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PAPER – IV PLANT DIVERSITY II (PTERIDOPHYTES, GYMNOSPERMS AND PALEOBOTANY

Unit - 4

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GYMNOSPERMS

UNIT IV

CONIFERALES

Coniferales, **"the dominant forest-makers of the world", are represented by about 54 living genera and over 500 species (Li, 1952). According to Foster and Gifford (1958) "the most dominant and conspicuous gymnosperms in the floras of the modern world belong to the order Coniferales".** They occur widely in Northern and Southern Hemispheres.

Many of the Coniferales have now become extinct. Exceptional diversity of conifers is represented in Western North America and Eastern and Central China. A rich coniferous flora is also available now in Australia and New Zealand. The Indian coniferous flora of Himalayas is represented by the genera such as Pinus, Abies, Picea, Cedrus, Tsuga, Cupressus, Juniperus, Araucaria and Podocarpus

Coniferales include extinct forms and living gymnosperms such as pine, spruce, cedar, yew, larch, etc. These are characteristic of temperate regions, majority of which are tall, evergreen forest trees.

They are usually monoecious with distinct male and female cones. They bear microsporophylls directly on the cone exis. Their female cones have ovules borne on ovuliferous scales in the axils of bracts arising from the axis of cone.

Coniferales represents an economically important group of gymnosperms. Its members are the source of valuable timber and pulp in the form of pines (Pinus), larch (Larix), firs (Abies), spruce (Picea), hemlock – spruce (Tsuga canadensis), Douglas-fir (Pseudotsuga douglasii), red wood (Sequoia), deodar (Cedrus), white cedar (Libocedrus), red cedar (Juniperus virginiana), etc.

Besides wood, conifers are also the source of several other articles such as oils, resins, terpentine, Canada-balsam, etc.

General Characters of Coniferales:

1. Plant body is sporophytic and the sporophytes are richly branched trees or shrubs. One species (Juniperus horizontals is prostrate. They are generally evergreen and xerophytic but genera such as Larix, Metasequoia and Taxodium are deciduous.

2. They are found from Carboniferous to the present times

3. Their growth habit varies from extremely tall trees as in Sequoia (Taxodiaceae) to miniature forms of Dacrydium (Podocarpaceae) which are only some centimeters high.

4. Branches may be of one kind or they may be dimorphic as in Pinus.

5. Stems contain a small pith and the secondary wood is pycnoxylic.

6. The secondary wood consists of tracheids with large uniseriate or rarely multiseriate pits on their radial walls.

7. Vessels are absent.

8. Resin canals are distributed in pith and cortex and sometimes also in wood.

9. Leaves are of two types, i.e. foliage leaves and scaly leaves. They are generally arranged spirally and only in opposite or whorled manner. Foliage leaves are filiform, needle-like and called needles. Occasionally the leaves are broad.

10. Plants are either monoecious or dioecious.

11. Reproductive organs are unisexual cones.

12. The sporophylls are generally arranged in the form of cones, and, therefore, the common name Conifers is given to them.

13. The micro-strobili or male cones are simple and contain many scale like microsporophyll‟s.

14. Pollen grains may be winged (Pinus) or un-winged (Taxodium). They are wind-dispersed.

15. The male gametes are non-motile.

16. The female cone or mega-strobili consist of many sterile bract scales and fertile ovuliferous scales.

17. On the upper surface or in the axil of ovuliferous scales are present one to many ovules.

18. Pollination is anemophyllous.

19. Female gametophyte is completely dependent on the sporophyte.

20. Oospore has the ability to produce more than one potential embryos, and thus conifers show the phenomenon of polyembryony.

21. Seeds are endospermic and winged with hard testa.

22. Two to many cotyledons are present in the embryo.

The family-wise splitting of the 42 genera of Coniferales, as mentioned by Sporne (1965), are as follows

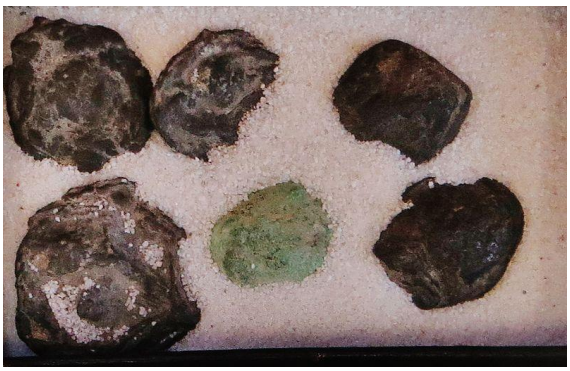
(i) Lebachiaceae:

Family of extinct genera including Lebachia, Ernestiodendron, Walchia, Walchiostrobus, Carpentiera and Buriadia.

(ii) Voltziaceae:

Family of extinct genera including Pseudovoltzia, Voltziopsis and Ullmannia.

https://commons.wikimedia.org/wiki/File:Ullmannia_frumentaria_fructification.jpg



ULLMANNIA(https://commons.wikimedia.org/wiki/File:Ullmannia_bronni.jpg)

(iii) Palissyaceae:

An extinct family including Palissya and Stachyotaxus.

(iv) Pinaceae:

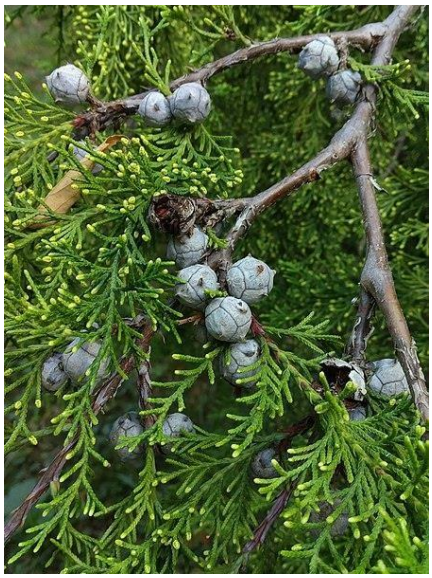
It includes living members, such as Abies, Pseudotsuga, Picea, Larix, Cedrus, Pinus and Tsuga.

(v) Taxodiaceae:

Includes living genera namely Sequoia, Sequoiadendron, Metasequoia, Taxodium, Cryptomeria, Sciadopitys and Athrotaxis.

(vi) Cupressaceae:

Includes living genera namely Cupressus, Chamaecyparis, Thuja, Juniperus, Callitris, Libocedrus and Papuacedrus.



https://commons.wikimedia.org/wiki/File:Thuja_occidentalis_-_cone_1_(aka).jpg

CUPRESSUS https://commons.wikimedia.org/wiki/File:Cupressus_lusitanica_06.jpg

(vii) Podocarpaceae:
Including living genera namely Phyllocladus, Dacrydium, Podocarpus, Saxegothaea, Microcachrys, Microstrobos and Acmopyle.

(viii) Cephalotaxaceae:
Including Cephalotaxus.

https://commons.wikimedia.org/wiki/File:Cephalotaxus_harringtonia_prostrata.jpg

(ix) Araucariaceae:
Includes Araucaria and Agathis.

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(i) Lebachiaceae:

Members of this fossil family, Lebachiaceae, are the earliest conifers known. These (Buriadia, Carpentieria, Ernestiodendron, Lebachia, Walchia and Walchiostrobus) have been reported from the early Permian and late Carboniferous deposits in different parts of the world.

