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।। सरस्वती नः सुभगा मयस्करत् ।।

PGBY-106 (N)

Gymnosperms and Palaeobotany

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॥ सरस्वती नः सुभगा मयस्करत् ॥

संदेश

प्रयागराज की पवित्र भूमि पर भारत रत्न राजर्षि पुरुषोत्तम दास टण्डन के नाम पर वर्ष 1999 में स्थापित उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय, प्रयागराज उ0प्र0 का एकमात्र मुक्त विश्वविद्यालय है। यह विश्वविद्यालय उ0प्र0 जैसे विशाल जनसंख्या वाले राज्य में उच्च शिक्षा के प्रत्येक आकांक्षी तक गुणात्मक तथा रोजगारपरक उच्च शिक्षा के अवसर उपलब्ध कराने में निरन्तर अग्रसर एवं प्रयत्नशील है। तत्कालीन देश की सामाजिक एवं आर्थिक परिस्थितियों में एक वैकल्पिक व नवाचारी शिक्षा व्यवस्था के रूप में भारत में मुक्त एवं दूरस्थ शिक्षा प्रणाली का पदार्पण हुआ था, परन्तु वर्तमान परिस्थितियों तथा तकनीकी का सार्थक प्रयोग करते हुये मुक्त एवं दूरस्थ शिक्षा आज की सर्वोत्तम पूरक शिक्षा व्यवस्था के रूप में स्थापित हो चुकी है।

वर्तमान शिक्षा प्रणाली के सामने व्याप्त पाँच मुख्य चुनौतियों - (i) पहुँच (Access), (ii) समानता (Equity), (iii) गुणवत्ता (Quality), (iv) वहनीयता (Affordability) तथा (v) जवाबदेही (Accountability) को केन्द्र में रखकर घोषित देश की राष्ट्रीय शिक्षा नीति (NEP-2020) के प्रस्तावों को क्रियान्वित करने में उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय कृत संकल्पित है। उ0प्र0 की माननीय राज्यपाल एवं कुलाधिपति की सद्इच्छाओं के अनुरूप उत्तर प्रदेश राजर्षि टण्डन मुक्त विश्वविद्यालय, शैक्षिक दायित्वों के साथ-साथ सामाजिक दायित्वों के निर्वहन में भी लगातार नवप्रयास कर रहा है। चाहे वह गाँवों को गोद लेकर उनके समग्र विकास का प्रयास हो या ग्रामीण महिलाओं, ट्रान्सजेन्डर व सजायाफ्ता कैदियों को शुल्क में छूट प्रदान कर उनमें आत्मविश्वास जागृति व उच्च शिक्षा के प्रति अलख जगाने का प्रयास हो।

राष्ट्रीय विकास को बढ़ावा देने के लिए शिक्षा एक मूलभूत जरूरत है। ज्ञान-विज्ञान एवं तकनीकी के क्षेत्रों में हो रहे तीव्र परिवर्तनों व वैश्विक स्तर पर रोजगार की परिस्थितियों में आ रहे परिवर्तनों के कारण भारतीय युवाओं को विभिन्न क्षेत्रों में गुणवत्तापूर्ण शैक्षिक अवसर उपलब्ध कराने पर ही भारत का भविष्य निर्भर करेगा। इसीलिए विभिन्न क्षेत्रों में सफलता हेतु शिक्षा को सर्वसुलभ, समावेशी तथा गुणवत्तापरक बनाना समसामयिक अपरिहार्य आवश्यकता है। वर्तमान परिस्थितियों ने परम्परागत शिक्षा को और भी सीमित कर दिया है जिसके कारण मुक्त एवं दूरस्थ शिक्षा व्यवस्था ही एकमात्र पूरक एवं प्रभावी शिक्षा व्यवस्था के रूप में सार्थक सिद्ध हो चुकी है। ऐसी स्थिति में विश्वविद्यालय का दायित्व और भी बढ़ जाता है। इस दायित्व को एक चुनौती स्वीकार करते हुए विश्वविद्यालय ने प्राचीन तथा सनातन भारतीय ज्ञान, परम्परा तथा सांस्कृतिक दर्शन व मूल्यों की समृद्ध विरासत के आलोक में सभी के लिए समावेशी व समान गुणवत्तायुक्त शिक्षा सुनिश्चित करने तथा जीवन पर्यन्त शिक्षा के अवसरों को बढ़ावा देने के लिए अपने शैक्षिक कार्यक्रमों में जागरूकता में प्रमाणपत्र, डिप्लोमा, परास्नातक डिप्लोमा, स्नातक, परास्नातक तथा शोध उपाधि के समसामयिक शैक्षिक कार्यक्रमों की संख्या तथा गुणात्मकता में वृद्धि की है।

शैक्षिक कार्यक्रमों में संख्यात्मक वृद्धि, गुणात्मक वृद्धि तथा रोजगारपरक बनाने के साथ-साथ प्रत्येक उच्च शिक्षा आकांक्षी तक पहुँच सुनिश्चित करने के लिए अध्ययन केन्द्रों व क्षेत्रीय केन्द्रों के विस्तार के साथ-साथ प्रवेश परीक्षा, प्रशासन तथा परामर्श (शिक्षण) में आनलाइन व्यवस्थाओं को सुनिश्चित किया गया है। विश्वविद्यालय कार्यप्रणाली में पारदर्शिता तथा जवाबदेही सुनिश्चियन की दृष्टि से तकनीकी के प्रयोग को बढ़ाया गया है। 'चुनौती मूल्यांकन' की व्यवस्था सुनिश्चित करने का कार्य किया गया है, तो शिक्षार्थी सहायता सेवाओं में भी वृद्धि की जा रही है। शिक्षार्थियों की समस्याओं के त्वरित निस्तारण हेतु शिकायत निवारण प्रकोष्ठ को सुदृढ़ करने के साथ-साथ पुरातन छात्र परिषद को गतिशील किया गया है।

"गुरुकुल से छात्रकुल" के सूक्त वाक्य को आत्मसात करते हुए विश्वविद्यालय ने शिक्षार्थियों को विश्वविद्यालय द्वारा तैयार किये गये गुणवत्तापूर्ण स्वअध्ययन सामग्री उपलब्ध कराने के साथ-साथ विश्वविद्यालय की वेबसाइट पर भी उपलब्ध कराया गया है। छात्रहित को ध्यान में रखते हुए शिक्षकों द्वारा तैयार व्याख्यान को भी ऑनलाईन उपलब्ध कराया गया है।

शोध और नवाचार के क्षेत्र में अग्रसर होते हुए विश्वविद्यालय अनुदान आयोग (UGC) नई दिल्ली तथा माननीय राज्यपाल एवं कुलाधिपति, उ0प्र0 की अनुमति से विश्वविद्यालय में शोध कार्यक्रम पुनः प्रारम्भ किया गया है तथा वर्ष पर्यन्त समसामयिक विषयों पर व्याख्यान, सेमिनार, वेबिनार तथा आनलाइन संगोष्ठियों आदि की श्रृंखला भी प्रारम्भ की गयी है। विभिन्न क्षेत्रों में रिसर्च प्रोजेक्ट सम्पादन पर भी ध्यान केन्द्रित किया गया है। पुस्तकालय को अत्याधुनिक तथा सुदृढ़ बनाने हेतु कदम उठाये गये हैं। शिक्षकों व कर्मचारियों के स्वास्थ्य तथा कल्याण की योजनायें क्रियान्वित की गयी हैं।

प्रो0 सत्यकाम
कुलपति

U.P.Rajarshi Tandon Open University, Prayagraj

PGBY-106 (N)
Gymnosperms and Palaeobotany

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COURSE INTRODUCTION

The objective of this course is to provide knowledge about gymnosperms and palaeobotany. Gymnosperms are a group of seed producing plants which do not produce flowers. Their seeds are found naked on megasporophylls. Gymnosperm includes conifers,cycads,ginkgoales and gnetales. Palaeobotany is the study of plant fossils to understand the evolutionary history and past environments. It provides insights into ancient plant life, climate and ecosystems based on the analysis of preserved plant remains. This course is organized into following three blocks.

Block-1

This block covers the introduction of gymnosperm and general account of class cycadopsida. This block is divided into three units.

Unit-1 General introduction of gymnosperms;This unit provides the all general information about gymnospers.

Unit-2 Cycadopsida-1; This unit provides knowledge about diversity of gymnosperms in plant kingdom.

Unit-3 Cycadopsida -2; This unit provides the knowledge about some extinct orders of gymnosperms.

Block-2

This block covers the knowledge about coniferopsida. This block includes six units.

Unit-4 Cordaitales; This unit provides the information about some families of order Cordaitales.

Unit-5 Ginkgoales; This unit is about ginkgo plant of order ginkgoales.

Unit-6 Coniferales-1; This unit provides the information about some fossil genera of conifers.

Unit.7 Coniferales-2; This unit provides the knowledge about some living genera of conifeales.

Unit-8 Coniferales-3; This unit provides the knowledge about some more families of coniferales.

Unit-9.Taxales; This unit gives the information about some important genera of taxales.

Block-3

Block three describes the palaeobotany and class gnetopsida.This block includes three units.

Unit-10 Gnetopsida; This unit provides the knowledge about some plants of gnetopsida.

Unit-11 Palaeobotany-1; This unit privides the information about paleobotany and geological time scale.

Unit-12 Palaeobotany-2; This unit gives the knowledge about fossilization process.

U.P.Rajarshi Tandon Open
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PGBY-106 (N)

Gymnosperms and Palaeobotany

1

Block

General Account of Gymnosperms and Cycadopsida

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BLOCK-I INTRODUCTION

General account of gymnosperms and cycadopsida

This is the first block of Gymnosperms and paleobotany.Gymnosperm are a group of seed producing plants that include conifers,cycads, and gingkgoales.They differ from angiosperms as their seeds are not enclosed within fruits.Gymnosperm do not produce flowers or fruits like angiosperms.Gymnosperm played a crucial role in the evolution of plants and are adapted to various environmental conditions.

Cycadopsida refers to a class of plants that includes cycads, which are seed plants with a long fossil history.They are characterized by large compound leaves and a sturdy trunk.Cycadopsida is a class within the division cycadophyta.The block first is organised in to three units.

UNIT-1 It covers the introduction and economic importance of gymnosperm.

UNIT-2 It covers about some orders of cycadopsida like pteridospermales, cycadales and nilssoniales.

UNIT-3 It gives the knowledge about bennettitales and pentoxylales.

UNIT-1 GENERAL INTRODUCTION

Structure

1.0 INTRODUCTION

Gymnosperms (gymnos-naked; sperma-seed) and angiosperms (Angios-closed; sperma seed) are the two sub-divisions of division Spermatophyta (sperma-seed; phyton-plant) of plant kingdom. Spermatophyta includes all those plants which bear seeds. Gymnosperms means naked seed, and therefore, this sub-division is characterized by having the ovules borne unprotected on the surface of megasporophylls. In angiosperms, on the other hand, the ovules are borne within a closed cavity. The ovary formed by the megasporophyll, and after fertilization the Ovary becomes a fruit which encloses one or more seeds. The word gymnosperm was first used by Theophrastus, one of Aristotle's pupils.

The lower gymnosperms, such as members of Cycadales, show resemblances with the higher cryptogams (i.e. pteridophyta) whereas the higher gymnosperms, such as Gnetales and Coniferales, resemble members of angiosperms to some extent. Gymnosperms thus form abridge between the pteridophytes and angiosperms, and have, therefore, been referred as "Phanerogams without ovary" by Goebel.

Objectives

- To learn about gymnosperms.
- To know how gymnosperm is different from pteridophytes and angiosperms.
- To know the classification of gymnosperms.
- To understand the evolution of gymnosperms .

- To know the economic importance of gynosperms.

GYMNOSPERMS

Gymnosperms form a small group of plant kingdom. they are represented by only about 70 genera and 725 species. Inspite of being represented by such a small number, the representatives of this group are widely distributed throughout the world. On many mountains they form a dominant part of the vegetation.Gymnosperms are most ancient and a history of the fossil records indicates that they once formed a predominant part of the earth's vegetation. An idea of their history may be gained from during successive geological periods. Both Pteridospermales and Cordaitales first appeared in the Upper Devonian or Lower Carboniferous, i.e. more than 300 million years ago. In additionto Pteridospermales and Cordaitales, two other groups of fossil gymnosperms, i.e. Benncttitales and Pentoxylales have been recognized. Bennettitales were distributed during Mesozoic period from Middle Cretaceous to Upper Triassic while the Pentoxylales were distributed during Jurassic period of Mesozoic era. The living members of the gymnosperms are represented by Cycadales, Ginkgoales. Coniferales and Gnetales.

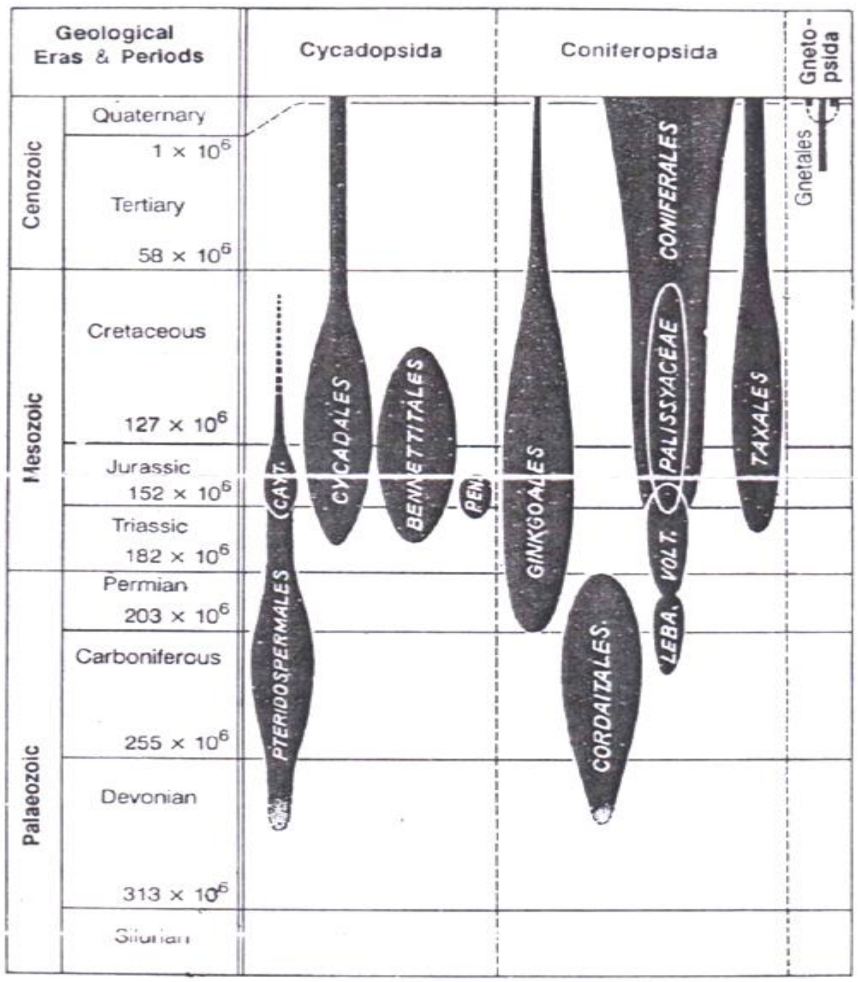


Fig. 1.1. Geological history of gymnosperms. (Cayt, Caytoniaceae; Pen, Pentoxylales; Leba, Lebachiaceae; Volt., Voltziaceae).

Gymnosperms are defined as those seed plants in which the ovules are not enclosed in ovary and the pollen typically germinate on the surface of the ovule. There is no double fertilization in gymnosperms, and the xylem in these plants lacks vessels (except in Gnetales). Theophrastus, was the first to use the word "gymnosperms" in 300 B.C. in his book "Enquiry Into Plants".

1.1 SALIENT FEATURES

1. The living gymnosperms are mostly woody, evergreen, perennials with shruby or tree-like habit. The plants show xerophytic characters. They form the major components of any temperate forest of the world.

2. Except a few deciduous genera (e.g.Larix and Taxodium), most of the gymnosperms are evergreen.

3. *Some of the gymnosperms attain a height up to 100 metres, e.g. Sequoia sempervirens*(nearly 112 metre, the tallest living tree). The smallest gymnosperms is Zamia pygmaea,a cycad. Its fronds are only 4 or 5 cm long.

4. From the economic point of view, gymnosperms are highly important in forestry and horticulture. They yield timber, resins, essential oils, drugs and edible nuts. The newspaper industry is almost completely dependent on the wood of conifers for its paper requirements.

5. The radicle forms the tap root. The tap root system is exarch and diarch to polyarch.

6. The stem is branched but generally unbranched in Cycas. In Cycas revoluta the stem sometimes shows branching.

7. In stem the vascular bundles are conjoint, collateral, open and endarch. They are usuallyarranged in a ring.

8. Cambium is present and the plants show secondary growth.

9. The xylem is composed of xylem parenchyma and tracheids with bordered pits. Vessels areabsent .

10. Phloem consists of sieve tubes and phloem parenchyma as in pteridophytes. Companion cells are absent.

11. The wood may be manoxylicor pycnoxylic (e.g. Coniferales).

12. The leaves are of two types, a*foliage and scaly leaves.* .

13. Usually the leaves are arranged in a spiral manner except in Cupressaceae and Gnetales .

14. *Presence of transfusion tissue is an important feature of the leaf of gymnosperms.*

15. The leaf in most genera contains a single vein. Venation, however, is parallel in Agathis, reticulate in Gnetum and dichotomous in Ginkgo.

16. Resin canals occur in the leaves of all conifers. Mucilage ducts are present in cycads while latex tubes are present in Gnetum.

17. The reproductive parts are generally arranged in the form of compact cones or strobilli. Male cones are usually smaller and short-lived than female cones.

18. In male cones, several microsporophylls are arranged on the central axis, each possessing several microsporangia containing microspores or pollen grains.

19. Sporangial development is similar to eusporangiate ferns.

20. Only one (Cycas) or two (Pinus) prothallial cells are present in the male gametophyte.

21. The ovules are covered by one or rarely two integuments, and are orthotropous. The integument consists of an outer fleshy, a middle stony and an inner fleshy layer.

22. Each ovule opens with a mouth opening or micropyle.

23. The ovules are not enclosed inside the ovary.

24. Double fertilization, a feature unique to angiosperms, is absent in gymnosperms except in Ephedra.

25. The pollination is direct. Atthe time of pollination a "pollination drop" is secreted by the ovule in almost all gymnosperms.

26. Gymnosperms are wind-pollinated.

27. The female gametophyte or endosperm in gymnosperm remains haploid. It is however, triploid in angiosperms.

28. Embryo development is meroblastic, i.e. develops from a small part of zygote. The embryois straight and embedded in the endosperm (except in Bennettitales).

29. Several members show polyembryony (e.g. Pinus).

30. Due to the absence of ovary, the true fruits are lacking.

31. The mature ovule forms the seed and the integuments of ovule form the seed coat.

32. Cotyledons vary from one to many (2 in Cycas, but 2-14 in Pinus) in number.

33. Polyploidy is rare in gymnosperms but common in Ephedra.

34. The diploid or sporophytic phase is dominant and independent in the life cycle while thehaploid or gametophytic phase is dependent and reduced.

35. Members of Cycadofilicales, Bennettitales and Cordaitales are altogether extinct and occuronly as fossils, while that of Cycadales, Ginkgoales and Coniferales are living as well asextinct. Members of Gnetales are living.

36. *Amongst the living or extant gymnosperms, Ginkgoales and Cycadales are very ancient and* they are called "living fossils".

37. According to Raizada and Sahni (1960) living gymnosperms in India are represented by16 genera and 52species .

Table 1.1 Living or extant gymnosperms of India

S.No.	Genus	Approximate number of reported species
1.	*Abies*	*5*
2.	*Cedrus*	*1*
3.	*Cephalotaxus*	*2*
4.	*Cupressus*	*1*
5.	*Cycas*	*5*
6.	*Ephedra*	*7*
7.	*Gnetum*	*5*
8.	*Juniperus*	*7*
9.	*Larix*	*1*
10.	*Libocedrus*	*1*
11.	*Picea*	*3*
12.	*Pinus*	*6*
13.	*Podocarpus*	*4*
14.	*Taiwania*	*1*
15.	*Taxus*	*1*
16.	*Tsuga*	*2*

38. Gymnospermous genera found under cultivation are Cycas, Biota, Thuja,*Araucaria, Ginkgo, Agathis, Cunninghamia and Taxodium.*

39. Plants show alternation of generations.

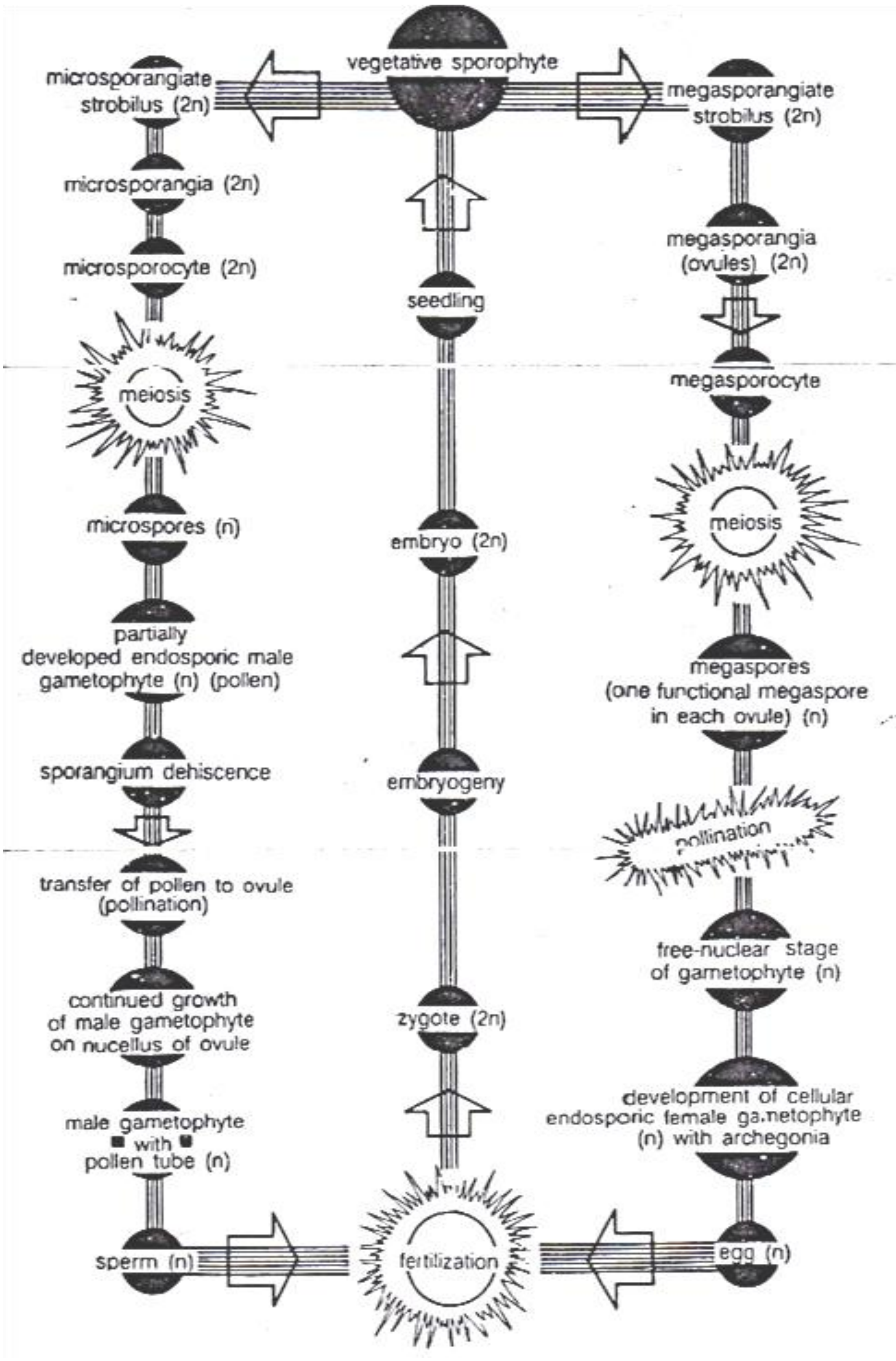


Fig. 1.2 Generalized reproductive cycle in gymnospers.

