

GYMNOLOGY

GNETOPSIDA

GENERAL CHARACTERISTICS

- Woody plants, some species are trees (*Gnetum gnemon*), many are lianes or shrubs and a few are stumpy turnip-like (e.g. *Welwitschia mirabilis*).



Welwitschia

- **Leaves** - simple, elliptical/ strap-shaped / scale leaves.
- They are generally opposite or whorled.
- **Vessels** are present in the secondary wood.
- **'Flowers'**- unisexual, dioecious and only monoecious in some species of *Gnetum*.



Gnetum

- 'Flowers' are arranged in compound strobili or 'inflorescences.'



- The male flowers are surrounded by a **perianth**.
- Each male flower contains an **antherophore** with **one to eight synangia**.
- A single erect **orthotropous ovule** is present in each female flower.
- Nucellus of the ovule remains **surrounded by two or three envelopes**.
- The micropyle of each ovule remains **projected** in the form of a long bristle-like tube.
- At the time of fertilization the pollen tube contains two male nuclei.
- Two cotyledons are present in the embryo.

GNETUM

Class- Gnetopsida

Order- Gnetales

Family- Gnetaceae

Genus- *Gnetum*



GENERAL CHARACTERS

- Gnetum **resembles** very much in its characteristics to an angiosperm than a gymnosperm.
- **Distributed** in the tropical and humid regions of the world
- Most species are climbers except few being shrubs and trees.
- 2 types of branches- **branches of limited growth** and **branches of unlimited growth**.
- Leaves - large, dorsiventral, uncostate reticulate venation

MORPHOLOGY OF ROOT

- Tap root system which is profusely branched.
- Shows normal secondary growth.

ANATOMY OF ROOT

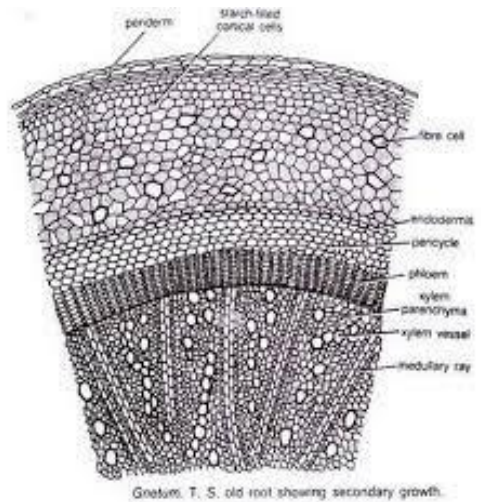
- Layers of starch filled cortical cells.
- 4-6 layers of pericycle.
- The primary vascular cylinder is **diarch** and **exarch**.
- The secondary xylem consists of **tracheids** possessing uniseriate bordered pits with conspicuous **Bars of Sanio**.
- The vessels are also present.

MORPHOLOGY OF STEM

- Exhibits **two types of branches**- **dwarf shoots** or branches of limited growth and **long shoots** or branches of unlimited growth.

ANATOMY OF STEM

- Resemble typical dicot stem.
- Sunken stomata is present.
- **Cortex** - Few layers
 1. **Outer chlorenchymatous**
 2. **Middle parenchymatous**
 3. **Inner sclerenchymatous layers**
- **Vascular bundles** - **Conjoint, Collateral, Open and Endarch**.
- Xylem comprises **tracheids & vessels**.
- Phloem comprises **sieve cells & phloem parenchyma**.
- Sclerotic cells present.
- The xylem parenchyma cells have simple pits.
- There are many uni- to multiseriate vascular rays.
- The secondary phloem consists of sieve cells and phloem parenchyma.
- The companion cells are totally absent in Gnetum.



MORPHOLOGY OF LEAVES

- **Dimorphism**- foliage leaves and scale leaves.
- A **dwarf shoot** bears 9 to 10 foliage leaves.
- Opposite decussate.
- The leaves are large, simple having an oval-shaped broad lamina with unicostate reticulate venation.
- The leaves are exstipulate, shortly petiolate with entire margin.
- The leaf of *Gnetum* resembles a dicot leaf.



ANATOMY OF LEAVES

- **Stomata** on both side except on veins.
- The **mesophyll** is differentiated into **palisade** and **spongy parenchyma**.
- **Stone cells** and **latex tubes** present on mid rib region.
- V.B- **conjoint, collateral**
- Xylem comprises **tracheids, vessels & xylem parenchyma**
- Phloem comprises **sieve cells & phloem parenchyma**.

