Structure and life cycle of *Gnetum*

- T.Y.B.Sc. SEM VI
- Gymnosperms

Classification:

Kingdom	: Plantae
Division	: Spermatophyta
Sub division	: Gymnospermae
Class	: Coniferophyta
	(Tree like habit, branched stem, simple leaves, pycnoxylic wood)
Order	: Gnetales
	(Shrubs or trees, dimorphic shoots and leaves, medullary rays multiseriate, resin canals absent, compound strobilus, orthotropous ovules, 2 cotyledons in seed)
Family	: Gnetaceae
Genus	: *Gnetum*

Distribution:

Gnetum, represented by about 40 species is confined to the tropical and humid regions of the world. Nearly all species, except G. microcarpum occur below an altitude of 1500 metres. Five species (*Gnetum contractum, G. gnemon, G. montanum, G. ula and G. latifolium*) have been reported from India. *Gnetum ula* is the most commonly occurring species of India. Majority of species of *Gnetum* are climbers or shrubs.

Species found in India:

Gnetum ula: It is a woody climber having branches with swollen nodes. It is found in Western Ghats near Khandala , forests of Kerala, Nilgiris , of Andhra Pradesh and Orissa. *Gnetum contractum*: A scandent Godawari district shrub growing in Kerala, Nilgiri Hills and Coonoor in Tamil Nadu. *Gnetum gnemon*: A shrubby plant found in Assam (NagaHills, Golaghat and Sibsagar). *Gnetum montanum*: A climber with smooth, slender branches, swollen at the nodes. It is found in Assam, Sikkim and parts of Orissa. *Gnetum latifolium*: A climber found in Andaman and Nicobar Islands.

Habit/ external morphology:

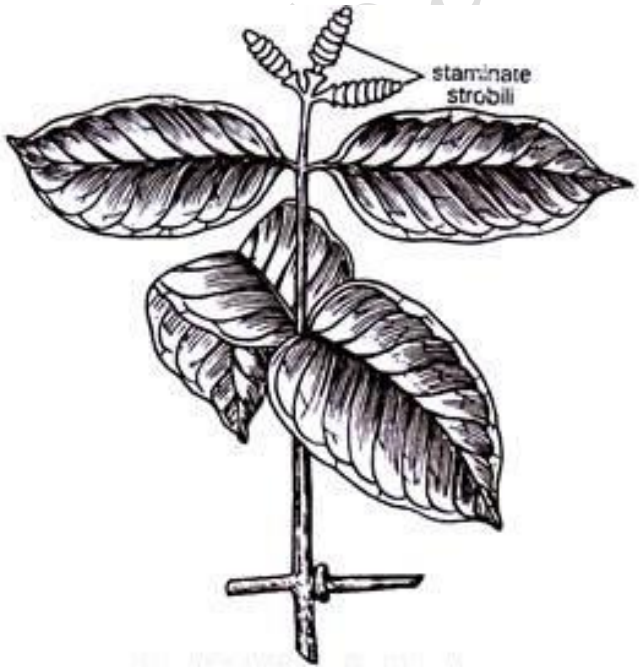
Majority of the *Gnetum* species are woody climbers (*G. ula, G. montanum*) except a few shrubs and trees (*G. gnemon*). *G. trinerve* is apparently parasitic. *Gnetum* is a sporophytic plant which looks very much like an angiospermic plant. It has true roots, stem and leaves.

Stem is woody; two types of branches are present on the main stem of the plant, i.e. branches of limited growth (dwarf branches) and branches of unlimited growth (long branches). Each branch contains nodes and internodes. Stem of several species of *Gnetum* is articulated (jointed). In climbing species, the branches of limited growth or short shoots are generally unbranched and bear the foliage leaves.

The leaves (8- 10) are arranged in decussate pairs. There are only 2 leaves at each node, the node is swollen. The leaf pairs often lie in one plane giving the appearance of a pinnate leaf to the branch. The leaves are large and oblong-elliptic with entire margin and reticulate venation (like dicotyledons). Distal end (apex) of the leaf is acute. The petiole is very short. Some scaly leaves are also present.

The root system consists of a tap root and lateral branches. It resembles that of the dicot plants.

The plants are dioecious i.e. male and female plants are separate. The reproductive organs are called strobili. They are produced at the tip of dwarf branches.



A twig of *Gnetum*

Anatomy of *Gnetum* : Young root :-

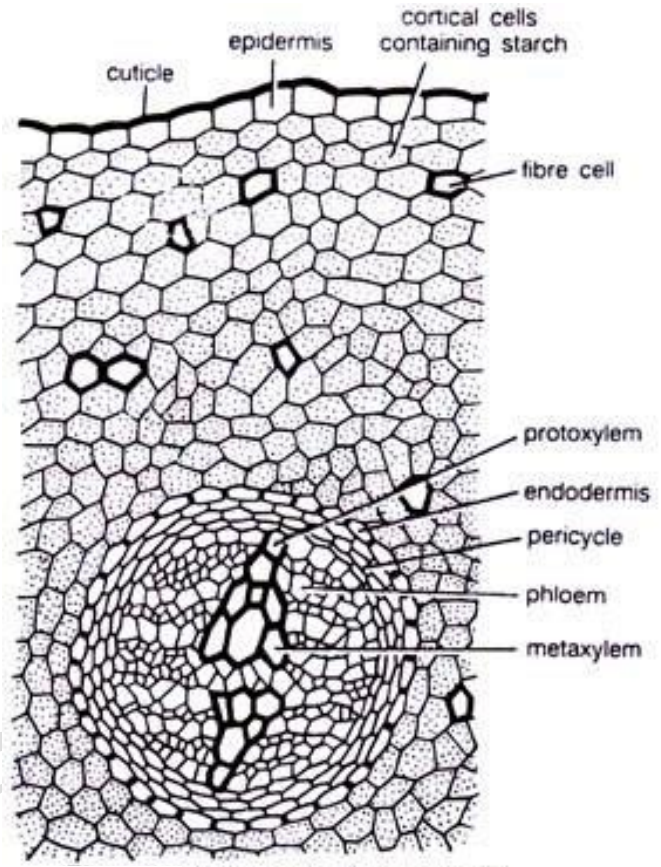
T.S. of the root is circular in outline. It shows an outer epidermis, a cortex and a vascular region.

