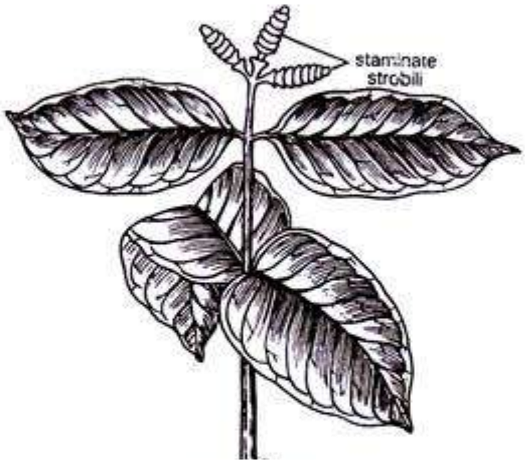
Gnetum

Distribution

1. Gnetum, represented by about 40 species is confined to the tropical and humid regions of the world.
2. Nearly all species, except G. microcarpum, occur below an altitude of 1500 metres.
3. Gnetum ula is the most commonly occurring species of India.

Habit of Gnetum

1. Majority of the Gnetum species are climbers except a few shrubs and trees.
2. G. trinerve is apparently parasitic.
3. Two types of branches are present on the main stem of the plant, i.e. branches of limited growth and branches of unlimited growth.
4. Each branch contains nodes and intenodes
5. In climbing species the branches of limited growth or short shoots are generally un-branched and bear the foliage leaves.
6. The leaves (9-10) are arranged in decussate pairs
7. They often lie in one plane giving the appearance of a pinnate leaf to the branch.
8. The leaves are large and oval with entire margin and reticulate venation as also seen in dicotyledons.
9. Some scaly leaves are also present.



Anatomy of Gnetum

(i) Root

1. Young root has several layers of starch-filled parenchymatous cortex,
2. the cells of which are large and polygonal in outline.
3. An endodermal layer is distinguishable.
4. Casparian strips are seen in the cells of the endodermis.
5. The endodermis follows 4-6 layered pericycle.
6. Roots are diarch and exarch.
7. Small amount of primary xylem, visible in young roots, becomes indistinguishable after secondary growth.

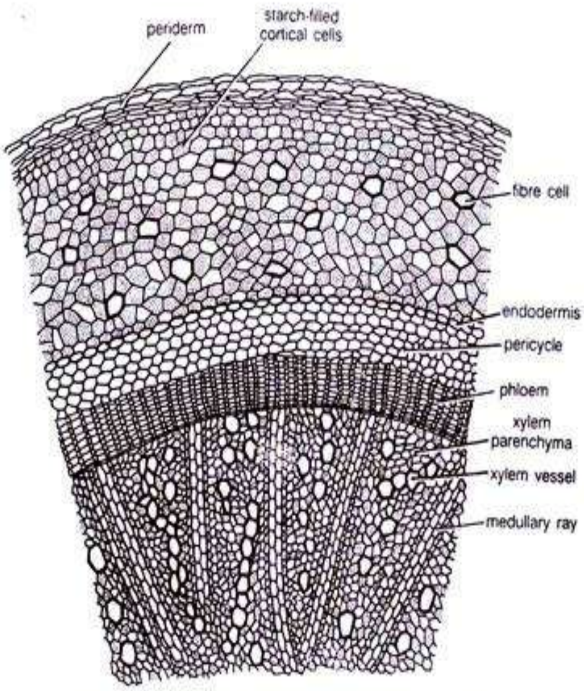


Fig. 13.4. *Gnetum*. T. S. old root showing secondary growth.

Secondary growth in root

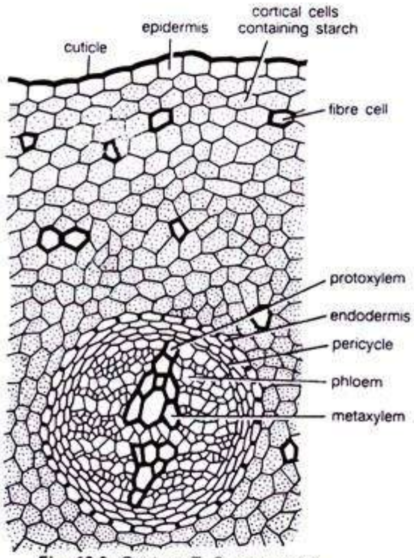


Fig. 13.3. *Gnetum* T. S. young root.