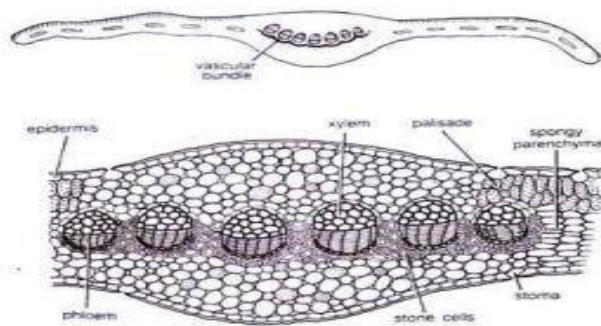
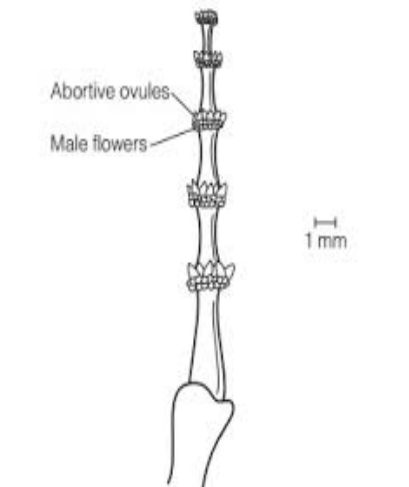
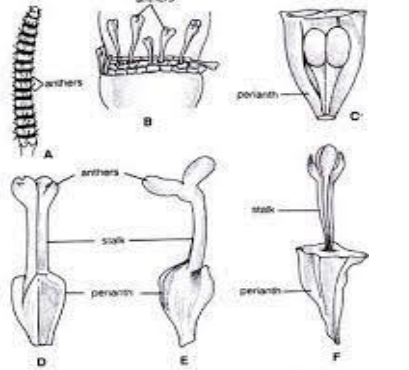
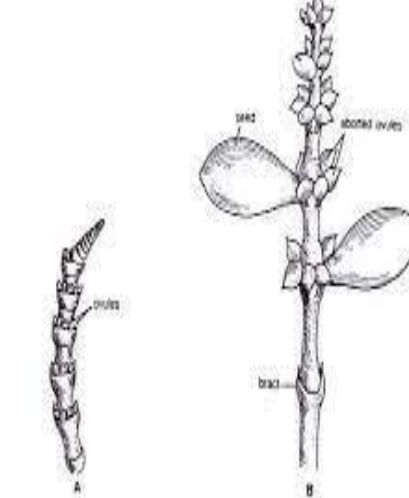
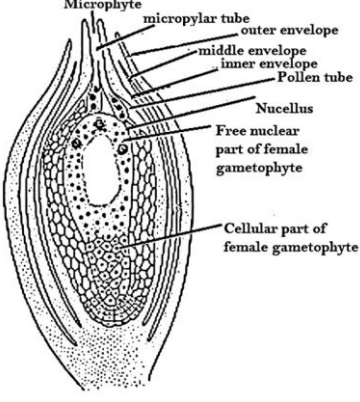


Fig. 13.9. Gnetum. Upper-T.S. leaf (diagrammatic) ; Lower-T.S. leaf (a part cellular).

REPRODUCTION

- Sexual reproduction
- Dioecious
- **Cones or strobili** is the reproductive structure (*Inflorescence*).

PLANT PART	FEATURES	FIGURE
Male strobilus	<ul style="list-style-type: none"> ● Compound and has a long slender axis. bearing 10-25 whorl of bracts (collars). ● About 12-25 male flowers are arranged in three to six rings above each collar. ● A single ring of 7-15 imperfect female flowers or abortive ovules is present just above the male flowers. 	
Male flower	<ul style="list-style-type: none"> ● A male flower consists of two unilocular anthers on a stalk (antherophore) enclosed in a small sheathing perianth. ● The stalk of the anther elongates rapidly at maturity pushing the anther beyond the collars through a slit in the perianth. 	 <p data-bbox="1047 1297 1453 1333">Fig. 13.11, Gnetum sp. 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 dehiscent male flower.</p>
Female strobilus	<ul style="list-style-type: none"> ● The female strobilus is similar to the male strobilus. ● A ring of 4-10 ovules (female flowers) is present above each collar. The male flowers are absent. ● The upper few collars are devoid of ovules and are thus sterile. 	 <p data-bbox="1047 1858 1453 1890">Gnetum. A, An old female cone of G. ula. B, A female cone of G. gnemon bearing</p>