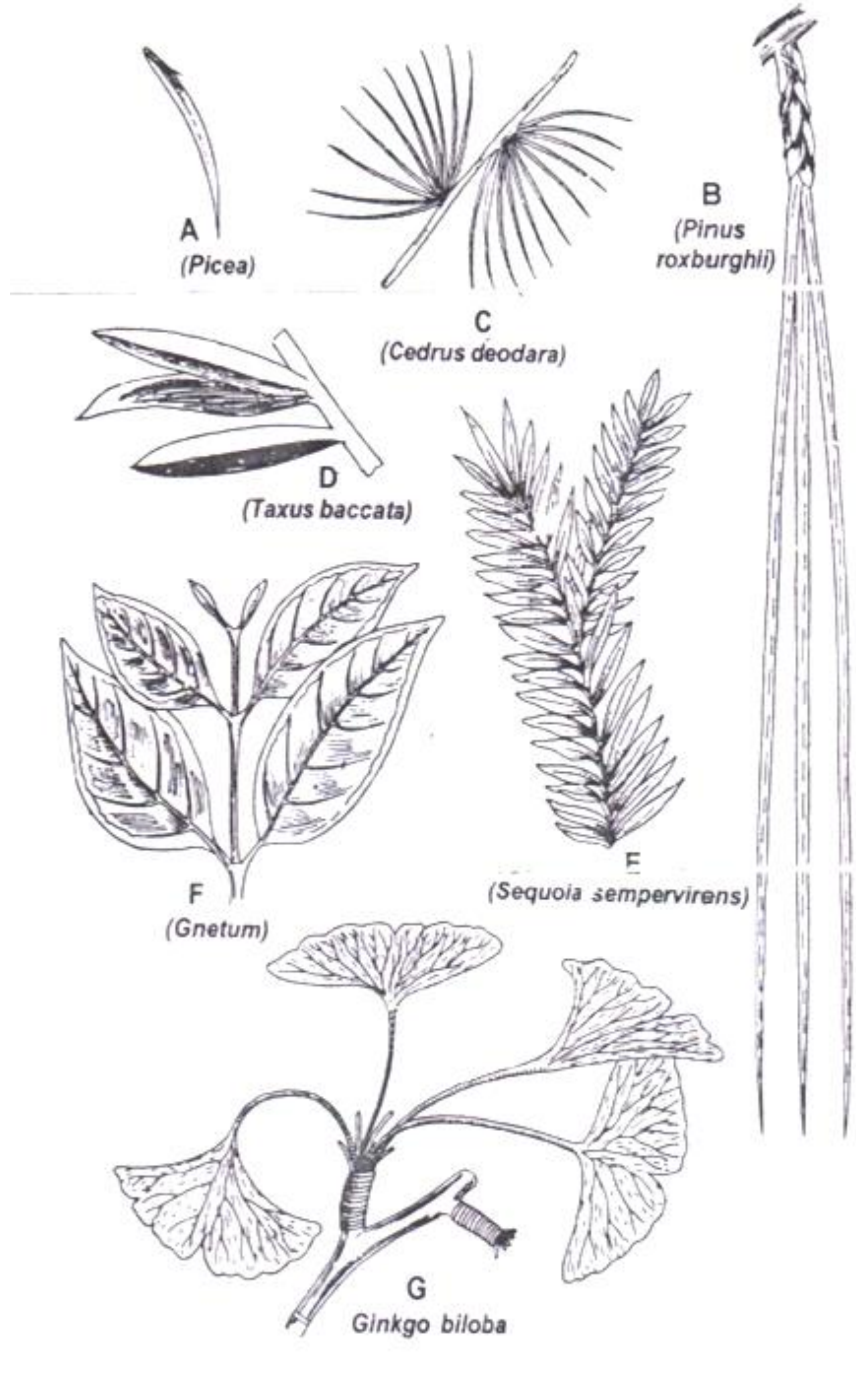


Fig. 1.3. Vegetative organs of some gymnosperms. A, A leaf of Picea; B, A dwarf shoot of Pinus roxburghii, ***with three leaves; C, Needle-like leaves of Cedrus deodara; D, Leaves of Taxus baccata; E, Leaves of Sequoia sempervirens; F, Leaves of Gnetum; G, Leaves of Ginkgo biloba.***

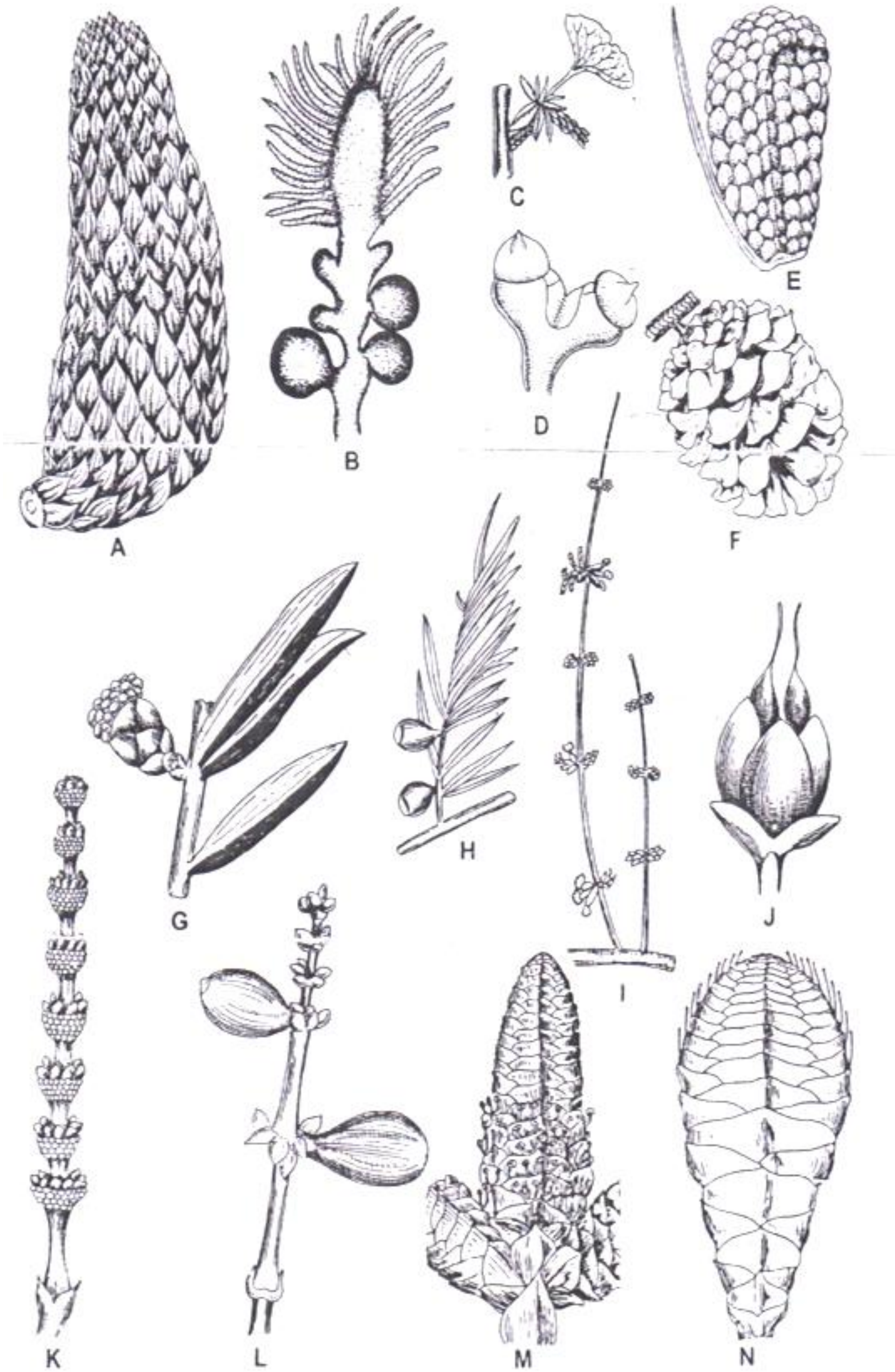


Fig. 1.4. Male and female cones/strobili of Cycas (A,B), Ginkgo (C,D), Pinus (E,F), Taxus (G.H), Ephedra*(I,J), Gnetum (KL) and Welwitschia (M,N)*.

External characters

The leaves may be simple or compound and small or very large. The leaves are mostly evergreen, but microphylls the venation may be parallel (Welwitschia), reticulate (Gnetum) or even dichotomous (Ginkgo). The shape of the leaf show great variation in gymnosperms.It may be needle-like (Pinus, Picea, Cedrus, etc.), lanceolate to ovate (Gnetum) or even wedgeshaped or fanshaped and bilobed (Ginkgo). The arrangement of leaves on the stem may be spiral (Taxus, Podocarpus, etc.), whorled (Cedrus) or opposite and decussate (Gnetum). In outline, the leaves may be bifacial (Ginkgo), circular (Pinus monophylla), semicircular (Pinus sylvestris) or even triangular (Pinus roxburghii).The stomata may be present on the lower epidermis of the leaf (Cycas) or on both the surfaces (Ginkgo). In Pinus and several other genera, the mesophyll is undifferentiated but, in several members, (e.g. Cycas) it is differentiated into palisade and spongy parenchyma. The resin canals may be present (Cedrus, Pinus, etc.) or absent (Ephedra).

Internal characters

Anatomically, the stem, when very young contains a ring of vascular bundles which are conjoint, collateral, open and endarch. They contain narrow or broad medullary rays. The mature stem in almost all gymnosperms contains secondary wood which may be either manoxylic or pycnoxylic. The manoxylic wood is soft and relatively sparse, with very wide parenchymatous rays (e.g. cycads), while the pycnoxylic wood is dense and compact with very small wood rays (e.g. conifers). The manoxylic wood is comercially useless whereas the pycnoxylic wood provides world's best timber. Except in Gnetales, wood vessels are absent in the xylem of all gymnosperms. The phloem lacks companion cells. The xylem is exarch in the roots, and endarch or mesarch in the stems. The secondary wood tracheids usually possess bordered pits. The medullary rays may be uniseriate or multiseriate. In young vegetative organs, the protoxylem contains spiral thickenings but in mature conditions the scalariform thickenings are present.

Reproductive Organs in Gymnosperms

Production of two types of spores (microspores and megaspores) by all gymnosperms makes them heterosporous. Microspores develop into male gametophytes, whereas megaspore matures into a female gametophyte. Microsporesare produced in microsporangia. Microsporangia are borne on microsporophylls. They latter remain arranged on an axis in the form of a loose or compact male strobilus or male cone. Similarly, a megasporeis produced in a megasporangium or ovule. The strobilus bearing several megasporophylls is called female strobilus or female cone.

In Cycas the male cones are compact and develop singly at the apex of male plant. Groups of microsporangia form sori on the ventral surface of the microsporophylls. The male cones are largest amongst gymnosperms and reach sometime up to 0.5 metre in length. The female cones are not compact. They are in the form of loosely arranged leafy structures called megasporophylls bearing ovules.

In Ginkgo the male strobili develop in groups in the leaf axils. They are formed by microsporangiophores. They are short. The female cones are in the form of two sessile ovules developing at the tip of a compact stalk. A collar is present at the base of each ovule.

In Pinus the male cones develop at the ends of the long shoots. Each male cone contains several microsporophylls. The mature female cone is large and woody bearing several megasporophylls.

In Taxus the male or staminate cone consists of over a dozen microsporophylls bearing pendant microsporangia. The female cone is present in the form of a single ovule.

In Ephedra the male strobilus develops in the axil of scaly leaves on the node. It is round or ovoid body bearing 2 to 12 pairs of bracts in opposite decussate manner. In the axil of each bract arises a male flower. Each male flower contains two bracteoles and a stamen. The female strobilus resembles male strobilus in the general morphology and bears two ovules in the axil of uppermost pair of bracts.

In Gnetum, the male and female strobili are compound structures developing in the axil of conate bracts. The bracts fuse to form a collar or cupule. In male strobilus several male flowers are arranged on each collar in 3 to 6 rings. In female strobilus, a ring of 4 to 10 ovules are present just above each collar.

In Welwitschia the plants are dioecious and possess dichasialy branched inflorescences. Each inflorescence contains opposite decussate bracts. Male flowers are present in male cone while female flowers are present in the ovulate or female cone.

Ovules in Gymnosperms

Ovules in gymnosperms are not enclosed in carpels, and the pollen grains germinate typically on their surface. They are unprotected or naked. In Cycas the ovule is orthotropous and unitegmic. The single integument covers the ovule all over except at the micropyle. This integument is threelayered, of which outer layer (sarcotesta) is fleshy, middle layer (sclerotesta) is stony, and the inner layer is fleshy. A small pollen chamber is present in the nucellar beak near the micropylar end of the ovule. The central part of the ovule is occupied by female gametophyte. Two archegonia develop in the female gametophyte near the archegonial chamber. The ventral canal cell is absent in the neck of the archegonium in Cycas while it is present in Ginkgo and Pinus. In Gnetum, the archegonia are absent. In Ephedra, Gnetum and Welwitschia, only two integuments are present in the ovule. Of these two integuments, the inner one comes out in the form of a micropylar tube.

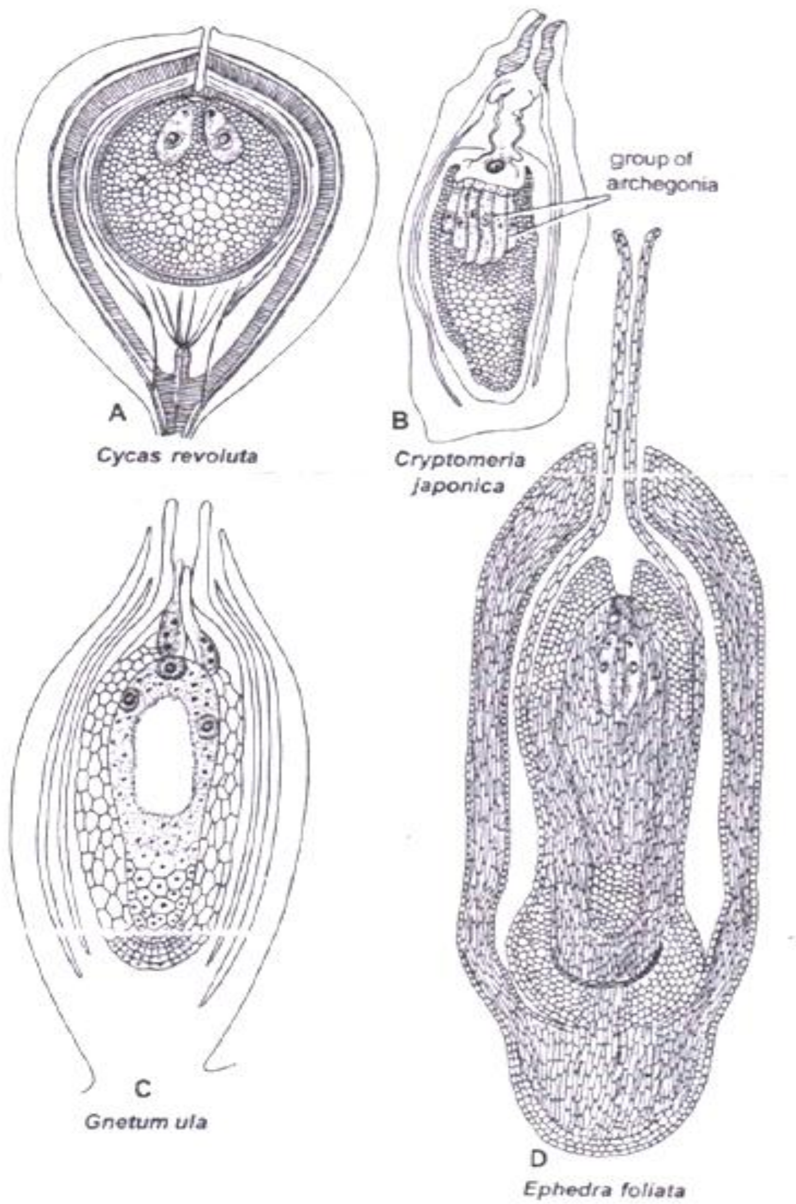


Fig. 1.5 A-D, Ovules in some gymnosperms. A, Cycas revoluta, B, Cryptomeria japonica; C, Gnetum ula D, Ephedra foliata.

Pollen Grains in Gymnosperms

*The pollen grains are unicellular, uninucleate and haploid structures. They are produced in a very large number in a microsporangium. In Cycas, Taxus and Ginkgo*the microspores are inaperturate, unwinged and round or somewhat spheroidal structures. On the other hand, the microspores are winged in Pinus, Abies, Picea and Cedrus. A prominent papilla is present on one side of the microspore in Cryptomeria griffthiana. In genera such as Juniperus and Cupressus the pollen grains are generally inaperturate. In Gnetales (Ephedra, Gnetum and Welwitschia) they are usually spheroidal with thick stratified exine. The microspore in all gymnosperms develops into a male gametophyte.

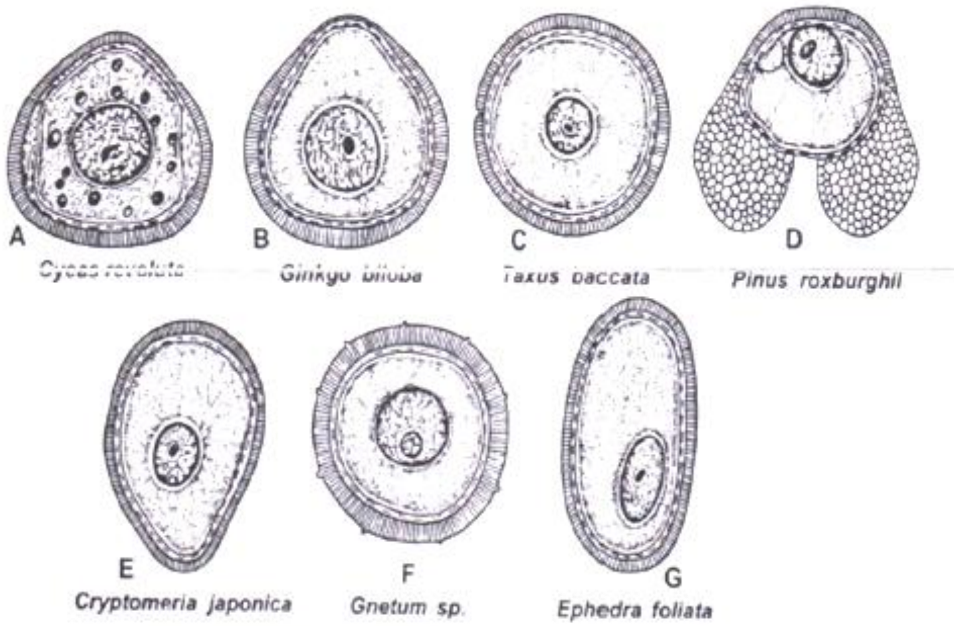


Fig. 1.6. Pollen grains in gymnosperms. A, Cycas revoluta, B, Ginkgo biloba, C, Taxus baccata, D, Pinus*roxburghi, E, Cryptomeria japonica, F, Gnetum ula, G, Ephedra foliata.*

Pollination and Fertilization in Gymnosperms

Pollination in gymnosperms, mainly takes place by means of wind. Wind transfers the semigerminated pollen grains from the male cones up to the micropyle of the ovule of female cone. These pollen grains get entangled in the liquid of the pollination drop. As the liquid of this pollination drop dries, the entangled pollen grains are drawn into the ovule. Once the semigerminated pollen grains or young microgametophytes are drawn into the ovule, the micropylar opening usually closes. Pollen tubes are produced from the pollen grains or young microgametophytes. These tubes penetrate the nucellar tissue of the ovule. In Ginkgo, Cycas and several other Cycadales, the pollen tubes function as haustorial organs.

After some time, the pollen tube bursts at its tip and liberates the multiflagellated male gametes into a cavity above the female gametophyte. The male gametes swim up to the archegonial neck and enter into the archegonium. One of the male gametes fuses with the female gamete or egg and results in the formation of a diploid zygote.

In conifers, the non-motile male nuclei are carried to the egg cell through the pollen tube, and this process is called siphonogamy. Production of pollen tubes was absent in members of fossil genera belonging to Pteridospermales, Bennettitales and Cordaitales. Fertilization in them was carried by motile spermatozoids under a process called zooidogamy.

EMBRYOGENY IN GYMNOSPERMS

The process leading to the formation and development of embryo is called embryogeny. In most of the living gymnosperms, except some members (e.g.

Sequoia sempervirens, Welwitschia and Gnetum) the initial changes in the development of embryo include the free-nuclear division. Only four (Pinus) or as many as hundreds (Cycas) of free nuclei are formed in the diploid zygote. Soon, the wall formation starts and the embryo becomes cellular. Organs such as suspensor, hypocotyl plumule and cotyledons are differentiated. In Pinus and several other conifers, cleavage polyembryony is observed Cleavage polyembryony is absent in Thuja.*In Araucaria angustifolia, as many as 32-48 free-nuclei are formed.*

In Actinostrobuspyramidalis of Cupressaceae, four nuclei are formed and then wall formation takes place forming four cells. Two of these cells are vertically placed and there is no further division in these upper cells. Lower two cells are transversely placed, divide once to form four embryonic initials..