- The secondary growth is of normal type.
- A continuous zone of wood is present in the old roots (Fig. 13.4).
- It consists of tracheids, vessels and xylem parenchyma
- The tracheids have uniseriate bordered pits along
- Vessels have simple or small multiseriate bordered pits.
- Some of the xylem elements have starch grains.
- Phloem consists of sieve cells and phloem parenchyma

(ii) Young Stem

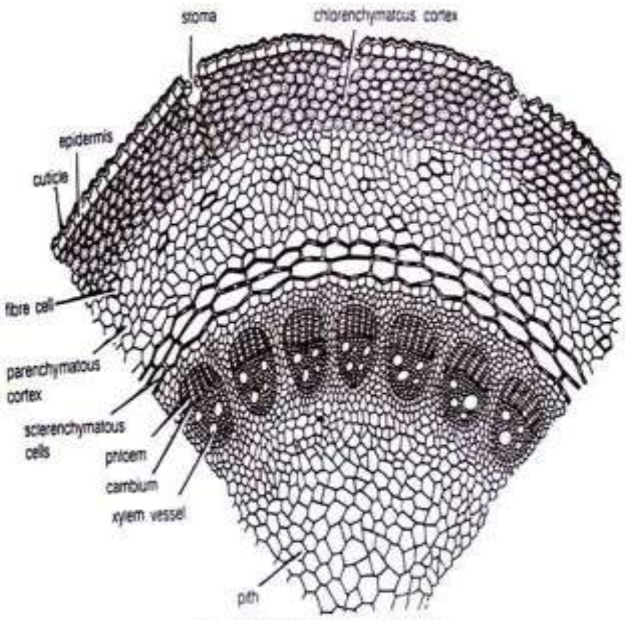


Fig. 13.5. Gnetum. T. S. young stem.

- The young stem in transverse section is roughly circular in outline, and resembles with a typical dicotyledonous stem.
- It remains surrounded by a single-layered epidermis, which is thickly circularized and consists of rectangular cells.
- Some of the epidermal cells show papillate outgrowths.
- Sunken stomata are present.
- The cortex consists of outer 5-7 cells thick chlorenchymatous region, middle few-cells thick parenchymatous region and inner 2-4 cells thick sclerenchymatous region.
- Endodermis and pericycle regions are not very clearly distinguishable.
- Several conjoint, collateral, open and endarch vascular bundles are arranged in a ring (Fig. 13.5) in the young stem.
- Xylem consists of tracheids and vessels.
- Presence of vessels is an angiospermic character.
- Protoxylem elements are spiral or annular while the metaxylem shows bordered pits which are circular in outline.
- The phloem consists of sieve cells and phloem parenchyma.
- An extensive pith, consisting of polygonal, parenchymatous cells, is present in the centre of the young stem.

Old Stem

1. Old stems in Gnetum show secondary growth.
2. In G. gnemon the secondary growth is normal, as seen also in the dicotyledons.
3. But in majority of the species (e.g., G. ula, G. africanum, etc.) the anamolous secondary growth is present.
4. The primary cambium is also present
5. The secondary cambium in different parts of cortex develops in the form of successive rings, one after the other (Fig. 13.6).
6. The first cambium cuts off secondary xylem towards inside and secondary phloem towards outside.
7. This cambium ceases to function after some time.