Epidermis: It is the outermost single layer. The epidermal cells are thin walled, rectangular and compactly arranged. The cells also give out unicellular root hairs; hence the epidermis is also called epiblema. Epidermis is cuticularized.

Cortex: Young root has several layers of starch filled parenchymatous cortex, the cells of which are large and polygonal in outline. Cortex lies just beneath the epidermis.

Endodermis: An endodermal layer is distinguishable (innermost layer of cortex). Casparian strips are seen in the cells of the endodermis. The endodermis is followed by 4- 6 layered pericycle.

Vascular bundle: Roots are diarch or triarch. Xylem is radial and exarch. Small amount of primary xylem, visible in young roots, becomes indistinguishable after secondary growth. The xylem is surrounded by phloem. Pith is absent.



Gnetum. T. S. young root.

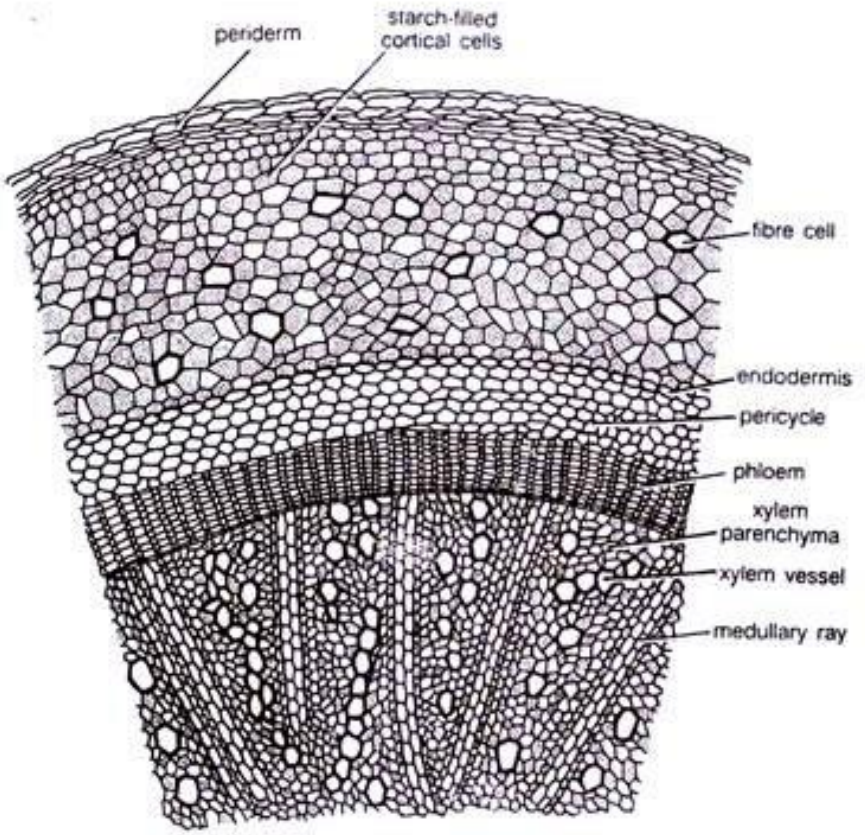
T.S. old root :

The secondary growth is of normal type. Small strips of cambium arise from the phloem to form a ring of cambium. This cambium produces xylem on the inside and phloem on the outside. A continuous zone of wood is present in the old roots. It consists of tracheids, vessels and xylem parenchyma. The tracheids have uniseriate bordered pits along with bars of Sanio. Vessels have simple or small small multiseriate bordered pits. Some of the xylem elements have starch grains. Bars of Sanio are generally absent in the vessels. Epidermis is replaced by periderm.

Xylem is traversed by medullary rays which are parenchymatous and have rays radially elongated cells. Calcium oxalate crystals are found in the cells of medullary rays.

Phloem consists of Sieve cells and phloem parenchyma. Some companion cells are present which arise from phloem parenchyma.

A Phellogen develops from the epidermis or outer layer of cortex. It produces cork towards the outside and secondary cortex towards the inside.



Gnetum. T. S. old root showing secondary growth.

T.S. of young stem (Primary structure):

A transverse section of young stem shows epidermis, cortex, endodermis and stele. It resembles a typical dicot stem.

Epidermis: It is the outermost layer made up of compactly arranged rectangular cells with thin walls and possess heavy cuticle. The cells have papillate outgrowths. Sunken stomata are present.

Cortex: It lies below the epidermis. It is differentiated into outer chlorenchymatous cortex, middle parenchymatous cortex and sclerenchymatous cortex.