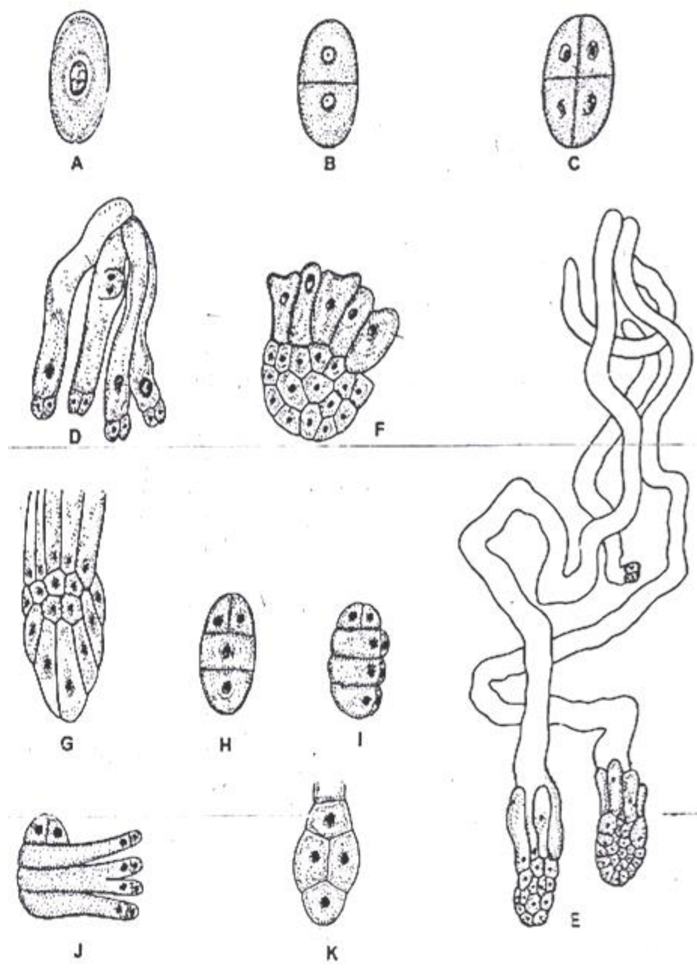


Fig. 1.7A-K. A-E, Embryogeny of Sequoia sempervirens; F-G, Proembryos of Araucaria angustifolia; H-K, Early embryogeny of Actinostrobus pyramidalis.

1.2 SIMILARITIES OF GYMNOSPERMS

Gymnosperms occupy a place in the Plant Kingdom in between pteridophytes and angiosperms. Due to their intermediate position, they resemble in certain characters with pteridophytes and also possess some features common with angiosperms. On the other hand, there are many dissimilaritiesalso which exist between gymnosperms and these two groups. Some of these similarities and dissimilarities are undermentioned:

Similarities with Pteridophytes

1. Plant body is sporophytic, and the sporophyte is differentiated into roots, stem and leaves in both gymnosperms and pteridophytes.

2. Members of both the groups show a regular alternation of sporophytic and gametophytic generations.

3. Cercinate vernation of the young leaves is seen in both the groups.

4. Xylem consists of tracheids and xylem parenchyma. Vessels are absent in pteridophytes as well as gymnosperms (except Gnetales).

5. Phloem lacks companion cells in both the groups.

6. Heterospory is common in both gymnosperms and pteridophytes.

7. Gametophytic generation is dependent upon sporophytic generation.

8. Cycads resemble pteridophytes in possessing ciliated sperms.

9. Permanent retention of megaspores within the megasporangium is observed in both the groups.

10. "Ferns with seeds" (Pteridosperms) was the common name given to the primitive gymnosperms like Cycadofilicales due to their resemblances with the ferns.

Dissimilarities from Pteridophytes

Some of the major differences of gymnosperms from pteridophytes are mentioned in Table 1.2.

Table 1.2 Differences of gymnosperms from pteridophytes

Gymnosperms	Pteridophytes
1. Roots are usually tap roots.	Roots are usually adventitious in nature
2. Majority of them show xerophytic characters.	Most of them are hydrophytes, i.e. grow in shady humid places
3. Cambium is present and the secondary wood is common.	Cambium is absent, and the primary growth isseen in most of the pteridophytes.
4. Neck canal cells and sometimes venter canalcell are absent in the archegonia,making the latter a	Neck canal cells and venter canal cells are present in the archegonia.

small-sized body.	
5. Microspores or pollen grains are shed onlyfor a small period, whereas the megasporeis retained permanently within the megasporangium.	Microspores and megaspores develop independently after being shed from their respective sporangia.
6. Due to the permanent retention of the megaspore in the ovule, it forms the seeds.	Seed formation is absent. Seed-like structures,however, are formed in some genera (e.g. Lepidodendron, Miadesmia).
7. Pollen tubes are formed.	Pollen tubes are not formed.

Similarities with Angiosperms

Gymnosperms resemble angiosperms in the following features:

1. Presence of well organized plant body, differentiated into roots, stem and leaves.
2. Presence of cambium in both gymnosperms and dicotyledons.
3. Presence of flowers in both the groups.
4. Presence of pollen tubes for carrying the male gametes to the female gamete.
5. Permanent retention of megaspore within the megasporangium in the members of both thegroups.
6. Presence of integument around the ovule.
7. During the embryo development the suspensor formation is a constant feature.
8. Formation of seeds.
9. Close similarity in the general life history of members of both the groups.

Dissimilarities from Angiosperms

Table 1.3: Differences of gymnosperms from angiosperms

Gymnosperms	Angiosperms
1. Vessels are absent (except Gnetales) in the xylem.	Vessels are present in the xylem.
2. Phloem lacks companion cells.	Companion cells are present.
3. The so called flowers of most of the	Flowers contain calyx and corolla and

gymnosperms are simple and unisexual.	may be unisexual or bisexual.
4. Óvules are naked i.e. not enclosed in carpel.	Ovules are not naked. They are always enclosed within the ovary.
5. Pollen grains land directly upon the ovule after pollination.	Pollen grains first fall on the stigma after pollination.
6. Pollination takes place only by wind.	Pollination takes place by various agencies such as insects, wind, water, animals, etc.
7. Cones are of usual occurrence.	Cones are not of usual occurrence.
8. Archegonia are present (except Gnetales).	Archegonia are absent.
9. Double fertilization is absent.	Double fertilization is present as a rule.
10.Endosperm is haploid tissue.	Endosperm is usually triploid.
11. Fruit formation is absent.	Fruit formation is present.

SAQ .

Fill in the blanks:

1. In gymnosperms xylem lacks.........and phloem lacks...........
2. When the gymnospermic wood is soft and loose, it is known as.........and when compact and massive...........
3. The formation of more than one embryo from the zygote is called as.............
4. The ovule bearing structure in the megasporophyll of pinus is called.........
5. Chilgoza is seed of pinus ....
6. Ginkgo boloba is considered a ....fossil
7. The pollen grain of pinusare.........

1.3 CLASSIFICATION OF GYMNOSPERS

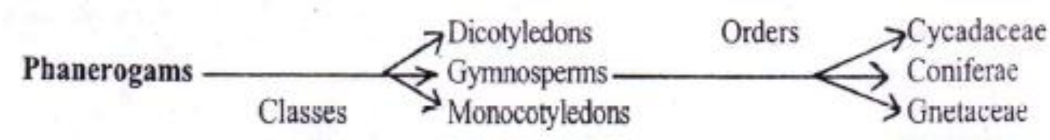
Taxonomic Ranks

The naming of species and their grouping into families, orders, classes, divisions, etc. is called. classification. The smallest group or unit of classification is the species. Similar species are grouped together in a genus. In the same fashion various genera are grouped into a family, various families into an order, orders into a class, classes into a division or phylum, and various divisions or phyla into a kingdom. The kingdom is a highest taxonomic rank. Many different positions have been assigned to gymnosperms in the plant-kingdom by different workers.

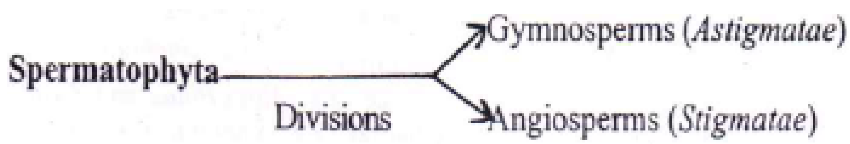
Systems Of Classification

Some Old Systems of Classification

After the recognition of gymnosperms in 1827 by Robert Brown, Brongniart (1843) includedthem under Dicotyledons. Bentham and Hooker (1862-1883) placed them between Dicotyledonsand Monocotyledons as under:



They included Ginkgo under Coniferae.However, it was Van Tieghem (1898), who, on the basis of some earlier embryological and developmental studies, removed Gymnosperms from this intermediate position and considered them as follows:

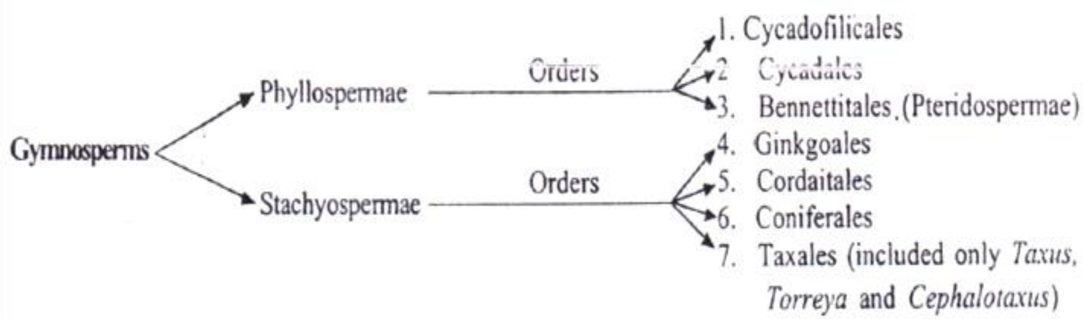


Besides Cycadales, Coniferales and Gnetales, three more orders were included under Gymnosperms namely Cycadofilicales, Bennettitales and Cordaitales on the basis of the accumulationof researches on the various fossil members of this group. Engler (1897) constituted a separate order Ginkgoales due to the discovery of motile sperms in Ginkgo. Thus, Coulter and Chamberlain (1917) recognized following seven orders in this group:

1. Cycadofilicales (Pteridospermae)
2. Bennettitales
3. Cycadales
4. Cordaitales
5. Ginkgoales
6. Coniferales
7. Gnetales

Classification Proposed by Birbal Sahni (1920)

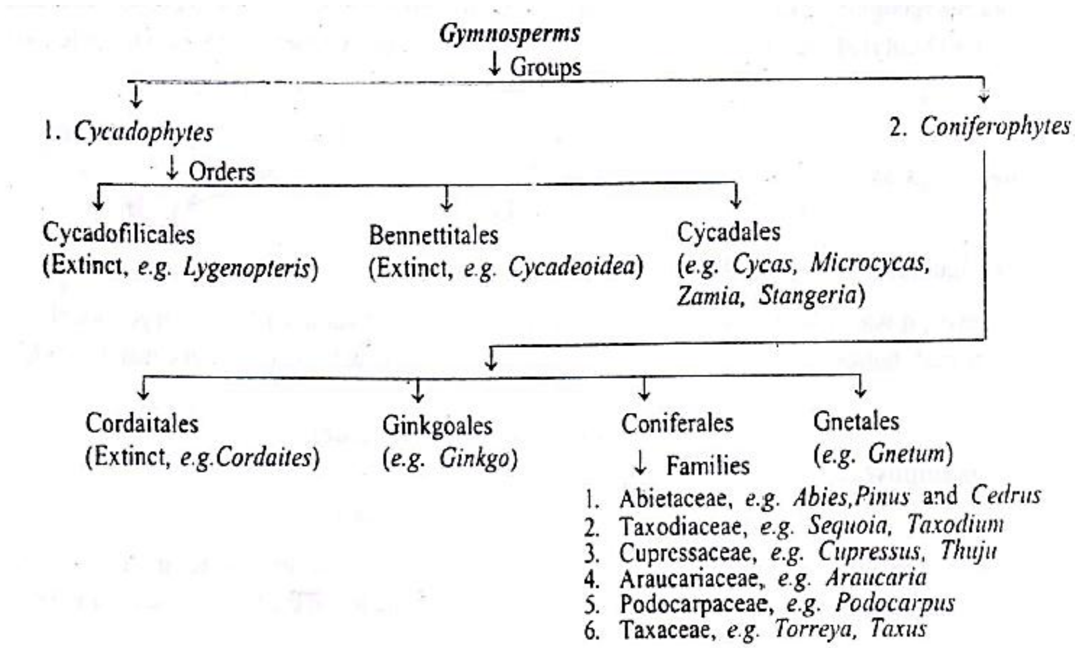
Sahni (1920), an eminent Indian botanist, gave for the first time a phylogenetic system for the classification of Gymnosperms. He divided Gymnosperms into two groups, i.e. Phyllosperms (ovules are borne on the leaves or leaf-like organs) and Stachyosperms (ovules are borne on the stem). His classification is based on the morphological nature of the ovule-bearing organs.



Gnetales have been left in a doubtful position by Sahni (1920).

Classification Proposed by C.J. Chamberlain (1935)

Chamberlain (1935), in his book Gymnosperms Structure and Evolution, divided Gymnospermsinto two main groups, i.e. Cycadophytes and Coniferophytes as mentioned below:



Classification Proposed by Sporne (1974)

Sporne (1974) adopted classification of Pilger and Melchior (1954) and recognized following three classes and nine orders:

1- **Cycadopsida:** Pteridospermales, Bennettitales, PentoxylalesandCycadales

2- **Coniferopsida**: Cordaitales, Coniferales, Taxales and Ginkgoalses

3- **Gnetopsida:** Gnetales.

Classification Proposed by Stewart (1983)

Stewart (1983) classified the gymnosperms mainly on the basis of the evidences available from the fossil records. He divided gymnosperms into three classes (Progymnospermopsida, Gymnospermopsida and Gnetopsida) as under:

1. Progymnospermopsida

1. Aneurophytales

2. Archaeopteridales

3. Protopityales

2. Gymnospermopsida

1. Pteridospermales	7. Czekanowskiales
2. Cycadales	8. Ginkgoales
3. Cycadeoidales	9. Cordaitales
4. Caytoniales	10. Voltziales
5. Glossopteridales	11. Coniferales
6. Pentoxylales	

3. Gnetopsida (Gnetum, Ephedra, Welwitschia)

Classification Proposed by Sandra Holmes (1986)

*Holmes (1986), in her book entitled "Outline of Plant Classification", divided gymnosperms into three classes (Cycadopsida, Gnetopsida and Coniferopsida) but also described some fossil ancestors*in a separate class Progymnospermopsida.

Division SPERMATOPHYTA

Sub-division Gymnospermae

Class Cycadopsida (Cycadatae)

Order Lyginopteridales (Cycadofilicales, Pteridospermales)

Order Caytoniales

Order Bennettitales

Order Pentoxylales

Order Cycadales

Order Nilssoniales

Class Gnetopsida*(Gnetatae, Chlamydospermae)*

Order Welwitschiales

Order Ephedrales

Order Gnetales

Class Coniferopsida

Order Ginkgoales

Order Cordaitales

Order Coniferales (Pinales)

Order Voltziales

Order Taxales

Class Progymnospermopsida(Fossils which are now thought to be neare gymnosperms although not of full gymnospermous status)

Order Pityales

Order Aneurophytales

Order Protopityales

1.4. ORIGIN AND EVOLUTION OF GYMNOSPERM FROM PROGYMNOSPERM

Some of the characters shared commonly by all the three orders (Pityales, Aneurophytales and Protopityales) of Progymnospermopsida include their (i) woody habit, (ii) complex system of branching, (iii) pycnoxylic secondary wood made of closely packed tracheids and narrow rays, (iv) dichotomous and pinnate pattern of fertile organs, and (v) terminal sporangia**.**

Since Protopitys occurred in Lower Carboniferous period, Rellimia and Aneurophytongermanicum in Middle Devonian and genera such as Tetraxylopteris and Archaeopteris in Upper Devonian age, Bonamo (1975) opined that direct line evolution of these genera appears to be impossible. Most probably the evolution did not progress from one order to another, and chief morphologial characters evolved quite independently from one another.

On the basis of the similarity in the basic organisation of the fertile organs, two independent lines of evolution may be traced among members of Progymnospermopsida. One line is exemplified by Rellimia to Tetraxylopteris type of Aneurophytales, in which the fertile organs were very complex and the number of sporangia was very large. The another line of evolution is exemplified by Rellimia to Archaeopteris type, in which the reduced type of fertile organs were present, and the sporangia were quite few in number.

Although, much can still not be said with certainity about the evolution of progymnosperms, some probable evolutionary trends of this group include (i) three dimensional to planated branching systems, (ii) unwebbed to webbed leaves or terminal appendages, (ii) spiral to opposite decussate phyllotaxy, (iv) homospory to certain evidences of heterospory, and (v) protostelic to siphonostelic type of anatomy.

Palaeobotanists, such as Bonamo (1975) and Beck (1976) opined that gymnosperms have evolved from progymnosperms. The primitive aspects of

Aneurophytales of Progymnosperms well established. These members extend farthest back in the geological column and include three dimensional branching system, terminal sporangia and a protostele. These members must have led to eustele found in Archaeopteridales (progymnospermous order), conifers and cycads. Scheckler (1978) also advocated for the evolution of the Archaeopteridales from some protostelic ancestors. Close relation between Aneurophytales and Archaeopteridales is also evidenced by the discovery of ray tracheids and grouped pittings in the secondary wood of Archaeopteris of Archaeopteridales and Triloboxylon of Aneurophytales. Some palaeobotanists also believe that Aneurophytales of Progymnosperms gave rise to Upper Devonain and Carboniferous members of Pteridospermales via Calamopitaceae of Palaeozoic Pteridosperms.

Beck (1976) recommended that conifers originated from Archaeopteridales of progymnosperms. Such a view came because of the striking similarities between the secondary wood of Callixylonof Pityales and lateral branch system of Archaeopteridales and those of Coniferales.

Taylor (1981) believe that "Archaeopteridales may be closely related *to an enigmatic group of plants referred to as the Noeggerathiales". Members of Noeggerathiales*are regarded by Taylor (1981) "as closely allied to sphenophytes by some and associated with ferns by others."

The complex problem of ancestory of gymnosperms has been tackled in several directions by Progymnosperms botanists. Some are of the opinion that Aneurophytes form a complex of progymnosperme which two lines diverged, one leading to the Upper Devonian - Lower Carboniferous-Cycadop (pteridosperm) line and the other to the Upper Devonian-Lower Carboniferous Archaeopt Coniferophyte line. Beck (1976) analysed this problem slightly differently. He mentioned although on the basis of available studies, it appears that Aneurophytes and Archaeopterids be to two clearlydefined lines of evolution, yet the "progymnosperms may comprise one brand line of evolution from which two main lines of evolution among gymnosperms(Cycadophytes Coniferophytes) originated". If these are the facts, "the gymnosperms could be considered to be monophyletic origin" (Beck, 1976).

1.5. ECONOMIC IMPORTANCE OF GYMNOSPERMS

From the point of view of economic importance, gymnosperms are widely used throughout the world for several purposes including timber, building construction, paper manufacturing, resin, varnishes, perfumes, essential oils, medicines, etc. Some of such aspects are discussed below.

Cycadales

As Food Plants

1- Cycadales are of definite importance as food plants and used variously as the source of food materials such as 'sago' and 'seed starch, vegetables, cakes, bread and poultry feild. The starch obtained from the stems of various cycads is called "sago", while that obtained from the cycad's seeds is called "seed starch". It is eaten as food after cooking in several parts of the world including India, Myanmar, Fiji, Malayasia, Sri Lanka, Madagascar and several other parts of south-eastern Asia, Sago is obtained from cycads usually before fruiting because fruiting depletes the store of starch in the stem

2- Seed starch, as much as 20 to 30 per cent, is obtained from the endosperm or kernel of the seeds of Cycas circinalis and Crumphii. It is made into flour and eaten after cooking in Andamans, New Caledonia, Sri Lanka and Australia.

3- The young leaves of Cycas circinalis, C. pectinata, C. revoluta, Crumphi and C. siamensis are cooked and used as vegetables in several parts of the world including India, Malayasia, Philippines, Indonesia and Japan. Extensive use of leaves, however, is reported to cause rheumatism.

4- Cakes are prepared from the seed kemels of several cycads in Sri Lanka, Fiji, Japan and India. The seeds are cut into pieces, dried and ground into a meal. The dough made from this meal is baked into cakes.

5- The interior part of the stem of several cycads boiled in water and used as feed for cattles, pigs and poultry.

6- Kaffir bread, used as food in some African countries, is prepared from the stem pith of Encephalartos.

As Medicinal Plants

Cycads are not used for medicinal purposes on a large scale. Some of their medicinal applications are undermentioned:

1. A decoction of the seeds of Dioonedule is used in Mexico for neuralgia.
2. Young seeds of various species of Cycas are used in Sri Lanka, Fiji, India and some other countries as a remedy in howel complaints and also as emetic and stomach purifiers.
3. Cycas gum is used to cure malignant ulcers in some African countries.
4. The pounded stem of Cycas pectinata is used as a hair wash for diseased hair roots in Assam.
5. Ulcerated wounds and swollen glands are treated in Cambodia from the mucilaginous terminal buds of Cycas circinalis.
6. Because of the strongly narcotic nature of the pollen grains of Cycas circinalis and C rumphil, the male cone scales of these species are sold in the market as an anodyne (a substance which relieves pain or diminishes distress).

7. In Indonesia, Philippines and some other Asian countries, the seeds of Cycas are made into a paste in coconut oil and used for wounds, swellings, sores, boils and various skin complaints.

8. The juice, obtained from the young leaves of Cycas revoluta, is used for curing blood vomiting and flatulence (affected by gases generated in the alimentary canal).

As Source of Gum

The gum, exuded from the injured petioles, stems or megasporophylls of Cycas circinalis, C revoluta, Crumphii, C.siamensis and some other Cycads is used variously as an (i) adhesive, (ii) antidote for snake bites and insect bites, and (iii) on the malignant ulcers.

As Source of Fiber

The surface fibers, obtained from the leaves of various species of Cycas (e.g. C. circinalis, Crevoluta) and Macrozamia are used for stuffing pillows, making mattresses and also for making cloth to some extent.

As Source of Hats, Mats, Baskets and Paper

Hats, mats, baskets, fences, brooms, cordage and twines are prepared from the leaves of various cycads, including Cycas, Encephalartos and Macrozamia. Paper is made from the fibers obtained from the stem of Macrozamia spiralis.

As Source of Oil

An orange yellow oil is obtained from the seeds of Cycas revoluta and a bright orange oil from the seeds of Macrozamia reidlei. In some parts of the world, these oils are used as those of palm oil. The fleshy layer of the seeds of Macrozamia reidlet contain as much as 28% oil.

