PALEOBOTANY

GEOLOGICAL TIME SCALE AND EVOLUTION OF PLANT GROUPS

Geological time scale

- ✶ The geological time scale is a record of the life forms and geological events in Earth's history.
- ✶ The age of the earth is probably about 4500 mya.
- ✶ The geological time scale divides the history of earth into:
  - ➢ *Eon*
  - ➢ *Era*
  - ➢ *Period*
  - ➢ *Epoch*

1	Eon	Eons are the largest intervals of geologic time. A single eon covers a period of several hundreds of millions of years.
2	Era	Two or more geological periods comprise an era, which is hundreds of millions of years in duration.
3	Period	Period is the basic unit of geological time, lasting tens of millions of years.
4	Epoch	An epoch is a division of a geologic period; it is the smallest division of geologic time, lasting several million years.

PRECAMBRIAN EON

- The Precambrian eon is the **oldest eon** of the earth.
- The period between the formation of Earth around 4600 mya to the beginning of Cambrian period (about 540 mya ago) is named as the Precambrian Eon.
- It accounts for 88% of the total geologic time. Very little is known about the Earth's history during this period.
- The fossil record of Precambrian time is very poor.

- The first three eons - *Hadean, Archaen and Proterozoic* eons can be referred to collectively as the Precambrian eon.

1.	The Hadean Eon	The eon of the earth between 4600 mya and 3800 mya Origin of the earth
2.	The Archean Eon	• The eon of the earth between 3800 mya and 2500 mya. • The significant observations of Archean are: ➢ Extensive mountain-building ➢ Existence of shallow seas ➢ Accumulation of free oxygen First one-celled organisms
3.	The Proterozoic Eon	• The Proterozoic Eon (2500-540 mya) is the eon after Archaen eon. • The significant observations of this period are: ➢ Cold climate Origin of planktonic prokaryotes, eukaryotes and multicellular life ➢ Occurrence of soft-bodied marine invertebrates and marine grasses Origin of Sponges, Cnidarians and Annelids -(Sea anemones) , (segmented flatworms)

PHANEROZOIC EON

- The term phanerozoic was derived from the Greek word "*Phaneros*" meaning "Visible", and Zoo means life.
- The term Phanerozoic was used to refer the eon of visible life on earth.
- The Phanerozoic Eon is divided into three ERAS :
  1. **Coenozoic era** -(Recent life)- 65 mya to the present
  2. **Mesozoic era**- (Middle life) - 245 – 65 mya
  3. **Palaeozoic era**-(Ancient life)- 540 – 245 mya

1. Palaeozoic era

- The duration of palaeozoic era is the time of Ancient life.
- This is the major era of earth's history.
- It is the **age of Invertebrates**.
- This era has the Span of time between 540 mya and 245 mya.
- It is further divided into six periods as:
  - **Permian - 286 - 245 mya**
  - **Carboniferous - 360 - 286 mya**
  - **Devonian - 410- 360 mya**

- **Silurian - 438 - 410 mya**
- **Ordovician - 505 - 438 mya**
- **Cambrian - 540 - 505 mya**

(i) Cambrian flora

- Early plants were small, unicellular or filamentous, composed mostly of soft body tissues, with simple branching.
- Marine multicellular filamentous algae evolved in oceans

(ii) Ordovician flora

- The Cambrian Period is followed by the Ordovician period.
- It has the duration between 505 and 438 mya.
- The significant observations of the Ordovician period are:
  - Dominance of marine and green algae.
  - The fossils of *Chara* and *Red algae* were reported from the sediments of the period.

(iii) Silurian flora

- The Ordovician period is followed by the Silurian Period.
- It is spread between 438 and 410 mya.
- The significant observations of the Silurian period are: Mild climate, stable and warm temperature.
- The first fossil records of vascular plants, i.e., land plants with vascular tissues, appeared in the Silurian period.
- The earliest known representatives of this group (mostly from the northern hemisphere) are placed in the genus *Cooksonia*. They had very simple branching patterns, with the branches terminated by flattened sporangia.
- By the end of the Silurian much more complex vascular plants, the *zosterophyllum*, had diversified and primitive *lycopods*, such as *Baragwanathia* (originally discovered in Silurian deposits in Victoria, Australia), had become widespread.

(iv) Devonian flora

- The Silurian period is followed by the Devonian Period.
- It spread between 410 and 360 mya.
- The significant observations of the Devonian period are:
  - Mountain-building activities prevailed
  - Climate became drier
  - Sea covered most of the land
- Green vegetation started - Fern vegetation evolved at the end (Rhynia,Psilotum etc)
- Age of fishes, sharks and rays.
- By the Late Devonian, forests of large, primitive plants existed: lycophytes, sphenophytes, ferns, and progymnosperms had evolved.
- Most of these plants have true roots and leaves, and many were quite tall.
- The tree-like *Archaeopteris*, ancestral to the gymnosperms, and the giant *cladoxylopsid* trees had true wood. These are the oldest known trees of the world's first forests.
- Earth appeared to look green.
- Some plants started to produce seeds rather than spores Origin of Bryophytes.