After the extinction of the Cordaitales, Lebachiaceae members of Coniferales appeared on the earth. Three genera of Lebachiaceae (Ernestiodendron, Lebachia and Walchia), commonly called "Walchias" had their restricted distribution and were available in Asia, Europe and North America. Carpentieria was available in the regions of Central Europe and Morocco while Buriadia in Brazil and India.

Branching in Lebachia, Ernestiodendron and Walchia was very regular, quite characteristic and resembled with that of the present-day Araucaria heterophylla of family Araucariaceae of Coniferales. The main branches in these three genera were arranged in whorls of 5 or 6 on the trunk. The secondary branches were in two rows i.e. arranged in a distichous manner.

The leaves were scale-like or needle-like and each had a pointed apex. They were spirally arranged (Fig. 11.5A) on the ultimate branches. Some of the leaves were also attached directly on the main branches as well as on the trunk, and the tips of these leaves were bifid, a characteristic feature not known in the modern conifers.

In Carpentieria (Fig. 11.5B), all the leaves were quite characteristically forked. In Buriadia, a member reported also from India, the leaves were deltoid in shape The venation in these leaves was dichotomous.

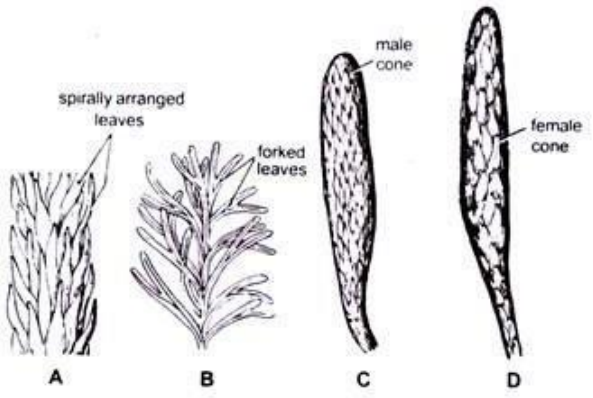


Fig. 11.5. A, A part of leafy axis of *Lebachia piniformis* showing spiral arrangement of leaves; B, Leafy axis of *Carpentieria frondosa* showing forked leaves; C, Male cone of *Lebachia piniformis*; D, Female cone of *L.piniformis*.

Lebachia, Ernestiodendron and Walchia were monoecious, i.e. both male and female cones developed on one and the same plant. In Lebachia piniformis the male and female cones (Fig. 11.5 C,D) were present singly at the tips of the ultimate branches. In some other species, however, the female cones were borne only at the tips of the penultimate branches of the plant.

The male cones of majority of the members of Lebachiaceae were simple strobili. Each male cone had a main axis on which the microsporophyll‟s were spirally arranged. Each microsporophyll had an un-forked apex and two microsporangia (Fig. 11.6 A).

Inside each microsporangium were present several pollen grains. Each pollen grain had a balloon-like air-sac. Except at the distal end, the body of the grain was surrounded by the air-sac.

The female cones of the Lebachiaceae resembled with those of Cordaitales. Several bracts were present in the female cones. Bracts were spirally arranged. They were subtended by secondary fertile shoots. Each bract had a bifid apex. The appendages on the secondary fertile shoots were arranged somewhat dorsiventrallv in Walchia, and mostly on the abaxial side in Lebachia.

In L. elongatus (Fig. 11.6B) several sterile appendages were present on each fertile short shoot. Of these sterile appendages one became fertile and terminated in an ovule.

The ovule was in erect position. Only several fertile appendages were present in Ernestiodendron filiciforme (Fig. 11.6C). The sterile appendages were absent in this species. Several sterile and fertile appendages were present in Walchiostrobus (Fig. 11.6D).

In some of its species reflexed ovules were present. The integument was bilateral in its symmetry i.e. it was formed by the fusion of two halves. Much is not known about the

internal structure of female cones. Some fossil records indicate that the integument was free from the nucellus in majority of Lebachiaceae.

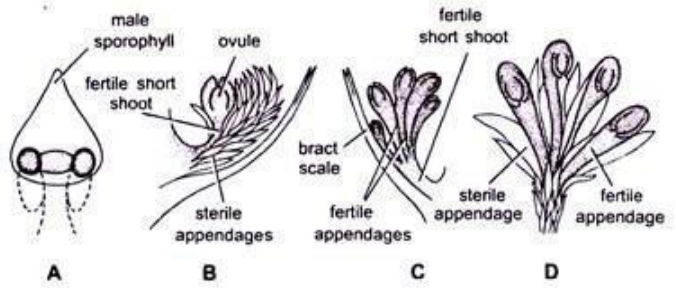


Fig. 11.6. A, A male sporophyll of *Lebachia hypnoides*; B, Fertile short shoot and bract scale of *Lebachia elongatus*; C, Bract scale and fertile short shoot in *Ernestiodendron filiciforme*; D, Fertile short shoot of *Walchiostrobus*.

(ii) Voltziaceae:

General Characteristics:

1. Voltziaceae is a family of fossil conifers represented by three genera, viz. Voltziopsis, Pseudovoltzia and Ullmannia.
2. These members were present luxuriantly during Upper Permian when members of Lebachiaceae had become extinct.
3. Female cones of Voltziaceae resembled greatly with those of Lebachiaceae
4. Fertile dwarf shoots of these members were more dorsiventral in nature than that of Lebachiaceae.
5. The fertile dwarf shoot of Pseudovoltzia liebiana (Fig. 11 7A) had three fertile appendages and five sterile appendages if observed from the adaxial side. Each fertile appendage had a single reflexed ovule.
6. In Ullmannia bronnii (Fig. 11.7B), the fertile dwarf shoot had only one fertile appendage (having a single reflexed ovule) and only one spathulate sterile appendage. Sporne (1965) opined that the presence of only one fertile and one sterile appendage **"was probably the result of extreme reduction and fusion."** Single sterile appendage of Ullmannia was "possibly homologous with the five sterile appendages of Pseudovoltzia".
7. In Voltziopsis africana (Fig. 11.7C) the ovules were exact and the fertile dwarf shoot had five sterile and five fertile appendages.

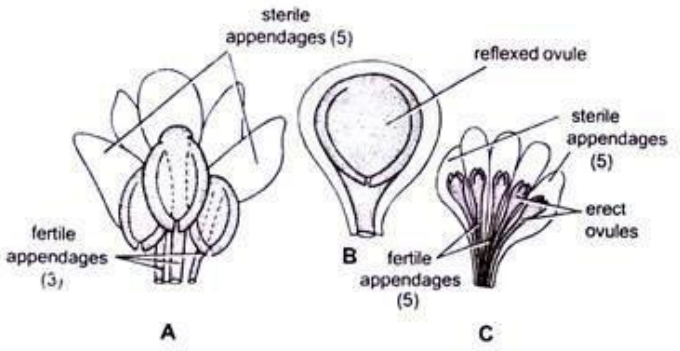


Fig. 11.7. A, Fertile dwarf shoot of *Pseudovoltzia liebiana* as seen from the adaxial side; B, Fertile dwarf shoot of *Ullmannia bronnii*; C, Fertile dwarf shoot of *Voltziopsis africana*. (after Florin).