<p>Ovule</p>	<ul style="list-style-type: none"> ● A single ovule represents a female flower. ● The ovules are orthotropous, crassinucellate (with massive nucellar tissue) ● Three envelope are present ● The outer envelope - perianth ● The middle and the inner envelope are the integuments. ● Numerous laticiferous ducts and sclereids are present. ● Epidermal stomata is present 	
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- Two sets of vascular bundles are formed.
- A shallow pollen chamber is present at the **tip of the nucellus**.
- The sporogenous cells function as **megaspore mother cells** which undergo **meiotic division**.
- The female gametophyte of Gnetum is **tetrasporic**.

GAMETOPHYTIC DEVELOPMENT

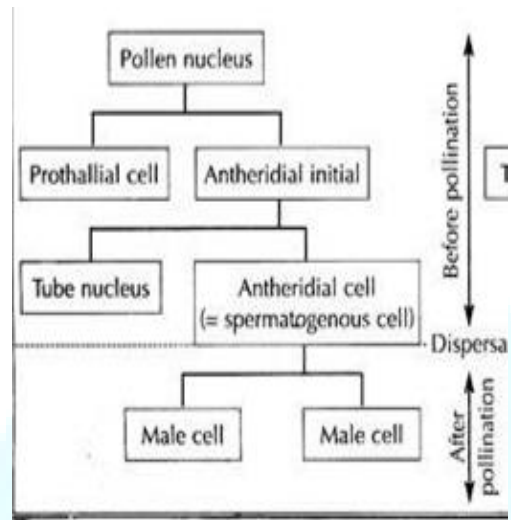
- The **spore** is the first phase of gametophyte generation.
- The **microspore/pollen grain** - Male gametophyte.
- **Tetranucleate coen megaspore** - Female gametophyte.

MICROSPORE DEVELOPMENT

- The pollen grains are released from the microsporangium at this **3-celled stage**.
- The exine is cast off during pollen germination.

E ▶ ENTRI

- Pollen tube arises from tube cell.
- The spermatogenous cell moves into the pollen tube and subsequently it divides to form two male cells
- The male gametes are non-motile.



POLLINATION

- Gnetum is wind-pollinated.
- Pollination drop is formed at micropylar end.
- The pollen grains get trap in the pollination drop.
- Due to the drying off of the fluid, the pollen grains are sucked into the micropylar canal and are finally collected in the pollen chamber.
- The mouth of the micropyle is then sealed from the outer environment due to the development of flage.

FERTILIZATION

- The pollen tube enters the female gametophyte and the male gametes move ahead of tube nucleus.
- The pollen tube ruptures to discharge the male gametes into the egg cell.
- One of the male nuclei fuses with the egg nucleus and zygote forms.

ENDOSPERM

- In gymnosperms, endosperms are cellular and haploid and are formed before fertilisation.

EMBRYOGENY

- Gnetum represents an intermediate stage between gymnosperms and angiosperm as there are **both free nuclear divisions and cell divisions**.
- Polyembryony is present.

SEEDS

- Gnetum seeds are oval in shape and green/brown/red in colour.
- The **seeds remain covered** with a three-layered envelop, of which **outer is fleshy, middle is stony and inner is papary**.
- The nucellus is used up and the embryo is embedded within the endosperm.
- The germination of seed is epigeal.