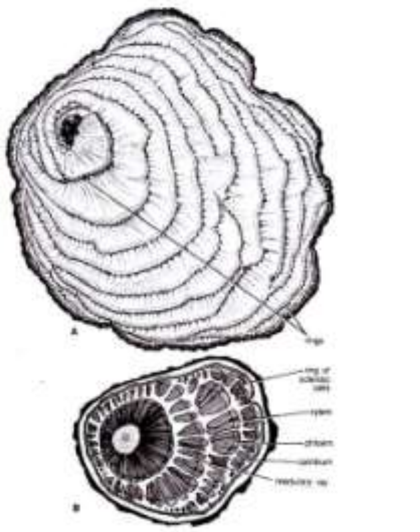


Fig. 13.6. Gnetum ula. T.S. old stem showing number of rings formed because of the anomalous secondary growth. (modified after Maheshwari and Vasil, 1961).

8. Another cambium gets differentiated along the outermost secondary phloem region, and the same process is repeated.
9. In the later stages, more secondary xylem is produced on one side and less on the other side, and thus the eccentric rings of xylem and phloem are formed in the wood.
10. This type of eccentric wood is the characteristic feature of angiosperm

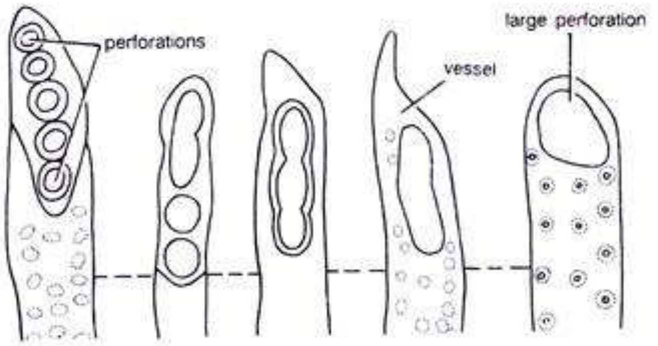


Fig. 13.7. *Gnetum africanum*. Perforation in the end walls of the vessels. (after Duthie, 1912).

11. The periderm is thin and develops from the outer cortex.
12. It also possesses lenticels.
13. The cortex also contains chlorenchvmatous and parenchymatous tissues along with many sclereids.
14. In old stems the secondary wood consists of tracheids and vessels.
15. Tracheids contain bordered pits on their radial walls while vessels contain simple pits.
16. Transitional stages (Fig. 13.7), containing one to many perforations in the terminal part of the vessels, are also seen commonly.

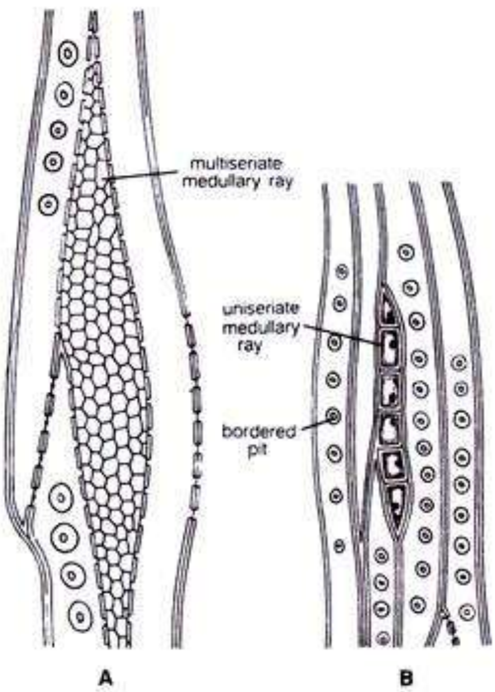


Fig. 13.8. *Gnetum gnemon*. T.L.S. stem. A, Showing multiseriate medullary ray; B, Showing uniseriate medullary ray.

17. In tangential longitudinal section (T.L.S) of the stem (Fig. 13.8), the wood xylem and medullary rays are visible.
18. Bordered pits on both the radial and tangential walls are present.
19. Medullary rays are either uniseriate or multiseriate and consist of polygonal parenchymatous cells.

20. They are boat-shaped (Fig. 13.8) and their breadth varies from 2 to many cells.
21. Sieve cells of the phloem contain oblique and perforated sieve plates.