(v) Carboniferous flora

- The main Early Carboniferous plants were the *Equisetales* (Horsetails), *Sphenophyllales* (scrambling plants), *Lycopodiales* (Club mosses), *Lepidodendrales* (scale trees), *Filicales* (Ferns), and the *Cordaitales*.
- These continued to dominate throughout the period, but during late Carboniferous, several other groups, *Cycadophyta* (cycads), the *Callistophytales* (another group of "seed ferns"), and the *Voltziales* (related to and sometimes included under the conifers), appeared.
- Origin of Gymnosperms.
- The fronds of some Carboniferous ferns are almost identical with those of living species.
- Probably many species were epiphytic.
- Fossil ferns "include *Pecopteris, Cyclopteris, Neuropteris, Alethopteris and, Sphenopteris, Megaphyton* and *Caulopteris* were tree ferns.

- The Equisetales included the common giant form Calamites, with a trunk diameter of 30 to 60 cm and a height of up to 20 meters.
- Sphenophyllum was a slender climbing plant with whorls of leaves, which was probably related both to the calamites and the lycopods.
- Cordaites, a tall plant (6 to over 30 meters) with strap-like leaves, was related to the cycads and conifers; the catkin-like inflorescence, which bore yew-like berries, is called Cardiocarpus. These plants were thought to live in swamps and mangroves.
- True coniferous trees (Walchia, of the order Voltziales) appear later in the Carboniferous, and preferred higher drier ground.

(vi) Permian flora

- The Permian began with the Carboniferous flora still flourishing.
- About the middle of the Permian there was a major transition in vegetation.
- The swamp-loving lycopod trees of the Carboniferous, such as *Lepidodendron* and *Sigillaria*, were replaced by the more advanced conifers, which were better adapted to the changing climatic conditions.
- The *ginkgos* and cycads also appeared during this period. Rich forests were present in many areas, with a diverse mix of plant groups.
- Rise of Conifers

2. Mesozoic era

- The duration of mesozoic era is the time of Middle life in the history of the earth.
- This is the Age of reptiles.
- This era has the span of time between 245 mya and 66.4 mya.
- It is further divided into three periods as:
  1) Cretaceous Period- 144 - 65 mya
  2) Jurassic Period- 208 - 144 mya
  3) Triassic Period - 245 - 208 m

(i) Triassic flora

- Seed ferns (Pteridosperms) become extinct ,whereas number of Cycads, conifers and Ginkgoales increased.
- The spermatophytes, or seed plants came to dominate the terrestrial flora: in the northern hemisphere, conifers flourished Dicroidium (a seed fern) was the dominant southern hemisphere tree during the Early Triassic period.
- Age of Cycads.

(ii) Jurassic flora

- Origin of angiosperms.
- Rise in the number of leptosporangiate ferns Conifers dominated the flora, as during the Triassic they were the most diverse group and constituted the majority of large trees.
- Extent conifer families that flourished during the Jurassic included the *Araucariaceae, Cephalotaxaceae, Pinaceae,Podocarpaceae, Taxaceae and Taxodiaceae*.

(iii) Cretaceous flora

- Flowering plants, also known as angiosperms, spread during this period, although they did not become predominant until near the end of the period.
- Their evolution was aided by the appearance of bees, in fact angiosperms and insects are a good example of coevolution.
- The first representatives of many modern trees, including figs and magnolias, appeared in the Cretaceous.
- At the same time, some earlier Mesozoic gymnosperms, like Conifers continued to thrive, although other taxa like Bennettitales died out before the end of the period.

3. Coenozoic era

- The duration of cenozoic era is the time of Recent life.
- This is the age of mammals.
- This is the age of angiosperms.
- This era has the Span of time from 65 mya ago to the present day.
- It is further divided into two major periods as :
  1) Quaternary Period (Age of man) and
  2) Tertiary Period (Age of mammals).

The Tertiary Period includes the epochs:

1. Pliocene 5.3-1.6 mya
2. Miocene 23.8-5.3mya
3. Oligocene 33.7-23.8mya
4. Eocene 55-33.7 mya
5. Palaeocene 65-55 mya.

THE QUATERNARY PERIOD INCLUDES THE EPOCHS:

1. Holocene 10000 years to the present
2. Pleistocene 1.6-0.01 mya

Palaeocene Epoch(65-55 mya):

- The significant observations of this period are:
  - Climate Tropical
  - Forest of Angiosperms
  - First large mammals
  - Development of Alpine mountains

Eocene Epoch (55-33.7 mya):

- The significant observations of this period are:
  - Moderate, cooling climate.
  - First grasses appeared
  - Woody angiosperms developed.
  - During this epoch Development of Himalayan mountain ranges.