(iii) Palissyaceae:

General Characteristics:

1. This is also a family of extinct Coniferales represented by two Mesozoic genera, viz. Palissya and Stachyotaxus.
2. Due to the absence of sterile appendages, these members resembled more closely with Ernestiodendron of Lebachiaceae.
3. Stachyotaxus elegans has been reported from the rocks of Late Triassic period of Mesozoic era of Europe and Greenland Its fertile dwarf shoot was fused with the subtending bract. Two ovules were present on the fertile dwarf shoot which was completely devoid of a sterile portion.
4. Palissya sphenolepis has been reported from the rocks of Jurassic period of Mesozoic era. As much as ten ovules were present on its each fertile dwarf shoot.
5. According to Florin (1958, 1963), Stachyotaxus of this family resembles closely with the Cephalotaxus of family Cephalotaxaceae of modern Coniferales, particularly in the arrangement of ovules on the fertile dwarf shoot.

(iv) Pinaceae:

General Characteristics:

Some of the major distinguishing features of Pinaceae, a family of living and modern Coniferales, are

1. Microsporophyll‟s bearing two pollen sacs.
2. Presence of winged pollen grains.
3. Ovulate strobilus cone-like.
4. Presence of two naked ovules on the upper surface of ovuliferous scales.
5. Seeds are dry and winged.
6. Plants show polyembryony.

Family is represented by 10 living genera and over 200 species. This is the largest family of Coniferales. From the point of view of economic importance, Pinaceae is at the top amongst all Coniferales.

These members provide most of the soft-wood timber which constitutes seven-eights of the world‟s total number. Genera of Pinaceae include Abies, Cathaya, Cedrus, Keteleeria, Larix, Picea, Pinus, Pseudolarix Pseudotsuga and Tsuga.

Distribution:

Pinus, one of the most important Coniferales, is represented by about 105 species. These are mainly distributed in the Northern Hemisphere, and found commonly in Northern Europe, Northern and Central America, subtropics of North Africa, India, Myanmar, Pakistan, Afghanistan, Indonesia, etc. (Fig. 11.8).

Six species of Pinus (P.roxburghii, P. wallichiana, P.insularis, P.gerardiana, P. armandii and P.merkusii) occur in India. They are distributed in Himalayas, north eastern India and some other parts of the country.

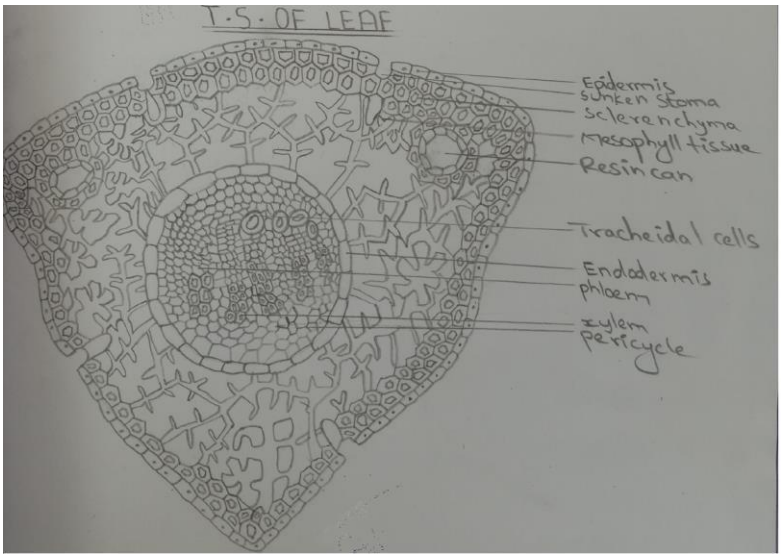
1. Pinus roxburghii (popularly known as “Chir”) grows from 460m to 1500m in Western Himalayas, extending to Bhutan and Eastern Nepal.
2. Pinus wallichiana (popularly known as “kail” or “blue pine” or „”Bhutan Pine”) grows from 1500m to 3000m in Kashmir valley, Shimla, Mussoorie and Eastern Nepal.
3. Pinus insularis (popularly known as “Khasi pine”) grows from 800m to 2000m in Garo, Khasi and Jaintia hills.
4. Pinus gerardiana (Chilgoza or Nioza) occurs in Northern Afghanistan, Tibet, Kashmir and Pakistan at an elevation of 1830m to 3600m.
5. Pinus armandii (North-eastern Himalayas).
6. Pinus markusii (Tenasarn Pine) is found in Andaman and Nikobar Islands and Myanmar.

Some other species, found in India but not indigenously, are Pinus canariensis (Kashmir), P.caribaea (Assam), P.halepensis (Srinagar), P.massoniana, P.patula, P.pinaster and P.taeda (Kulu, Manali), P. radiata (Nilgiris) and P.thunbergii (West Bengal).

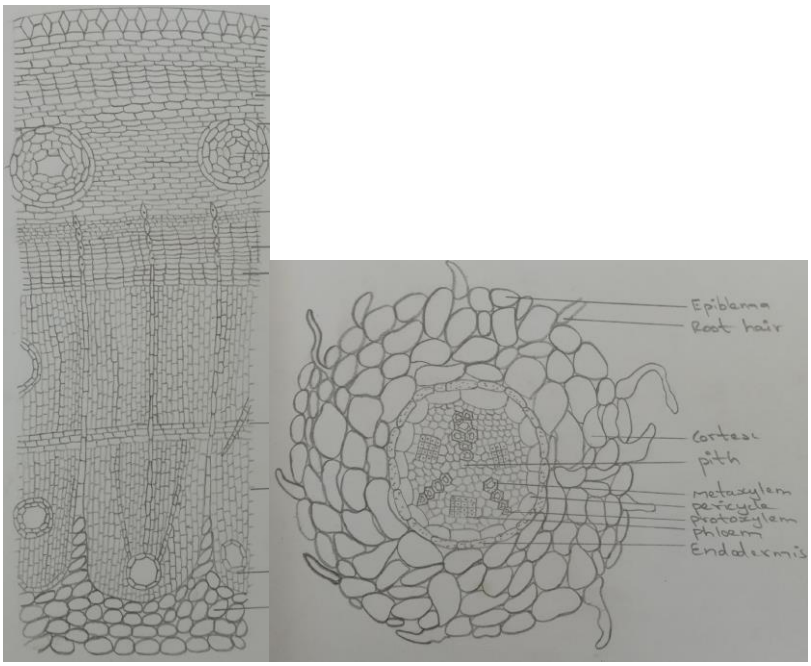
Pinus trees survive for a very long period. Maheshwan and Konar (1971) have mentioned the presence of a tree of Pinus aristata, which is more than 4600 years old and still occasionally produces cones in Inyo National Forests of California, U.S.A.