Leaf

1. Internally, Gnetum leaves also resemble with a dicot leaf.
2. It is bounded by a layer of thickly circularized epidermis on both the surfaces.
3. Stomata are distributed all over the lower surface except on the veins.
4. The mesophyll is differentiated generally into a single-layered palisade and a well-developed spongy parenchyma.
5. The latter consists of many loosely-packed cells.

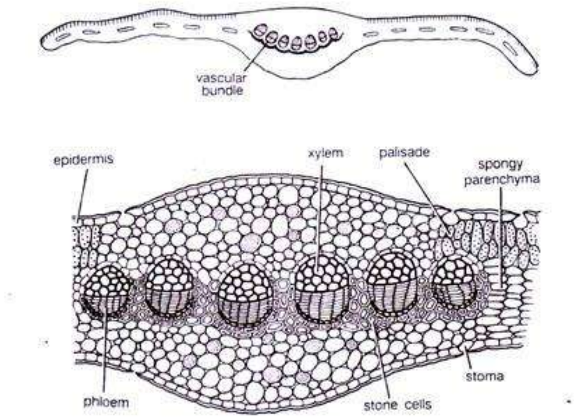


Fig. 13.9. *Gnetum*. Upper-T.S. leaf (diagrammatic) ; Lower-T.S. leaf (a part cellular).

6. Many stellately branched sclereids are present near the lower epidermis in the spongy parenchyma.
7. Many stone cells and latex tubes are present in the midrib region of the leaf.

8. Several vascular bundles in the form of an arch or curve are present in the prominent midrib region (Fig. 13.9).
9. A ring of thick-walled stone cells is present just outside the phloem.
10. Each vascular bundle is conjoint and collateral.
11. The xylem of each vascular bundle faces towards the upper surface while the phloem faces towards the lower surface.
12. The xylem consists of tracheids, vessels and xylem parenchyma while the phloem consists of sieve cells and phloem parenchyma.

Reproduction of Gnetum

1. Gnetum is dioecious.
2. The reproductive organs are organised into well-developed cones or strobili.
3. These cones are organised into inflorescences, generally of panicle type. Sometimes the cones are terminal in position.
4. A cone consists of a cone axis, at the base of which are present two opposite and connate bracts.
5. Nodes and internodes are present in the cone axis.
6. Whorls of circular bracts are present on the nodes.
7. These are arranged one above the other to form cupulas or collars (Fig. 13.10).
8. Flowers are present in these collars.
9. Upper few collars may be reduced and are sterile in nature in G. gnemon.

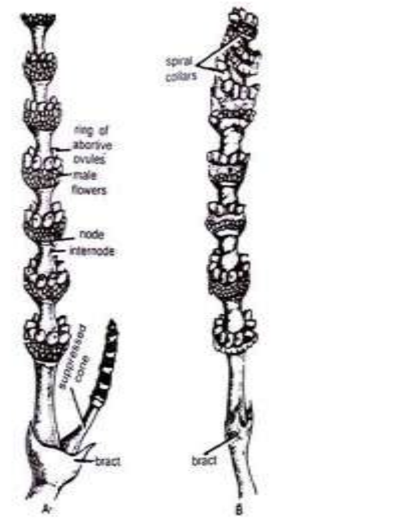


Fig. 13.10. Gnetum. A, A branch bearing a panicle of a well-developed male cone and a suppressed cone in G. ula; B, An old cone of G. gnemon showing spiral collars at the apical end. (Modified after Madhulata, 1960)

Male Cone and Male Flower

1. The male flowers are arranged in definite rings above each collar on the nodes of the axis of male cone.
2. The number of rings varies between 3-6.
3. The male flowers in the rings are arranged alternately.
4. There is a ring of abortive ovules or imperfect female flowers above the rings of male flowers.
5. Each male flower contains two coherent bracts which form the perianth (Fig. 13.11).
6. Two unilocular anthers remain attached on a short stalk enclosed within the perianth.
7. At maturity, when the anthers are ready for dehiscence, the stalk elongates and the anthers come out of the perianth sheath.
8. In Gnetum gnemon a few (2-3) flowers are sometimes seen fusing each other (Fig. 13.12).