Outer cortex is 5- 7 cells in thickness & consists of polygonal cells rich in chloroplasts. Intercellular spaces are small.

Middle cortex is a few cells in thickness. It consists of compactly arranged thin walled cells containing stored food. Fibre cells are seen scattered in this layer.

Inner cortex is 2- 5 cells in thickness. The cells are thick walled and polygonal. Branched or unbranched pit canals are seen here.

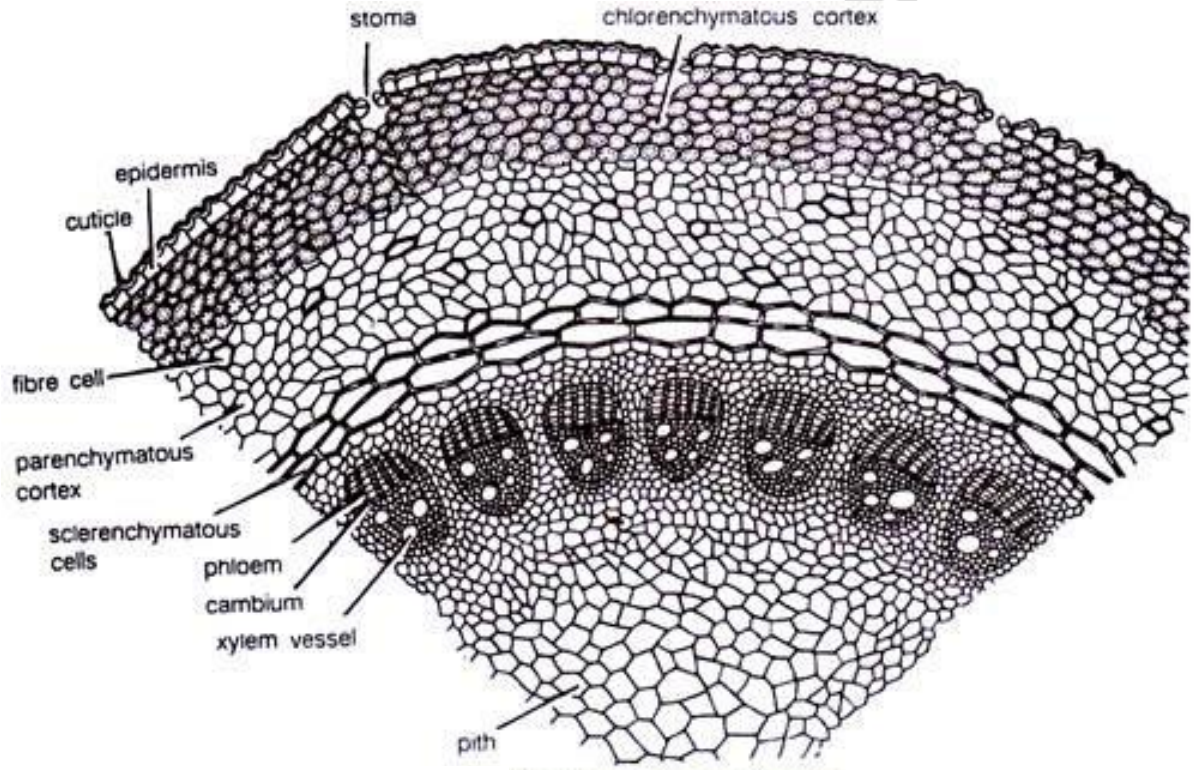
Endodermis: It is the innermost layer of the cortex. It consists of a single layer of thin walled cells and is not very conspicuous.

Stele: It consists of Pericycle, vascular bundles and pith.

Pericycle: It is not very conspicuous in the young stem.

Vasculature: 20- 24 vascular bundles are arranged in the form of a ring. VBs are conjoint, collateral, endarch and open. VBs are separated from each other by medullary rays. Each VB has an outer phloem, middle cambium and inner xylem tissue. Phloem consists of sieve tubes and phloem parenchyma. Cambium consists of elongated meristematic cells. Xylem consists of tracheids and vessels. Tracheids have a row of bordered pits on the oblique wall. Tracheids of protoxylem have annular spiral thickenings but those of metaxylem have reticulate thickenings.

Pith: It's in the centre of the stem; has polygonal parenchymatous cells & are thin walled and compactly arranged.



Gnetum. T. S. young stem.