As Decorative Material

The leaves of several cycads are cut, dried with special methods and used as decorative pieces in Japan, Ryukyu Islands and some other countries. It is developing as a good exporting business in Ryukyu Islands and some other countries from where these leaves are exported to Germany, Switzerland and USA.

As Nitrogen Fixers

The coralloid roots of Cycas and some other Cycads (eg Encephalartos) contain some nitrogen fixing algae (Anabaena) and bacteria (Azotobacter, Pseudomonas radicicola).

Some Other Uses

Cycas revoluta wood is used in Japan for making boxes, bottle stands and decorativepieces. Fresh or dried leaves of Cycads are used in religious ceremonies in Gua, Andamans, Philippines and Australia. *Empty seeds of Cycas circinalis are* *used as snuff boxes India and Australia.*Stem of Cycas rumphii is used to build small houses.

Coniferales

From the economic importance point of view, the Coniferales are highly prized in the international market. They supply us wood, used for all possible purpose, and several other articles such as resins, rosins, sandarc, copal, amber, terpentine, canada balsam, tannins, paper, several essentialoils and fatty oils, etc. Several of the conifers are highly prized garden ornamentals, such as species of Araucaria, Agathis, Thuja, Cryptomeria, Cupressus and Pinus.

Wood

1. Agathis australis is the largest timber producing tree of the world. Because of its hard, strong, lustrous, fine and even-textured wood, it is used for almost all practical purposes.
2. The heartwood of Cedrus deodara is strongly scented and extensively used for making doors, window panes, electric poles, building models, boats, carriages, railway sleepers and several other similar purposes. The wood of Cedrus is in great demand because it is very durable, oily and sweet and scented.
3. The wood of several species of Larix is used for boat making, poles, posts, railway sleepers,
4. The wood of Abies pindrow and Picea smithiana is used for making boxes and packingcases. Wood of Abies alba is used in general carpentry, musical instruments, hoards, boxes, etc.
5. The wood of Pseudotsuga taxifolia yields veneers and plywood.
6. The wood of several species of Pinus is used for heavy construction work such as railwaywagon flooring, ship building, agricultural implements, doors, poles, frames, furniture, etc.
7. Wood of Podocarpus is used to obtain plywood while that of Phyllocladus for makingsleepers, mine timbers, small vessels, etc.
8. High quality pencils and cigar boxes are made from the wood of Juniperus virginiana.
9. Wood of Thuja plicata and Biota is highly resistant to different weathers because it issaid to possess some antibiotics.
10. Decorative furniture is prepared from the wood of Callitris verrucosa while match sticksare prepared from the wood of Chamaecyparisobtusa.
11. Wooden poles, beams, sleepers, doors, cooling towers and green houses are prepared fromthe wood of Taxodium disticum.
12. Cryptomeriajaponica is one of the most utilized timbers of Japan. It is widely used forfurniture, building construction, panelling, etc.

Canada Balsam

Canada balsam, used as a mounting medium in microscopic preparations, is obtained from Abies.It does not crystalize or granulate on drying. It is also used for cementing the lenses in opticals.

Resins, Rosins and Turpentines

Resins are plant exudates. They make the wood resistant to decay. Conifers are the major resin yielders of the world. They are used in enamels, plasters vamishes, paper sizing, medicines, etc. Turpentines are obtained from coniferous trees. On distillation turpentines yield the essential oil. In India, a very important resin is obtained by tapping the chir pine (Pinus roxburghii) and blue pine (P. wallichiana).PineOil of turpentine (mixture of rosin and essential oils) is of major importance in paint and varnishindustry. Rosin or colophony, a brittle aromatic solid is used in manufacture of soap, varnishes, paints, linoleum, oil cloth, printer's ink, plastics, drugs, chemicals, etc.

Spruce Gum

It has a pleasing resinous taste and obtained from Picea rubens. The gum softens in the mouthand assumes a reddish colour.

Copals

The copals comprise a considerable group of hard resins of recent semifossil and fossil origin Copals have almost no oil, and yield a hard elastic varnish. They are much valued in varnish industry of their hardness and high melting point. Kauri copal is obtained from Agathis australis and Mania copal from Agathis alba.

Sandarac

Sandarac is a soft pale yellow resin obtained chiefly from Tetraclinis articulata of Cupressaceae.

Amber

Amber is a fossilized terpenoid resin obtained from Pinus succinifera. It is an exceedingly hard and brittle substance. It has been largely used for beads and other ornamental purposes. It is widely used for the mouthpieces of pipes and holders for cigars and cigarettes. A valuable varnish is also prepared from amber. Amberis also used in medicine and X-ray therapy.

Tannin

Tannin, obtained from the bark of several species of Araucaria, Agathis, Dacrydium, Phyllocladus, Pinus, Picea and Sequoia.It is used to some extent in the tanning industry.

Paper

Newsprint, writing paper and some high quality printing paper is made from the wood pulpof several species of Coniferales including Abies balsamaea, A. pindrow, Cryptomeria japonica, Juniperus virginiana, Picea smithiana, Pinus roxburghii, P. sylvestris, P. wallichiana, Tsuga canadensis, etc: Canada and U.S.A, the two largest paper producing countries of the world, use conifers such as Picea, Pinus, Larix, Pseudotsuga and Abies. Excellent quality pulp for paperinIndia is obtained from Picea smithiana, Abies pindrow and Pinus roxburghii. Kraft paperis obtained from Cryptomeria japonica. Wood pulp of Picea and Tsuga is also used to obtainproducts like rayon, transparent and photographic film, lacquers, etc.

Food

Seeds of Pinus gerardiana (Chilgoza) and several other species such as Pedulis, Proxburghiiand P.monophylla are edible.

Essential Oils and Fatty Oils

The fatty oils obtained from the seeds Pinus cembra and Cephalotaxus drupacon are useful for food purposes and also in paints. The fatty oil obtained from the seeds of Cephalotaxusdrupaceais used as an illuminant in Japan. Several essential oils are also obtained from Coniferales

Taxales

1. Its wood yields a valuable timber for making poles and agricultural implements.
2. Wood is also used for making pen holders and pencils.
3. In earlier times, its wood was reported to be used for preparing bows and other weapons, probably because of the presence of some poisonous alkaloids
4. In Laddakh, the bark of the tree is used as a tea substitute.
5. Thewood of Taxus baccata is oily and offers the heaviest wood amongst the softwoods.and used widely for making decorative veneers, flowers and turnery.
6. Taxine, a toxic alkaloid, is present in the leaves, shoots end seeds of Taxus baccata, and, therefore, the plant is considered to be poisonous.
7. Due to the presence of traces of ephedrine, Taxus leaves are used in treating bronchitis.
8. The seeds of Torreya nucifera yield a fatty oil which is edible and also used for making paints.

GNETALES

Ephedra

1. Ephedrine, an alkaloid obtained from several species of Ephedra, is used in the preparation of medicines for treating asthama, bronchitis, cough, cold, nasal disorders and hay fever.

2. A decoction of stems androots of several species is used in curing syphilis and rheumatismin Russia.

3. Ephedra gerardiana tincture is effective as a cardiac and circulatory stimulant.

4. Rhizome of Ephedra gerardiana is used as fuel by the people of Tibet.

5. Some species are grown as omamental plants.

Gnetum

1. Seeds of Gnetumgnemon, G. latifolium and Gula are eaten after boiling or roasting.

2. Young leaves and inflorescence of Gnetumgnemon and G latifolium are cooked as vegetable.

3. A fiber of high tensile strength is obtained from the bark of Gnetumgnemon and G. latifolium, and used for making fishing nets and ropes.

4. Paper is made from the pulp produced from the bark of Gnetumgremon.

5. A fixed oil, used for illumination and also affective in rheumatism, is obtained from thekernels of Gnetum ula. It is used widely in Kerala and Assam.

6. Gnetummontanum possesses pesticidal properties.

1.7 SUMMARY

1- The gymnosperms are a group of seed producing plants that includes Gynkoales, cycads, conifers, and gnetophytes.

2- Gymnosperms are fouund in colder regions where snow fall occurs.

3- The term gymnosperm comes from word Gymnospermos, which means 'naked seeds'.

4- They are perennial or woody trees.

5- They do not produce flowers and fruits.

6- Seeds are not found inside a fruit.

7- The main plant body is a sporophytic and differentiated in to root, stem, and leaves.

8- Most of gymnosperms are trees and some are shrubs. There are no herbs found in gymnosperm.

9- Pinus as well as other conifers are evergreen tree.

10- They are heterosporous. They forms microspore and megaspores.

11- All gymnosprrms are wind pollinated because stigma is absent in gymnosperms.

12- The number of cotyledons in seed is one or two as in cycas or many as in pinus.

13- Haploid endosperm is found in gymnosperm.

14- Reproductive organs of gymnosperms are male and female cone.

15- Conifers and other gymnosperms are economically essential.

16- Gymnosperms are good sourse of food.

17- Conifers are used in paper and furniture production.

1.8 TERMINAL QUESTIONS

Q.1 What are Gymnosperms? Give an outline classification of this group.

Answer-

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Q.2 Give an account of general charactersand classification of Gymnosperms.

Answer-

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Q.3 Describe the economic importance of gymnosperms.

Answer-

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Q.4 Write short notes on:

A. Economic importance of Gymnosperms

B. Stomatal apparatus in Classification of gymnosperms

C. Polyembryony in Gymnosperms

Short Answer

Q.5 Differentiate between Gymnosperms and pteridophyte on the basis of a single character.

Answer-
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Q.6 What distinguishes Gymnosperms from Pteridophytes?

Answer-
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Q.7 Differentiate between gymnosperms and angiesperms.

Answer-
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1.9 ANSWER

SAQ.

1. Vessels, companion cells
2. Manoxylic, pycnoxylic
3. Polyembryony
4. Ovuliferous scale
5. Gegardiana
6. Living
7. Winged

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UNIT-2 CYCADOPSIDA-1

Structure

2.0 INTRODUCTION

Cycadopsida is a class of gymnosperm comprising plants with leaves.They appears like palm tree.They contains a group of plants with a lot of primitive characters.Because of these primitive characters, cycadales are sopposed to be the living fossils.Cycadales are intermediate plants between higher cryptogams and the angiosperms.The pteridospermales and cycadeoideales are the extinct species.It is believed that cycadales were derived from the pteridospermae.Cycadopsida are found in tropical and subtropical regions of the world.The genus cycas is widely distributed and found both in Northern and Southern hemispheres.Cycadopsida are terrestrial vascular plants. They do not form flower but reproduce sexually and forms naked seeds.

Objectives :

- To learn about class cycadopsida.
- To know about external and internal morphology of pteridospermales-cycadales and nilssoniales.
- To know about families of pteridospermales.
- To know about geographical distribution and evolutionary tendency of order cycadales.
- To learn about general characters of order nilssoniales.

2.1 PTERIDOSPERMALES

The Pteridospermales are popularly known as "seed-ferns". They possessed fern-like foliage, bore seeds, and are, therefore, called pteridosperms. They first appeared on the earth in Upper Devonian times of the Palaeozoicera. They were at their climax in Carboniferous period and became extinct in Jurassic period of Mesozoic era. The details of only a few fossil plantsof this order is fully known, therefore, the present account is based on the available detailsof separate parts placed in the form of form-genera.

General Characters

1. Extinct Palaeozoic and Mesozoic plants found from Devonian to Jurassic periods.
2. Plants possessed slender stems with large frond-like leaves as in Alethopteris, Sphenopteris.etc.
3. Primary xylem was mesarch, represented by solid or medullated protostele. Polystelic condition was also observed in some members.
4. The secondary wood was manoxylic and limited in amount.
5. The radial walls of tracheids had multiseriate pits.
6. The cortex was well developed and had longitudinally aligned fibre strand.
7. Leaves were usually fern-like, relatively large, pinnately compound, and often pinnate severaltimes.
8. The leaves were covered by a resistant cuticle.
9. Ovules borne separately along margins, or on surface of pinnately compoundmegasporophylls.
10. Ovule bearing frond or megasporophyll was not part of a cone.

11. Megasporophylls were not arranged in strobili.

12. Megasporophylls were like foliage leaves, or specialized structures, sometimes peltate.

13. Microsporophylls pinnately compound and not in strobili.

14. The microsporangia had no annulus and were sometimes grouped into synangia.

15. A well-developed vascular supply was present in the seed.

16. The seeds were also provided with a definite pollen chamber, e.g. Lagenostomalomaxi.

17. The seeds of Pteridospermales resemble with those of the present-day Cycads.

Classification

Arnold (1948) divided Cycadofilicales into following three families:

1. Lyginopteridaceae, e.g., Lyginopteris, Heterangium.

2. Medullosaceae, e.g., Medullosa.

3. Calamopityaceae, e.g., Calamopitys.

But Sporne (1974) divided Pteridospermales (Cycadofilicales) into following seven families

1. Lyginopteridaceae

2. Medullosaceae

3. Calamopityaceae

4. Glossopteridaceae

5. Peltaspermaceae

6. Corystospermaceae

7. Caytoniaceae.

Sporne (1974) mentioned that the first three families (Lyginopteridaceae, Medullosaceae and Calamopityaceae) were confined to Palaeozoic era while the last four (Glossopteridaceae, Peltaspermaceae, Corystospermaceae and Caytoniaceae) were restricted to the Mesozoic or extended from the late Palaeozoic into the Mesozoic.

Fig. 2.1. Fronds of some Lower (A to D) and Upper (E to M) Carboniferous Pteridosperms.

A, A complete frond of Diplopteridiumteilianum; B, A part of frond of Sphenopterisaffinis; C, A complete frond of Sphenopteridiumcapillare; D, A part of the frond of Adiantitesmachaneki; E, A pinna of Meriopteris showing double dichotomy, F, A complete frond of Odontopteris; G, Upper part of frond of Alethopteris; H, Upper part of the frond of Neuropteris; I, A pinnule of Sphenopteris; J, Pinnule of Pecopteris armasii; K, Pinnule of Lonchopteris; L, Pinnule of Neuropteris; M, Pinnule of Linopteris.

Fig. 2.2. Leaves and reproductive structures of some Mesozoic Pteridospermales.

A, A leaf with reproductive body of Hirsutum; B, A part of leaf of Glossopteris colpodes showing venation; C, Fertile leaf of Lidgettoniaafricana; D, A part of frond of Lepidopterisnatalensis; E, Seed-bearing structures of Peltaspermumthomas; F, Cupulate disc of P. rotula; G, Microsporophyll of Antholithus; H, Opposite sides of microsporangiophore of Antholithus; I, Xylopterisdensifolia, J, Umkomasiamacleanii; K, Microsporophyll of Pteruchusstormbergensis; L, A leaf of Sagenopterisphillips; M, Rachis of Caytonianathorstii with fruiting body, N, A synangium of Caytonanthusarberi, O, Microsporophyll of C. arberi (A, after Plumstead; B, after Pant, C-E, I-K, after Thomas; F, G, L-O, after Harris)

Families

[a]Lyginopteridaceae

Taylor, Millay (1981) and Stewart (1983) listed following distinguishing features of this family.

1. Members have been reported from both the Upper and the Lower Carboniferous periods ofPalaeozoicera.

2. The plants were not very large and attained a maximum height of two metres.
3. Several plants were lianes or vine like in their general habit.
4. They had axillary branching fronds with bifurcate rachis.
5. The leaves were highly dissected and produced along the stem at widely separated intervals.
6. Fronds usually had a bifurcate rachis.
7. Petioles had a V or W shaped trace, formed as a resut of the fusion of several smaller traces.
8. A large amount of secondary xylem was present in the stems.
9. Cauline vasculature was generally monostelic.
10. Due to the monostelic stems, it was always difficult for the stems to support the weight oftheir large fronds, and, therefore, the plants must have had a straggling growth habit.
11. The tracheal pitting was usually of the multiseriate, elliptical bordered type.
12. A "dictyoxylon cortex" was present in some members, i.e. anastomosing longitudinallyoriented bands of sclerenchyma were present in the outer cortex.
13. Often one or two massive traces were seen into the leaves.
14. Ovules were radially symmetrical, small, attaining a length of 3-5 mm. Theywere borne in cupules.
15. The cupules were small and uniovulate in some while large and multiovulate in othermembers.
16. The integument of the ovules was simple and relatively thin.
17. The nucellus was fused with the integument of the ovule.
18. A structurally complex pollen chamber or pollen receiving device was present. Many members showed a mechanical method of sealing the pollen chamber.
19. Only the integument of the seed had a vascular supply and that too also by radially arranged strands.
20. The apex of the nucellus elaborated into a lagenostome or salpinx on the branches of fronds.
21. Pollen producing organs were small, laminar, or terminal in position and present in clusters.
22. Symmetry of the synangia or pollen producing organs was radial to bilateral.

23. Pollen grains had a structurally homogenous exine. They were small and of trilete type.

LYGINOPTERIS OLDHAMIA

Nomenclature

Lyginopterisoldhamia (=Calymmatothecahoeninghausii) is one of the best known of Carboniferous fossil plants of Pteridospermales. For several decades the roots, stems, leaves and seeds of this plant were independently known to the botanists but it was not realised that these all were the partsof a single plant. Various parts were discovered and named as under:

Leaves: Sphenopterishoeninghausii

Stems: Lyginopterisoldhamia

Petioles: Rachiopteris aspera

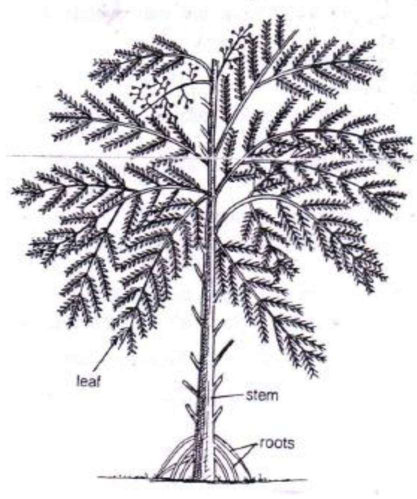
Roots: Kaloxylonhookeri

Seeds: Lagenostomalomaxi

Capitate glands on the cupulate envelope enclosingthe seeds are present. Similar type of glands was reported on the stem, leaves and also on rachis, and thisbecame the basis of the fact that all these structures, described under different names, belongedto one and the same plant, i.e. Lyginopterisoldhamia.

External Features

The plants were probably climbers. The stem was long and aerial varying from 2 mm to 4 cm in diameter. Branching in the stem has been reported in a few cases. The weak stem had adventitious roots, probably prop roots. The leaves were many and spirally arranged. Characteristic spines, perhaps helpful in climbing, were present both on stem as well as leaves. The leaves were bipinnate to tripinnate. The pinnae had pinnules or leaflets, and were present at right angles to the rachis. The rachis and the petiole were fixed or attached with capitate glands.



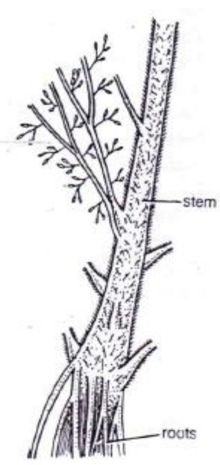


Fig. 2.3 Lyginopterisoldhamia **A part of stem with roots.**

Anatomy

Stem: The stem pieces are seen beautifully preserved in the European and American coal balls in the form of petrifactions and large compressions. A reconstruction of the transverse section of the stem shows the presence of a mesarch siphonostele with a well developed centrally located pith. There are separate regions of secondary wood and thick cortex. The latter is clearly differentiated into outer and inner cortex regions.

The outer cortex contains radially broadened fibrous strands which form a net-like structure. The inner cortex consist of consists ofcortexparenchymatous cells. The pericycle, present just inner to the cortex, consists of many short cells and some sclerotic cells.

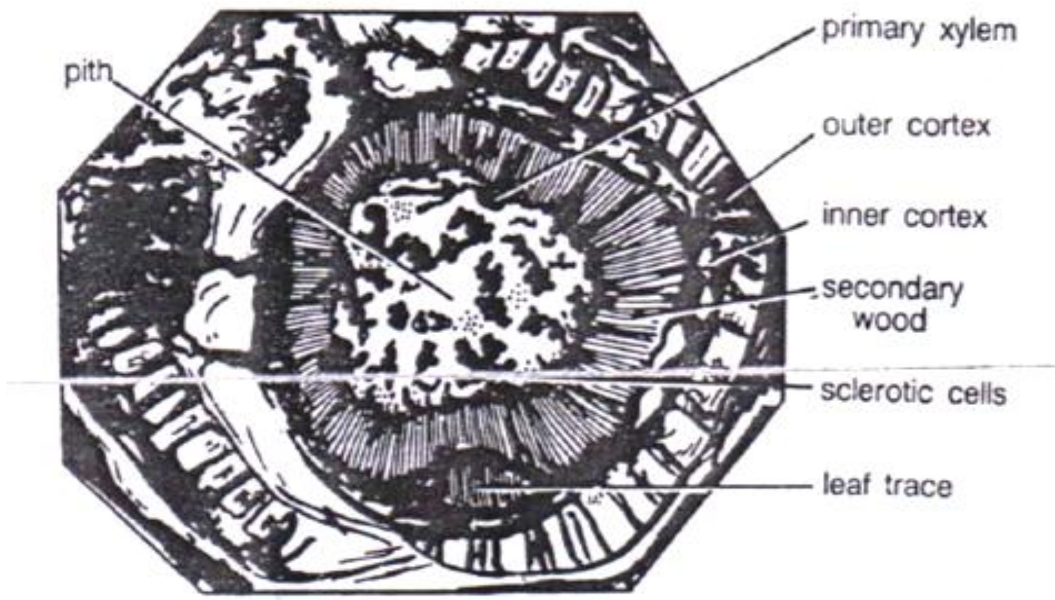
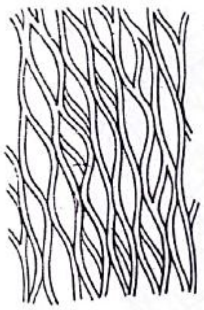


Fig. 2.4. Lyginopterisoldhamia T.s. stem (modified after Kidston).

Five mesarch primary vascular bundles, separated by parenchymatous areas, *Lyginopterisoldhamia. T.S. stem (modified after Kidston).* constitute the primary structure of the stem. The primary phloem, consisting of small cells, is present towards the outer side in each vascular bundle. The cambium is also seen preserved in between phloem and xylem in some specimens. The xylem consists of tracheids. The protoxylem tracheids have spiral thickenings. Centripetal tracheids of the metaxylem have multiseriate bordered pits while the centrifugal tracheids are scalariform. The pith is large and parenchymatous. Some thick walled cells, called "sclerotic nests", are scattered throughout the pith.