LIFE CYCLE OF GNETUM

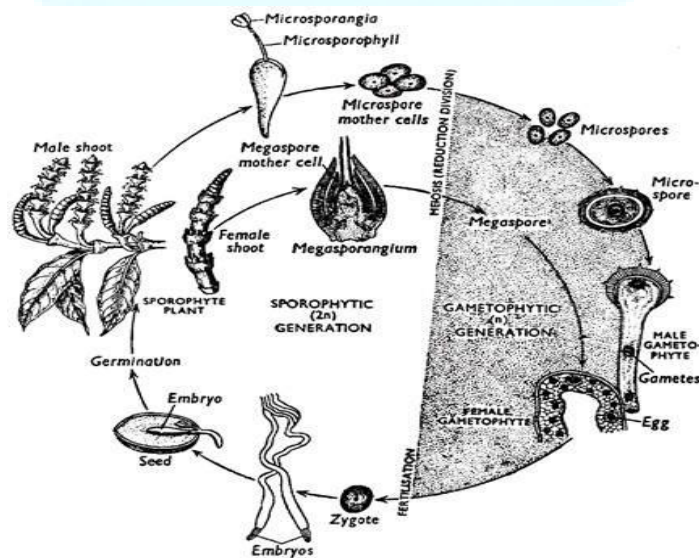






Fig. 1.82 : Life cycle of *Gnetum*

ECONOMIC IMPORTANCE OF GYMNOSPERMS

<p>1. Ornamental value</p>		<ul style="list-style-type: none"> • A number of gymnosperms are grown as ornamental plants, e.g., <i>Cycas</i>, <i>Araucaria</i>, <i>Thuja</i> etc. • Various species of <i>Taxus</i>, especially <i>T. baccata</i> (English yew) and <i>T. cuspidata</i> (Oriental yew) are commonly planted as ornamentals. • <i>Podocarpus macrophyllus</i> is widely planted as ornamental. <div style="display: flex; justify-content: space-around; align-items: center;">   </div>
<p>2. Food value</p>		<ul style="list-style-type: none"> • ‘Sago’ starch obtained from pith and cortex of stem of <i>C. revolute</i>, <i>C. rumphi</i> etc. • ‘Seed starch’ obtained from seeds of <i>Cycas rumphii</i>, <i>Dioon edule</i> etc. It is prepared into flour and cooked before eating. • Seeds of <i>Pinus gerardiana</i> (chilgoza) are edible. • ‘Kaffir bread’ prepared from the stem pith of <i>Encephalartos</i>. • Young leaves of <i>Cycas</i> cooked as vegetables. <div style="text-align: center; margin-top: 20px;">  </div>

<p>3. Medicinal value</p>		<ul style="list-style-type: none"> • Ephedrine (alkaloid) extracted from <i>Ephedra</i> used in treating asthma, cough, cold, bronchitis etc. • The juice extracted from young leaves of <i>Cycas revoluta</i> is used for curing blood vomiting and flatulence. • The presence of taxol, a highly toxic alkaloid having antimitotic activity makes it potential agent for anticancer chemotherapeutic treatment. • The kernels of <i>Gnetum ula</i> yield an oil used as a massage oil in rheumatism. <div style="text-align: center;">  </div>
<p>4. Industrial uses</p>		<ul style="list-style-type: none"> • Gum <ul style="list-style-type: none"> ➤ <i>Cycas</i> gum used as adhesive, antidote for snake bites. • Tannins <ul style="list-style-type: none"> ➤ Tannins extracted from bark of <i>Araucaria</i>, <i>Pinus</i>, <i>Sequoia</i> etc. used in leather industry. • Canada balsam <ul style="list-style-type: none"> ➤ It is turpentine obtained from <i>Abies balsamea</i> and used as a mounting medium in biological preparations. • Amber (fossil resin) <ul style="list-style-type: none"> ➤ Obtained from <i>Pinus succinifera</i>. ➤ Wood of <i>Pinus</i> is used for doors, poles, beams, railway wagon flooring etc. ➤ Plywood prepared from <i>Podocarpus</i>. ➤ Papers like newsprints, writing and printing papers are being prepared from the wood pulp of, <i>Gnetum Pinus, Picea, Abies</i> etc. ➤ The leaves of cycads are used for preparing baskets, mats, hats, brooms etc. ➤ The fibres obtained from the leaves of <i>Cycas</i> and <i>Macrozamia</i> are used for stuffing pillows and

		making mattresses.
5.	Source of oil	<ul style="list-style-type: none"> • Oils extracted from seeds of <i>C. revoluta</i>, <i>Macrozamia riedlei</i>, <i>Pinus cembra</i> and <i>Cephalotaxus drupacea</i> are used as edible oils. • Red cedar wood oil extracted from the heartwood of <i>Juniperus virginiana</i> is used for cleaning microscopic preparations and for oil immersion lenses. • Oils obtained from <i>Cedrus deodara</i>, <i>Cryptomeria japonica</i> and <i>Cupressus serm-peruvians</i> are used in preparations of perfumes.

