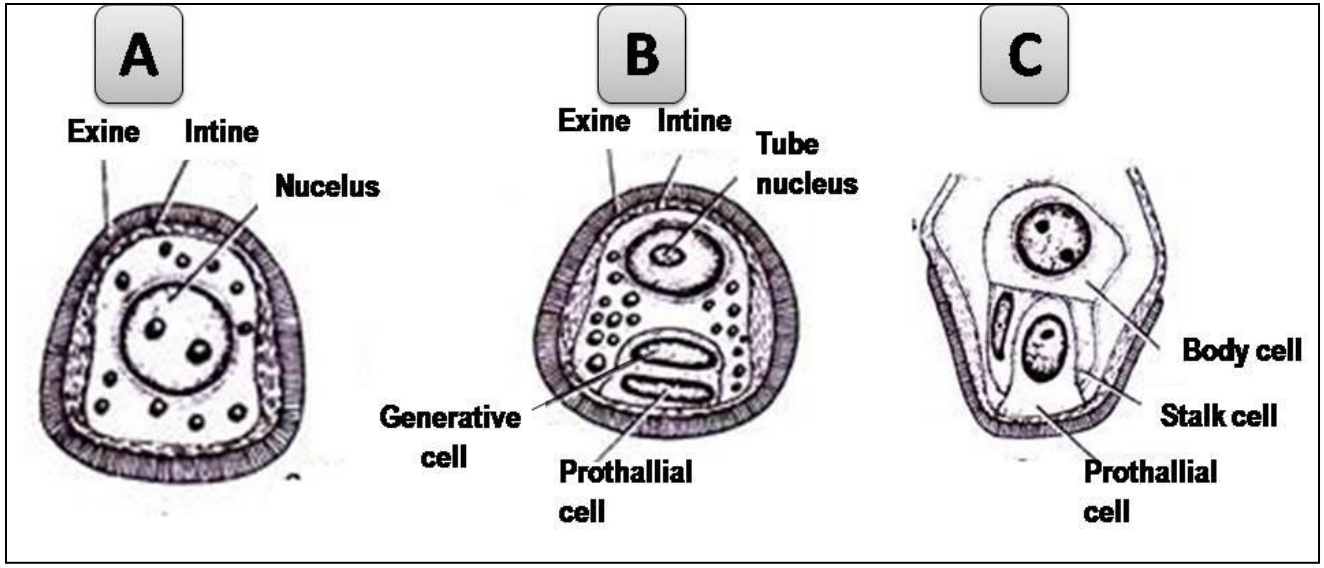
Outer fleshy layer of integument of the ovule forms coloured seed coat. Middle stony layer forms its hard testa. The inner fleshy layer is converted into papery layer called as tegmen. The micropyle is present as such in the seed. The nucellus forms a nucellar cap at the micropylar end. As soon as seeds fall from the plant they begin to germinate if conditions are favorable. Hence there is no resting period. Germination is hypogeal.

Pollen Grain and Male Gametophyte

Microspores (pollen) grains are haploid structures each of which develops into a male gametophyte. Microspores are surrounded by an outer thick exine and inner thin intine. The exine is thick at the bottom and thinner at the top. A single prominent nucleus of the microspore is centrally positioned and is surrounded by dense cytoplasm which contains some reserve food.

Germination of microspore is precocious i.e. starts within the microsporangium itself. Microspore (at three celled stage) are released from microsporangium and further germination occurs on the nucellus after the completion of the pollination. Some of the pollen grains reach up to the micropyle of the ovule and get entangled in the pollination drop. Through the micropyle such young pollen grains reach up to the pollen chamber of the ovule. Each pollen grain germinates by producing a pollen tube that penetrates through the nucellar

tissue. After few weeks, the generative cell divides into a stalk cell (which remains in contact with prothallial cell) and a body cell, which divides into two multi-flagellate spermatozoids.



A-Pollen grain, B,C- Developmental stages of male gametophyte (Dioon edule)

REPRODUCTIVE STRUCTURES OF GINKGOALES

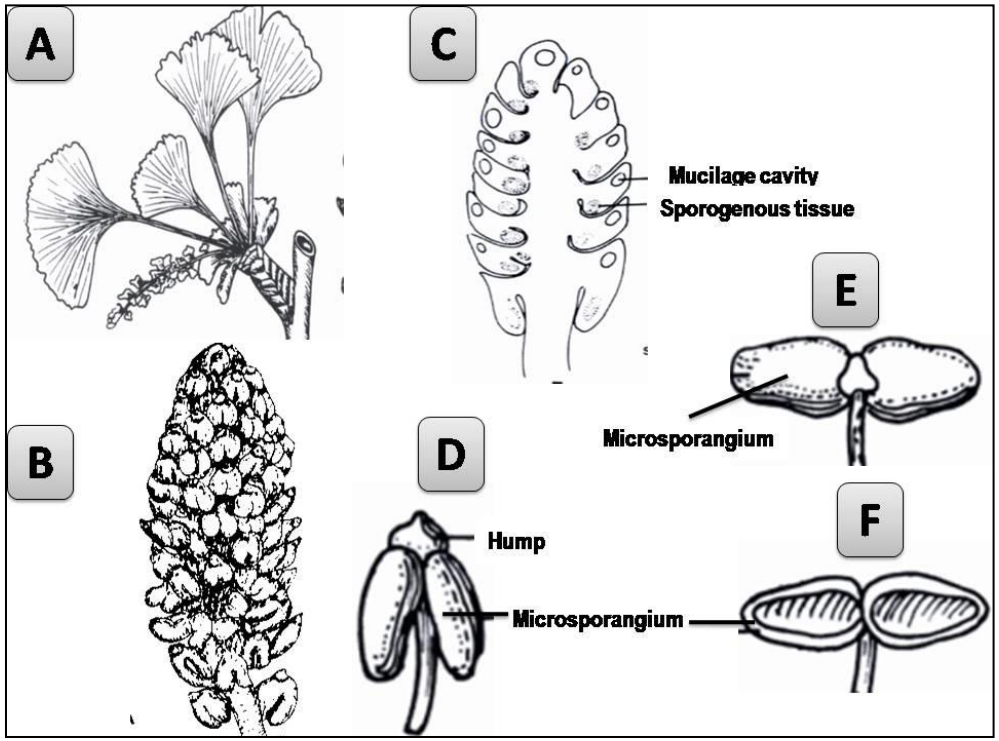
At present order Ginkgoales is represented by only one living member, i.e. *Ginkgo biloba*. *Ginkgo biloba* is dioecious. Male and female plants are, however, difficult to be differentiated, when young. According to Lee (1954) sex in Ginkgo is determined by sex chromosomes (XY in male and XX in female). Reproductive bodies of Ginkgo are most primitive among living seed plants except some Cycadales.