Oligocene Epoch (33.7-23.8 mya):

- The significant observations of this period are:
  - Warm but cooling climate
  - Rise in the number of woody angiosperms
  - Early ancestral elephants
  - Carnivores well-established

Miocene Epoch (23.8-5.3 mya):

- The significant observations of this period are:
  - First Apes appeared
  - Whales, Apes and grazing mammals dominated.
  - Spread of grasslands as forests contracted

Pliocene Epoch (5.3-1.6 mya):

The significant observations of this period are:

- Ice Age begins.
- Seas restricted.
- Cool and dry climate.
- Spread of herbaceous dicotyledonous plants.
- Many of the existing generation of mammals and recent mollusks appear.
- Horses and Elephants became almost modern in appearance.

- .First known appearance of hominids (human like primates).
- Large carnivores were dominated.

<u>THE QUATERNARY PERIOD INCLUDES THE EPOCHS</u>:

1. Holocene 10000 years to the present
2. Pleistocene 1.6-0.01 mya.

Pleistocene Epoch(1.6-0.01 mya):

The significant observations of this period are:

- The Era of ice ages.
- Glacial climate.
- Dominance of herbaceous plants and grasses
- Evolution of modern humans
- Formation of large scale Deserts – Sahara was formed
- Extinction of many species due to ice ages.

Holocene Period (10000 years to the present):

The significant observations of this period are:

- Dominance of Man
- Increase of herbaceous plants and evolution of monocots
- Beginning of Agriculture.
- Humans built cities.
- Paleolilthic and Neolithic cultures began around 10000 BC.
- Man used iron implements

TYPES OF FOSSILIZATION AND FOSSIL PTERIDOPHYTES

Palaeobotany is derived from Greek word *palaeo- ancient*, *old* and *botany - the study of plants.*

- The study of fossil Plants – Palaeobotany.
- Fossil plants are found in stratified rocks or sedimentary rocks.
- **Prof. Birbal Sahni** is popularly known as Father of Indian Paleobotany.
- *Birbal Sahni Institute* of Palaeobotany is situated in Lucknow.

Fossil

- The word fossil is derived from the Latin verb '*fodere*' which means "to dig up". Thus, a fossil refers to anything that is excavated from the earth.
- A fossil is an impression, cast, original material or track of any animal or plant that is preserved in rocks after the original organic material is transformed or removed.

NOMENCLATURE OF FOSSILS

Sixth International Botanical Congress (1935) -Each fossilized plant part or organ is given a name which is equal to the status of a genus.

Rules of naming form genera

- Stem - dendron : Lepidodendron
- Leaf - phyllum : Lepidophyllum
- Woody Plant Part - Xylon : Mycloxylon
- Seed - spermum, carpon, stoma : Lepidocarpon
- Cone - strobus : Lepidostrobus, Androstrobus
- Microsporangia - theca : Polytheca

The fossils may be categorised into the following types:

SI.no	Type	Features
1	Chemical Fossils	• These are the remnants of organic compounds preserved in sediments or in parts of fossilised structures without undergoing any or minimal change. • These include amino acids, hydrocarbons, fatty acids, lipids, carbohydrates and the derivatives of other organic compounds.
2.	Trace Fossils or Ichnofossils	• Sometimes, indications of prior existence of organisms in the sediments of earth may be regarded as trace fossils or Ichnofossils. • These include animal tracks or foot print preserved in rocks, burrows of invertebrates, coprolites (fossil excretes), gastroliths (polished stones in the abdomen of dinosaurs), gnawed bones, etc.
3.	Micro fossils	• Microscopic organisms like bacteria, spores and pollen grains, fungal and algal spores, diatoms, epidermal and wood fragments of plants etc. preserved in the sedimentary deposits are referred to as microfossils.
4.	Mega fossils	• Large parts of plants like leaf, stem, root, flower, seed, etc. and animal remains as whole organism or in parts, preserved in the sedimentary deposits are called megafossils. • These are visible to naked eyes and are the better source of morphological as well as anatomical studies.

FOSSILIZATION

- The process of preservation of living beings or their parts in the form of fossils is known as Fossilization.
- Two theories have been proposed to explain the fossilization process in plants:
  1. Replacement Theory
  2. Infiltration Theory

1. Replacement theory

- According to this theory, fossilization takes place by the replacement of the molecules of the original substances of the plants one by one by the

molecules of minerals in soil solution. This occurs due to hydrolysis or weathering of the organic substances present in the plant body.

2. Infiltration theory

- According to this theory, fossilization takes place as a result of infiltration and precipitation of minerals through the cell wall.
- After burial the plant undergoes partial disintegration and the free carbon release in this process forms carbonates by reacting with infiltrated calcium, magnesium etc.

Factors affecting fossilization

- Nature of plant
- Rapidity by which material is prevented from decay by organisms
- Changes to which rocks are subjected during/after the burial of plant part
- Extent of mineralization

KINDS OF FOSSILS

SI.NO	TYPE	FEATURES
1.	Compressions	• Most common kind of fossil. • Much of the organic matter is preserved with the impression of the plant. • Cell pattern of the cutinised epidermis is retained sometimes. • These are formed due to great vertical pressure of the sediments lying over them. • Coal is a complex kind of compression.
2.	Impressions	• These are prints made by plants or plant fragments which come in contact with the soft clay. • The plant material disorganizes or decays completely leaving impression on the rock. • They are usually darker in colour than the surface of the rock.
3.	Incrustation or Mold And Cast	• A replica of a plant or animal is preserved in sedimentary rocks. • An organism is buried in sediment and then dissolved by underground water leaving a hollow depression called a mold. • The mold shows only the original shape and marking of the organism. • It does not reveal the internal structure Minerals or sediments fills the hollow depressions and forms a cast. • In these types, only external forms are preserved, while internal cellular details are not preserved.