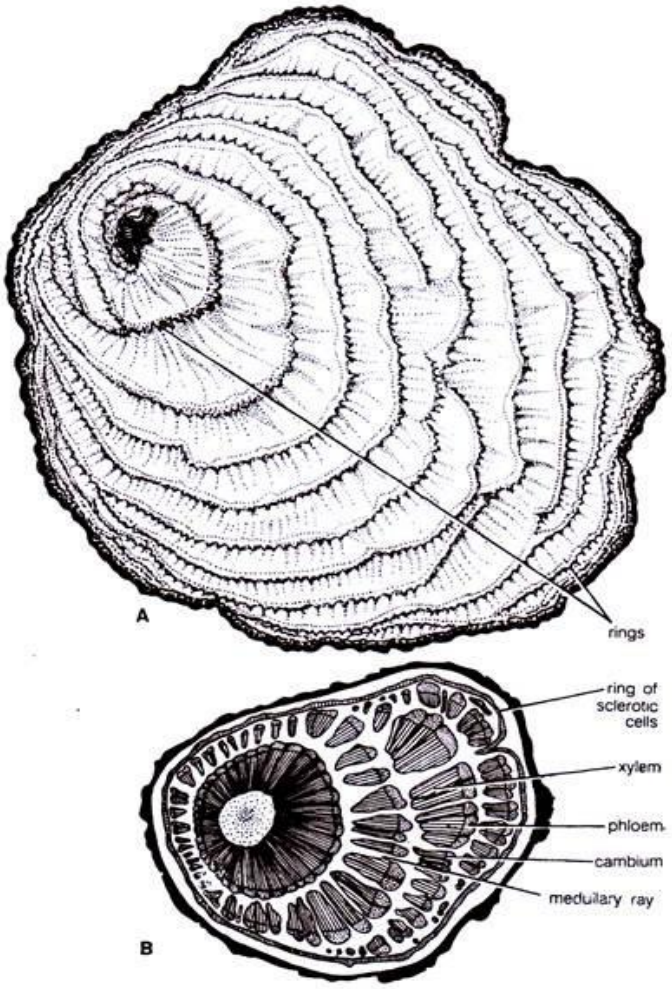
T.S. of old stem: secondary growth :-

The secondary growth is of normal type in erect woody species. It is similar to that in dicot stems. The parenchymatous tissue in between the vascular bundles give rise to strips of cambium called interfascicular cambium. These cambia join the cambia of the VBs and form a complete cambium ring. This cambium ring produces secondary phloem of the outer side and secondary xylem on the inner side. The inter

fascicular cambium produces broad parenchymatous medullary rays which connect the pith and cortex. A phellogen multiseriate is formed at the outer surface. It forms cork towards the outside and secondary cortex towards the inside.

Anomalous secondary growth :-

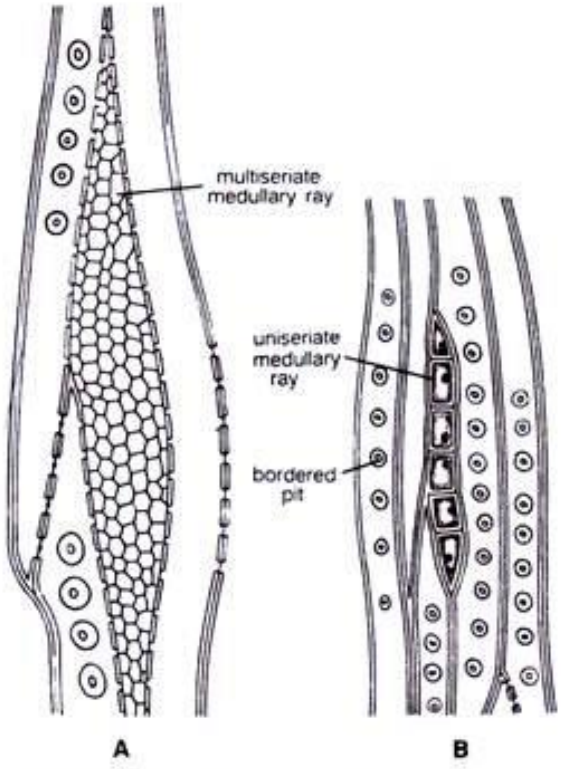
It takes place in climber such as *Gnetum africanum*, *Gnetum ula* etc. Here, the normal secondary growth takes place as usual in the erect species. Later on, many cambia differentiate one after the other in the cortex; each one forming phloem outside and xylem inside. The VBs so formed are wedge shaped. This ring of VBs is called the coaxial ring. The coaxial ring gets incorporated into the normal growth ring. Usually the 2nd co axial ring is produced after the first ring gets completed. Sometimes when the co axial ring is incomplete the wood is called eccentric. There seems to be no correlation between seasonal changes and development of coaxial rings. So it should not be confused with the normal growth rings or annual rings. A phellogen arises from the epidermis or outer layer of cortex. It forms cork/ periderm outside and secondary cortex inside.



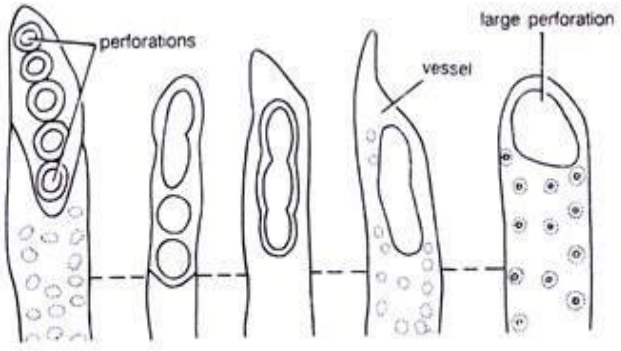
Fi *netum ula*. T.S. old stem showing number of rings formed because of the anomalous secondary growth. (modified after Maheshwari and Vasil, 1961).

T.L.S. of *Gnetum* stem:

In tangential longitudinal section of stem, the wood xylem and medullary rays are visible. Bordered pits are present on both radial as well as tangential walls. Medullary rays are either uniseriate or multiseriate and are made of polygonal parenchyma. Sieve of phloem consists of oblique and perforated sieve plates.



Gnetum gnemon. T.L.S. stem. A, Showing multiseriate medullary ray; B, Showing uniseriate medullary ray.



Gnetum africanum. Perforation in the end walls of the vessels. (after Duthie, 1912).