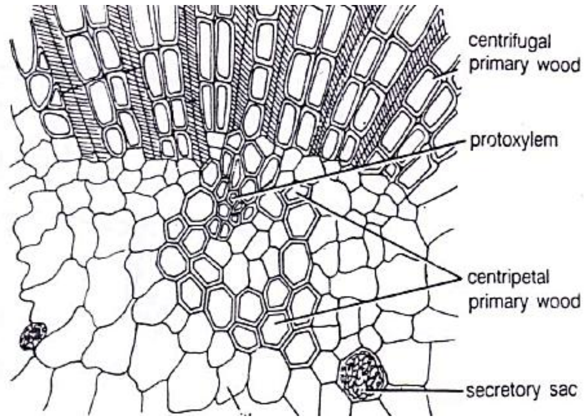


Fig. 2.5. Lyginopterisoldhamia. Cuter cortex of the stem in L.S. showing fibrous strands. (after Beck).

,Lyginopterisoldhamia. A part of T.S. stem. (after Williamson and Scott).

One leaf trace traverses through the petiole and branches, into two parts to supply to the forking rachis. The secondary structure of the stem exhibits the presence of periderm just inner to the two cortical layers. The primary phloem gets crushed and inner to this is present the cylinder of the secondary vascular tissue, which surrounds the primary xylem. Several secondary medullary rays are present in this region. The leaf traces interrupt the cylinder of secondary vascular tissue. Many large and small cells are alternately present in the secondary phloem. The cambium and then secondary xylem are present inner to the secondary phloem region. The secondary xylem consists of large tracheids with multiseriate bordered pits arranged on the radialwalls.

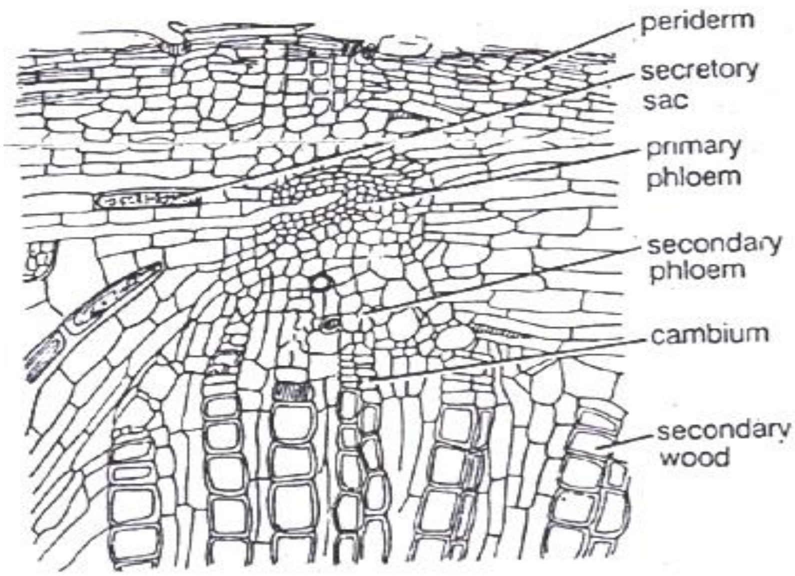
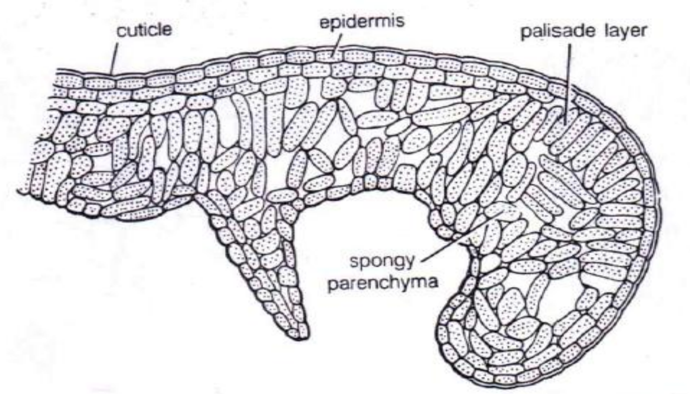


Fig. 2.6.Lyginopterisoldhamia A part of T.S. old stem.

(after Williamson & Scott).

Leaf: Prior to the discovery of the connection between the stem and leaf, the leaf of Lyginopterisoldhamia was described as Sphenopterishoeninghausti. As it is clear from the impressions of Sphenopteris, the rachis was forked and had strong pinnae, which were again divided pinnately. The leaves were as long as 50 cm. They were circinately rolled with their petiolar base somewhat swollen. Hairs and glands were present on the entire leaf. These hairs had round tips. Histologically, the leaf epidermis was cutinised on the adaxial surface. Mesophyll was differentiated into palisade and spongy parenchyma



(Fig. 2.7). The stomata were present only on the abaxial surface.

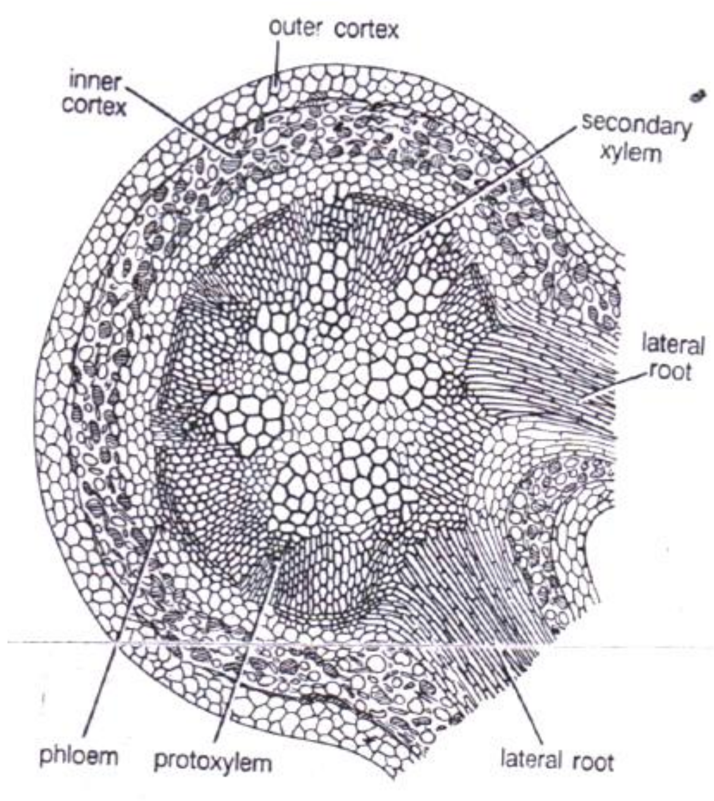


Fig. 2.8. Lyginopterisoldhamia. T.S. root. (after Scott).

Root: In transverse section the cortex of the root is differentiated into outer and inner cortex. The outer cortex is made of 2 to 3 layers at thin-walled cells while the inner cortex is 4-6 layered and contains many cells of mucilaginous nature. The outer cortex of Lyginopteris root has been compared with the velamen of orchid root by Scott. The stele may be tetrarch to octarch with each arm of xylem having a small amount of protoxylem towards the outer side. Rootlets show diarch condition. The protoxylem consists of spiral tracheids. The phloem groups alternate with the xylem. In the prepared sections the endodermis and pericycle are clearly observed. The secondary wood develops in the larger roots. No distinct pith is present.

Reproductive Organs

Lyginopterisoldhamia was heterosporous, and its ovules and seeds were enclosed within well protective cupules. Kidston (1905) discovered the impressions of Crossotheca in connection with the leaves of Sphenopterishoeninghausii, and thus it was concluded that Crossotheca is the microsporangium of Lyginopteris because the leaves of Lyginopteris were described under the name Sphenopterishoeninghausii. The ovules and seeds of Lyginopteris were described under the name Lagenostomalomaxi. Arnold (1947) stated that the microsporangiate structures of Lyginopteris belong to Telangium.

Microsporangium-Crossothecahoeninghausii has been described as the microsporangia bearing member of Lyginopteris. Six to seven bilocular, pendant microsporangia were present on more or less peltate fertile pinnules called microsporophylls. Each microsporangium was about 3 mm. in

Fig. 2.9. Crossothecahoeninghausi. (after Kidston)

length and its dehiscence was longitudinal. Each microspore had a thick rough exine. Some other microsporangiate organs attributed to Lyginopteridaceae are Feroxotheca, Teiangiopsis and Teiungium (Steward, 1983).

Ovule and Seed-*Oliver and Scott (1903) described Lyginopterisoldhamia seeds as Lagenostomalomaxii. Seed was a small, barrel shaped structure measuring 5 to 6 mm. in length and about 4 mm in width. Each seed was surrounded by a cupule present at the end of the slender rachis . Rachis was also covered by glands and hair-like leaves and stem. The seeds and the cupules are known only in a petrified condition. Single vascular bundle of the rachis divided into about 10 vascular strands which traversed laterally into the cupule. Several glands were present on the outer surface of the lobed cupule).*

The ovule in Lagenostomalomaxi was orthotropous. The nucellus was free at the tip . In the later stages of development it was surrounded by a bell shaped pollen chamber orlagenostome. The ovule was surrounded by an outer hard stony layer and an inner fleshy layer. It resembled with a Cycad seed to some extent.

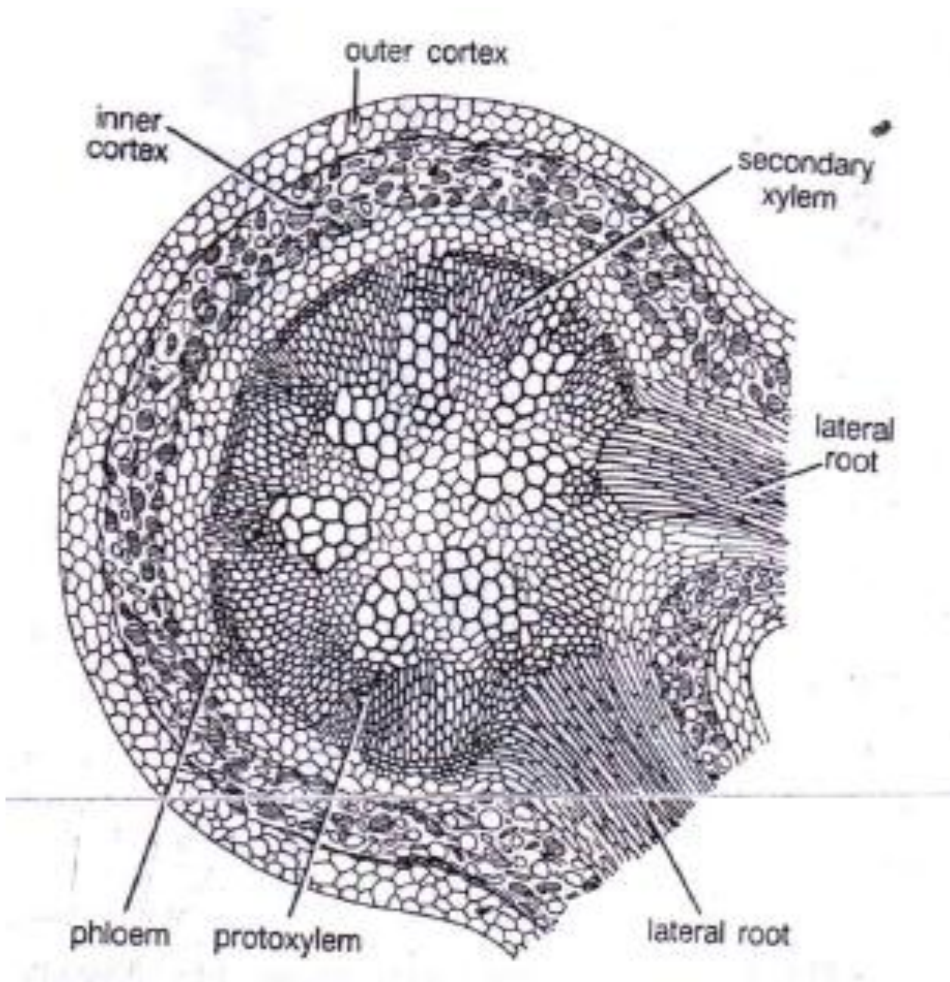


Fig. 2.10. Lyginopterisoldhamia. T.S. root. (after Scott).

Root: In transverse section the cortex of the root is differentiated into outer and inner cortex . The outer cortex is made of 2 to 3 layers at thin walled cells while the inner cortex is 4-6 layered and contains many cells of mucilaginous nature.

The stele may be tetrarch to octarch with each arm of xylem having a small amount of protoxylem towards the outer side. Rootlets show diarch condition. The protoxylem consists of spiral tracheids. The phloem groups alternate with the xylem. In the prepared sections the endodermis and pericycle are clearly observed. The secondary wood develops in the larger roots. No distinct pith is present.

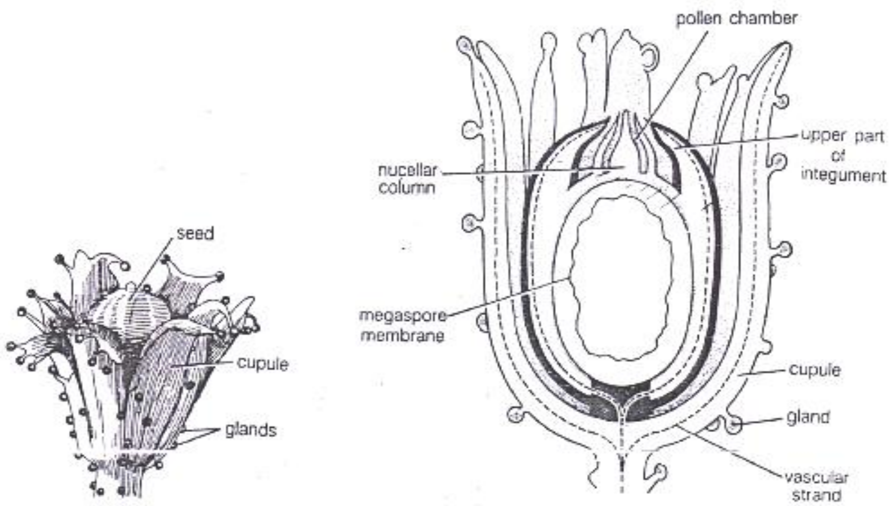


Fig. 2.11. Lyginopterislomaxi. L.S. upper part of the seed. (after Oliver and Scott, 1904).

Heterangium

It is another important member of Palaeozoic Cycadofilicales belonging to family Lyginopteridaceae. It occurred in Upper and Lower Carboniferous beds and the best-known species is Heterangiumgrievii. This stem genus is found in the form of compressions and petrifactions.

The largest stem of this genus was approximately 4 cm in diameter. It was rarely branched. In a transverse section the longitudinal ribs of sclerenchyma are present in the outer cortex. *Many stone cells are embedded in the parenchymatous inner cortex. Numerous strands of tracheids separated by the parenchymatous bands are present in the vascular column. The stele is thus solid in Heterangium. One protoxylem is present in the leaf trace. The plant body of Heterangiumgrievii resembles greatly with that of Calymmatothecahoeninghausii.*

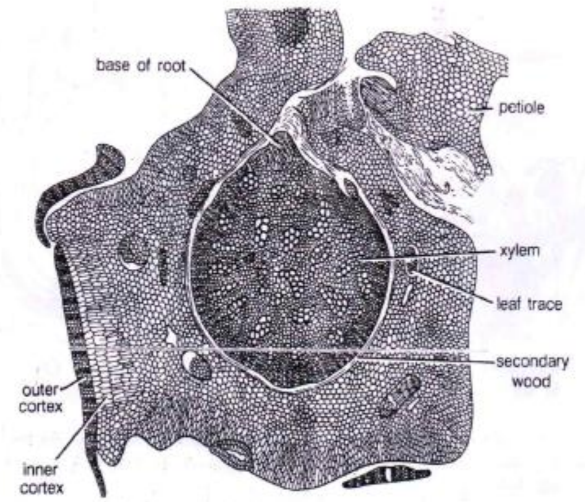


Fig.2.12. Heterangiumgrievii. T.S. stem. (after Scott).

Tetrastichia

Tetrastichia was a monotypic genus of Lyginopteridaceae represented by only T. bupatides. It has been reported from the Lower Carboniferous of Scotland along with another monotypic genus (Tristichiaovensii) of the family. Its primary stem structures had close similarities with the ferns but its cortical bands of sclerenchyma and its secondary wood resembled very closely with the stems of Pteridospermales. In transverse section the stem was less than 1 cm in diameter. It was branched in an opposite decussate manner. The primary xylem was usually four-armed but also sometimes five-armed. It was made of a solid protostele. Reticulate or scalariform pitted tracheids were present in the protostele. Parenchymacells were completely absent.

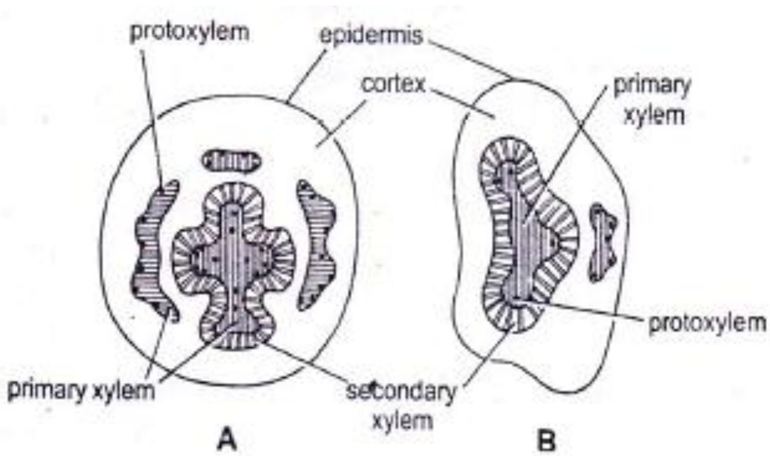


Fig. 2.13. Vascular systems of Tetrastichiabupatides (A) Tristichia ovens (B).

Mesarch protoxylem group was present in the middle region of each branch of the stem. From this protoxylem group originated several branch trace protoxylems. The basal part of each of the lateral branch of the stem was swollen. The shape of the vascular bundle which entered in this basal part was like a butterfly. The lateral branches of the stem were considered as "petioles".

A narrow zone of secondary wood was present in some of the branches while in other branches the secondary thickenings were absent. The tracheids had reticulate thickenings. The rays were both uniseriate as well as multiseriate. "Sclerotic nests" or group of stone cells were present in the inner cortex. A network of plates of fibres was present in the outer cortex

[b] Medulloseae

General Characteristics

1. Members of this fossil family of PalaeozoicPteridospermales were present between Upper Carboniferous and Permian periods.
2. Plants were larger and more massive than Lyginopteridaceae members. They had trunk like stems and massive pollen bearing organs and seeds.
3. All members were polystelic, and as much as forty steles were present in the stems of some of the species.
4. Each of the many steles of the stem had the ability to undergo secondary thickening, and surprisingly the intervening tissues were without any disruption.
5. Meristematic parenchyma cells were present between the xylem tracheids of both primary and secondary woods.
6. *It has been suggested by Delevoryas (1955) that in these plants the primary wood at any particular level continued to increase with age.*

*Medullosa and Sutcliffia are the examples of the stem genera, while Myeloxylon is the petiole genus of family Medullosaceae. The seed genera are exemplified by Codonospermum, Stephanospermum, Polylophospermum and Polypterospermum while the examples of pollen bearing organs include Aulacotheca, Codonotheca, Potoniea and Whittleseya.*Questora, a genus with only one vascular segment in its stem, has been included under Medullosaceae by Mapes and Rothwell (1980).

[[c] Glossopteridaceae

General Characteristics

1. These plants occurred widely during Upper Carboniferous and Lower Permian times (ie. as back as 280 million years ago) in Indian peninsula, Antarctica, South America, South Africa and*Australia. Since all these regions together represent a hypothetic continent, Gondwanaland,* separated from the other continents by Tethys Sea, the flora which occurred there is alsocalled Gondwanaland flora.
2. Since the most abundantly occurring leaf-genus of Gondwanaland flora is Glossopteris, *this flora is also called Glossopteris flora.*
3. The leaves were generally tongue shaped.
4. The length of the leaves varied from a few centimetres to several decimetres.
5. The leaves had a reticulate venation and are believed to belong to some ancientferns by some botanists.

6. A midrib was present in the leaves of most genera [Glossopteris). In Gangamopteris*, however, the midrib was absent.*

7. Thestems were probably delicate and the leaves were borne in whorls.

8. Scaly leaves with reticulate venation were also present in some members.

9. The pittings of the tracheids of stem resembled more with conifers than cycads.

10. Several microsporangia and seeds have also been observed to be attached with Glossopterislike leaves.

11. *In Lanceolatus the seed-bearing* valve was fused completely with the leaf.

12. In Lidgettoniaafricana, the reproductive organs were stalked peltate.

13. bodies attaining a diameter of about 5mm. In this case the fertile leaves were much smaller than the sterile leaves.

14. According to Plumstead (1958) members of Glossopteridaceae might have been the ancestorsof flowering plants.

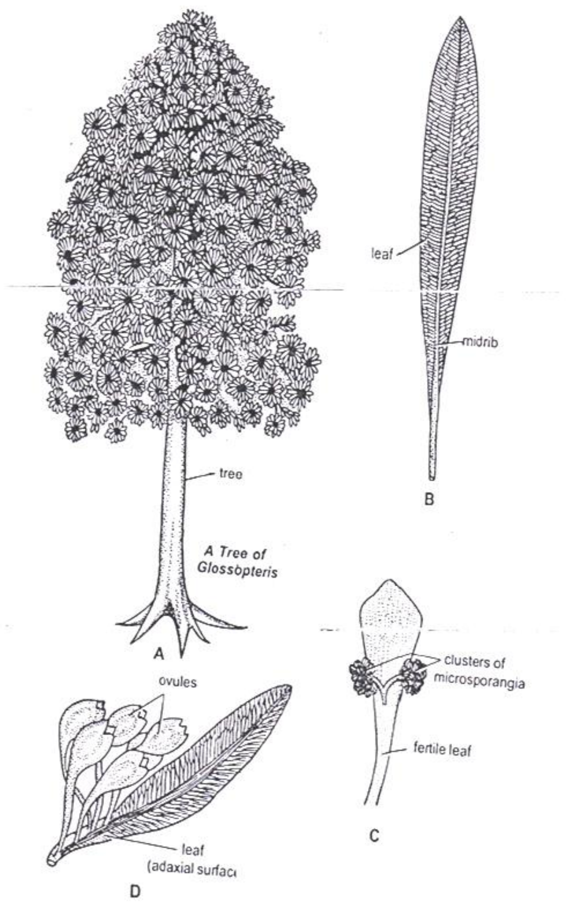


Fig. 2.14.A, Reconstruction of Glossopteris, B, A leaf of Glossoptens; C, A fertile leaf of Eremonia; D, Ovules of Denkania Indica developing in a row on the adaxial surface of leaf.