FOSSIL GYMNOSPERMS

Class : *Cycadopsida*

Order : *Pteridospermales*

Family : *Lyginopteridaceae*

Genus : *Lyginopteris*

- The stem was slender, erect, branched, 2mm to 4mm in diameter and covered with large scales.
- Plants are vine -like with large fronds.
- The leaves were **bi-or tripinnately compound** and **arranged spirally on the stem.**
- The pinnae were borne at right angles to rachis and were arranged opposite to each other.
- The **pinnae bore pinnules.**

- From the base of the plant arises roots.

T.S. OF STEM

- Outermost layer is the epidermis.
- Next to epidermis is the **outer cortex** which consists of **radially broadened fibrous strands** that form a vertical network.
- The **inner cortex** consists of **parenchymatous cells**.
- Next to the cortex is the **pericycle** which consists of **sclerotic cells** called **sclerotic nests**.
- Next to the pericycle are **five strands of primary vascular bundles**.
- These are **separated by parenchymatous areas**.
- Each **vascular bundle** is **mesarch** and consists of **primary phloem** towards the **outer side**.
- In the **centre** there is a **large pith** made up of **parenchymatous cells**.

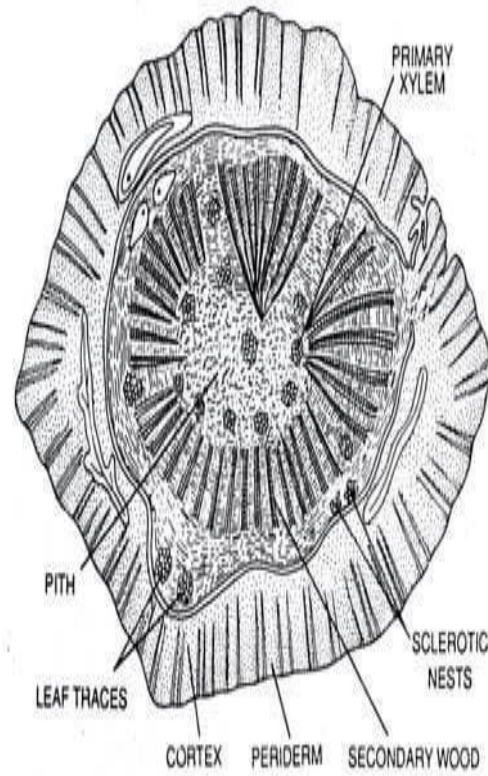


Fig. 2.4. *Lyginopteris althamiae*. T.S. of the stem showing well-developed secondary wood and leaf traces.

FORM GENERA

STEM - Heterangium

FROND - Sphenopteris

PETIOLE -Rachiopteris

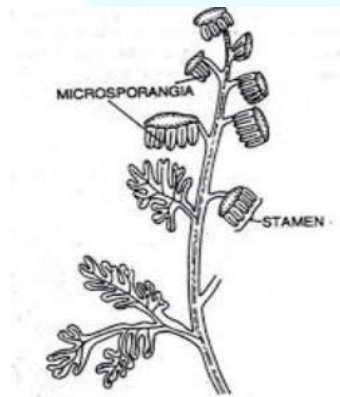
ROOT - Kaloxylon

SEEDS- Lagenostoma

POLLEN BEARING ORGAN - *Crossotheca*

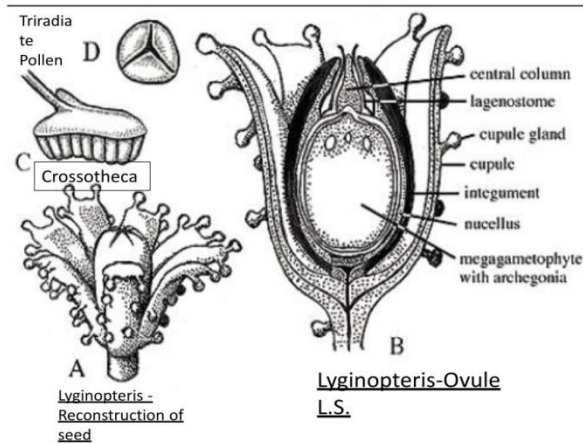
Male Fructification - *Crossotheca*

- In *Crossotheca*, a number of boot shaped bilocular microsporangia were arranged radially on the underside of discs.
- **Microsporangia** were borne as elongate, pendant appendages on the ultimate pinnule of the frond.
- The sporangia lack annulus and resembles those of *Cycas*.
- On dehiscence microsporangia were carried by wind.
- The **microspores** are **spherical with the tri-radiate markings (trilete)**.