PINUS- HABIT TS OF LEAF

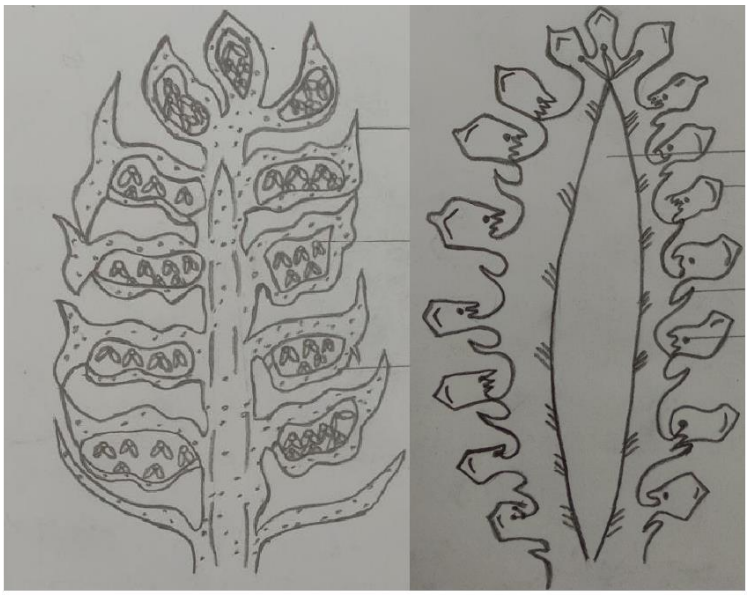
TS of Old Stem



TS OF ROOT



Pinus Male Cone and Female Cone (LS)



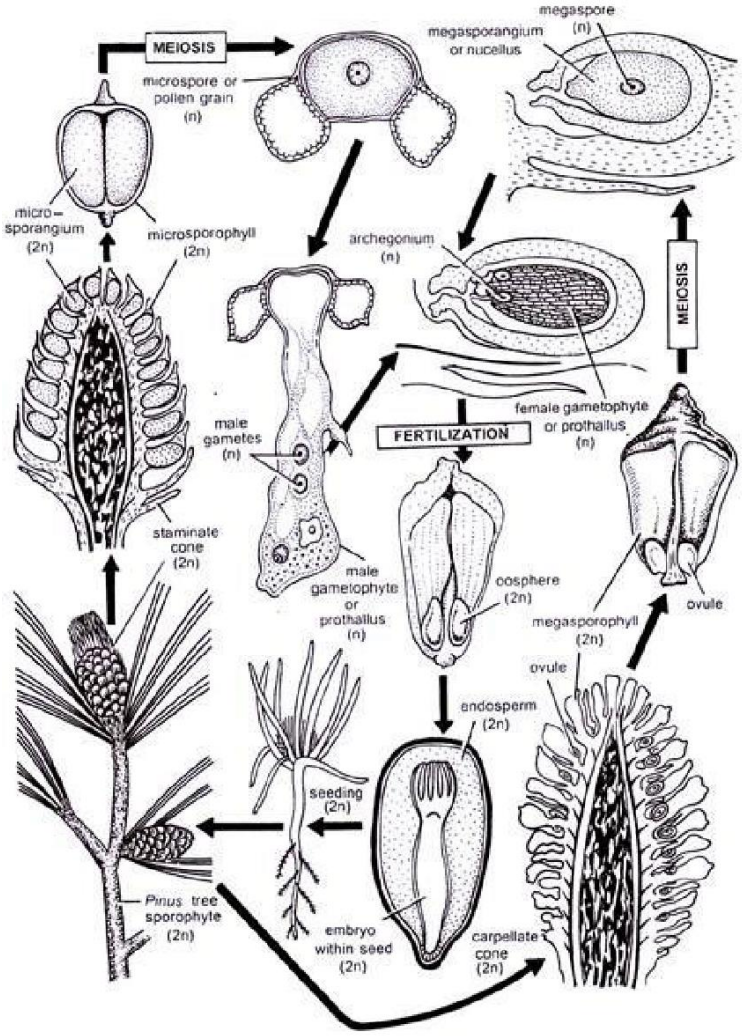


Fig. 11.46. Life cycle of *Pinus*.

(v) Taxodiaceae:

Taxodiaceae is a family of living Coniferales. It is represented by only 10 genera (Athrotaxis, Cryptomeria, Cunninghamia, Glyptostrobus, Metasequoia, Sciadopitys, Sequoia, Sequoiadendron, Taiwania and Taxodium) and about 18 species. Except Athrotaxis, Cunninghamia, Taiwania and Taxodium all other remaining six genera are monotypic. These four genera are represented by only 3 species each.

The family Taxodiaceae has been a great forest maker of the northern hemisphere in the past but now shows only a restricted distribution in the world. The family includes some largest and oldest trees (Sequoia sempervirens and Sequoiadendron giganteum) of the world.

(vi) Cupressaceae:

A coniferous family of 22 living genera and about 150 species, Cupressaceae are distributed almost equally in both northern and southern hemispheres. About 11 of its genera occur in northern hemisphere (e.g. Biota, Cupressus, Juniperus) and remaining 11 genera in southern hemisphere (e.g. Libocedrus, Callitris).

About half of the genera of the family are monotypic. Some of the important genera, along with the reported number of their species in parenthesis, include Juniperus (60), Cupressus (20), Callitris (16), Chamaecyparus (7), Libocedrus (5), Thuja (5), Papuacedrus (3), Acmophyle (3), Actmostrobus(2), Biota (1) and Thujopsis (1).

(vii) Podocarpaceae:

This important coniferous family of southern hemisphere is represented by 7 living genera (Acmopyle, Dacrydium, Microcachrys, Microstrobos, Phyllocladus, Podocarpus and Saxegothaea) and over 150 species. Some of its members, however, occur also in the northern hemisphere.

(viii) Cephalotaxaceae:

This small coniferous family comprises of only one genus (C.ephalotaxus) and its 6 species.

Some details of the morphology and life-history of Cephalotaxus are discussed below:

Cephalotaxus (haploid chromosome number n= 12) is found in subtropical forests of Japan, Central China, eastern Himalayas and some other parts of eastern Asia. Plants are large shrubs or small trees attaining a height of 12 to 16 metres.

Young branches develop in opposite or whorled manner. Leaves are linear, arranged spirally on the branches and reach up to 7-8cm in length (Fig. 11.54A). In C. drupacea the leaves are arranged in opposite decussate manner.

All species of Cephalotaxus are strictly dioecious. Each female cone contains a highly reduced secondary fertile short shoot. A few opposite decussate bracts are present on this shoot. Each bract contains a pair of erect ovules (Fig. 11 54B,C). Out of theses two ovules, only one generally develops into a seed. Each seed is large, olive-like and reach up to 3.5 cm in length (Fig. 11.54A).

The ovule and later on this seed contains an outer fleshy layer surrounding a stony layer. The integument is free only at the apex, and in the remaining part it remains fused with the nucellus. The outer fleshy layer is supplied by two vascular bundles.

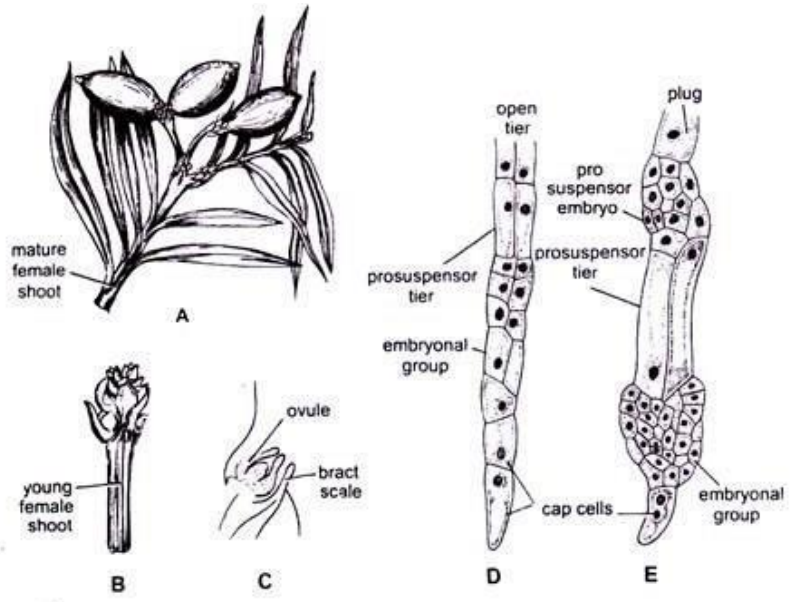


Fig. 11.54. *Cephalotaxus harringtonia*. A, A mature female shoot; B, A young female shoot; C, L.S. ovule and bract scale; D-E, Embryo development in *Cephalotaxus drupacea*.