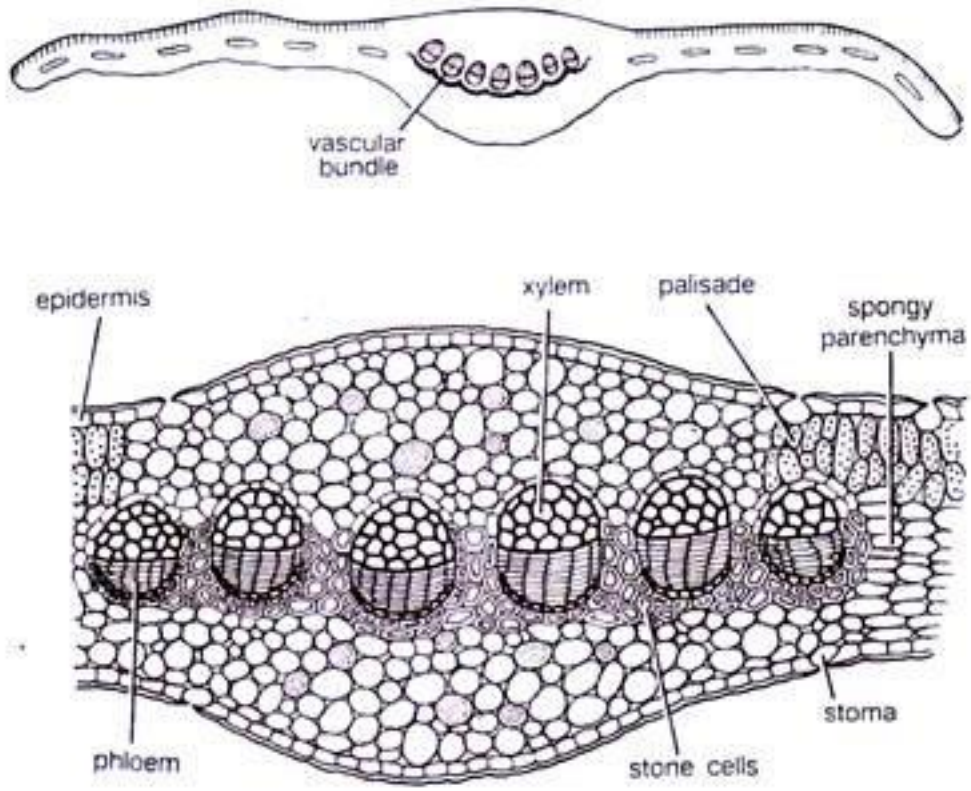
Leaf anatomy:-

The internal structure of *Gnetum* is very similar to that of angiospermic leaves. The leaf is differentiated into an epidermis, a mesophyll and a vascular region.

Epidermis: It is the outermost layer. It is differentiated into upper epidermis on the dorsal side and lower epidermis on the ventral side. The epidermal cells have undulate (wavy) walls. The lower epidermis has stomata while upper epidermis is lined with a thick cuticle.

Mesophyll: It lies below the epidermis. It is differentiated into a palisade layer and a spongy parenchyma. The palisade layer consists of a single layer of elongated cells rich in chloroplasts. The spongy layer consists of loosely arranged lobed cells. In the midrib region, the cells are polygonal and compactly arranged. They are parenchymatous. This region also has latex cells, branched sclerides and fibres also.

Vascular region: The vascular bundles are arranged in the form of an arch. Each vascular bundle is conjoint, collateral, and endarch. The xylem of each bundle is located upwards while phloe
downwards. The vascular bundle is surrounded by a sheath of thick walled cells. There is a patch of stone cells at the base of each bundle. The xylem consists of tracheids, vessels and xylem parenchyma. The phloem is made up of sieve tubes, phloem parenchyma and companion cells.



Gnetum. Upper-T.S. leaf (diagrammatic) ; Lower-T.S. leaf (a part cellular).

Reproduction:

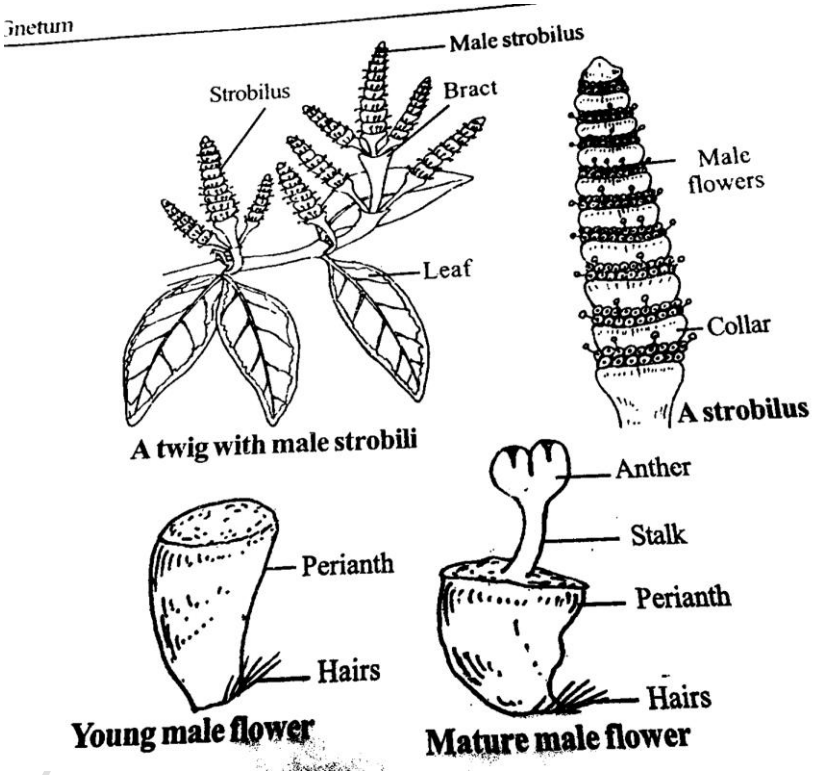
Gnetum is a dioecious plant i.e. the male and female strobili are produced by separate plants. For convenience, the reproductive organs are called flowers. *Gnetum* is heterosporous. It produces microspores inside the male flowers and megaspores inside the female flowers. The microspore gives rise to pollen tube which contains the male gametophyte. The megaspore produces an embryo sac inside the ovule. It represents the female gametophyte.