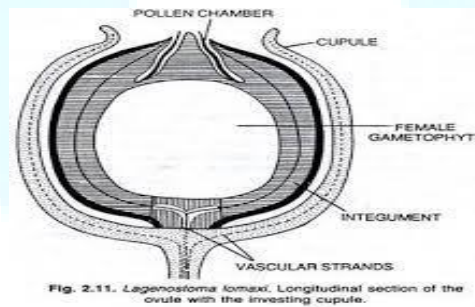


V.S OF OVULE

- Female Fructification discovered from carboniferous - *Lagenostoma oldhamia*.
- The **ovules** are **barrel shaped with single stout integument**.
- The **ovules are covered** with protective covering called the **cupule**.
- These cupule bears **capitate glands**.
- The ovule is **orthotropous** and consists of **well developed nucellus**.
- The nucellus apex has a **hollow pollen chamber(Lagenostome)**.



- The **pollen chamber** in this **ovule** is **conical in shape** and has central core of tissue, shaped like inverted bell. This is known as the **central column of the pollen chamber**.
- The pollen chamber is formed as a result of the formation of flask shaped prolongation from the nucellar tip. The central column arises from the base of the flask shaped pollen chamber.



Class : Cycadopsida

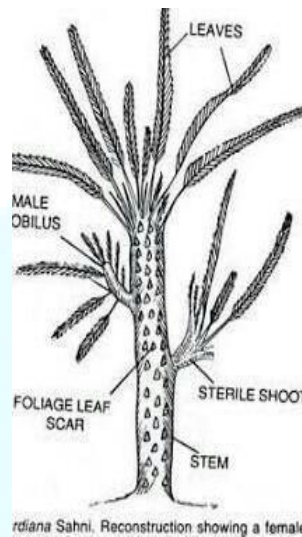
Order : Bennettitales(Cycadeoideales)

Family : Williamsoniaceae

Genus : Williamsonia

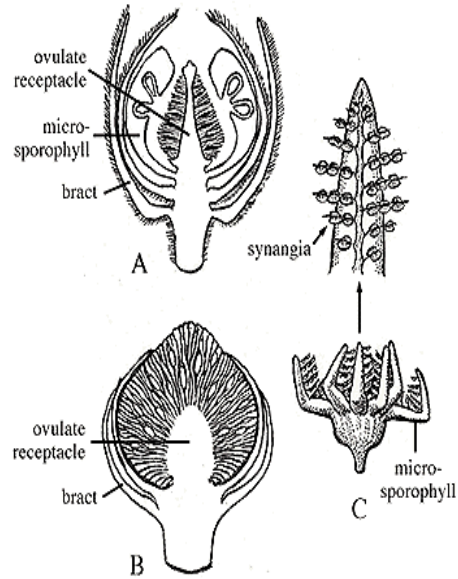
ENTRI

- Williamson (1870) described first species of the genus reported from Jurassic era named *Williamsonia gigas*.
- In India, a new species *Williamsonia sewardiana* was constructed by Prof. Birbal Sahni (1932) on his studies of material of Jurassic period collected from Rajmahal Hills.
- The plants were tall, slender, branched palm like reaching upto height of 2m.
- The trunk is with rhomboidal scars left by the fallen leaves.



Female Flower

- The female flower in *W.gigas* and *W. sewardiana* have a distinct conical receptacle surrounded by simple perianth like bracts, that had scales at their bases.
- The stalked ovules and interseminal scales were arranged in close spirals around the conical receptacle.
- The tip of the receptacle was naked.
- Each orthotropous ovule consists of short stalk through which is attached to the receptacle.
- The nucellus is fused with the integument except at tip.
- The tip of nucellus extend to form nuclear break and pollen chamber.