Pant (1977) and Gould &Delevoryas (1977) have reconstructed the Glossopteris plant. It was a large tree with a high trunk of about 6 metre. A Vertebraria type of root system supported the plant. Its trunk had Araucarioxylon type of gymnospermous wood. The leaves were arranged either spirally or in whorls. It is not yet known whether Glossopteris trees were monoecious or dioecious because all fructifications have been reported in detached state. Surange and Chandra (1976), however, opined that Glossopteris plants were dioecious in nature. According to Pant (1977), Vertebraria was a stem system but Gould (1977) opined that Glossopteris leaves were tongue-shaped with a prominent mid rib. The venation was reticulate. The leaves were generally sessile and rarely petiolate. According the Pant Glossopteris leaves were typically dorsiventral and hypostomatic, and the stomata were haplocheilic and sunken. Mesophyll was divided into palisade and spongy tissues,Several male, female and bisexual fructifications have been reported. All these are leaf borne and hence occupy unique position among gymnosperms. The leaf or bract associated with fructifications have together been termed as "fertiliger" by Pant (1987). Eretmonia, Glossotheca and Nesowalesia are the names of male fructifications of Glossopteridaceae. Whorls of microsporangia were present on two branches on the upper half of the lamina of Eremonia. The pollination was probably anemophilous according to Pant (1987). Many female fructifications have been reported, and nearly all of them have been studied as compression-impressions only. Denkania indica, Partha and Mooia are the female fructifications described by different workers.

Glossopteris is a member of gymnosperms because of the some similarities given by Pant. It possesses gymnospermous wood as in Vertebraria. It possesses gymnospermous type of axis on which leaves havebeen found attached. there is Similarity in stomata, cuticle and xylem in the leaves. Presence of exposed seeds found attached to leaves. Similarity in pollination. Seeds had bisaccate pollen.

[d] Peltaspermaceae

Plants of this fossil family occurred on the earth in the Triassic period of Mesozoic era, and were first reported by Thomas (1933) from Natal in South Africa.It has following characters.

1. These fossils have now been widely reported from Sweden, Greenland, Argentina, Australiaand China.

2. *Frond-genus Lepidopteris, seed-bearing organs Peltaspermum and*pollen-bearing organs Antevsia are some of the reported members of the family. Much is notknown about the general growth habit and the stems bearing these reported organs of thefamily.

3. *Leaves (Lepidopteris) were lanceolate, bipinnate or tripinnate and had unbranched rachis.* They attained a length or about 30 cm.

4. Antevsia, the pollen-bearing organs, were bipinnate bodies with alternate primary branching. The ultimate branches possessed 10-12 pollensacs. Each poliensacwas about 2mm long. The wall of pollen sac possessed stomata. The pollen grains were unwinged and each had a longitudinal furrow.

5. *The seed-bearing organs (Peltaspermumthomasii) were present on the leaves, and had* several stalked, peltate heads of a diameter of about 5 mm. Each head contained two seeds.

6. In P. rotula, however, as many as 10-12 seeds were present in each head. according to Bierhorst (1971). Peltaspermaceae represents probablya "link between more primitive fems and angiosperms"

[e] Corystospermaceae

General Characteristics

1. Thomas (1933) created this family on the basis of some fossils collected from Triassic periodof Mesozoic era from the molten beds of the upper part of Karro formation in Natal. (South Africa). Members have later been reported from Australia, Argentina, India and someotherplaces.

2. *Reported genera of this family include fronds (Xylopteris, Dicroidium), pollen*bearing organs (Pieruchus, Prerorachis), and seed bearing organs (Umkomasia, Pilophorosperma, Spermatocodon).

3. In frond genera (e.g. Xylopteris), the rachis divided into two equal parts near the*base. Open venation is present in the pinnae. Dicroidiumfeistmantelli was bipinnate and quite* large reaching up to about 1 metre in length.

4. *The pollen-bearing organs (Preruchus, had a central axis having short lateral*branches. At the tip of each branch was present a peltate head bearing up to 30 or moresporangia. Eachsporangium was about 3 mm long.

5. In seed bearing organs, the seeds were borne singly in helmet shaped cupules as in Umkomasia. Small bracts and bracteoles were also present, and because of these the entirestructure has been termed as inflorescence. The cupules splitted into twohalves in Umkomasia a long and bent bifid micropyle was present in seeds.

[f]Caytoniaceae

General characters

1. Fossils of this family have been reported from the rocks belonging to Upper Triassic, JurassicandLower Cretaceous periods of Mesozoic era. Plants of this group were discovered first by Thomas in 1925 from Middle Jurassic rocks of Cayton Bay in Yorkshire (England).

2. *Leaves are present in the form of Sagenopteris, seed bearing organs in the form of Caytoniaand pollen bearing organs as Caytonanthus.*

3. Sagenopteris had a slender petiole terminating into four leaflets. The leaflets werearranged in two pairs. A prominent mid-rib was also present. The veins were forking with anastomosing lateral connections.

4. The seeds were found attached on a rachis in the form of small, fruit. In each "fruit" these were about 8 seeds. Each seed was enclosed in a cupule.

5. *Pollen bearing organs (Caytonanthus) had a dorsivental rachis possessing somewhat opposite* pinnae. A synangium was present on each terminal branchlet pinnae. Each synangium possessed four loculiof the irregularly branched.

6. *Thomas* (1925) opined that Caytoniaceae had definite relation with the origin of plants but laterworkers criticized and rejected this opinion.

Angiospermic Characters of Caytoniaceae

1. The curved cupules had stalked, orthotropous ovules. Since these ovules closed after pollination, they resembled closely with that of angiosperms.
2. Reticulate venation of leaves.
3. Development of abscission layer.
4. Presence of bud scales.
5. Presence of microsporophylls possessing tetralocular synangia.

Gymnospermous Characters of Caytoniaceae

1. Male fructifications were radially symmetrical.
2. Filament and connective tissues absent in the male fructifications.
3. Presence of winged pollen grains. Leaves had no blindvein ends.
4. Megasporophylls were pinnate in nature.
5. Pollen were discovered inside the micropyle as well as at the tip of the nucellus of the ovules

Similarities of Pteridospermales

Pieridospermales (Cycadofilicales) may be assigned as intermediate position between fernsand Cycadophytes due to their several resemblances with both the groups. But due to the presenceof exposed seeds they belong to gymnosperms with certainity. Some of their possible affinitieswith ferns and Cycadophytes are mentioned below.

Similarities with Ferns

1. Large and pinnately compound leaves.
2. Youngleaves are circinately coiled.
3. Mesarch or rarelyexarch condition. Leaf traces are also mesarch.
4. Absence of vessels in the xylem and companion cells in the phloem.
5. Polystelic condition of Medullosaresembles with ferns.

6. The sporangia were borne on the foliage leaves.

SAQ.1

Fill in the blanks

1. Presence of............canals is characteristic feature of conifers. [resins,mucilage, gum]
2. Conifers are widely distributed in ....regions. [temperat,tropical].
3. The group of seed producing plants is known as............[spermatophytes, cryptogams].

2.2 CYCADALES

Cycadales, consisting of 11 living genera and more than 100 species, are distributed in both tropical and warm temperate regions of the world. They appeared first in Upper Triassic times, and are present even today. This indicates clearly that they are extremely ancient plants. Cycads are woody plants which resemble palms on casual observation. They have a stocky cylindrical stem possessing a crown of very large palm like leaves. They possess naked seeds on modified leaves (sporophylls) and are thus true gymnosperms.

General Characters

1. The plant body is sporophytic. The sporophyte is differentiated into well developed roots, columnar and generally unbranched stem and pinnately compound leaves.
2. Members exhibit xerophytic characters. The growth of cycads under xerophytic conditionsis extremely slow. It has been estimated that a plant of Dioon grows only 2 to 2.5 metrein one thousand years under natural conditions.
3. Young leaves show circinate vernation.
4. The wood is manoxylic.
5. Mucilage canals are present in the pith as well as cortex.
6. The leaf trace is diploxylic.
7. Plants are dioecious without exception, and the reproductive organs are generally in the formof cones.
8. The cones are generally terminal or lateral in position.
9. In male cones the microsporophylls are arranged on cone axis, and form a compact structure.

10. Microsporangia are arranged on the abaxial side of the microsporophylls.

11. The flagella on the sperms are arranged in spiral bands. The male gametes are very large.

12. Megasporophylls are foliage leaf like structures. their tip portion of is sterile. Several ovules (2-8) are arranged in the middle region of the megasporophylls.

13. The ovules are orthotropous.

14. The apical meristem in all Cycads extremely massive.

GENERA OF CYCADALES

Undermentioned is the list of all the eleven living genera of Cycadales arranged alphabetically: Bowenia, Ceratoramia, Chigua, Cycas, Dioon, Encephalartos, Lepidozamia, Macrozamia, Microcycas, Stangeria and Zamia.

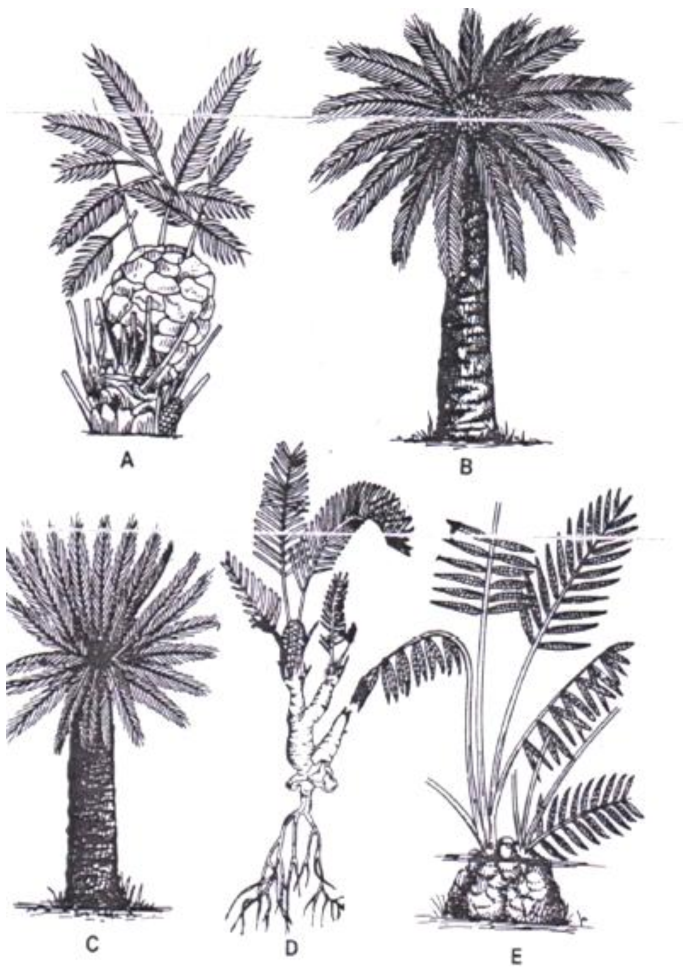


Fig. 2.15.. Some Cycadales. A, Bowenia spectabilis, B, Cycas revoluta, C. Dioonspinulosum, D, Zamia fordiana, E. Stangeriaparadoxa

Cycadales are thus now represented by 11 genera.

Classification

Spore (1965) divided the Cycadales into following two families

1. **Nilssoniaceae**: It includes all fossil forms such as leaves (eg.Nilssonia, Pseudoctenis),*pollen bearing organs (e.g. Androstrobus) and seed bearing organs (e.g. Beania).*
2. **Cycadaceae**: It includes all living genera (e.g. Cycas, Microcycas, Dioon, Ceratozamia, Zamia, Stangeria, Bowenia, Encephalartos and Macrozamia), and a fossil genus (Palaeocycas) But Bierhorst (1971) divided Cycadales into following three families.

1. Cycadaceae.
2. Stangeriaceae
3. Zamiaceae

Cycadaceae

Geographical Distribution of Cycadaceae

Cycadaceae were almost worldwide in distribution in the past ages, and the members of this family have been in existence for at least past 200 million years. The members are, however, now restricted to four main regions in the world, namely Central America, South Africa, Eastern Asia and Australia. Cycas occurs in Japan, Queensland and India, while Bowenia and Macrozamia in north-west Australia and Queensland and Encephalartos in South Africa Stangeria is restricted to Natal (South Africa), while Zamia is found commonly in Chile, and Ceratozamia and Dioonin Mexico. Microcycas occurs only in Cuba, while Lepidozamia is found only in Australia.

The distribution of all the 11 genera of Cycadaceae is mentioned below:

(a) Eastern Hemisphere

Encephalartos and Stangeria: South Africa

Bowenia, LepidozamiaandMacrozamia: Australia

Cycas: Indian sub-continent, China, Japan, Australia, Madagascar

(b) Western Hemisphere

Ceratozamia and Dioon: Mexico

Microcycas: Cuba

Zamia: Mexico, West-Indies, North-western South America and Florida.

External Features

Plants of this family are slow growing and provide a general look like that of a palm with cylindrical and generally unbranched stem, reaching upto 10-15 metres in some species Macrozamia and Dioon. The Stem is spherical or tuberous in Bowenia and Zamia. The stem apices are massive and quite large in cycads, and in them the tunica is absent. A crown of pinnate leaves is present at the apex. The leaves are large, pinnate or bipinnate and spiraly arranged. In some genera, the rachis is incurved and the leaflets are enrolled in the bud condition showing circinate vernation as in Cycas. The rachis of the young fronds show sub circinate venation in Stangeria, Bowenia and Ceratozamia. The leaves reach only up to 4-5 cm in length in Zamia pygmaea while up to 3 metres in Cycas thouarsii and C. circinalis. A distinct midrib is present in leaflets of Stangeria and Cycas. The midrib is absent in several other genera, a open dichotomous venation is seen in such cases. The leaves are long lived and persist on stem for several years. On being shed, they leave a scar on the stem.

Anatomy

Stem-Due to the presence of persistent leaf bases, the cycadaceous stems are roughly circular in outline. Both centrally located pith and the peripheral cortex are large and well-developed and contain mucilage canals. The endodermis and pericycle are not clearly demarcated. The primary vascular bundles are conjoint, collateral, open and endarch. The leaf traces are cauline i.e. develop singly from the vascular cylinder of the stem. They completely girdle the stem cortex, and presence of these 'girdling bundles' is a characteristic feature of the family. leaf traces, when enter the petiole, form an omega shaped (2) or horse shoe shaped pattern in several cycads. Both centripetal and centrifugal xylem are present in the leaf trace bundles, they are diploxylic. A leaf trace usually passes halfway round the stem horizontally, and thus enters the leaf almost opposite to its point of origin. At intervals it is be joined by other traces and thus each leaf receives a number of bundles.

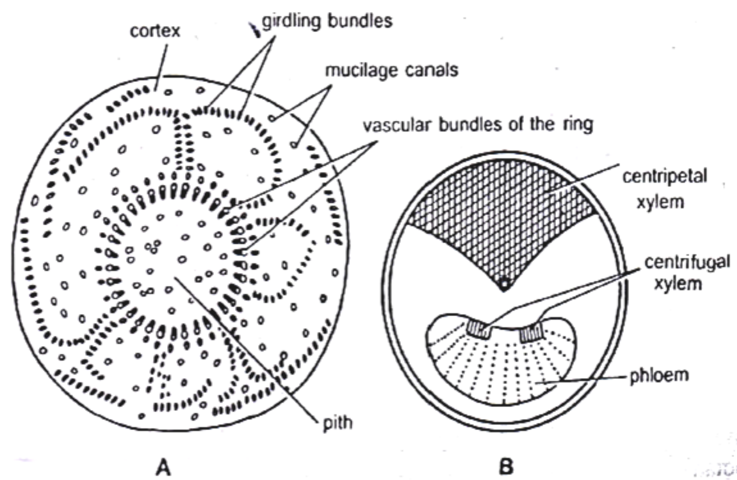


Fig. 2.16.A. T.S. stem of Zamia floridana showing girdling leaf traces, several mucilage canals and sc secondary wood; B, A leaf trace bundle of Cycas revoluta showing diploxylic condition.

In many members of Cycadaceae the stem or trunk is very strong, stout, large and well developed, but the amount of secondary wood is surprisingly small. The mechanical strength to such a strong trunk is provided by persistent leaf bases. In majority of Cycadaceae, only a single persistent cambium is present. But in most of the species of Cycas and some species of Encephalartos and Macrozamia a succession of cambial layers is seen, and these cambial layers form co-axial cylinders of secondary xylem and phloem. Presence of scalariform tracheids in the secondary wood, a primitive characteristic feature, is present in the stems of Stangeria and Zamia. The wood in Cycadaceae is very diffuse and contains 1-7 cells wide medullary rays.

Leaf and Root-Anatomically, the cycads leaves remain covered by a thick cuticle. Haplocheilic type of sunken stomata are present. The vascular bundles, in general, are diploxylic, i.e. two types of xylem (centripetal and centrifugal) are present. The centripetal xylem is triangular with a single protoxylem group. A parenchymatous region usually separates the two types of xylem. Cycadaceous roots are usually polyarch. Several xylem bundles alternate with the equal number of phloem bundles. Towards the apex, the number of bundles decreases regularly resulting ultimately into a diarch condition at the tip of the root. Concentric cylinders of secondary wood are produced by the accessory cambial rings in the older roots. The primary xylem is exarch. An algal zone is present in the cortex of the coralloid roots of majority of the living genera of Cycadaceae.

Reproductive Structures of Cycadaceae

All Cycadaceae are strictly dioecious, i.e. possess male and female reproductive structures on different individuals of the same plant species.

Megasporophylls and Female Cones-The reproductive organs are borne in the form of compact cones in all living genera, except Cycas. The female cone is absent in the female plant of cycas. In Cycas, loose and leaf like megasporophylls are spirally arranged and alternate with the vegetative leaves. Subopposite pairs of ovules are usually present in the lower part of each megasporophyll in Cycas.The megasporophylls in the female cone remain spirally arranged around the cone axis. In Ceratozamia, Macrozamia and Zamia, the megasporophylls are peltate structures. Only one female cone is usually borne at the apex but sometimes two cones may develop due to the development of another meristem. The smallest female cones (upto 2-3 cm in length) of Cycadaceae develop in Zamia pygmea, while in Macrozamia denisonii they reach up to 60-75cm in length. In Dioonspinulosum also they reach up to 50-60 cm in length. Because of its leaf like nature, the megasporophyll of Cycas is regarded to be the most primitive.

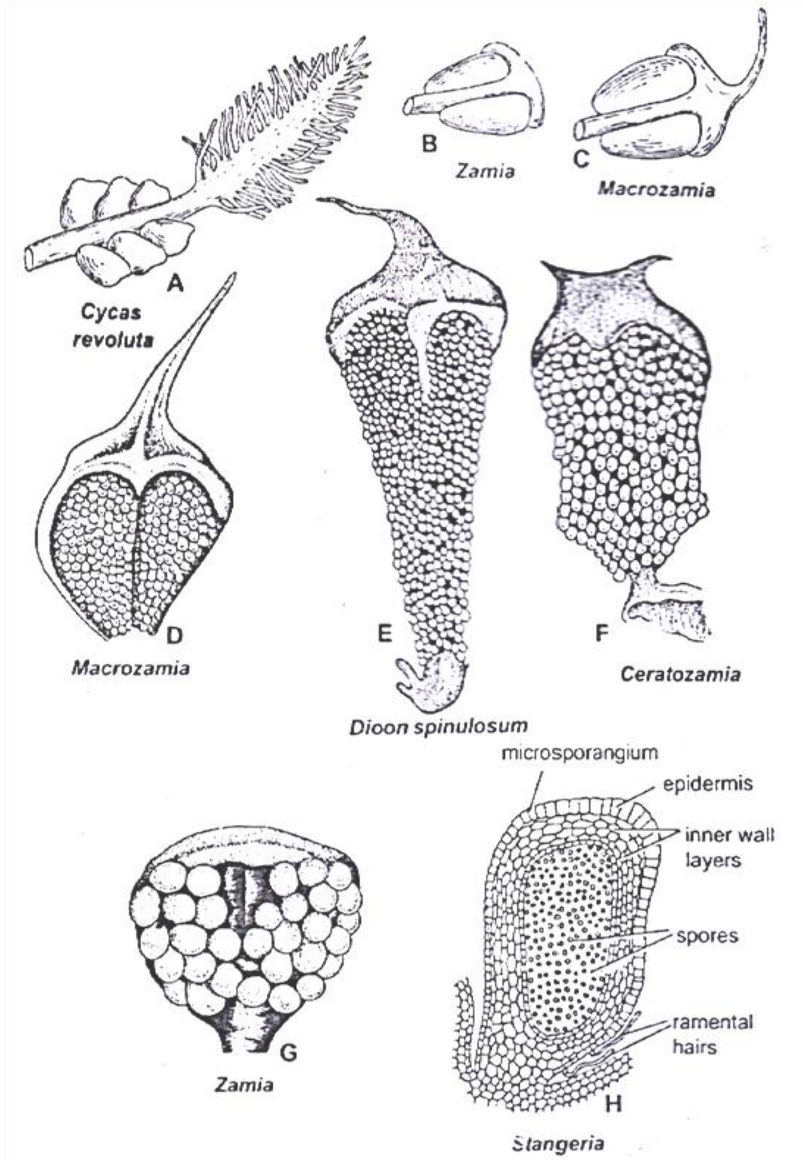


Fig. 2.17 A-H. A-C, Megasporophylls of Cycas revoluta (A), Zamia (B), Macrozamia (C); Microsporophylls of Macrozamia (D), Dioon (E), Ceratozamia (F), Zamia (G), H, A sporangium of Stangeria.

The megasporophylls of Macrozamia and Zamia are peltate, bear only two ovules, and their distal part is not leaf-like. These are, therefore regarded as most advanced. This also suggests that ovules are foliar in origin, and Cycadales are therefore, phyllospermous. According to the another view, the Cycadales are stachyospermous and not phyllospermous. Botanists supporting this second view believe that peltate megasporophylls of Zamia and Macrozamia with two ovules are most primitive, and the entire series has progressed in an opposite direction. Leaf like megasporophylls of Cycas revoluta with several ovules represent the most advanced stage.

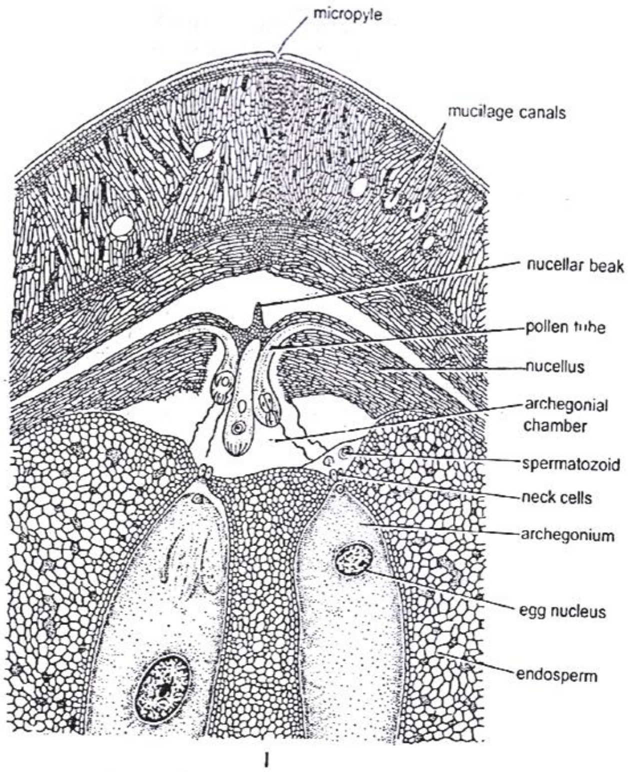


Fig. 2.18 I. V.S. ovule of Dioonedule.