4.	Petrifactions	• These are the best, but rarest types of fossil which preserve the external form as well as the internal structures. • They are formed by molecule replacement of plant part by soluble minerals they eventually harden. • Buried plants absorbs mineral solutions like carbonate, sulphates, silicates, phosphate etc. • This infiltration is followed by precipitation so that calcium carbonate, magnesium carbonate, iron sulphite and silica gets impregnated within plant tissue.
5.	Compaction Fossils (Mummified plants)	• These are the plants or plant fragments compressed by vertical pressure. • Occasionally in leathery leaves or tough fruits, the tissues are retained in mummified condition.
6.	Amber	• The fossilised resin of extinct coniferous trees, Pinus succinifera in particular, is called Amber. • These resinous excretions flows due to injuries caused by boring insects or decaying branches. • The resin, before becoming amber can trap insects, pollen, leaves etc.
7.	Coal Balls	• The petrified spherical balls containing plant parts are commonly termed coal balls . • These spherical balls are formed as a result of infiltration of plant debris in swamps by carbonates of calcium or magnesium, thus restricting the conversion of the debris into coal. • Coal balls occur in localised regions and they range in few centimeters to several meters and weigh from a few to several pounds. • Coal balls are specifically significant in palaeobotanical studies.
8.	Pseudofossils	• Sometimes inorganic rocks that appear to be fossils are actually mineral deposition. • These fake structures are mistaken for plant or animal remains. These are known as pseudofossils.

FOSSIL PTERIDPHYTES

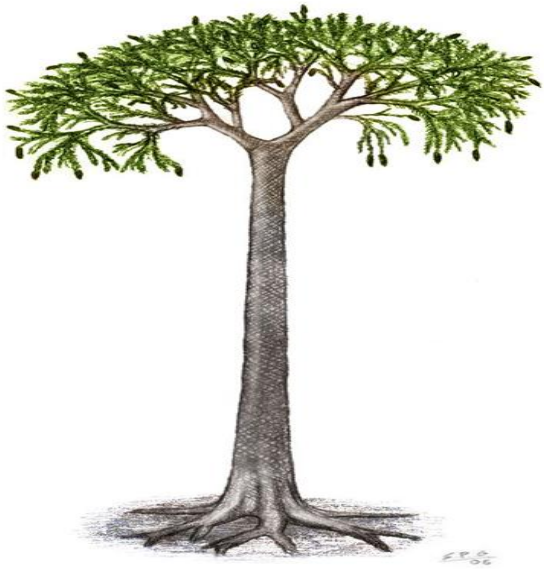
DIVISION: LYCOPHYTA

CLASS: LIGULOPSIDA

ORDER: LEPIDODENDRALES

FAMILY: LEPIDODENDRACEAE

GENUS: LEPIDODENDRON



(i) More than one hundred species under the genus Lepidodendron have been described.

(ii) It appeared during upper devonian, flourished in carboniferous and disappeared in permian.

(iii) It is a giant tree and reaches up to a height of 40 meters and the diameter of the trunk was approximately 50 centimeters.

(iv) The trunk was straight and columnar, unbranched up to certain distance above the ground.

(v) The leaves known as *lepidophyllum*, are spirally arranged.

vi) Leaves (lepidophyllum) were deciduous, simple ligulate, linear to acicular in shape and 2 to 18 cm in length.

vii)Upon abscission a flat rhomboidal scar persisted on the stem resembling a small cushion.

viii)The base of the stem had a stigmarian type of root system.

ANATOMY OF THE TRUNK

The trunk was differentiated into central stele surrounded by cortex

●The cortical zone was very thick and can be differentiated into.

(a) Inner cortex,

(b) Secretory zone,

(c) Middle cortex and

(d) Outer cortex

- The inner cortex was made up of parenchyma cells.
- The Secretory zone consisting of glandular cells which were filled with a dark coloured substance. They probably secreted the waxy material which covered the surface of the stem.
- The middle cortex was similar to inner cortex in structure and appearance.
- The outer cortex was composed of alternating patches of parenchymatous and sclerotic tissue.

- The outer cortex was encircled by hard periderm layer formed by phellogen.
- The stele was either siphonostelic or protostelic.
- The protoxylem was exarch and polyarch.
- The meta xylem of tracheids was with scalariform thickening and the protoxylem was with spiral thickenings.
- The secondary wood has scalariform tracheids and small wood ray.