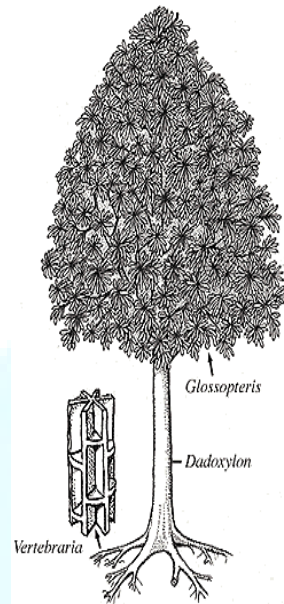


GLOSSOPTERIS

- Glossopteris flora was first studied by **Brogniart (1828)**.
- More than 50 species has been reported.
- Glossopteris flora flourished well in **Gondwana island** formed **during upper carboniferous-lower Permian period**.
- The **leaves of Glossopteris** are **simple, entire and sessile** (rarely petiolate eg - ***Glossopteris petiolata***) . Leaves show a great variation in size and shape. They have a strong midrib with **reticulate venation**

E ▶ ENTRI

- The **detached roots of Glossopteris** plant are called **Vertebraria**. The roots are flattened and grooved with wedge-like sectors that radiate from the centre of the axis
- The **trunk of Glossopteris** plant is called **Dadoxylon**.



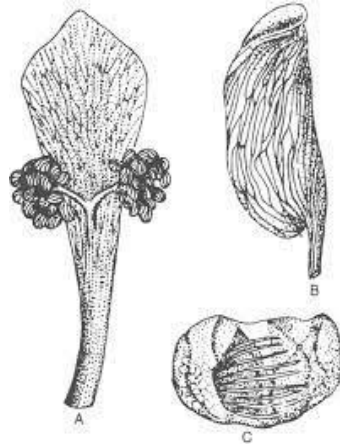
Male Fructifications of Glossopteris :

Eretmonia and Glossotheca

- **Eretmonia** consists of a **stalked and triangular lamina**.
- Two branches are borne on lamina and each bears whorls of microsporangia.
- Each microsporangium ruptures longitudinally
- Pollen grains are striated and bisaccate.
- Pollination was probably anemophyllous.

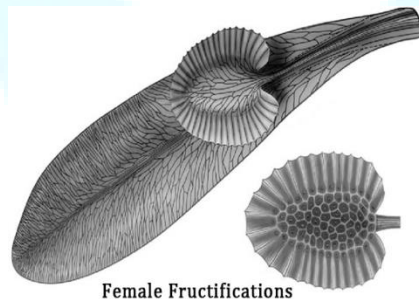
Glossotheca :

- It has 2-3 sporangia bearing pedicels.
- Each pedicel bifurcates into two daughter branches containing clusters of elongate sporangia at their tips.



Female Fructification of Glossopteris :

- The **dorsiventral structure bearing seeds** of Glossopteridales are variously termed as **capitulum, megasporophyll, cupule, fertiliger** or **cladode**.
- It has two bilaterally concave valves.
- A wing like expansion is present along the line where the two valves join.
- Small sac like structure is present on the concavity of both the valves.



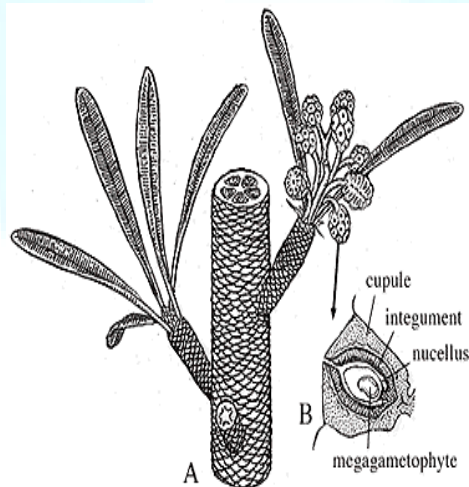
Female Fructifications

PENTOXYLON

- This group has been discovered and named as ‘**Pentoxyleae**’ by well known Indian Botanist Professor **Birbal Sahni(1948)**.
- This is a group of fossil plants discovered from **Raj Mahal Hills** revealing their **existence in Jurassic period**.