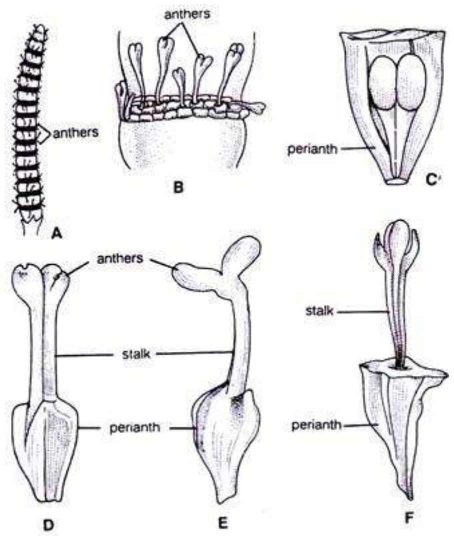


Fig. 13.11. *Gnetum ula*. A, A male cone; B, A part of 'A' showing male flowers; C, L.S. male flower; D-E, Male flowers with anthers emerged out of a perianth; F, A dehisced male flower.

Fig. 13.12. *Gnetum gnemon*. Showing fusion of male flowers. (modified after Madhulata, 1960).

Development of Male Flower (Figs. 13.13, 13.14):

1. In very young cones, certain cells below each collar become meristematic.
2. They divide repeatedly and form a small hump-like outgrowth.
3. Certain cells on the upper side of this annular outgrowth start to differentiate into the initials of the ovules.
4. They develop into abortive ovules which form the uppermost ring.
5. The cells of the lower side of this annular outgrowth form the primordium of male flower.

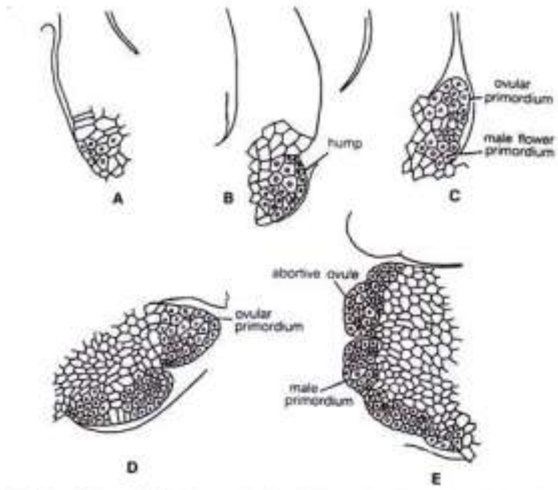


Fig. 13.13. *Gnetum ula*. Development of male flower (modified after Vasil, 1959).

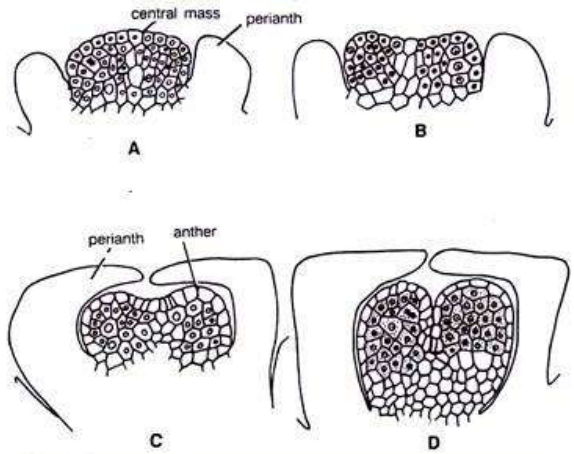


Fig. 13.14. *Gnetum ula*. Further development of male flower (modified after Vasil, 1959).

6. A central cushion of cells develops by the repeated divisions in the male flower primordium.
7. This cushion gets surrounded by a circular sheath called perianth.
8. The sheath-like perianth encloses the central cushion-like mass only partially.
9. With the development of a depression or notch in the central mass two lobes differentiate and later on develop into two anther lobes.
10. With the help of many divisions the basal portion of this central mass of cells starts to differentiate into a stalk.
11. This stalk elongates and pushes the anther lobes towards the outer side.