Male Strobilus

Microsporangiate strobilus arise in terminal and pendulus clusters from tips of spur shoots of male trees. They exhibit from superficial resemblance with catkin inflorescence. Each male strobilus contains several microsporophylls arranged loosely on a central axis. Each microsporophyll has a long stalk terminating into a hump or knob. It contains two pendant microsporangia. According to some workers this terminal knob represents an abortive sporangium. A mucilage duct is present in the knob. Rarely more than two sporangia are present in a microsporophyll. Sporangia are tubular in structure having multilayered sporangial wall. Outermost layer specifically differentiated into single layered tapetum. Sporogenous cells form many tetrads of haploid microspores (through meiosis) which later separate into

spherical microspores. Development of microsporangium is eusporangiate microsporangium arise from single initial cell which divides to form primary cell wall and primary sporangenous cells.

Microsporangium is of eusporangiate type, i.e., single archesporial cell divides by a periclinal wall forming primary wall cell and primary sporogenous cell. The former develops into wall of microsporangium while the latter develops into sporogenous tissue. Sporangium dehisces by means of a longitudinal slit.



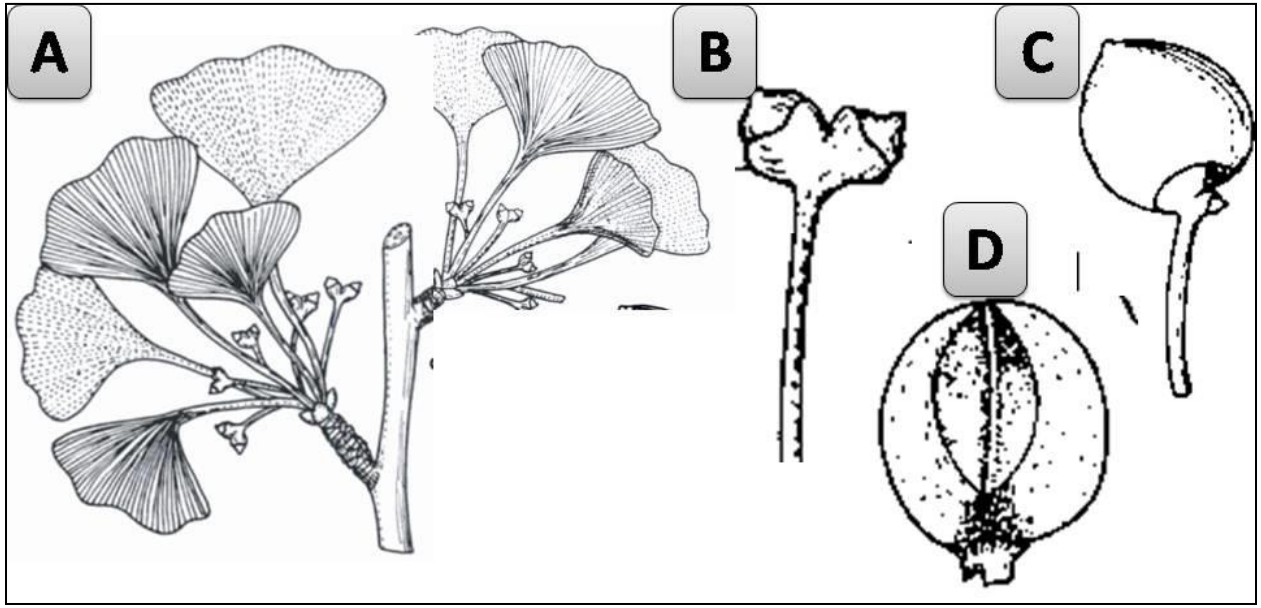
G. biloba: A- Part of long shoot bearing short shoot and male strobilus, B- Male strobilus showing arrangement of sporophylls, C-LS of male strobilus, D-Microsporophyll with two pendant sporangia, E-Mature sporangia pulled apart due to dehydration. F- condition after sporangia has dehisced

Female Strobilus

Megasporangiate organs are borne on dwarf shoots of female tree. They arise in axils of foliage or scaly leaves at apices of dwarf shoots. These are much reduced structures, each having a long stalk or peduncle. Ovules are borne on long stalk or penduncle. Each long stalk possess 2 or 3 (rarely more) ovules at the tip. Penducle bifurcates at tip to give rise to two branches each of which bears sessile ovules, from these only one exhibits maturation and others get aborted. Each ovule is encircled at the base by a collar (which is regarded as megasporophyll by Chamberlain), four vascular traces supply to penducle having two ovules and with increase in number of ovules vascular traces doubles. For e.g. if 3 ovules are present then number of vascular traces will be six. The leaves surrounding the ovules do not show their bilobed character.