Male strobilus :-

A cluster of male strobili is borne at the tip of dwarf branches. It is called an infloresence- panicle type. It has a slender axis which bears a few stout warted nodes. Each strobilus is about 5 cm. long. Each

node has 2 small opposite bracts. A single strobilus emerges from the axil of each bract. The margin of the leafy bracts fuses to form a cupule like structure called a collar.

A strobilus may have 10- 25 collars. In the axil of each collar, 35 whorls of male/ staminate flowers arise. Each whorl may have 20- 40 flowers. The flowers are sessile on the axis. Thus the strobilus looks like a spike infloresence. In some infloresences, a few male flowers are replaced by female flowers but they never develop into seed (they are sterile). They are aborted during the early stage of development. Each male flower is enclosed within a perianth when it is young. When the flower matures, the perianth opens and 2 anthers attached to a short stalk come out. The anthers are unilocular; the flowers are unisexual male.



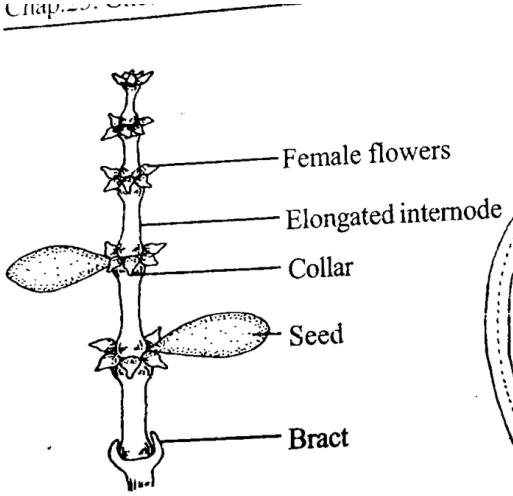
Gnetum male strobilus

Female strobilus :-

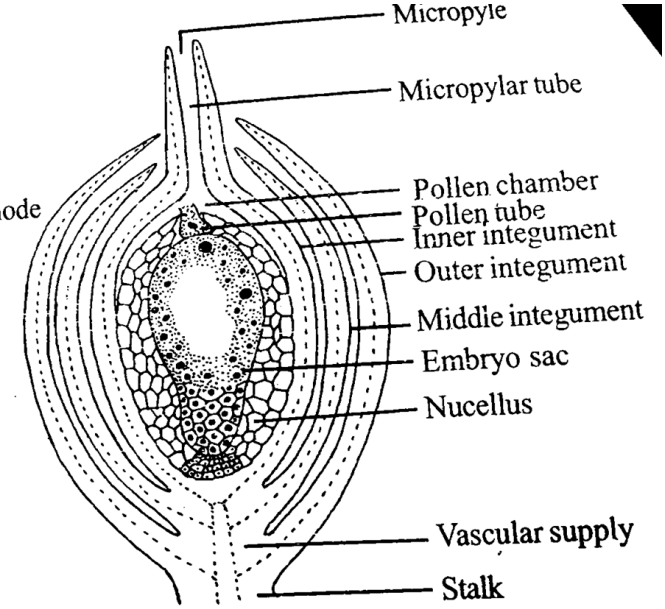
The female strobilus of *Gnetum* looks similar to the male strobilus. It is 5- 7 cm long and consists of a short axis with nodes. Each node has 2 opposite leafy bracts which are fused to form the collar. Usually there are 4- 8 female flowers above a single collar. The number of flowers may be fewer on the upper collars. In a young strobilus, the collars are compact and female flowers are tiny (almost invisible). As the cone matures, the internodes elongate and the female flowers get exposed. Only a few of the flowers develop into seeds.

Each female flower consists of a short stalk and an ovule (megasporangium). The ovule is made up of spherical nucellus surrounded by 3 envelopes called integuments. The integuments arise in acropetal succession. The innermost integument extends beyond the others to form a micropylar tube. It