The male cones contain several spirally arranged microsporophyll‟s. Two or three microsporangia are present on each microsporophyll. Each microsporangium contains several pollen grains. The pollen grains are without any wings or air-bladders.

Pollination in Cephalotaxus takes place by a simple drop-mechanism. There are no male prothallial cells in any species of this genus. A tube nucleus and a generative nucleus are present in the pollen grain at the time of pollination.

The young male gametophyte in this condition passes through a long resting period of about 4-5 months. After the expiry of this resting period the fertilization takes place in the next season only. Male gametes are usually of unequal size. At the time of fertilization the archegonia are widely separated. Only one pollen tube enters in the archegonium.

The zygotic nucleus divides and re-divides to form as many as sixteen free nuclei. Wall formation starts at this stage. Young embryo consists of an open tier of 3-5 cells, a suspensor tier of 3-5 cells and an embryonal tier of 8-10 cells (Fig. 11.54D).

Lowermost one or two cells of the embryonal tier form a cap. The cap cells soon disintegrate. The cells of the suspensor tier elongate, and a few of these cells give rise to „suspensor embryos". The secondary suspensors develop from some upper cells of the embryonal tier.

(ix) Araucariaceae:

Agathis and Araucaria (commonly called Monkey Puzzle) are the only living genera of this extremely old family, the fossil record of which goes back to the Triassic period of Mesozoic era. During Triassic period, members of Araucariaceae were distributed widely in both the southern and northern hemispheres.

Both the living genera are found these days only in the southern hemisphere. Araucaria is represented by about 16 species and found commonly in Australia and South America while Agathis is represented by about 20 species and found from New Zealand to Philippines Island and Fiji to Malaysia.

The basic haploid chromosome number in both Araucaria and Agathis is 13. The leaves are large, evergreen and spirally arranged. The main branches are generally whorled. Leaf bases expand as the branch bearing them enlarges (Fig. 11.55A).

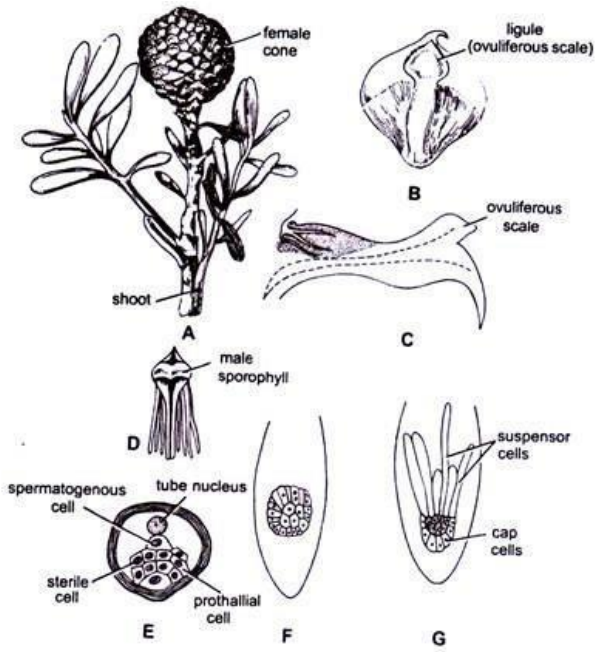


Fig. 11.55. A, A twig of *Agathis australis* with female cone; B, Adaxial view of a cone scale of *Araucaria* bidwillii; C, L.S. of a cone scale of *A. bidwillii*; D, Adaxial view of a microsporophyll of *A. angustifolia*; E, A pollen grain of *A. cunninghamii*; F-G, Stages of embryogenesis in *Agathis australis*.

Araucaria is dioecious whereas Agathis is usually monoecious. The female cones of Araucaria are almost spherical and in some of its species (A. bidwillii) they reach up to 30-35 cm in diameter. The female cones in some of the species of Agathis (Fig 11.55A) reach only up to 5 cm.

In Araucaria the tip of the ovuliferous scale remains free and represents ligule (Fig. 11.55B,C). In Agathis, however, the ovuliferous scale remains completely fused with the bract scale. Each cone scale usually contains only one reflexed ovule in both Agathis and Araucaria. Each ovule contains only one archegonium.

The male cones are well-developed and reach up to 25cm or even more in some species (e.g. Araucaria rulei). Each male cone contains several microsporophyll‟s and each microsporophyll bears many microsporangia (Fig. 11.55D) or pollen sacs , varying from 8-15 in Araucaria and 5-15 in Agathis.

The pollen grains in Araucariaceae are wingless. As many as 13 to 40 extra prothallial cells are produced in the pollen grains of Araucaria (Fig. 11.55E). In Agathis, however, the number of extra prothallial cells in the pollen grain are only 6 to 10. Pollination does not take place by drop-mechanism.

In Araucaria. the pollen grains are lodged on the ligule and the pollen tube develops towards the ovule. At the time of pollination a beak develops on the nucellus of the ovule. This beak projects through the micropyle. Male gametes are generally unequal in size. Out of two male gametes only one remains functional and fertilizes the egg.

Embryogenesis in both Araucaria and Agathis is different from that of other Coniferales. As many as 32 free nuclei in Araucaria and 64 free nuclei in Agathis are formed by the division of the zygotic nucleus. All these free nuclei in both these genera move towards the centre of the egg cell and remain there in the form of a group.

At this stage the cell wall formation takes place Arrangement of these cells is also peculiar. There is a central group with two tiers of cells surrounded by an outer jacket layer (Fig 11.55F). Suspensor develops by the elongation of the upper cells of the jacket. A cap-like structure is formed by the lower jacket cells (Fig. 11.55G).

The cells of the suspensor elongate and divide once. In Agathis, the elongating suspensor cells sometimes come out of the apex of the archegonium. Of the two central tiers of cells, the upper one develops into secondary suspensor while the lower one gives rise to embryo. Cleavage polyembryony is absent.

Economic Importance of Coniferales:

Great importance is attached with the Conifers mainly because of their utility to human being.