12. Each anther lobe remains surrounded by an epidermal layer and a few wall layers which enclose a microsporangium.
13. The innermost wall layer enclosing the sporogenous tissue is known as tapetum.
14. The sporogenous cells become loose, contract, round up and change into the spore mother cells.
15. In the process of microspore formation the tapetum and two wall layers are used for the developing microspores.
16. The spore mother cells undergo meiosis and ultimately the spore tetrads are formed.
17. The characteristic radial thickenings develop in the epidermal cells.
18. They help in the dehiscence of microsporangium.
19. The microspores are ornamented.

Female Cone

1. The female cones resemble with the male cones except in some definite aspects.
2. A single ring of 4-10 female flowers or ovules is present just above each collar (Fig. 13.15).
3. Only a few of the ovules develop into mature seeds (Fig. 13.15B).
4. In the young condition, there is hardly any external difference between female and male cones.
5. All the ovules are of the same size when young but later on a few of them enlarge and develop into mature seeds.
6. All the ovules never mature into seeds.

Ovule or Female Flower

1. Each ovule (Fig. 13 16) consists of a nucellus surrounded of three envelopes.
2. The nucellus consists of central mass of cells.
3. The inner envelope elongates beyond the middle envelope to form the micropylar tube or style.
4. The nucellus contains the female gametophyte.
5. There is no nucellar beak in the ovule of Gnetum.
6. Stomata, sclereids and laticiferous cells are present in the two outer envelopes.

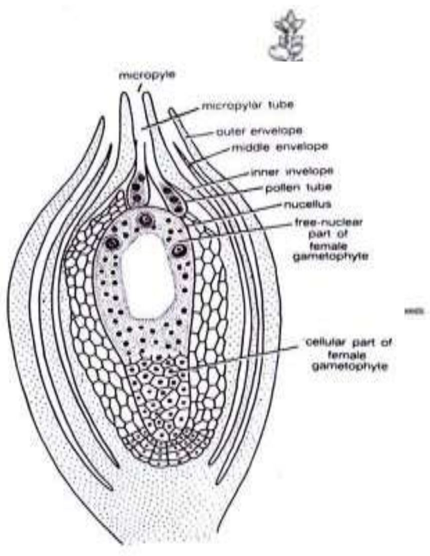


Fig. 13.16. *Gnetum*. L.S ovule

Abnormal Cones

1. More than one rings of ovules in the male cones in Gnetum gnemon have been reported by Thompson (1960) and Madhulata (1960).
2. Collars, arranged spirally in the female cones of G. gnemon and G. ula have been observed by several workers including Maheshwari (1953).

3. Pearson (1912) reported some cones bearing only two collars in G. buchholzianum.
4. Rarely, the lower collars in the male cones bear one or two fertile ovules whereas normal male flowers are present in the upper collars of the same cone.

Male Gametophyte

1. Pollen grains or microspores are roughly spherical in outline.
2. They are uninucleate and remain surrounded by a thick and spiny exine and thin intine.
3. Mature pollen grains are shed at three-nucleate stage.
4. These include prothallial nucleus, tube nucleus and generative nucleus (Fig. 13.20, Upper) in Gnetum Africanism and G. gnemon according to Pearson (1912, 1914).
5. This three-nucleate stage is reached by first dividing the microspore nucleus mitotically into two and then one of them again gets divided.
6. Further development is affected only in the pollen chamber.
7. The intine comes out by rupturing the exine and forms a pollen tube.
8. The tube nucleus migrates into the pollen tube.
9. The generative nucleus also adopts the same course and divides into two unequal male gametes in the tube.
10. Prothallial nucleus does not enter the pollen tube.