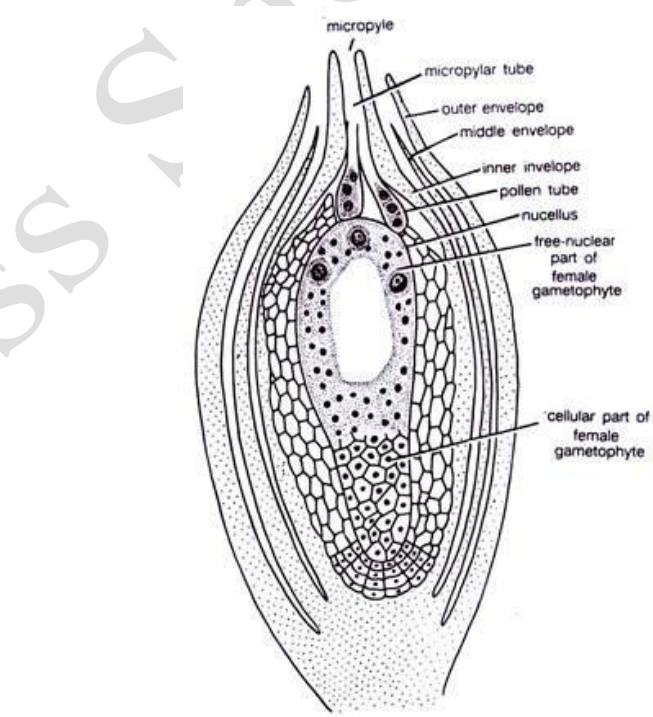
is fused to the lower half of the nucellus and forms a pollen chamber towards the micropylar end. In some species, the middle integument is stony. All the 3 integuments receive vascular supply.



Female cone of Gnetum.



Structure of an ovule.



Gnetum. L.S ovule.

The integuments :-

There are different views regarding the morphological nature of the integuments:

1. The outer integument is analogous to the ovary and the inner two are the real integuments Van Tieghem (1869).
2. The 3 integuments are the splitting products of a single integument (Strausburger , 1872).
3. The outer integument is analo to and the inner two are the real integuments as in an angiospermic (Beccari, 1877).
4. The outer 2 integuments are perianth and the inner one is analogous to ovary. (Lignier and Tison, 1912).

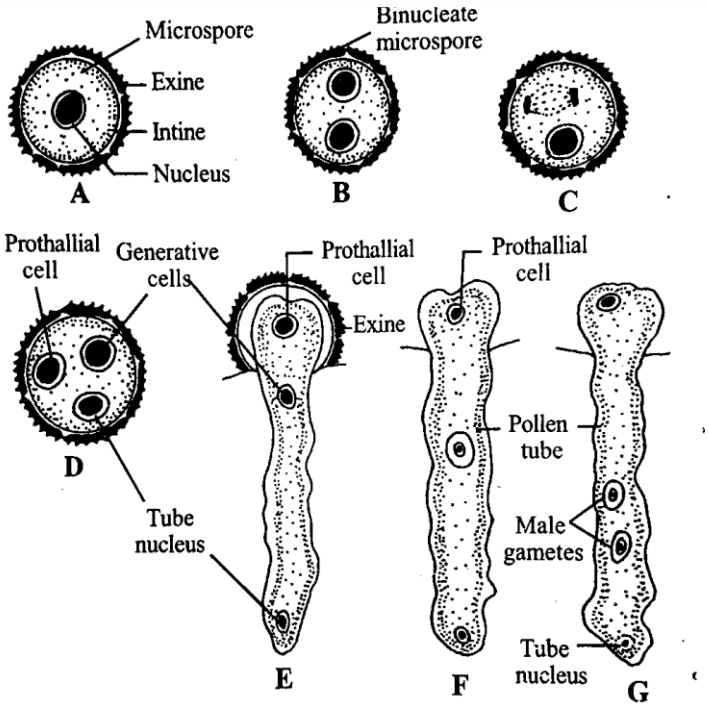
Gametophytes :-

Gnetum is a diploid sporophytic plant. It produces 2 types of spores- heterosporous.
As the plant is dioecious, the microspores and megaspores are produced in 2 separate individuals. The microspores germinate to form a tubular male gametophyte. The megaspores give rise to embryo sacs or female gametophytes. Both male and female gametophytes are very much reduced.

Microspore and development of male gametophyte :-

The microspore is the 1st cell of the male gametophyte. It is a haploid cell; spherical in shape; bounded by 2 layers- The intine and exine. Exine is the thick outer layer and bears spiny outgrowths. Intine is the smooth inner layer. The spore contains a haploid nucleus and dense cytoplasm. The nucleus divides into 2 daughter nuclei. One of the daughter nuclei redivides into 2 thus forming a trinucleate cell. Usually the microspores are shed at the trinucleate stage.

Further development takes place inside the pollen chamber of the ovule. The exine then ruptures and the intine protrudes out to form a pollen tube. One nucleus approaches the growing tip of the pollen tube and guides its growth towards the embryo sac; hence it is called tube nucleus. The 2nd nucleus remains inside the grain and plays no role; it is called stalk cell or prothallial cell. The 3rd nucleus develops a cell wall around it to form the generative cell. This cell divides into 2 equal or unequal male gametes. One of these gametes fuses with the egg to form the zygote.



Microspore and developmental stages of male gametophyte.

Female gametophyte :-

The female gametophyte (mega- gametophyte) is endosporic. It is produced inside the ovule. During early stages, there are 8- 16 megaspore mother cells in the nucellus of each ovule. Each of these megaspore mother cells undergoes meiosis to form 4 haploid nuclei which further form 4 cells. This 4 celled structure inside the sac like structure is called embryo sac or female gametophyte. Thus 8- 16 embryo sacs are produced inside each nucellus. Out of these 8- 16 embryo sacs, only 1 develops further, the rest disorganise. Inside the functional embryo sac, free nuclear division takes place and 256 to 1500 free nuclei are formed. The embryo sac elongates towards the chalazal side and a large vacuole develops in the centre. The nuclei of the chalazal side form proper cells while the nuclei at micropylar end remain free. This is the mature female gametophyte.