1. Wood of members like Cedrus deodara, Pseudotsuga taxi folia, Abies spectabilis, Picea smithiana, various species of Larix, Agathis, Pinus, Taxodium, Thuja, Podocarpus and many others are used for the preparation of various common articles of our daily use. Wood of most of these genera is used as such for building materials and other purposes.
2. Various types of resins are obtained from different species of conifers.
3. Turpentine in India is obtained from various species of Pinus such as P. insularis, P. roxburghii, P. wallichiana, etc.
4. Satidarc, used in the preparation of metal varnish, paper varnish or leather varnish is obtained from some Australian species of Callitris.
5. Canada balsam, used as a mounting medium in microscopic preparations, is obtained from Abies balsamea.
6. Many essential oils used in toilet preparations, saving soap, perfumery‟ and medicines are obtained from Tsuga canadensis, Picea glauca, Abies sibirica, Cedrus deodara, etc.
7. In India, paper is made from Picea smithiana, Pinus roxburghii, Abies balsamea, Tsuga, etc.
8. Common garden ornamentals in Coniferales include Araucaria, Thuja, Cupressus, Cryptomeria japonica, etc.

TAXALES

Taxonomic Position of Taxales:

Family Taxaceae, along with 5 of its living genera and 200 species, was usually treated as belonging to Coniferales until the beginning of the twentieth century. Besides the present members of Taxales, certain members of Podocarpaceae and Cephalotaxaceae, such as Podocarpus and Cephalotaxus, were also included under Taxaceae.

It was Professor Birbal Sahni (1920), a well-known Indian botanist, who suggested that Cephalotaxus, Taxus and Torreya should be treated under Taxales. Florin (1948, 1951) has, however, opined that Cephalotaxus should not be included under Taxales but under Coniferales because it is a true Conifer.

Ramanujam (1976) mentioned that the order Taxales is poorly represented in the fossil flora of India.

General Characters of Taxales:

1. The sporophytic plant body consists of evergreen, slow-growing, profusely branched shrubs or small trees.
2. The leaves are simple, linear with acute apex. They are spirally arranged on the branches.
3. The secondary wood is compact and pycnoxylic.
4. The wood is elastic because tertiary spirals are present on the walls of the tracheids.
5. The resin canals are absent in wood or leaves.
6. Plants are unisexual with only a few exceptions.
7. Micro-sporangiophores are arranged in the form of small cones.
8. On each micro-sporangiophore 2-8 pollen sacs are present on a scale-like or peltate disc.
9. Prothallial cells are absent in the male gametophyte.
10. The ovule is solitary and borne terminally on a dwarf shoot.
11. An aril is present at the base of each ovule.
12. Pollination takes place by pollination drop mechanism.
13. The embryo is dicotyledonous.
14. The seeds are endospermic.

Types of Taxales:

(i) Palaeotaxus:

It is the only known fossil representative of Taxales. Its fertile specimens have been discovered from the rocks of the Triassic period of Mesozoic era. Plants had solitary terminal ovules, a characteristic feature only of Taxales.

The ovule and later on the seed was borne at the tip of a short shoot. Its lower parts were enclosed by spirally arranged bracts (Fig. 12.22 A). Aril was also present. Except at the top of the micropylar end, the ovule was enclosed by the aril.

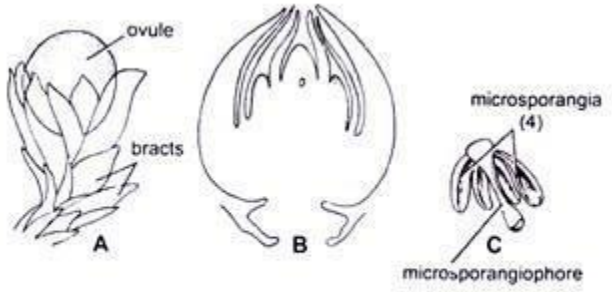


Fig. 12.22. A, A reconstructed female shoot of *Palaeotaxus rediviva*; B, L.S. young ovule of *Torreya taxifolia*; C, A microsporangiophore of *T. taxifolia*.

(ii) Austrotaxus:

It is a living Taxad, represented by only one species. Plants are found growing in New Caledonia. Its male cones are quite peculiar and made up of micro-sporangiophores.

Each micro-sporangiophore remains subtended by a bract, and only because of this peculiarity Nakai (1938) suggested that Austrotaxus should be placed in a separate family Austrotaxaceae. Each micro-sporangiophore terminates into a synangium formed by the fusion of 3 or 4 microsporangia.

(iii) Pseudotaxus (= Nothotaxus):

It is found growing these days in a small region of the forests of east China. It is also represented by only one species. Its male cones are also made of micro-sporangiophores similar to Austrotaxus, but here the bracts are irregularly distributed.

Each micro-sporangiophore of Pseudotaxus is actually a highly reduced male cone, and, therefore, the entire structure, formed by a group of micro-sporangiophores, is a compound structure.

(iv) Torreya:

It is represented by 5 species and occurs in some east-Asian countries and some parts of USA, including Florida and California. Plants are mostly large trees attaining a height of 25 to 30 metres but some are only shrubs. The leaves of some of the species (e.g. Torreya californica) attain a length of 6 to 9 cm. or even more.

Only a single vascular bundle is present in each leaf. Wood parenchyma is present in the secondary wood of the stem. The tertiary spirals are well-developed in the tracheids. In the

ovule (Fig. 12.22B) the aril remains fused with the integument for most of its length except near the micropyle.

There is no vascular bundle in the integument of its own. Two vascular bundles, however, run inside the aril and reach up to the apex of the mature ovule.

From each of these vascular bundles develops a branch which passes through a foramen and supplies the stony layer of the ovule. Each of these branches then divides and forms a loop which surrounds the mature ovule or seed. The female gametophyte in the mature seed develops very fast and without any definite division pattern.

The ultimate result is the formation of an irregular- shaped surrounding tissue. The micro-sporangiophores (Fig. 12.22C) are not peltate. They are dorsiventral, scale-like structures. Each micro-sporangiophore contains four pendulous microsporangia or pollen sacs.

Male prothallial cells are absent. The size of the male gamete cells is quite unequal. Each female gametophyte contains only one archegonium. The ventral canal nucleus is absent in the archegonium of Torreya.

(v) Amentotaxus:

This occurs in several parts of some east-Asian countries and represented by only four species. Its chief characteristic feature is shown by its seed which remains surrounded by its aril and several bracts, and all these structures develop at the terminal part of a peduncle. The peduncle attains a length of 1 – 2 cm. The aril remains fused with the integument, and there is no vascular supply at all to the integument.

Taxus:

https://commons.wikimedia.org/wiki/File:Taxus_baccata_04_ies.jpg

GINKGOALES

The order Ginkgoales is today represented by only one living member, i.e. Ginkgo biloba. Ginkgoales was, however, very abundantly represented in the world by several species of about 16 genera during the Triassic period of Mesozoic age, i.e. about 200,000,000 years ago. Today, all the genera, except Ginkgo biloba, are extinct.

According to Dallimore and Jackson (1948), G. biloba is represented by five varieties viz. Ginkgo biloba var. aurea (Nelson) Beisson, G.biloba var. fastigata Henry, G.biloba var. paciniata Carriere, G. biloba var. pendula Carnere and G. biloba var. variegata Carriere. Due to the presence of a number of primitive characters, as well as because of its long geological records, Ginkgo is called a **"living fossil".**

Details of the geological history of Ginkgoales indicate that its members started appearing on the earth during Permian, achieved luxuriance and worldwide distribution during Triassic and Jurassic periods of Mesozoic age, started fading out of existence during Cretaceous and now represented only in some parts of Southern and Eastern China by only one living member i.e. Ginkgo biloba.