The development of ovule, mega-sporogenesis and structure of the mature ovule is similar to that of Cycas. There is a thick integument consisting of three layers, i.e., outer fleshy, middle stony and inner fleshy layers. Each ovule is characterized by presence of large and prominent nucellus. Free apex of the nucellus breaks down into a pollen chamber to form nucellar beak. A functional spore mother cell deep inside nucellus tissue. The spore mother cell develops into a tetrad, of which only the innermost megaspore remains functional which develops into female gametophyte. Ovule possesses well developed vascular supply. However, two vascular strands enter the inner fleshy layer which reach

up to e free part of the nucellus without branching and outer fleshy layer lacks vascular supply.



G. biloba: A- Long shoots with drawf shoots bearing leaves and female strobili, B- Axis with a pair of sessile ovules, C- Later stage with one mature ovule (other aborted), D-Seed

REPRODUCTIVE STRUCTURES OF CONIFERS

There exists a great amount of variation in reproductive structures of members of different families of conifers. Here we will discuss reproductive structure of family Pinaceae.

Female reproductive structure

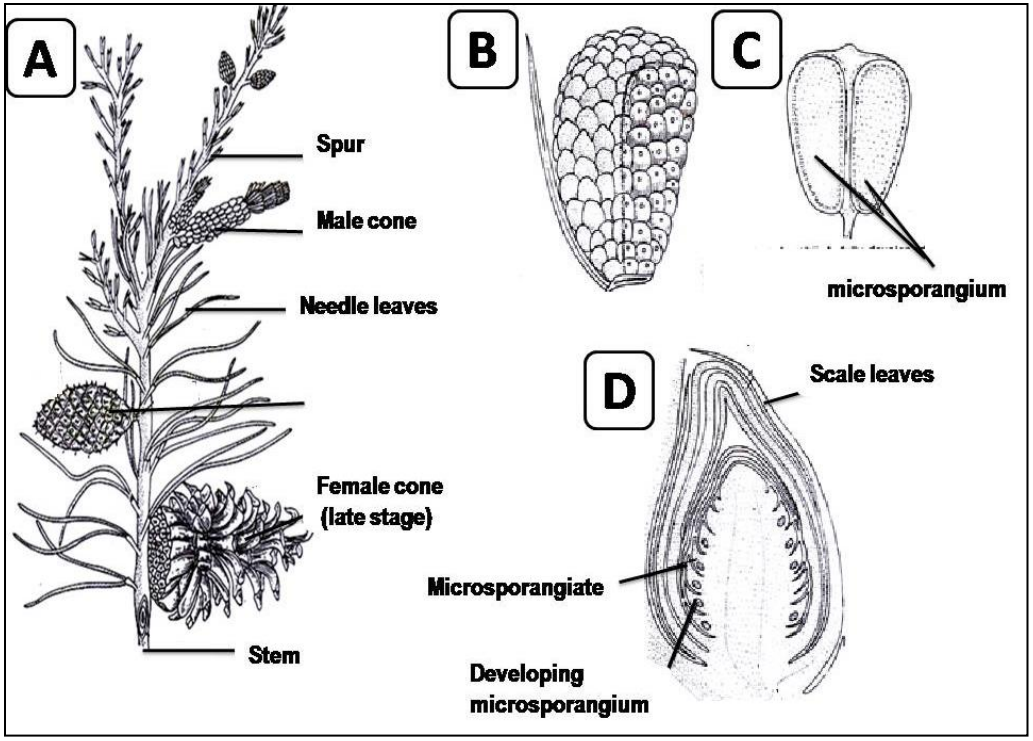
Megasporangiate cones are composed of number of spirally arranged bracts, in axil of these bracts are produced ovuliferous scales. In each of these scales two ovules are present. Ovules are unitegnic i.e, have single integument and three layers outer and inner fleshy and middle stony. Integument is fused to nucellus except for its upper part. Nucellus is thick, well developed and is known as megasporangium. In most of Pinaeae a deeply seated cell inside nucellus acts as megaspore mother cell. Konar reported that in *P. roxburghii* a hypodermal archesporal cell undergoes differentiation and division to form outer primary parietal cell and inner sporogenous cell. This sporogenous cell functions as megaspore mother cell. Three to four megaspores are formed due to reductional division. In *Cedrus deodara* a resting period of four months has been reported before the start of division of nucleus. The numer of free nuclei produced varies from species to species. Megaspore remains surrounded by a spongy tissue during free nuclear stage , this layer however disappears after formation of complete female gametophyte. Free nuclear division is followed by wall

formation. Development of archeagonia occurs from superficial cells of female gametophyte present at micropylar end. Their number varies from one genera to another for e.g. 1-5 in *Larix deciduas*, 3-5 in *Cedrus deodara,* 7-12 in *P. roxburghii,* etc. An archegonial chamber is formed by neighbouring tissue of gametophyte. Archegonium contains a short neck and long venter. Neck consists of several neck cells however neck canal is absent. Cytoplasm of egg contains perotid vacoules or para-nuclei which play a nutritive role. Female cones takes place of long shoots and takes two years for development.