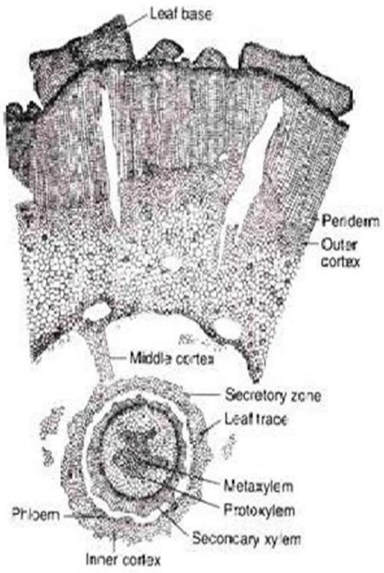


Fig. 7.40 : T.S. of *Lepidodendron* stem

ANATOMY OF LEAVES

- Leaf is known as Lepidophyllum.
- They were borne spirally on the stem and were triangular in shape.
- Stomata were present on the abaxial side.
- The leaf base was seen with a small single vascular strand.
- The vascular strand was flanked by two triangular or rounded areas or scars - one on each side.

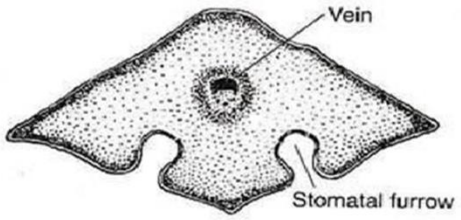


Fig. 7.42 : T.S. of acicular part of *Lepidodendron* leaf

- These scars were termed as **parichnos**. The parichnos represented secretory or aerating parenchyma cells extending from stem cortex into the leaf.
- A ligular scar or pit was present in the centre of the cushion above the parichnos.

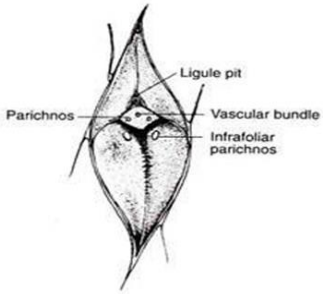


Fig. 7.39 : Leaf cushion of *Lepidodendron*

- The ligule was shrunken and small.
- The mesophylls were present in the central region of the leaf.

REPRODUCTIVE ORGAN

- Strobili of Lepidodendraceae were discovered from carboniferous rocks and were named as form genus Lepidostrobus.
- These strobili (lepidostrobus) were elliptical, born terminally on the lateral branches of the crown.
- They were 2.5 to 30 cm long and l to 7.5 cm in diameter.
- The strobili were heterosporous having microsporophylls and megasporophylls, arranged spirally on the axis of the strobilus.

- The sporophylls were ligulate.
- The sporangia were sessile, elongated and of same size born on adaxial surface near the base of the respective sporophylls.
- The microsporangium had many small microspores and the megasporangium had 5-16 megaspores.
- The size of the microspores ranges from 0.02 to 0.03 mm in diameter and that of megaspores ranges from 0.5 to 2.0 mm in diameter.

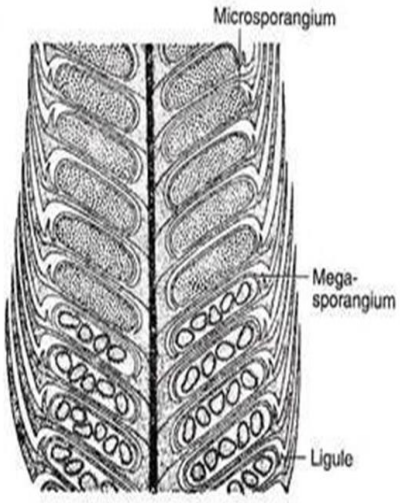


Fig. 7.43 : L.S. of *Flemingites* cone

STRUCTURE OF GAMETOPHYTE

- The male gametophyte has not yet been reported.
- Female gametophyte with archegonia has been reported.
- The megaspore developed into female gametophyte while still within the megasporangium.

DIVISION: PSILOPHYTA

CLASS: PSILOPHYTOPSIDA

ORDE: PSILOPHYTALES

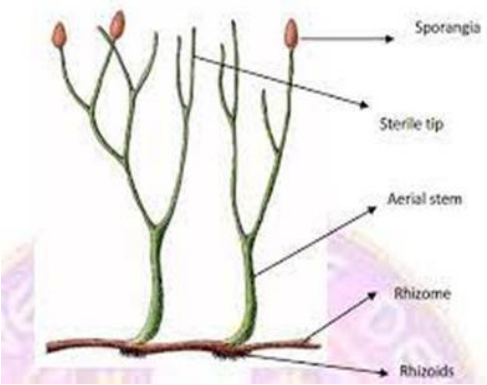
FAMILY: RHYNIACEAE

GENUS: RHYNIA

- Fossil plant.
- ***Rhynia major*** and ***Rhynia gwyne vaughani***
- Discovered by – Robert Kidston and William Lang (1971)
- Devonian period

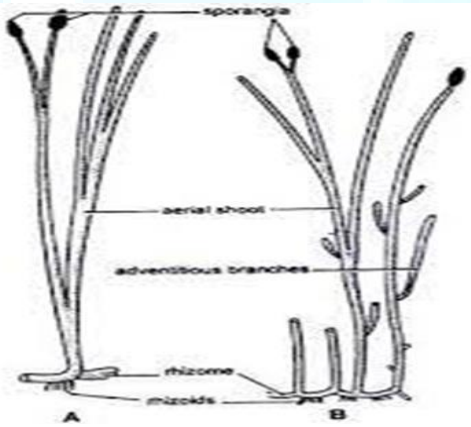
MORPHOLOGY

- **Plant Body** – subterranean, creeping, cylindrical and dichotomously branched rhizome with dichotomously branched aerial leafless shoots
- Root absent but tuft of rhizoids develop from rhizome.