Ramanujam (1976), while tracing the geological history of Ginkgoales, reported that a few records of this order are known from Late Palaeozoic of India. These include Ginkgophyton, Psygmophyllum and Rhipidopsis.

Seward (1938) considered Ginkgo **"as one of the wonders of the world" and stated that has persisted with little change until the present through a long succession of ages when the earth was inhabited by animals and plants".** Arnold (1947) mentioned that "Ginkgo biloba is one of the oldest living plants and may indeed be the oldest living genus of the seed plants"

General Characteristics of Ginkgoales:

Some general characteristics of Ginkgoales are:

1. Tall, well-branched trees with short and long shoots. However, some earliest fossil members were without short and long shoots.
2. Wood is pycnoxylic.
3. Leaves are large, leathery and fan-shaped or strap-shaped. They are often deeply divided.
4. Dichotomous venation is usually present in the leaves.
5. Un-branched, catkin-like male organs are axillary in position.
6. Male organs bear micro-sporangiophores.
7. Each micro-sporangiophore possesses 2-12 pendulous microsporangia.

8. Spermatozoids are motile and contain spiral bands of flagella.
9. Ovules are terminal in position on branched or un-branched axillary axes. They are 2-10 in number.
10. Seeds are large-sized.
11. Each seed contains a fleshy outer layer and a middle stony layer.

Sporne (1965) divided Ginkgoales into following two families: 1. Trichopityaceae, represented by an extinct genus Trichopitys.

2. Ginkgoaceae, represented by one living genus (Ginkgo) and six extinct genera (Arctobaiera, Baiera shown in Fig. 10.1, Eretmophyllum, Ginkgoites, Sphenobaiera and Windwardia).

Fig. 10.1. *Baiera gracilis*, a bilobed leaf. Both the lobes show repeated dichotomy. (after Renault, 1884).

Phylogeny of Ginkgoales:

Some of the striking peculianties of Ginkgo biloba, the only living representative of Ginkgoales, include:

(i) Bilobed, fan-shaped leaves with dichotomous open venation,
(ii) Ovule bearing a collar at the base,
(iii) Micro-sporangiophore bearing a hump-like outgrowth at its apex,
(iv) Presence of tent pole at the tip of the female gametophyte, and
(v) Absence of suspensor in its embryo.

In-spite of these characteristics, Ginkgoales resemble in some or other aspects with Cordaitales, Pteridospermales, Filicales, Cycadales and even Coniferales.

GNETALES

Taxonomic Arrangements of Gnetales:

Foster and Gifford (1959) described Gnetales as "a small group of gymnosperm-like plants" while Maheshwari and Vasil (1961) Mentioned that " the order Gnetales, formerly included three genera, Ephedra, Welwitschia and Gnetum which were considered to be highest evolved among the gymnosperms and believed to show an approach to the angiosperms".

But mainly due to the presence of naked ovules and also because of the absence of true sty le and stigma in Ephedra, Welwitschia and Gnetum, these members can only be treated under gymnosperms and not under angiosperms.

Formerly, these genera (Ephedra, Welwitschia and Gnetum) were considered to be the only living representatives of family Gnetaceae of order Gnetales. But Sporne (1965) and others divided Gnetales into three families, each having a single genus, viz. Gnetaceae (Gnetum), Welwitschiaceae (Welwitschia) and Ephedraceae (Ephedra).

Due to the heterogenous nature of this order several workers advocated strongly for a split of the Gnetales into three independent orders viz. Ephedrales, Welwitschiales and Gnetales. Each order contains only one family and only one genus.

Chamberlain (1935) opined about this controversy very clearly and mentioned, **"It seems to be a matter of taste whether the Gnetales should be put into one family, with three genera, or into three families, with one genus in each. All agree that there are only three genera, Ephedra, Welwitschia and Gnetum".**

In the present text, the classification proposed by Sporne (1965) for Gnetales has been followed. Delevoryas (1962) opined that except for the fossil remains of Ephedra and Welwitschia- like pollens, the fossil-history of Gnetales is almost unknown.

General Characteristics of Gnetales:

Gnetales, believed by some botanists to be the ancestors of flowering plants or angiosperms, are the highly evolved members of gymnosperms and show following characteristics:

1. These are woody plants, of which some species are trees (Gnetum gnemon), many are lianes or shrubs and a few. are stumpy turnip-like (e.g. Welwitschia mirabilis).
2. Leaves are simple elliptical or strap-shaped or sometimes reduced to minute scales. They are generally opposite or whorled.
3. Vessels are present in the secondary wood.

4. „Flowers“ are unisexual, usually dioecious and only rarely monoecious as in some species of Gnetum.
5. **„Flowers“** are arranged in compound strobili or „inflorescences“.
6. The male flowers are surrounded by a perianth. Each male flower contains an antherophore with one to eight synangia.
7. A single erect orthotropous ovule is present in each female flower.
8. Nucellus of the ovule remains surrounded by two or three envelopes.
9. The micropyle of each ovule remains projected in the form of a long bristle-like tube.
10. At the time of fertilization the pollen tube contains two male nuclei.
11. A unicellular primary suspensor is present in the embryo.
12. Two cotyledons are present in the embryo.

Classification of Gnetales:

Sporne (1965) divided Gnetales into following three unigeneric families:

(i) Gnetaceae: Gnetum

(ii) Ephedraceae: Ephedra

(iii) Welwitschiaceae: Welwitschia

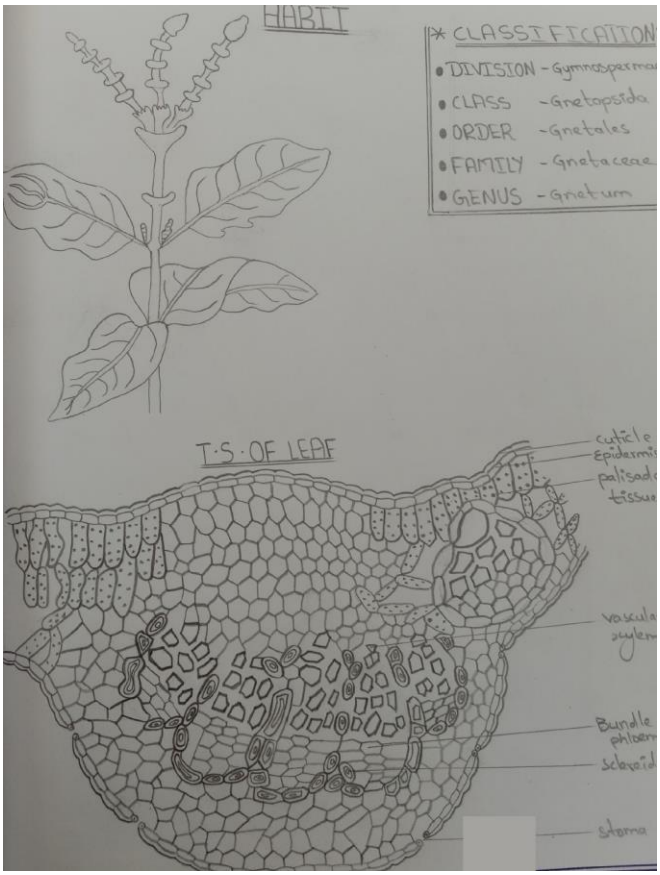
(i) Gnetum:

The plant body is sporophytic and resembles remarkably with a dicotyledonous plant, specially when it is not in the fruiting stage. Most of the species are lianes or climbers with twining stem, except a few which are shrubs or trees, e.g., Gnetum gnemon and G. costatum.