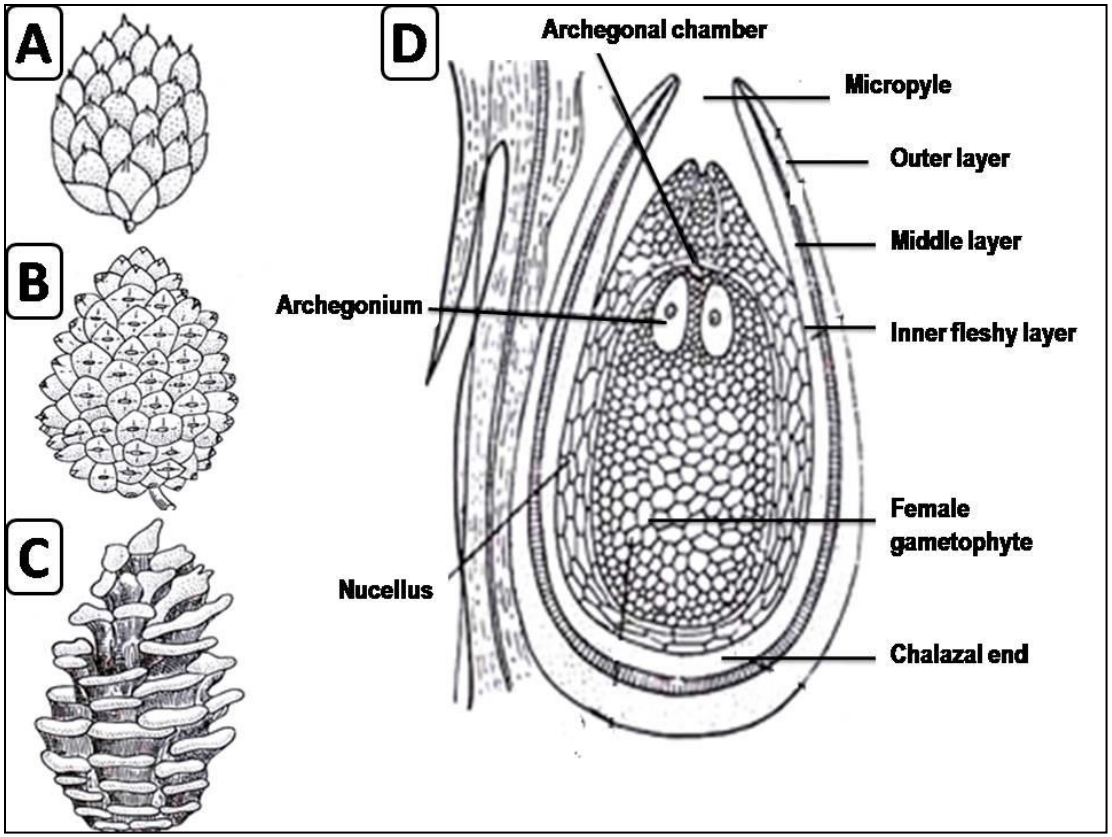
Male reproductive structure

Microsporoangiate cones bear spiral sequence of microsporophylls. Each microsporophyll contains a sterile distal flap and a pair of elongated microsporangia. Microspongia dehisce by longitudinal split however oblique and transverse dehiscence has been rarely reported. Male cones take place of short shoots and are aggregated in *Pinus*. Wall of mature sporangium is made up of 2-6 layers. Tapetum is present and in species such as *P. roxburgii* it originates from innermost layer. Tapetum alongwith all wall layers except for the outer layer or epidermis degenerate during meiosis and microspore maturation. Cells of epidermis develop tanniferous contents. Their walls becomes thick and a thick cuticle develops on outer tangential walls. Microspores of Pinaceae contains two wings. Microspores in genus *Tsuga* are wingless except *T. martensiana.* Young microspores consists of a three layered exine (outer ectine,

middle mesine and inner endine) and inner intine whose outer layer is well developed and inner layer does not develops in young grains but is prominent in mature grains as pectocellulosic tissue. Germination of pollengrains begins within microsporangium and are shed at 4 (*Pinus, Keteleeria davadiana*) or 5 (*Abies, Larix*) celled stage.



A- Pinus spp. Showing male and female cones, B- Mature male cone, C- Microsporophyll with 2 undehisced sporangia, D- VS of young male cone.



A- First year female cone, B-Second year female cone, C- Third year female cone, D- LS of ovule of Pinus roxburghii

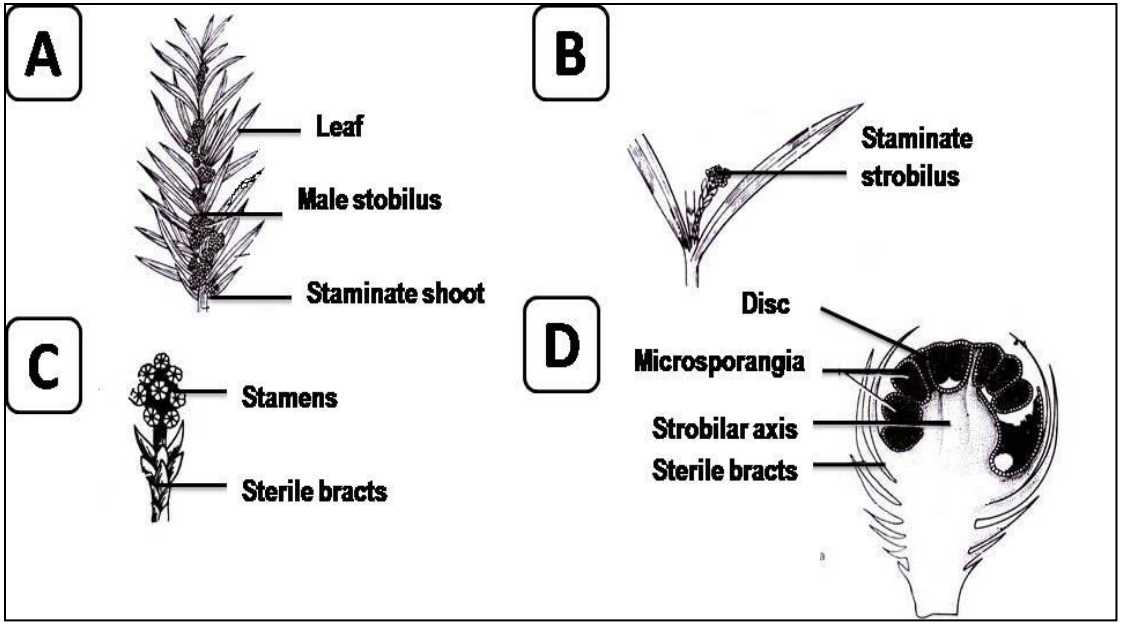
REPRODUCTION IN TAXALES

Taxus is usually dioecious, however monoecious trees have also been reported. The male and female plants have no difference in their vegetative organisation, and they can be differentiated only when the plants begin to flower or in fruiting stage. The reproductive structures become prominent on the plant in February-March.