E ▶ ENTRI

- This also shows a combination of features characteristic of the **Bennettiales, cycadales and coniferales**.
- **Lam (1952)** suggested that Pentoxyleae should be given a rank equivalent to Bennettiales and cycadales in the Gymnospermous classifications.
- **Sporne (1965)** has treated this group as an order under the name “Pentoxylales”.
- Long and short shoots were present.
- **Short shoots** possess **spirally arranged leaves** and terminally located reproductive organs.
- Leaves were thick **simple, lanceolate** and has **diploxylic leaf trace**.
- Leaves possess **open venation**.
- Possess **haplocheilic stomata**.
- Stems were **polystelic**.
- Wood of **Pentoxylon** was **pycnoxylic** and **resembled Araucaria**.
- **Ovules were sessile**.



STEM GENERA

Pentoxylon sahni

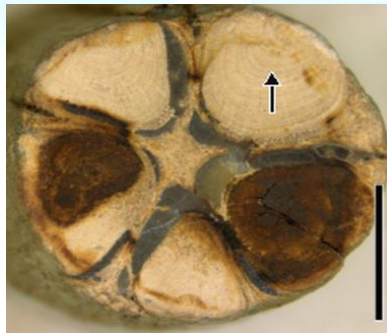
- *Pentoxylon sahni* - the stem genera of Pentoxyleae

E ▶ ENTRI

- The stems of *Pentoxylon sahnii* attained a diameter from 3mm to 2 cm
- The stem has always been reported in association with the leaves called *Nipaniophyllum*.

Pentoxylon stem

- Presence of **five stele** in C.S. of stem has been the **main reason for giving the name Pentoxylon to the genus**.
- Each stele had its **own cambium**.
- The cambium was uniformly active in the young stems, but at maturity more secondary tissue developed towards the centre, and thus the secondary wood appears **eccentric**.
- Primary phloem and primary xylem were present towards outer and inner sides of the cambium.
- Medullary rays of the main steles were **uniseriate** and they lack ray tracheids, wood parenchyma and resin canals.
- The secondary wood resembled greatly with that of **Araucaria**.

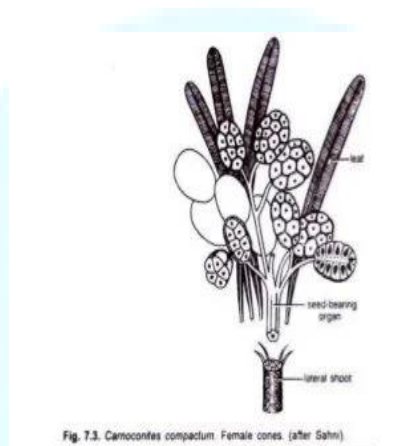


Leaves of Pentoxyleae

- *Nipaniophyllum*
- The leaves has been described under the name *Nipaniophyllum raoi*
- They were found attached with the shoots of *Pentoxylon sahnii*.

E ▶ ENTRI

- They were present on the short lateral shoots.
- Each leaf has **simple, petiolate, strap-shaped** and possessed a well developed mid rib with many lateral veins.
- **Seed bearing organ of Pentoxyleae - carnoconites**
- Seed bearing organs were forked and found attached terminally on the lateral dwarf shoots.
- The female reproductive organs were like stalked mulberry, consisting of about **20 sessile seeds** attached to central receptacle and surrounded by stony layer and then fleshy outer layer of integument uniting them.



- **Microsporangiate or Male organs** of Pentoxyleae were named as *Sahnia nipaniensis* by Vishnu -Mittre(1953)
- Each microsporophyll possessed many **pear shaped, unilocular sporangia**.
- The terminal position of the sporophyll was also occupied by a sporangium.

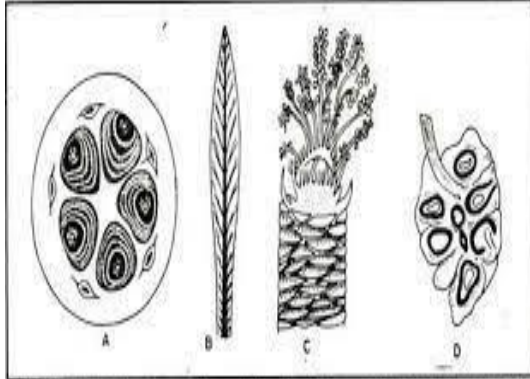


Fig 8.19. A - T.S. through stem of *Penoxylon* Sp., B - Whole mount of leaf, C - Microsporophyll, D - V.S. through ovules.



Fig. 7.5. *Sahnia nipaniensis* A detached microsporophyll (after Vishnu-Mittre).