SPOROPHYTE

- In *Rhynia gwyne vaughani* aerial shoots has many adventitious branches.
- Aerial branches ends in tapering vegetative apices or pear shaped sporangia.



ANATOMY OF RHYNIA STEM

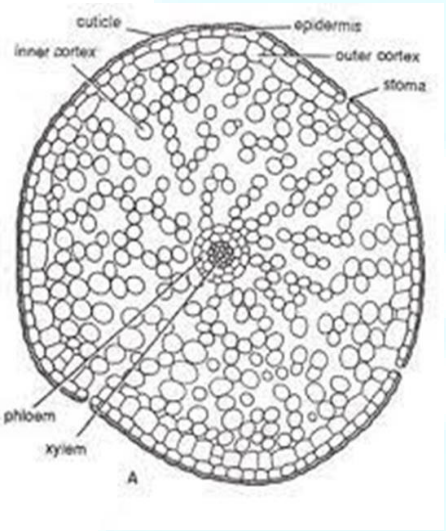
1. **Epidermis** – single layered, thick cuticle, stomata present

2. **Cortex** – outer and inner

- Outer–1-4 layered, compact polygonal parenchymatous cells.
- Inner- spherical, parenchyma cells with intercellular spaces.

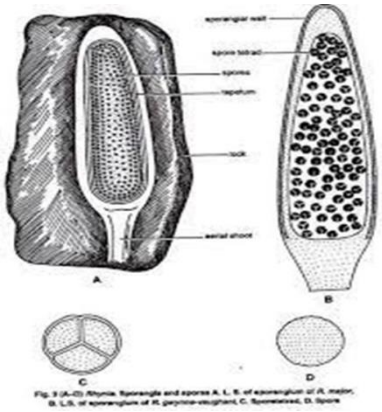
3. Central Cylinder

- Protostele, primitive.
- Xylem composed of tracheids with annular and spiral thickening
- No sieve plates in phloem.
- Endodermis and pericycle absent.



REPRODUCTIVE STRUCTURE

- Sporangia were present singly at the tips of some aerial branches.
- Sporangia – oval to cylindrical, with distal pointed and broad basal end
- Sporangia of *Rhynia major* were larger than *Rhynia gwyne vaughani*.



STRUCTURE OF SPORANGIUM

Sporangium is surrounded by multilayered jacket.

●Outer layer was a cuticularised epidermis

●Middle layer – 2-3 layers of parenchyma cells

●Innermost layer – tapetum

●Large number of spore tetrad in sporangial cavity.

●Spores homosporous

●No specialised mechanism for dehiscense.

GAMETOPHYTE

●Lyon (1957)- Some germinating spores which show multicellular structure developing at the end of germ tube was the indication of the presence of gametophyte in Rhynia

●Merker(1959) is of the opinion that the underground creeping parts of Rhynia is the gametophyte but not the rhizome

●Not much is known about gametophyte of Rhynia.

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 broadend 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.

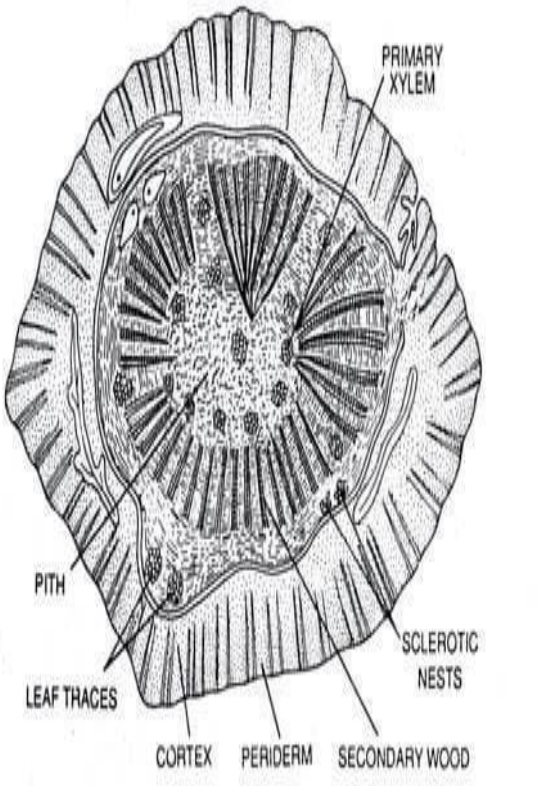


Fig. 2.4. *Lyginopteris oldhamia*. T.S. of the stem showing well-developed secondary wood and leaf traces.