Male Strobilus or Male Flower

Male strobili are yellow coloured which develop in axil of foliage leaves. Each strobilus consist of several overlapping sterile bracts. Some of these bracts towards the tip region of strobilus are replaced by stamens or micro-sporangiophores. Stamens are short-stalked with a pelate disc having 4-8 pendant microsporangia. The stalk is completely surrounded by microsporangia. The axis of the male strobilus contains a broad apex which is consumed in the formation of a stamen. In young male strobilus microsporangia are compactly arranged but at maturity they get loosened and undergo dehiscence. Presence of peltate micro-sporangiophores is an important characteristic feature of *Taxus*. Mature microsporangium is surrounded by an epidermal layer followed by two wall layers and sporogenous tissue. The outermost sporogenous cells differentiate into a tapetum. The sporogenous cells function as microspore mother cells and undergo meiosis to form microspores

or pollen grains. These microspores are arranged isobilaterally or tetrahedrally for some time. Microsporangium is similar to that of *Pinus* and exhibit eusporangiate type of development. Four to eight archesporial cells develop hypodermally. These cells divide to form above mentioned wall layers and sporogenous tissue.



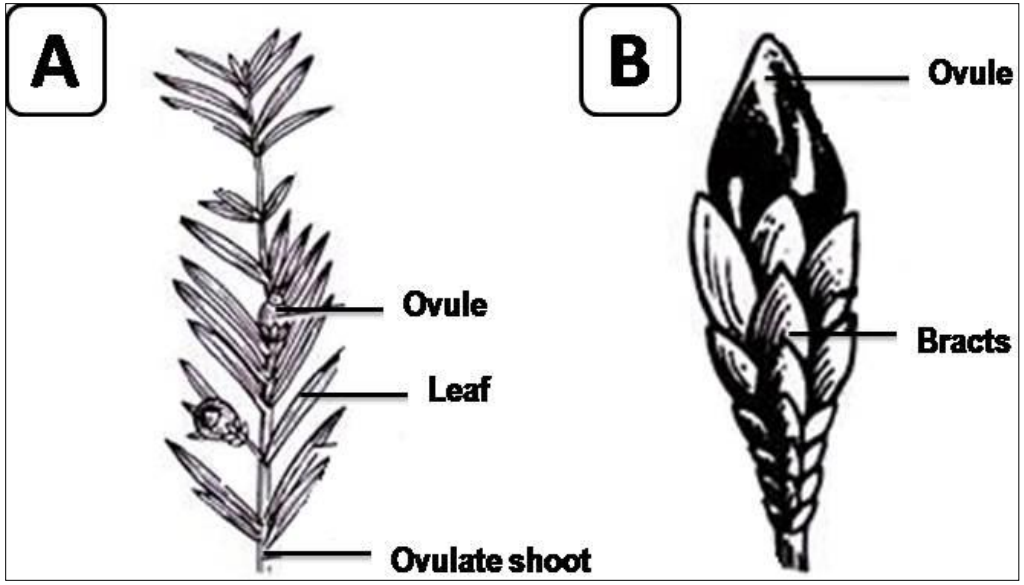
A- Male shoot of T. baccata with staminate stobili, B-Single branch with male strobilus, C- Male strobilus wiyh many stamens, D- L S of male srobilus.

Female Strobilus or Female Flower

The female strobili in Taxus are greatly reduced and they hardly appear as cones or strobili. They arise in the axils of leaves early in the season but mature in the next season. Each female reproductive organ comprises of a short primary axis containing scaly leaves or bracts which are arranged in opposite decussate manner. A short secondary axis which develops from the axil of upper three scaly leaves contains few pairs of scaly leaves and a terminal ovule.

The ovule is orthotropous and rounded or oval in shape, contains thick integument which is present upto the base of ovule forming a long micropyle. Integument is free of nucellus and is differentiated into outer and inner fleshy and middle stony layers. Two vascular strands enter the integument from the base of the ovule and reach up to its top. A ring-like outgrowth called a aril or cupule develops from the base of the integument surrounds the entire ovule. At young stage aril is green and saucer-shaped after maturity it becomes red and cup-shaped. Aril is also supplied by two minute and rudimentary vascular bundles. Pollen chamber and nucellar beak are absent. The apex of the female gametophyte changes into a flask-shaped structure called tent-pole which however disappears in the later stages. In general about 10 archegonia develop in a female gametophyte but sometimes the number of archegonia may reach upto 25. In the young ovule develops an archesporial initial which divides penclinally to form an outer parietal cell and an inner primary sporogenous cell. The primary

sporogenous cell further divides to form many sporogenous cells, out of which one or more functions as megaspore mother cells. The megaspore mother cell undergoes meiosis to form four megaspores arranged in linear tetrad. Out of these lowermost megaspore remains functional while others degenerate. The functional megaspore nucleus divides and develops into multicellular gametophyte.