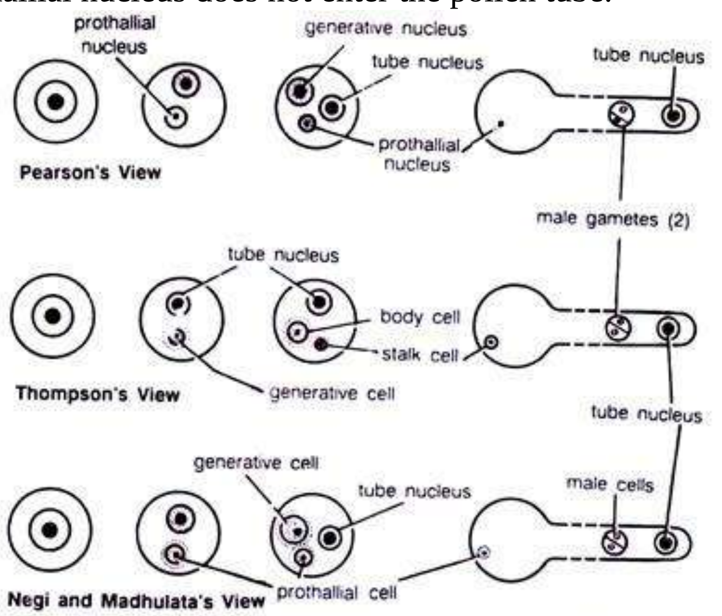


Fig. 13.20. Diagrammatic representation of different views on the development of male gametophyte in *Gnetum* (modified after Negi and Madhulata 1957)

Pollination

1. Wind helps in carrying the pollen grains up to the micropylar tube of the ovule.
2. The micropylar tube secretes a drop of fluid in which certain pollen grains get entangled and reach up to the pollen chamber.
3. The nucellus cells below the pollen chamber are full of starch.

Fertilization

1. At the time of fertilization, the pollen tube pierces through the membrane of the female gametophyte just near to a group of densely cytoplasmic cells.
2. The tip of pollen tube bursts and the male cells are released.
3. One of the male cells enters the egg cell.
4. The male and female nuclei, after lying side by side for some time, fuse with each other and form the zygote.

Endosperm

1. In all gymnosperms, except Gnetum, a cellular endosperm (Fig. 13.21) develops before fertilization.
2. In Gnetum, the cell formation, although starts before fertilization, a part of the gametophyte remains free-nuclear at the time of fertilization.
3. After fertilization the wall formation in the female gametophyte starts in such a way that the cytoplasm gets divided into many compartments.
4. Each of these compartments contains many nuclei (Fig. 13.21C).
5. All the nuclei of one compartment fuse and form a single nucleus.
6. The wall formation starts from the base and proceeds upwards.
7. The wall formation varies greatly in Gnetum.
8. Only the lower portion of the gametophyte may become cellular leaving the remaining upper portion free-nuclear.
9. Sometimes the entire gametophyte may become cellular.
10. In some cases the upper portion may become cellular instead of the lower portion.
11. Sometimes only the middle portion may become cellular and in still other cases there may not be any wall formation at all.
12. The characteristic triple fusion of the angiosperms is, however, absent in Gnetum.

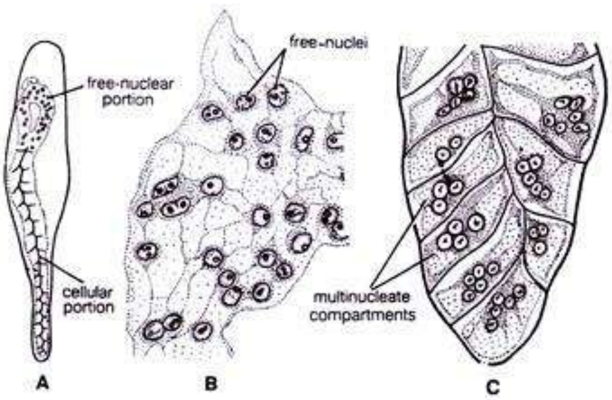


Fig. 13.21. *Gnetum ula*. A, Female gametophyte showing the development of endosperm; B, A part of upper portion of 'A'; C, A part of lower portion of 'A'. (modified after Vasil, 1959).

The Embryo

Maheshwari and Vasil (1961) have stated that in all the angiosperms the first division of the zygote is accompanied by a wall formation but in all gymnosperms, except Sequoia sempervirens, these are free-nuclear divisions in the zygote. Gnetum in this respect forms a link in between gymnosperms and angiosperms by showing both free-nuclear divisions as well as cell divisions.