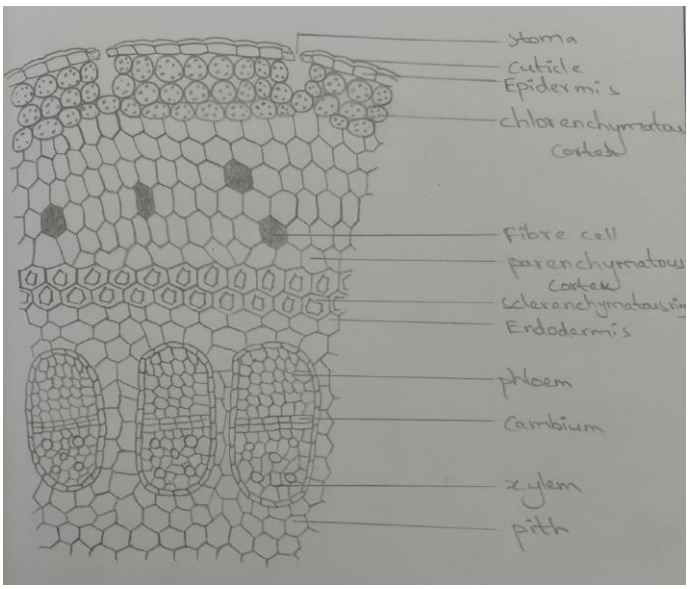
(ii) Ephedra:

Ephedra, the lone genus of family Ephedraceae of order Gnetales, is represented by some 40 species. It is distributed in mountainous or rocky places, or in sandy desert regions throughout the world. Most of the species are shrubs, and a few are lianes.

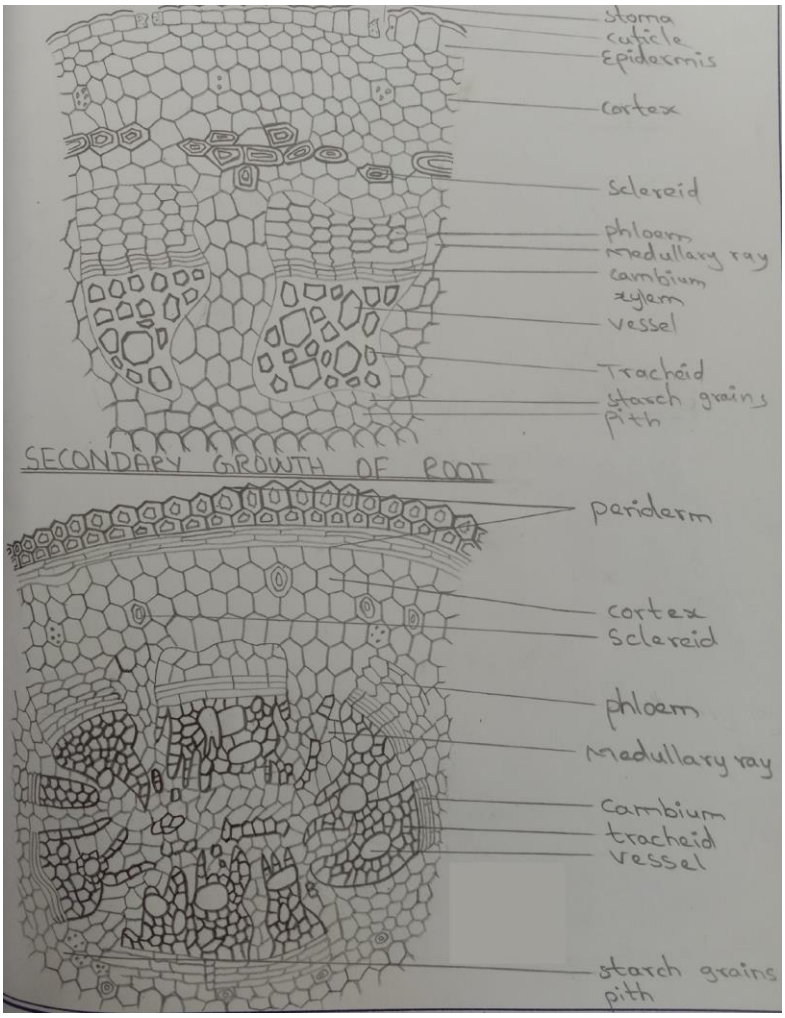
Ephedra triandra, a South American species, usually reaches up to a diameter of 30 cm. and a height of several metres and appears like a tree. Ephedra is known for „ephedrin“ a well-known drug, obtained from its various species of Asiatic origin. Khoshoo (1961) states that haploid chromosome number in Ephedra is 7 and 14.



TS OF STEM



TS OF YOUNG AND MATURED ROOT



(iii) Welwitschia:

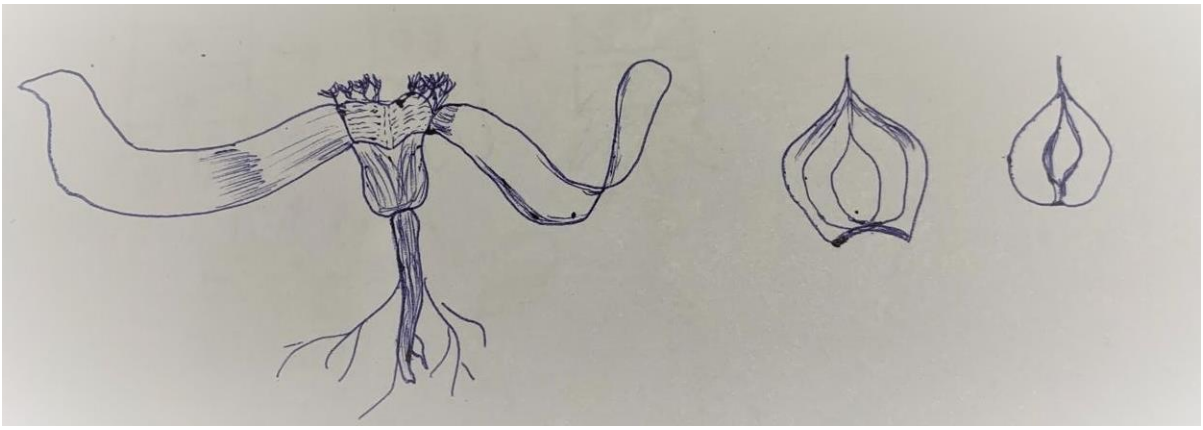
Welwitschia bainesii (= W. mirabilis) is the only species of genus Welwitschia, the sole representative of family Welwitschiaceae of Gnetales. This is the most strange or bizarre of all gnetalean plants showing a very restricted distribution in a narrow coastal belt of about 1000 Km long in south-west Africa.

The specific name (Welwitschia mirabilis) of this African genus **"is very appropriate because the adult sporophyte is unlike that of any known plant on the earth"**. According to the recent nomenclatural changes, however, the correct and valid name is Welwitschia bainesii. The common name "desert octopus" is often riven to this genus because of its peculiar habit.

Welwitschia - Habit

(https://www.flickr.com/photos/dweickhoff/4737195986)

Welwitschia - Diagram



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