A- An ovulate shoot of T. baccata, B- Female strobilus with terminal ovule

Male Gametophyte

Microspore develops into a male gametophyte. At the time of shedding or dispersal it is uninucleate, Microspores are carried away by wind, few microspores reach up to the micropyle, where they are caught into pollination drop. Microspores are then taken up to the nucellus where germination occurs. During germination, the microspore nucleus divides to form a tube cell and a generative cell. The exine gets ruptured and the intine protudes out to form a pollen tube. The tube nucleus moves towards the tip of the pollen tube. The generative cell divides into a stalk cell and a body cell. Body cell later divides to form two unequal male gametes.

Female Gametophyte

The functional megaspore develops into the female gametophyte. It enlarges in size and its nucleus divides by many free nuclear divisions to form about 256 nuclei. A central vacuole develops after which free nuclei become parietal in position. There is a centripetal wall formation due to which the whole of the tissue ultimately becomes cellular. Certain archegonial initials are differentiated towards the micropylar end of the cellular female gametophyte. Each archegonium contains 2 to 4 neck cells with a large venter containing an egg nucleus. Venter canal cell is absent. The cytoplasm of egg cell contains small and large cytoplasmic inclusions, a zone of mitochondria and lipid globules.

Fertilization and Embryogeny

Fusion of functional male nucleus (larger one) and the egg nucleus occurs to form a zygote. The tip of the pollen tube present near the neck of the archegonium, bursts, both the male gametes, along with stalk nucleus and tube nucleus, are liberated into archegonial venter after which fertilization occurs. As already stated the remaining three nuclei (stalk nucleus, tube nucleus, smaller male cell) degenerate. Because there are several archegonia present in female gametophyte, many eggs can be fertilized, which results in simple polyembryony. However, only one embryo attains maturity to form one ovule. The zygotic nucleus divides to form 16 to 32 nuclei. Only 16 free nuclei are formed in *Taxus baccata* according to Sterling (1948). After division, cell formation begins the entire structure becomes cellular. Some of the cells present at the tip of this pro-embryo develop into embryo while the cells above it elongate to suspensor. Complete endosperm is absorbed by developing embryo, hence the seed is non-endospermic. Mature embryo is orthotropous and dicotyledonous.

Seed

Seed coat is three-layered. The outermost layer is thin, brown and detaches soon, middle layer is hard and stony wand the innermost layer is fleshy. The mature seeds are covered by a red coloured aril. The aril serves to attract birds and help seed dispersal. The germination is hypogeal.

REPRODUCTION IN GNETALES

Gnetum is dioecious and hence male and female reproductive organs are borne on separate plants. These reproductive organs are arranged into cones or strobili. These stobili are further organized into inflorescences. Cones arise in axils of paired and decussate scale leaves. These leaves are fused at base to form boat shapes structures. These are called as bracts. Bracts bear accessory or auxillary buds which may also develop into inflorescence.

Male strobili and male gametophyte

Male strobili consist of elongated axis having nodes and internodes. Nodes bear scaly bracts arranged in whorls. Bracts fuse to form a cup shaped structure called as cupule or collar. Each node of axis has a collar and above each collar are present 2-6 rings of male flowers and every ring contains a number of male flowers (arranged alternately in rings). Above rings of male flowers is present a ring of abortive female flower or ovules. In *G. africanum* the cone can be bisexual as in this case ovules in the ring becomes fertile.

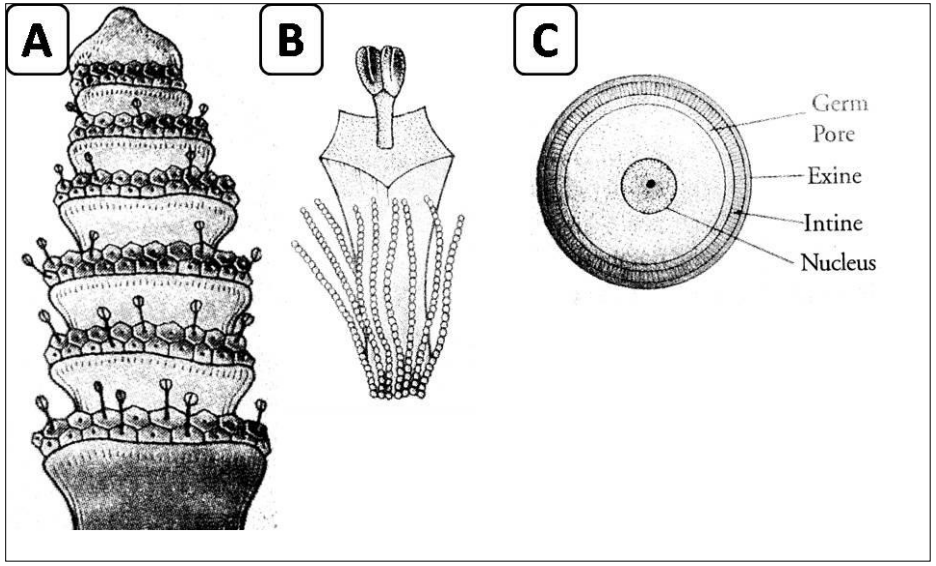
Male cones are compact and enveloped within bracts. Due to elongation of internodes collar separate from one another. Collars contain sclereids of different shape and size and laticiferous tubes. Each male flower is enclosed within perianth. It contains a stalk and on apex of stalk two anthers are present. Each anther possesses single locule or microsporangium. At the time of maturity (before dehiscence) stalk elongates and emerges out of perianth, as a result of which anthers and stalk become visible. Male flowers are interspersed with uniserate and multicellular hairs.

Cells present below collar become meristematic and divide to form an annular outgrowth (below collar). Upper cells of this outgrowth differentiate to form initials of ovule which eventually develop into abortive ovule on uppermost ring. Lower cells of outgrowth also differentiate to form primodia which develops rings of male flowers. Initials of male flower divide to form a centrally located cushion of cells which is surrounded by a cellular sheath (which develops into perianth having a slit). The central mass formed deepens and is differentiated into two lobes which develop into anther. From lower cells of central mass is formed a stalk, due to elongation of this stalk, upper part is pushed out through the slit (in perianth). Differentiation of male flowers is basipetalous.