According to this second view, the ovules are cauline in origin, and Cycadales are, therefore, stachyospermous.

Microsporophylls and Male Cones-The male cones are compact structures consisting of a central cone axis covered by several spirally arranged microsporophylls. Except Macrozamia moorei, the male cones are terminal in position. The microsporophylls, in general, are triangular or conical structures possessing definite sterile and fertile portions. The sterile portion is usually distal in position and produced into a single spinous projection as in Macrozamia, Dioon and Cycas. But in Ceratozamiamexicana it is produced into two such projections. The lower or abaxial surface of the microsporophyll contains thousands of microsporangia in most of the genera. In Zamia, however, only 20-50 microsporangia develop on a microsporophyll. The haploid chromosome number varies from 8-13 in Cycadaceae. It is 8 in Stangeria, 9 in Dioon, 11 in Cycas and 13 in Microcycas.

Ovule and Female Gametophyte-Cycadaceousovule is generally sessile structure. It is surrounded by a single integument. A distinct micropyle is present at the distal end. The integument consists of three layers, of which outer and inner layers are generally fleshy, while the middle one is a stony layer. The nucellus consists of parenchymatous cells, when young. A megaspore mother cell is soon distinguished in the nucellus. This mother cell divides meiotically into 4 haploid megaspores. From which three degenerate and only one remains functional. Several free nuclear divisions in the functional megaspore followed by wall formation in the later stages result into the development of cellular female gametophyte. As many as 1000 free nuclei may be seen, and the wall formation usually starts at the peripheral region. A vascular strand generally enters through the basal part of the ovule and constitutes its vascular supply. In some cycadaceous ovules, the vascular strand may divide even before entering the basal part of the ovule. In most of the cases, however, two concentric vascular systems (outer and inner) are established at the base of the ovule. The outer vascular system consists of about twelve vascular strands and move upwards through the outer fleshy layer from chalazal end to micropylar end of the ovule. The strands of the inner vascular system move upwards through that part of the ovule where the inner fleshy layer remains in close contact with the nucellus. Stomata-like structures, possessing cells resembling guard cells and subsidiary cells, have also been reported on the outer surface of the nucellus in the ovules of Ceratozamia, Cycas, Encephalartos and Zamia.

A lysigenous cavity develops within the nucellar beak in the cellular female gametophyte. This cavity represents the pollen chamber. One or more archegonial initials appear at the micropylar end of the female gametophyte. Each of these initials develops into an archegonium .

Pollen Grain and Male Gametophyte Microspores or pollen grains are haploid structures, and each develops into a male gametophyte. Each microspore remains surrounded by an outer thick exine and inner thin intine. The exine is more thick at the bottom and comparatively thinner at the top. The generally thin initne is slightly thicker along the sides. The single prominent nucleus of the microspore is centrally located & remains surrounded by dense cytoplasm which contains some reserve food.

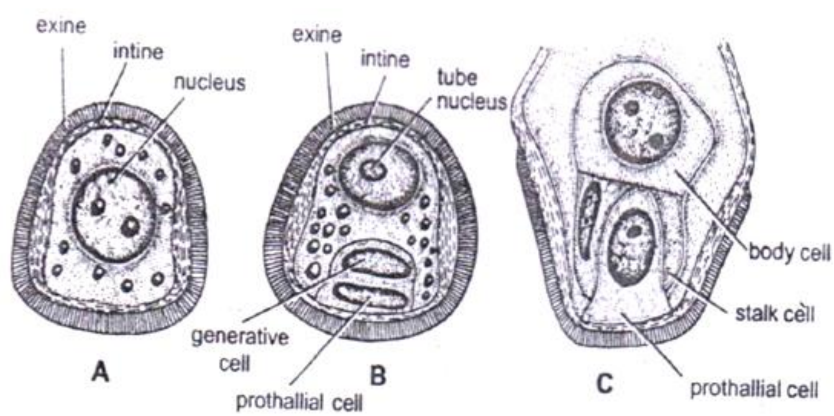


Fig. 2.19. Some stages of the development of male gametophyte in Dioonedule. A, A pollen grain; B-C, Stages of male gametophyte development.

Germination of the microspore starts within the microsporangium itself. They are released from the microsporangium when they are usually at 3-celled stage (a persistent prothallial cell, a generative cell and a tube nucleus). Their further germination takes place on the nucellus after the completion of the pollination process. Pollination is affected by wind. Under this process, some of the pollen grains at 3-celled stage, reach up to the micropyle of the ovule and get entangled in the pollination drop. Through the micropyle such young pollen grains reach up to the pollen chamber of the ovule. Each pollen grain germinates by producing a pollen tube that penetrates through the nucellar tissue. In majority of the genera the tube nucleus moves into the pollen tube. After a few weeks, the generative cell divides into a stalk cell and a body cell. The stalk cell usually remains in close contact with the prothallial cell. The body cell divides into two multiflagellate spermatozoids. The spermatozoids are well-developed, and in Dioon they reach upto 275 u in diameter, which is probably the largest size of the male gametes in the plant kingdom.

Embryogeny After fertilization, the diploid oospore enlarges in size inside the venter of the archegonium. The zygotic nucleus undergoes repeated free-nuclear divisionsand as many as 64 (Bowenia) to 1000 (Dioon) free nuclei are formed. Wall formation starts at the base and proceeds towards the archegonial neck. The cells of the upper region elongate and develop into suspensor . Various parts of the young embryo are developed from the basal cells. Soon, two cotyledons develop. The root apex develops in the young embryo towards the neck of the archegonium. Between the root apex and the suspensor develops the coleorrhiza. The suspensor becomes coiled, and in some cycadsit reaches upto 7-8 cm in length. Cycads show polyembryony, but only one out of the several developing embryos attains maturity.The embryos are dicotyledonous.

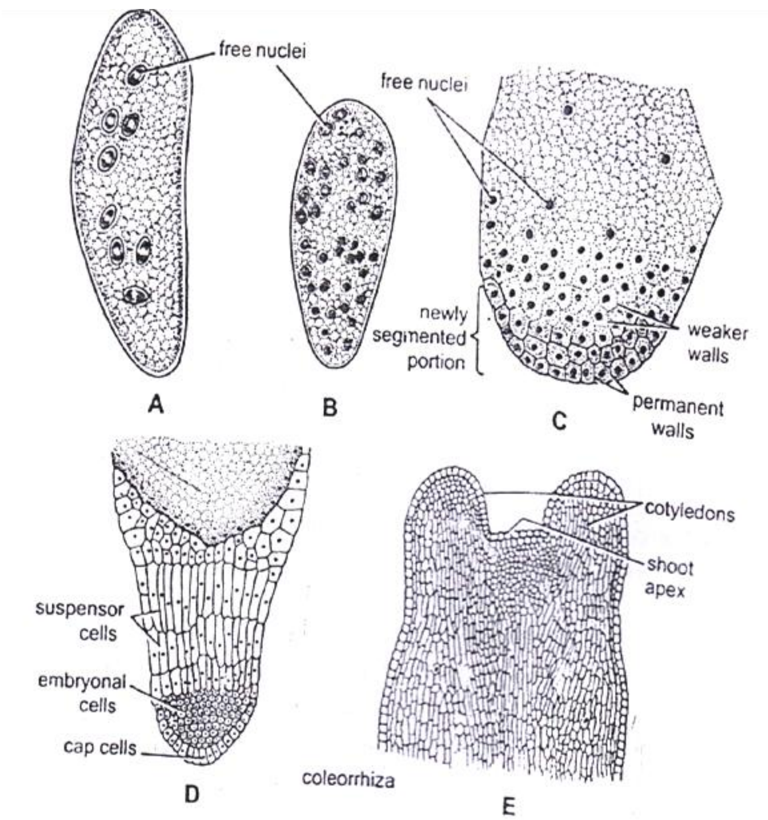


Fig. 2.20 A-E, Embryogeny of Zamia umbrosa.

Seed Formation and Germination Variously coloured and beautiful seed coat of the seed is formed by the outer fleshy layer of the integument of the ovule. Middle stony layer forms its hard testa. The inner fleshy layerif at all persists at maturity, changes into a papery layer called tegmen of the seed. The nucellus may form a nucellar cap at the micropylar end. The micropyle persists as such in the seed. The coild suspensor of the embryo is finally pressed against the micropylar end. The embryo extends the exine length of the seed. Cycadaceous seeds require almost no resting period for germination. Upon falling from the plant, a seed starts germination immediately if conditions are favourable. The germination of the seed is hypogeal.

FOSSIL CYCADACEAE-

Sporne (1965) discussed Palaeocycas as the only fossil genus belonging to Cycadaceae. Florin (1933) described the female sporangiophores of this genus belonging to Palaeocycas integer andits leaves belonging to Bjuvia simplex. The female sporangiophores of Palaeocycas integer were described from Upper Triassic rocks of Sweden. These sporangiophores are believed to have borne seeds. Its leaves resembled that of present day banana plants and reached up to 1 metre in length and 20 cm in breadth. The female sporangiophores were comparatively much smaller reaching only up to 13 cm in length and about 5 cm in breadth. The leaves of this plant were arranged in the form of a crown at the top of a strong stem according to Florin. Female sporangiophores had seeds and were loosely aggregated in the centre of the crown of leaves. The plants looked like that of the present day Cycas plants. There is close similarities between the shape of epidermal cells, guard cells and subsidiary cells of both Palaeocycas and Bjuvia. It indicates that they both belong to only one cycad.

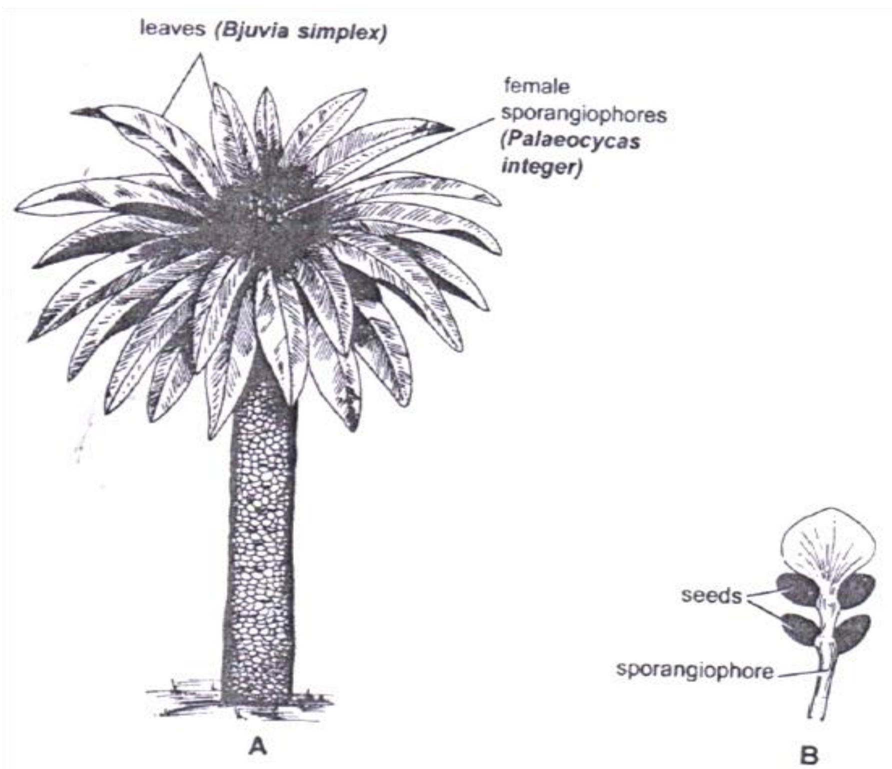


Fig. 2.21. Palaeocycas. Reconstruction of a plant bearing leaves named as Bjuvia simplex (A) and a single female sporangiophore (B) named as Palaeocycas integer. (A-B, after Florin).

Cycas fujiana, a fossil Cycadaceae was reported by Yokoyama (1911) from early Tertiary of Japan. Florin (1933) described Cycas blomquistii as yet another fossil Cycadaceae, and Harris (1950) described Cycaditescteis from Mesozoic era of Yorkshire. From the Jurassic age of Mesozoic era, a Cycas like megasporophyll has also been described under the name *Cycadospadix*.

Economic Importance of Cycadaceae Cycadaceae in general, are not of much use. However, some of their uses are undermentioned.

1. ***Beverage-yielding Cycad:*** *A beverage is prepared from the pith of Encephalartos by some tribal people of Central Africa.*
2. ***Edible Cycads****: Underground tuberous stems of Bowenia spectabilis are cooked and eaten by some native people of Queensland. Bread is prepared from the starch of Encephalartos. Macrozamia and Zamia. Boiled seeds of Dioonmejiae are also used for making bread. The kernels of Dioonedule are roasted and eaten with taste by certain tribal people. The seeds of Encephalartos yield a gum which is eaten by the people where this plant grows.*
3. ***Hats and Mats from Cycads:*** *Hats, mats, baskets and several other similar articles are prepared from the leaves of Encephalartos in some African countries. Ramental hairs obtainedfrom the leaf bases of Macrozamia are used as stuffing fibres.*
4. **Medicinal Value:** A decoction prepared from the seeds of Dioonedule is used by the Mexicans for treating neuralgia.
5. ***Oil from Cycads:*** *Seeds of Macrozamia yield an oil used as palm oil by some native people.*
6. **Poisonous Cycad:** Some poisonous substances have been reported in the leaves of Macrozamia. Animals eating leaves of this cycad many show some symptoms similar to rickets
7. **Starch-yielding Cycads:** Sago starch or "arrowroot" is obtained from the seeds and stems*of Macrozamia, Zamia and Encephalartos.*

Evolutionary tendency of Cycadales

The evolutionary history of an organism or of a taxonomic group of organisms is called phylogeny. In general, it is believed that Cycadales originated from some members of Pteridospermales, which are also called Cycadofilicales or popularly known as "seed ferns". There are several common characteristics found in both Cycadales and Pteridospermales. Of these, some are undermentioned

1. The wood is manoxylic in both Cycadales and Pteridospermales.
2. Mucilage canals are present in the cortex and pith of the stem of both cycads and "seed ferns".
3. Extensive cortex is present in most of the Cycadales and in some Pteridospermales (eg. Medullosa).
4. Centripetal xylem is present in some Cycadales and also in the vegetative organs of some "seed ferns" or Pteridospermales.
5. Male gametes or spermatozoids are multiciliate and motile in both the groups.
6. In both Pteridospermales and some Cycadales (e.g. Cycas), the megasporophylls remain spirally and loosely arranged, and they do not form a compact cone.

7. In Calymmatotheca the ovules remain attached on the proximal parts of the leaves and their distal or tip regions remain sterile. In this regard, they resemble with the megasporophylls of Cycas, in which upper part is dissected, leafy and sterile while the lower part bears ovules.
8. The seeds of Lagenostomalomaxi of Pteridospermales remain surrounded by an outer hard stony layer and an inner fleshy layer. They resemble the seeds of cycads to some extent.
9. The vascular supply of the ovules of cycads and some Pteridospermales also show some similarity with each other.
10. Both Cycadales and Pteridospermales possess pinnately compound leaves.
11. Pollen chamber is present in the ovules of both these groups.

On the basis of the detailed anatomical studies of several cycads, Cycadales originated from some members of Medullosaceae, a family of Pteridospermales, which extended from the Upper Carboniferous to the Permian. Cycads descended from Medullosa stellata whose stem had a medullated vascular cylinder. The centripetal parts of the stelar rings of M. stellata were lost progressively and this resulted ultimately into a complete loss of central star rings. There also existed a close similarity between the vascular organization of Cycas siamense and Medullosaporosa. Secondary wood occurs in the form of successive rings in both Cycadales and Medullosaceae.

Cycadales originated from some members of Palaeozoic Pteridospermales because of the existence of some definite similarities in both these groups. These similarities include the presence of well-developed persistent cortex, mucilage canals, manoxylic wood, centripetal xylem and structure of ovule in both these groups.

Inspite of the close resemblances of Cycadales with Pteridospermales, these members also show similarities and differences with other gymnosperms, such as Bennettitales, Pentoxylales, Cordaitales and even Ginkgoales.

2.3 NILSSONIALES

Family Nilssoniaceae

All reported members of this family of Cycadales are fossils. Its seed bearing organs have been described as belonging to genus Beania while its leaves have been described under two fossil genera i.e. Nilssonia and Pseudoctenis. The pollen-bearing organs of Nilssoniaceae are described as Androstrobus.

Beania, a fossil cycad, is represented by its seed bearing structures. Its fossils have been reported from the Jurassic of Yorkshire. Harris (1961) described its two species viz. B. gracilis B. mamay. In both these species, the sporophylls were peltate and arranged spirally around the central cone axis. Two ovules were arranged on each sporophyll, and the entire cone wasnotfusedas compact body but a loose structure. The sporophylls in B. gracilis ranged from 1.5 to 2.5 cm in length and its entire cone attained a length of about 10 cm. A hypothetical longitudinal section of its female sporangiophore has been reconstructed by Harris

(1961), and according to him in the lower two third part of its seed the integument was fused to the nucellus but in the remaining one third apical part the integument was free and not fused to the nucellus. The integument was formed by an outer fleshy layer, middle stony layer and an inner fleshy layer. In the lower two third part of the seed the vascular strands were seen running longitudinally in the integument. In B. mamay, the sporangiophores were bifid structures. Thomas and Harris (1960) described the male cones of Nilssoniaceae under the name Androstrobus. The pollen bearing organs or male cones of A. manis were compact bodies and had several spirally arranged peltate microsporophylls. Numerous fingers like pollen sacs were arranged irregularly on the abaxial side of each microsporophyll. In size these cones attained a length of about 5 cm and a breadth of about 2 cm.

The leaves attached to the plant, to which the male cones of Androstrobus manis were attached, have been described as Nilssonia compacta. These leaves were broadly linear and attained a length and breadth of about 40 cm and 9 cm, respectively. The lamina of these leaves was cut irregularly into truncate segments. The veins were parallel and at right angle to the rachis of the leaf. Some scaly leaves were also seen attached to such plants.

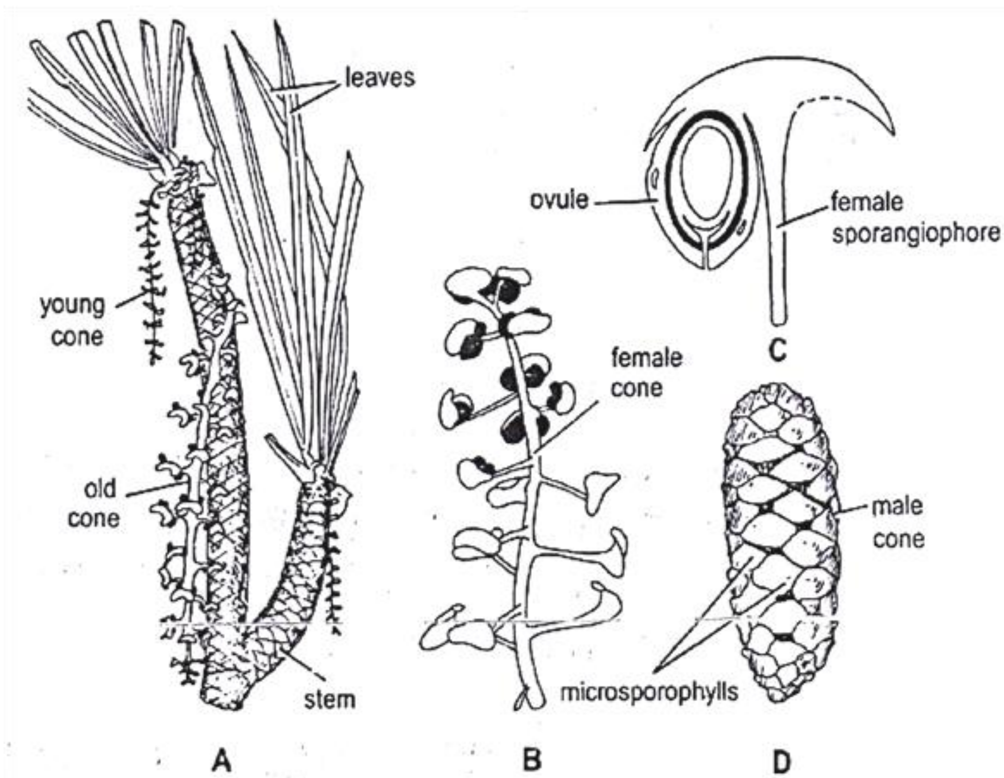


Fig. 2.22.A-C, Beania A, A reconstruction of B mamayi bearing loosely arranged cones and leaves. (Nilssoniatenuinervis) on an imaginary stem; B, A female cone of Beaniagracilis, C, L.S. of a female. sporangiophore of B. gracilis, D, Reconstruction of a male cone of Androstrobus manis (all after Harris).

In the Jurassic rocks the leaves of Nilssoniatenuinervis have been observed to be attached on the plant bearing male cones described as Androstrobus wonnacotti and female cones described as Beaniamamayi. According the Harris (1961), the leaves described as Nilssoniatemuinervis were attached on such a plant which had a stout stem.

2.4 SUMMARY

- Cycodopsida are vascular plants. These are terestrial plants.
- They do not form flowers but producees uncovered seeds.
- Pteridospermales are characterstic gymnosperm plants which bore fern like foliage and possess uncovered seeds.
- Pteridospermales have large and pinnately compound leaves.
- In pteridospermales sporangia were born on the foliage leaves.
- All cycades are xerophytes. These plants are low and palm like in habbit.
- The stem of cycades are short, unbranched, columnar and covered with dense persistent leaf bases.
- The leaves are pinnately compound and arranged in a terminal crown.
- There is narrow zone of conducting tissue. The conducting strand is represented by conjoint, collateral, endarch and open vascular bundles around the pith, separated from each other by medullary rays.
- Cycads are dioecious 'ie' micro and megasporophylls develop on separate plants.
- The ovules are straight and sessile.
- Male gametes of cycads are motile.
- Nilssonia is a genus of fossil foliage traditionally assigned to the cycadales.
- Nilssoniales is a extinct texon. There is no living individual this order.

2.5 TERMINAL QUESTIONS

Q.1 Discuss general characters of Pteridospermales.

Answer...

....

....

....

Q.2 Write brief account of the morphology, anatomy and fructifications of Pteridospermopsida with particular reference to two genera studied by you.

Answer...
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....