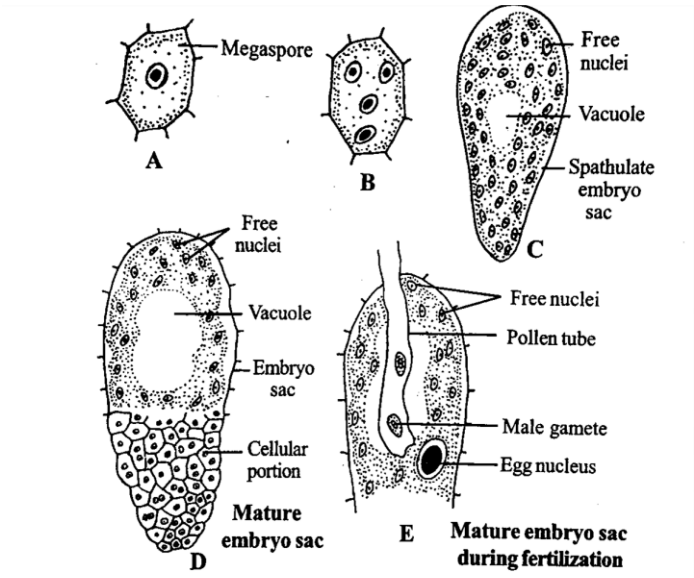


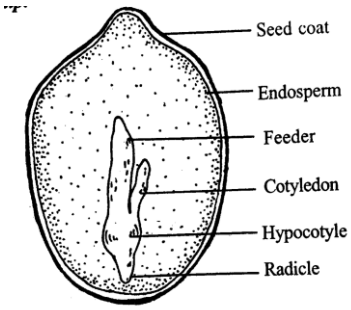
Fig.25.15: Development of female gametophyte of Gnetum.

Fertilization :-

After reaching the pollen chamber, the microspore germinates to form pollen tube. The generative cell and tube nucleus enter the pollen tube. When the pollen tube approaches the embryo sac, 1 or 2 free nuclei of the embryo sac enlarge and act as female nuclei. The pollen tube penetrates the micropylar end of the embryo sac and ruptures. The generative cell divides into 2 male gametes which are released in the free embryo sac. One male gamete fuses with the egg cell to form diploid zygote. The other fuses with a free nucleus to form a diploid endosperm. The zygote then develops into an embryo.

Seed :-

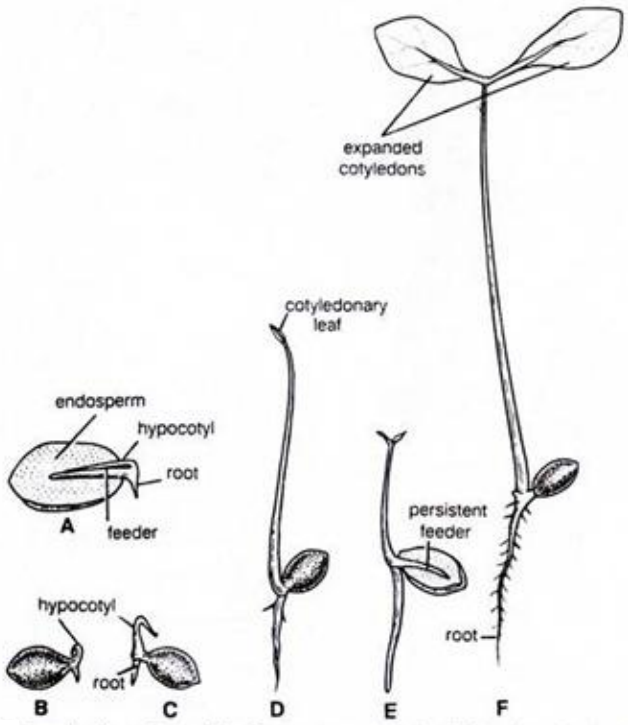
The seed is an oval or slightly elongated structure. It is green to red in colour. It is bound by a three layered envelope. The outer envelope is parenchymatous with fibres and sclerides. The middle envelope is stony. The inner envelope consists of columnar cells. Inner to the inner envelope, there is a layer of parenchymatous tissue. This surrounds the endosperm. A strip of nucellus lies at the micropylar end of the seed. A single embryo is embedded in the endosperm of the seed. It consists of stem apex, 2 cotyledons and a root tip.



A seed of Gnetum.

Seed germination :-

Seed germination is epigeal type. Seeds are shed when embryo development is just complete. They germinate 11-12 months after falling down on the soil. The root emerges and bends down to enter the soil. It forms a tap root system. 2 cotyledons come out by splitting the seed coat & become the first 2 leaves. A plumule arises from the middle of the 2 cotyledons & forms shoot. The seedling so formed grows into a diploid sporophytic plant.



Germination of seed in *Gnetum gnemon*. (modified after Madhulata, 1960).

Economic importance of *Gnetum* :-

1. Seeds of *G. gnemon*, *G. ula*are roasted & eaten.
2. Bark of *G. gnemon* yields fibres for ropes.
3. Wood of *G. gnemon*is used for making paper pulp.
4. Seed kernels of *G. ula* yield oil that can be used to cure rheumatism & used as illuminant. It is also used as cooking oil.
5. *G. montanum*is used as fish poison.

Life cycle of *Gnetum*:

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