A microsporangium develops in each anther. Each anther lobe is surrounded by wall layers. The innermost layer which encloses a sporogenous tissue is called tapetum. Sporogenous cells become loose and spore mother cells (SMC) . These SMC undergo meiosis to from spore tetrads. Male gametophyte is represented by microspore or pollen grain, which is spherical in shape, uninucleate and enveloped by thick and spiny exine and thin intine. It is wingless and is released at three nucleate condition.

Nucleus of microspore divides into two daughter nuclei which are either present free in cytoplasm or an evanescent plate is formed between them. One of the nuclei again divides and hence there are present three nuclei which have been named as prothallial nucleus, generative nucleus and tube nucleus. After release of pollen further development occurs in pollen chamber. Exine gets ruptured and intine grows to form a pollen tube. The tube nucleus is first to move into the pollen tube. Generative nucleus gets surrounded by a membrane and forms generative cell. It also migrates into pollen tube and divides to form two unequal male gametes.

Prothallial nucleus never enters pollen tube and it rather disappears before pollen tube is formed. Thomson have however state that no such prothallial nucleus is formed in male gametophyte and by first division only tube nucleus and generative cell are formed.



Gnetum ula, A- Male cone, B- Single male flower, C-Structure of microspore

Female strobilus

Female strobilus exhibit similarity with male strobili except that in female strobilus only a single ring of 4-10 ovules is present above collar. At younger stages male and female cones cannot be morphologically distinguished, they can only be differentiated when ovules grow and project beyond the collar. Only few ovules attain maturity and rest of them fall down. Ovules contain a centrally located nucellus which contains female gametophyte and is surrounded by three envelopes. Outermost envelope is perianth, middle one is known as outer integument and innermost envelope is called inner integument. The outer two envelope contains stomata, sclereids and laticiferous ducts. Perianth is thick and fleshy. The innermost third envelope is fused with the nucellus at the base while its upper portion remains free and forms micropylar tube. The micropylar canal gets closed after pollination.

In the young conditions, an outer epidermal layer can be distingushed in the nucellus. Two to four archesporial cells which develop below epidermis at a later stage divide periclinally to form outer primary parietal cells and inner sporogenous cells. The sporogenous cells divide to form megaspore mother cells. Female gametophyte possesses tetrasporic development and 256-1500 free nuclei are formed. Active development is initiated in 2-4 female gametophyte out of which one reaches maturity. Free nuclei get disposed into central vacuole. Gnetum lacks archegonia. One to two nuclei at micropylar end act as egg nuclei.

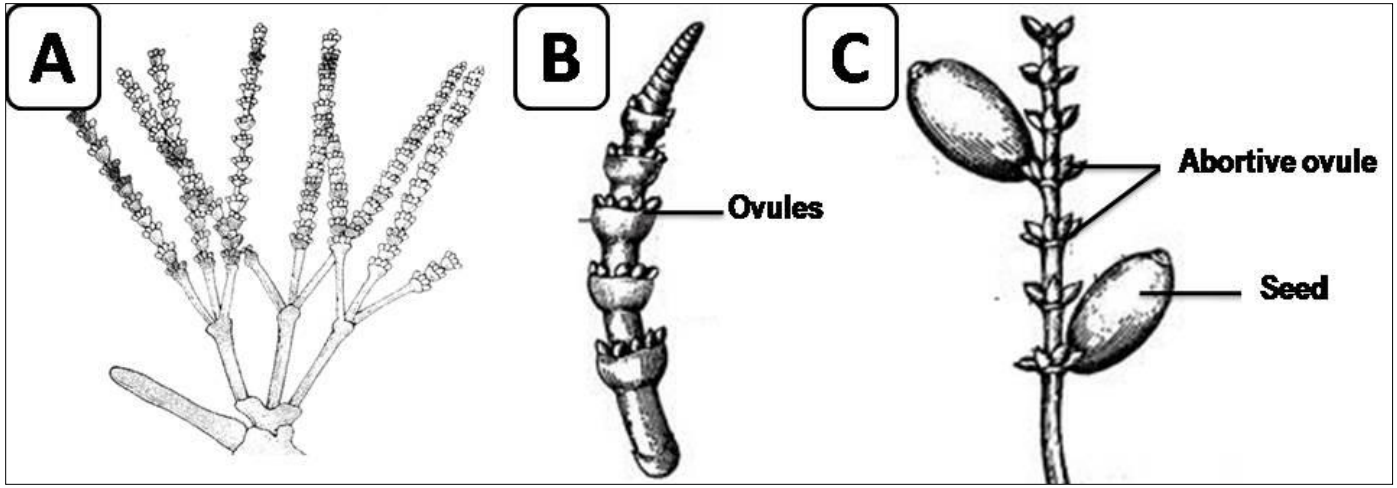
Cells of nucleus of female gametophyte divides to form a tissue called as pavment tissue. The tissue consists of several rows, the tissue however later gets absorbed. Nucellar cells are rich in starch. Nucellus gets completely absorbed by growing gametophyte except for a small portion from which develops cuticle.
Pollination is mediated by wind. The micropylar tube secretes a fluid in which pollen grains get entangled and finally reach up to the pollen chamber. During fertilization, the pollen tube pierces through membrane of female gametophyte, tip of pollen tube bursts and the male cells are released. One of the male cells enters the egg cell. The male and female nuclei fuse to form zygote.