FORM GENERA

STEM - Heterangium

FROND - Sphenopteris

PETIOLE -Rachiopteris

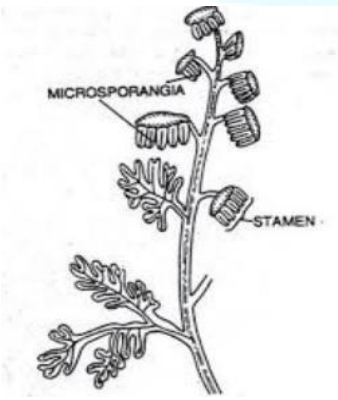
ROOT - Kaloxylon

SEEDS- Lagenostoma

POLLEN BEARING ORGAN - Crossotheca

Male Fructification - Crossotheca

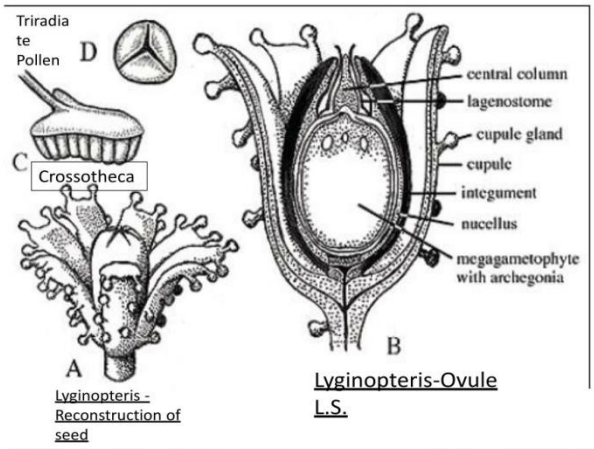
- In Crossotheca, a number of boot shaped bilocular microsporangia were arranged radially on the underside of discs.
- Microsporangia were borne as elongate, pendant appendages on the ultimate pinnule of the frond.
- The sporangia lack annulus and resembles those of Cycas.
- On dehiscence microsporangia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



ENTRI

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).



Lyginopteris - Reconstruction of seed

Lyginopteris-Ovule L.S.

- 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.

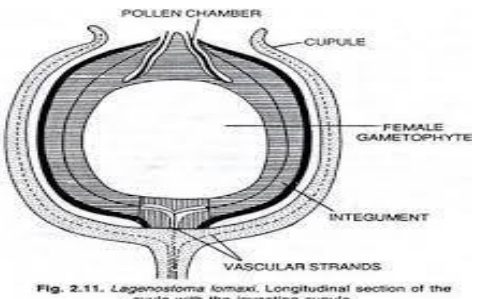


Fig. 2.11. *Lagenostoma lomaxi*. Longitudinal section of the ovule with the investing cupule.

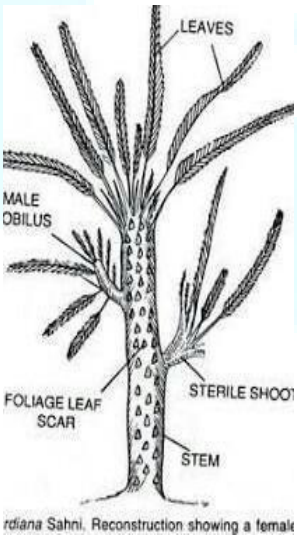
Class : Cycadopsida

Order : Bennettitales(Cycadeoideales)

Family : Williamsoniaceae

Genus : Williamsonia

- 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.

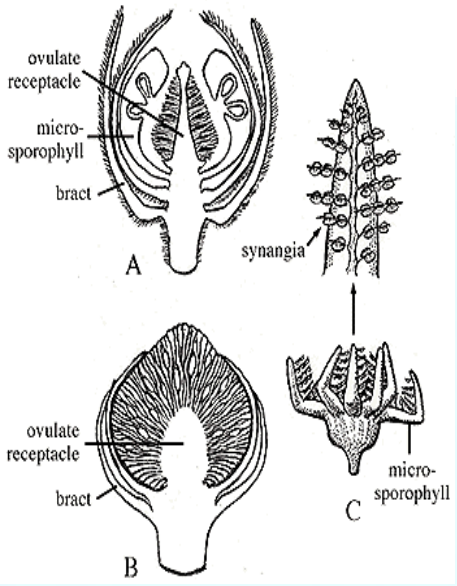


rdiana Sahni. Reconstruction showing a female

Female Flower

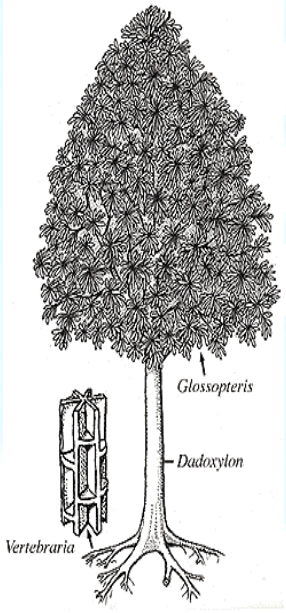
- The female flower in *W.gigas* and *W. sewardiana* have a distinct conical receptacle surrounded by simple perianth like bracts, that had scales at their bases.