Thompson (1916) opined that a two-celled pro-embryo is formed (Fig. 13.22 A). From each of these two cells develops a tube called suspensor (Fig. 13.22B). Now the nucleus divides and one of the two nuclei undergoes free-nuclear divisions forming four nuclei. The embryo gets organised by these four nuclei (Fig. 13.22C, D). There is no division in the other larger nucleus..

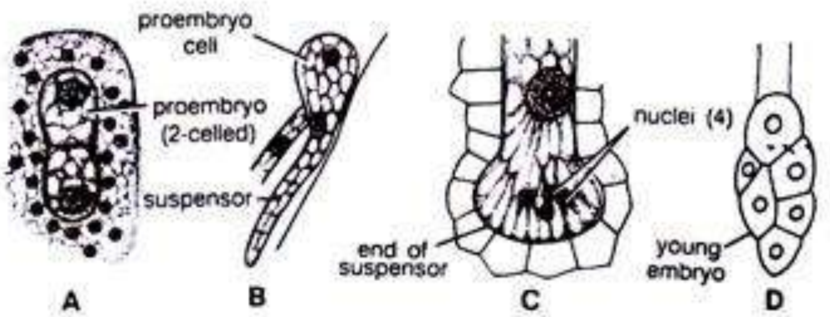


Fig. 13.22. *Gnetum.* Development of embryo. A-B, *G. gnemon*; C-D, *G. maluccense* (after Thompson,1916).

Seed

Gnetum seeds (Fig. 13.26) are oval to elongated in shape and green to red in colour. It remains surrounded by a three-layered envelope which encloses the embryo and the endosperm. Outer envelope is fleshy, and consists of parenchymatous cells. It imparts colour to the seed.

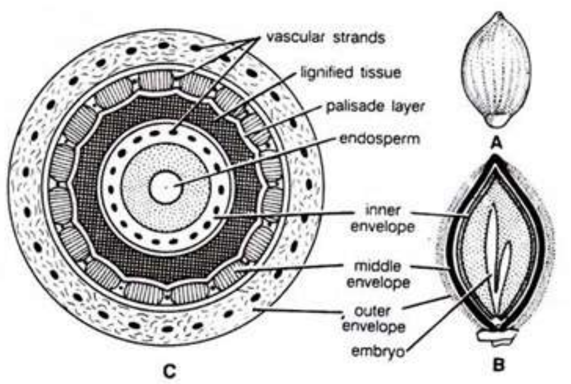


Fig. 13.26. *Gnetum.* A, An entire seed; B, L.S. seed; C, T.S. seed.

The middle envelope is hard, protective and made up to three layers, i.e., outer layer of parenchymatous cells, middle of palisade cells and innermost fibrous region. The inner envelope is parenchymatous. Branched vascular bundles traverse through all the three envelopes.

Germination of Seed

Germination is of epigeal type (Fig. 13.27). The cotyledons are pushed out of the seed. The hypocotyl elongates, and this brings the cotyledons out of the soil. The first green leaves of the plant are formed by the cotyledons. The first pair of foliage leaves is produced by the development of plumule. A persistent feeder is present up to a very late stage in the seed.

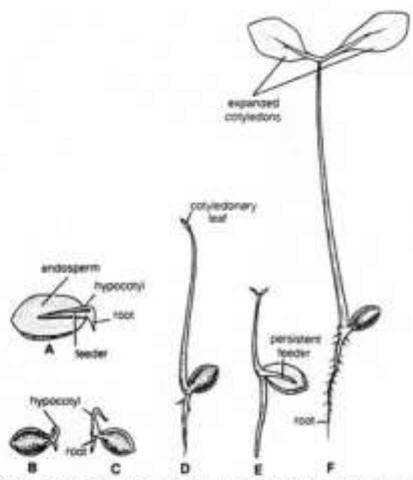


Fig. 13.27. Germination of seed in Gnetum gnemon. (modified after Madhulata, 1960).