Endosperm

Lower part of gametophyte becomes cellular before fertilization occurs and upper part becomes cellular after fertilization. Zygote is surrounded by cells in different stages of its development into embryo. A peculiar feature of endosperm is that its cells become multinucleate and the nuclei may fuse to form polyploidy cells. In some cells two nuclei may fuse and in other more nuclei may fuse, the ploidy level varies from haploid (n) to polyploid (upto 12n).

Gametophyte in *Gnetum* shows variations from other gymnosperms in the following mentioned aspects:
Gametophyte becomes partially cellular before fertilization and cell formation is completed after fertilization. In some species gametophyte may be free nuclear before fertilization.

Cells are multinucleate and show graded ploidy.
Since archegonium is absent free nuclei or specialized cells act as eggs.
Tetrasporic development in gametophyte.

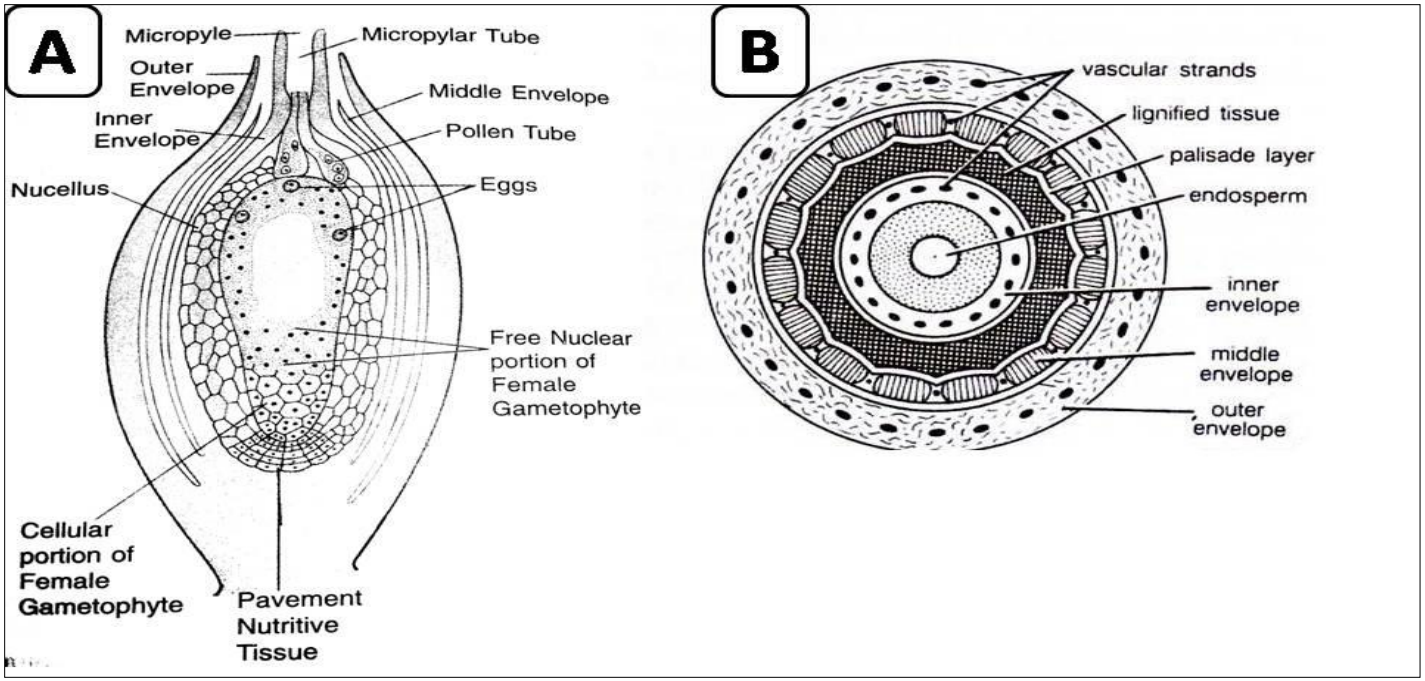


Gnetum latifolium, A- Branch with female cones, B-Mature female inflroscence, C- Female inflorescence with seeds.

Seed

Thoday (1911) has describes the structure of seed of *G. africanum* and *G. ula*. The seed contains three envelopes as described below:

Envelope	**Features**
Outer envelope	Green in colour, succulent, free from other envelope, made up of parenchymatous cells, contains sclereids and fibres, epidermis punctured by stomata.
Middle layer	Stony layer, main functionis to provide protection, stomata, sclereids, fibres, latex tubes present. Palaside like cells present below epidermis,
Inner layer	Made up of parenchymatous cells, lacks stomata, sclereids and laticifers. This layer forms micropylar tube.



Gnetum, A- L S of ovule, B- T S of seed

SUMMARY

- Coniferales are usually monoecious with distinct male and female cones.
- Pollination is anemophyllous.
- Seeds are endospermic and winged
- Microsporangia are sessile about 2-8 in number and are bilocular or trilocular.
- Seed germination occurs without any resting period and is of epigeal type.
- *Taxus baccata* is an evergreen tree and is found in North and South America, Europe and Philippines, Algeria, Morocco and India.
- *T. baccata* possesses a huge trunk and all branches exhibit unlimited growth.
- The female strobili in Taxus are greatly reduced and male strobili are yellow coloured which develop in axil of foliage leaves.
- Pollen chamber and nucellar beak are absent in *Taxus*
- Cone have an attractive appearance due to crimson or scarlet colour of mature cones.
- Microsporangiate strobilus (or male cone) is a compound structure having a quadrangular cone axis.
- *Gnetum* genus includes about 30 -35 species which comprises of woody trees, shrubs and climbers.
- *Gnetum* is dioecious and reproductive organs are arranged into cones or strobili.

SUGGESTED READINGS

- Kumar A. Botany for Degree Gymnosperm. S. Chand Publishing.
- S.P Bhatnagar and Alok Moitra Gymnosperms. Newage International publications