- 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 veination
- 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 :

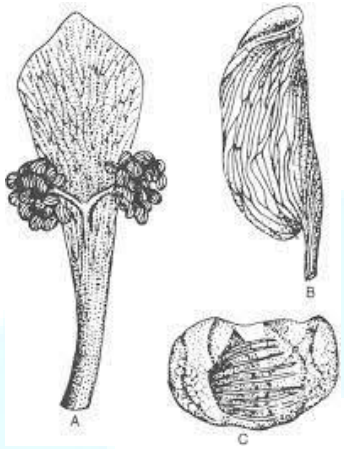
Eretmonia and Glossotheca

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

- Pollination was probably anemophyllous.

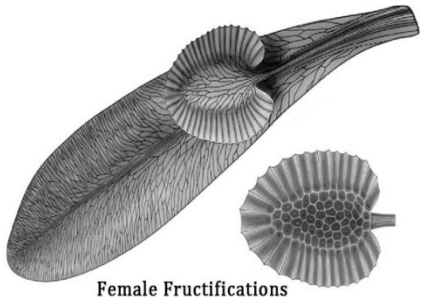
Glossotheca :

- 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 :

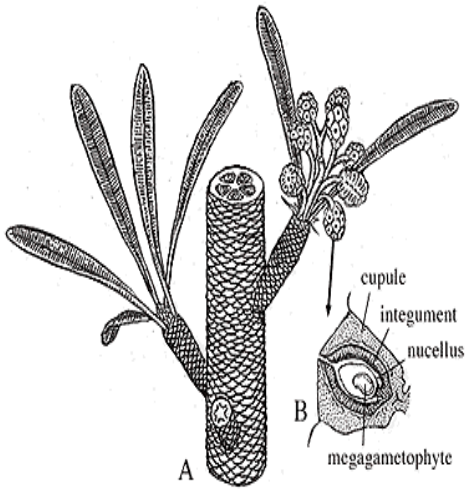
- The dorsiventral structure bearing seeds of Glossopteridales are variously termed as capitulum, megasporophyll, cupule, fertiliger or cladode.
- It has two bilaterally concave valves.
- A wing like expansion is present along the line where the two valves join.
- Small sac like structure is present 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.
- This also shows a combination of features characteristic of the Bennettitales, cycadales and coniferales.
- Lam (1952) suggested that Pentoxyleae should be given a rank equivalent to Bennettitales 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 vienation.
- Possess haplocheilic stomata.
- Stems were polystelic.
- Wood of Pentoxylon was pycnoxylic and resembled Araucaria.
- Ovules were sessile.



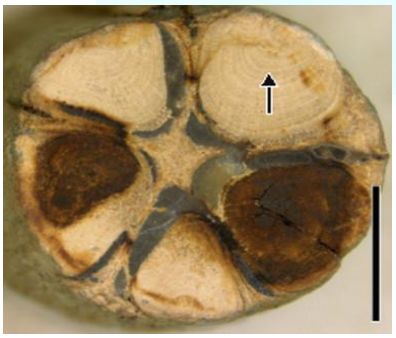
STEM GENERA

Pentoxylon sahnii

- *Pentoxylon sahnii* - the stem genera of Pentoxyleae
- 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 sahni.
- 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.

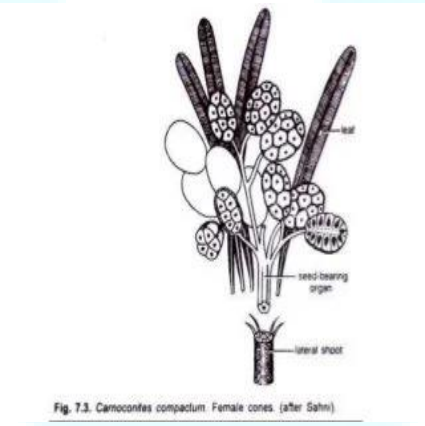


Fig. 7.3. Carnoconites compactum. Female cones. (after Sahni)

- 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.

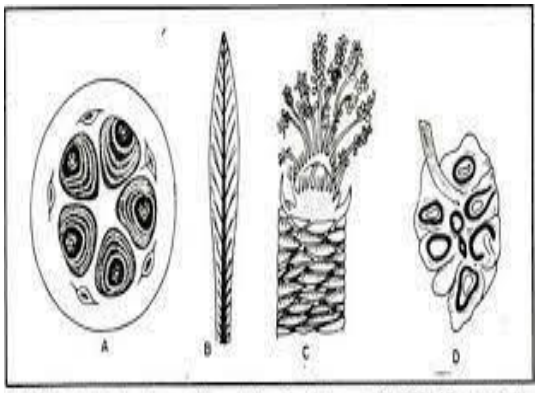


Fig 8.19. A – T.S. through stem of Pentoxylon Sp., B – Whole mount of leaf, C – Microsporophyll, D – V.S. through ovules.

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