Q.3 Discuss the anatomy Pteridosperms with suitable examples

Answer...
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....

Q.4 Give a brief account of the family Glossopteridaceae.

Answer...
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....

Q.5 Give a general account of nilssoniales.

Answer...
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Short answers

Q.6 Give an account of male reproductiveorgans of Glossopteridaceae.

Answer...
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....

Q.7 Give an account of female fructificationsofGlossopteridaceae.

Answer...
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....
....

Q.8 Draw labelled diagrams of the following

A. Variation pattern of Glossopteris

B. Shape of the lamina

C. Multicellular hair of Glossopteris

OBJECTIVE QUESTION

1. The smallest known gymnosperm
    a. Zamia pygmae
    b. Pinus insularis
    c. Cycas revoluta
    d. Ginkgo biloba
2. Red wood tree is
    a. Pinus
    b. cydrus
    c. Metasequaia
    d. Sequaia
3. Dry fruit chilgoza is the seed of-
    a. Zamiapygmaea
    b. cycas revoluta
    c. Pinusgerardiana
    d. cedrusdeodra
4. Sago is obtained from
    a. Pinus
    b. cycas
    c. ginkgo
    d. gnetum
5. Terpentine is obtained from
    a. cycas
    b. ephedra
    c. pinus
    d. ginkgo
6. Ephedrine is obtained from
    a. cycas
    b. pinus
    c. ephedra
    d. cedrus

7. Timber is obtained from

   a. cycas

   b. zamia

   c. ephedra

   d. cedrus

8. Fruits are not formed in gymnosperm

   a. They are seed less plants

   b. They are not pollinated

   c. They have no ovary

   d. The process of fertilization does not take place in them

9. In which of the following features do gymnosperms resemble angiosperms

   a. Presence of vessels in the wood

   b. Nature of endosperm

   c. Mode of fertilisation

   d. Presence of ovule

10. Gymnosperms are also called softwood

   a. cambium

   b. phloem fibres

   c. thick walledtracheids

   d. xylem vessels

2.6. ANSWERS (OBJECTIVES)

1.a 2.d 3.c 4.b 5.c 6.c 7.d 8.c 9.d 10.d

SAQ.

1.Resin 2. Temperate 3. Spermatophyts

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UNIT-3 CYCADOPSIDA-2

Structure

3.0 INTRODUCTION

Cycadopsida have cylindrical, stockystem. It bears a crown of large, coarse palm like leaves. Their seeds are naked and are born on modified leaves called sporophylls. Bennettitales are an extinct seed plant. They resemble cycads in structure and morphology of leaves. Bennettitales were abundant during the mesozoic era. pentoxylales is an extint order of plants. It is known from the jurassic and early cretaceous of east gondwana. The first plant of pentoxylales were reported by Birbal sahni in1948.The stem of pentoxylales made of 5 or 6 vedge shaped segments embedded within thin walled ground tissue.

Objectives

1. To know about origin,history and distribution of bennettitales.
2. To understand the different families of bennettitales.
3. To understand the general characteristics of pentsoxylales.
4. To know the affinities of bennettitales.
5. To understand the origin and evolution of pentoxylales.

3.1 AFFINITIES OF BENNETTITALES

This group of fossil plants flourished well during the Triassic to Lower Cretaceous periods of Mesozoic era. As the Carboniferous period is called the "Ages of Ferns", the Mesozoic era is called the "Ages of Cycads". It is due to the fact that Cycadeoideales co-existed with Cycadales during Mesozoic era from Jurassic upto Cretaceous period, so this period is called Age of Cycads.

Bennettitales are found either in the form of compressions or petrifactions. Due to Cycad like form of their fronds and the presence of short stems covered with an armour of presistent leaf bases, Cycadeoideales have been treated under Cycadophyta.

Table 3.1: Differences between Bennettitales and Cycadales

Bennettitales	**Cycadales**
Stomata syndetocheilic.	Stomata haplocheilic
Secondary wood manoxylic	Secondary wood polyxylic
Leaf traces arise always singly at the point of their orgin	Traces arise as two independent units at the point of their origin
Fructifications are flower like structures.	Fructifications are strobilar in nature.
Flowers are bisporangiate and plantsare monoecious.	Flowers are monosporangiate and plants are dioecious.
Microsporophylls large, uni-or bipinnate, arranged in whorls and fused at the base.	Microsporophylls simple with sori on lower side and arranged spirally.
Arrangement of stalked ovules along with interseminal scales.	Such an arrangement is not found
Seeds exalbuminous	Seeds always endospermic

NOMENCLATURE, HISTORY AND DISTRIBUTION

The name "Bennettitales" has been given to honour JJ. Bennett, an English botanist. The fossilised trunk of genus Bucklandia was the first specimen of Bennettitales that was collected from Great Britain in 1825. Williamson (1870) coined the name Williamsonia for a combination of foliage and reproductive organs of Williamsonia gigas. Professor Birbal Sahni (1932) discovered Williamsonia sewardiana from the Upper Gondwana beds of India**.** *A rich fossil flora of Bennettitales has been reported from Rajmahal Hills of Bihar (India). Some of the reported members include Bucklandiasahnit, B. indica, Dictyzamites, Otozamitesbenghalensis, Cycadinocarpusrajmahalensis, Sahnioxylonrajmahalensietc.*

General characters

1. These extinct Mesozoic plants were present on the earth from Triassic to Cretaceous.

2. Bennettitales were so abundant during Mesozoic era that this period is known as 'Age of Cycads"

3. The members of this group are found either as compressions or petrifactions.

4. The stems were stout or slender and had a wide pith.

5. The stem grew very slowly and had manoxylic wood

6. Resembling living Cycads, the Bennettitalean leaves were mostly pinnately compound, and onlyoccasionally simple.

7. Venation was open and only rarely closed.

8. Syndetocheilic type of stomata were present.

9. The wall of the epidermal cells was sinuous.

10. The reproductive organs were organisedin the form of hermaphrodite [Cycadeoidea) or unisexual (Wielandiella) "flowers", which in turn were protected by many bracts.

11. The flowers' developed in the axil of leaves.

12. Male reproductive organs were borne in a whorl. They were free or fused, entire or pinnately compound.

13. Microsporangia were present abaxially in the form of synangia.

14. Microsporophylls sometimes surrounded megasporophylls forming hermaphrodite "flowers".

15. Ovules were numerous and stalked and borne on a conical, cylindrical or dome shaped receptacle.

16. Many interseminal bracts were present on the ovule containing receptacle.

17. The scales or bracts were united at end to form shield through which micropyle protrudes.

18. Seeds were dicotyledonous.

3.2 CLASSIFICATION

Walton (1940) recognized following two families in Bennettitales

1. Williamsonieae: Flowers fully exposed and present on slender stems, e.g. Williamsonia, Williamsoniella and Wielandiella.

2. *Bennettiteae: Flowers deeply sunk among the persistent leaf buses and were present on short thick trunk eg Cycadeoidea.*

Amold (1948) classified Bennettitales into two families viz. Williamsoniaceae and Cycadeoideacene while Spome (1965) divided it into following three families

1. Williamsoniaceae, eg. Williamsonia, Pterophyllum.

2. Wielandiellaceae, eg.Wielandiella, Williamsoniella.

3. Cycadeoideaceae, eg.Cycadeoidea (Bennettites)

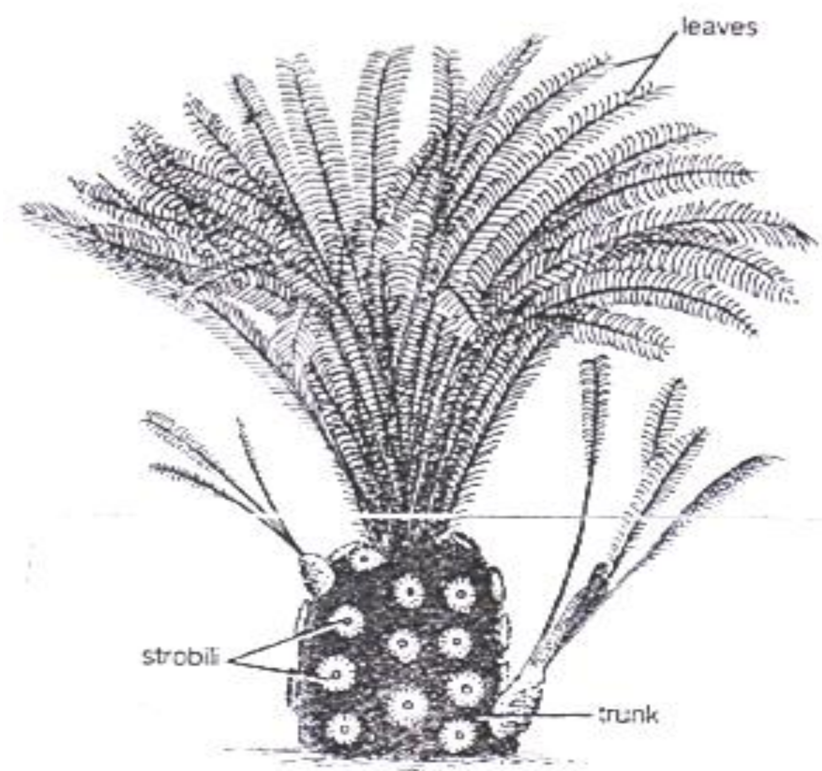
3.3 FAMILIES

a.Cycadeoideaceae

Cycadeoidea also called Bennettites by several European palaeobotanists. It was represented by about 30 species. The name Cycadeoidea was put forward in 1827 for petrified trunks from Isle of Portland. It has been reported from Upper Jurassic to Upper Cretaceous rocks of America, India, Russia and several European countries. It occurs in the form of a large number of petrifactions in different parts of the world.

Morphological Features-The Cycadeoid trunks were short, stout, spherical to subspherical and unbranched or branched. The trunks and leaves of many of its species show remarkable resemblance with those of living Cycads. Some of the species were short while others (Cycadeoideajenneyana) attained a height of 3 to 3.6 metres. The trunk generally attained a diameter of about 50 cm, and had many persistent, rhomboidal leaf bases . A compact crown of Cycad like, large, pinnately compound leaves was present at the apex. The leaflets had many parallel veins.

Anatomy The stem was roughly circular or oval in outline. It remained covered by heavy armour of leaf bases. The epidermis was not very distinct. The cortex was parenchymatous and possessed many mucilage canals and leaf traces. Many conjoint, collateral, open and endarch vascular bundles constituted the primary vasculature of the stem . A large centrally located pith was present.



3.1 Cycadeoideadacotensis. External features. (after Macride)

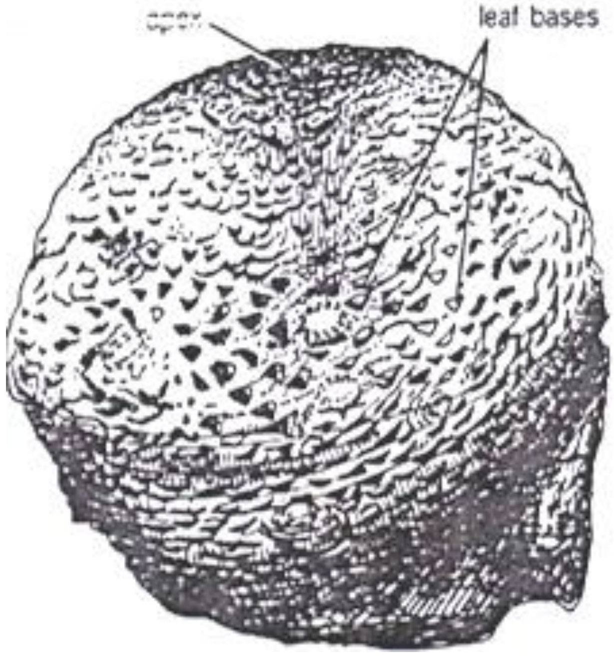


Fig. 3.2 Cycadecideacolossalis showing almost completely spherical stem. (After Wieland)

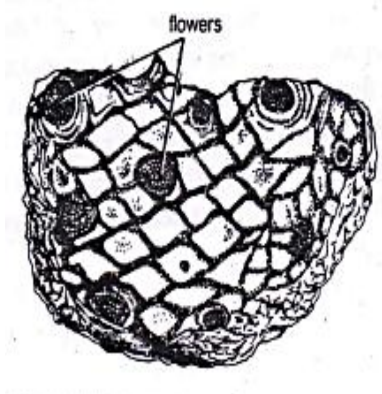


Fig. 3.3. Cycadecidegibsonianus Tangential section through leaf base and flowers.

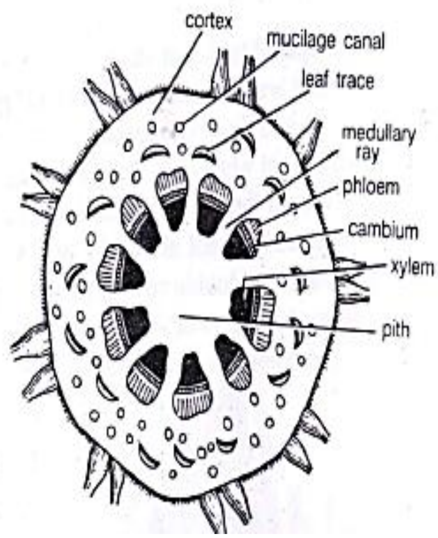


Fig. 3.4. Cycadeoidea Diagrammatic representation of TS. stem showing primary structure.

In xylem most of the tracheids were rectangular in shape. They were scalariform. The tracheids of protoxylemwere spiral. The secondary xylem and the secondary phloem were traversed by secondary medullary rays, which were either uniseriate or biseriate. Cambium was clearly visible.A leaf trace developed singly from the primary vascular strand. It divided into many mesarch strands upon entering into the cortex. At the place of its origin the leaf trace was C-shaped.

Reproductive Organs The Bennettitalean reproductive organs are "flowers". The flower buds in the plants were present in the axil of leaf bases. As many on 500 flower buds were present on a single trunk in species such as Cycadeoideadartonii (Monanthesiadartonii). In several species of Cycadeoidea all the flower buds were present on a trunk at almost the same stage of development.

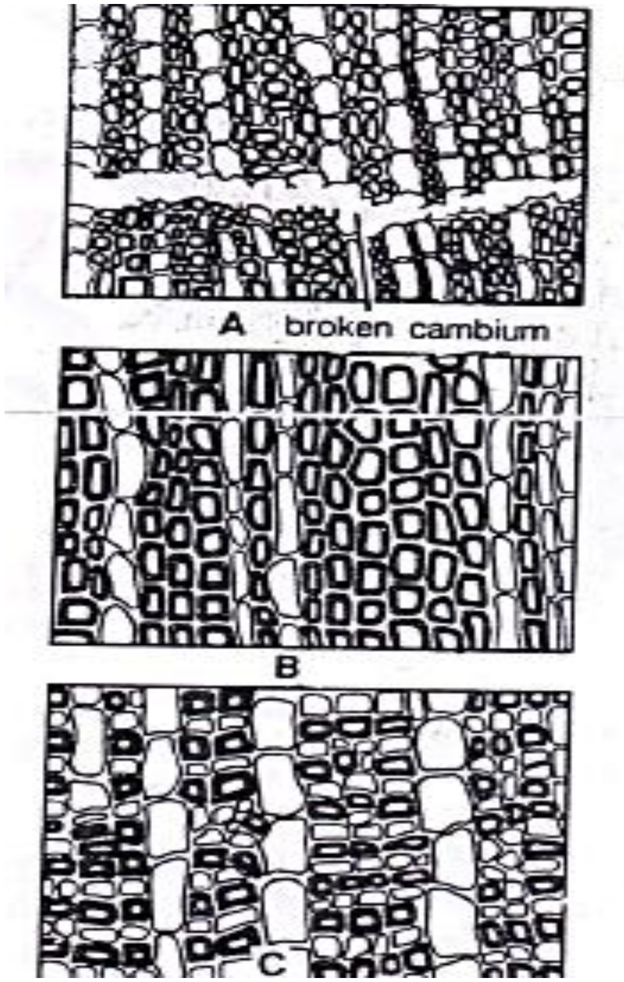


Fig. 3.5 Cycadeoideawielandii A, T.S. stem passing near cambium; B. T.S. secondary word; C, T.S. Phloem showing thin-walled and thick-walled tracheids (all after Wieland).

Flower Hermaphrodite flower developed on a short pedicel. They were surrounded by as many as one hundred bracts, which were hairy andprotective. Flowers in different species were of different size. In Cycadeoideadartonii they attained a length of about 2 cm and a diameter of about 1.5 cm while in C. dacosensis each flower was about 8 cm long and 3 cm in diameter. In C. dacotensis the lower two-third portion of the floral axis had about 100-150 bracts. A whorl of stamens was present above the bracts. Each stamen was pinnately branched and each pinna had a double row of purse-shaped sporangia. Each sporangium resembled with a synangium. A conical floral axis was present just above the whorl of stamens. The entire compact structure resembled with a strobilus.

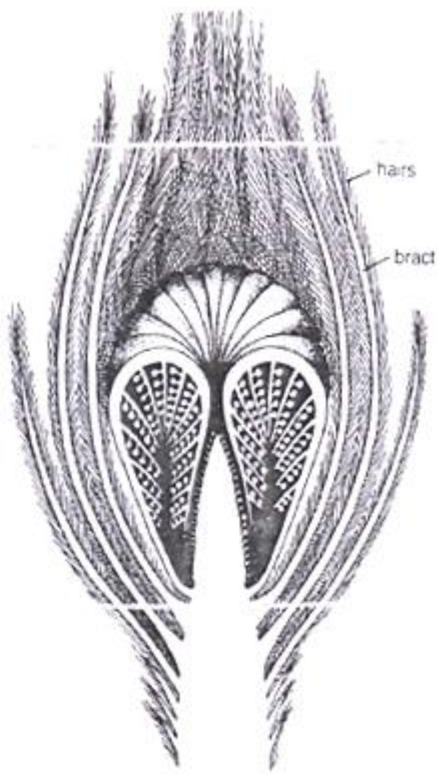
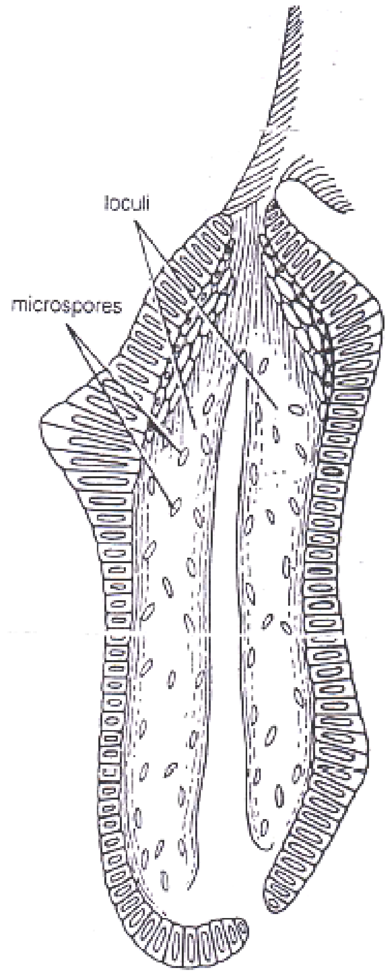


Fig. 3.6 Cycadeoidea Diagrammatic representation of unexpanded strobilus. (afterWieland, 1906).

Fig. 3.7 Cycadeoideadecotensis. Apical part expanded and curved microsporophy

Microsporophyll: According to Wieland (1906), the androecium consisted of about 20 pinnate, microsporophylls. These were somewhat fixed or united at the base. Bean-shaped pollen capsules were arranged in two rows on each pinna of the sporophyll. These microsporophylls remained folded around the gynoecium when young. At maturity they expanded. Delevoryas (1963), however, opined that the microsporophylls never expanded. He concludes that synangia-bearing structures, described as pinnae by were similar to the trabeculae. These trabeculae established a connection between outer and inner walls of the androecium. Pollen capsules or synangia were borne along these trabeculae. Several (20-30) pollen sacs or microsporangia were present in a pollen capsule or synangium. The wall of a synangium consisted of outer palisade-like, thick-walled cells followed by thin-walled layer and then a tapetum. The tapetum was not clearly demarcated. The pollen grains were oval in shape.

Gynoecium: The gynoecium receptacle was spherical or conical in shape. Hundreds of the stalked ovule along with an approximately equal number of interseminal scales were present on



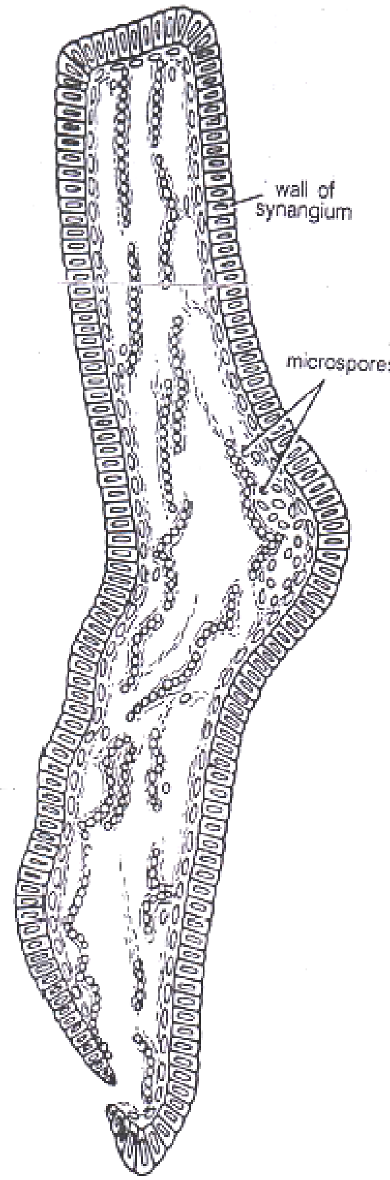
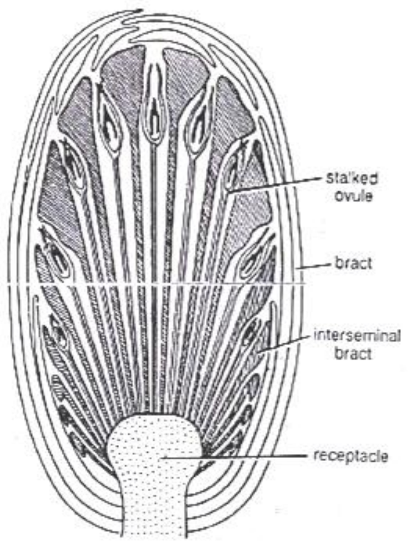


Fig. 3.8. Cycadecideadacofensis. L.S. sporangium showing stalk and twoloculi with microspores.

Fig. 3.9. Cycadecideadacofensis. T.S. of a synangium (after Wieland, 1906)

the receptacle. Each ovule was about 1 mm in length. The integument of the ovule was fused with the nucellus, except at the apex. The ovule was orthotropous with a long micropylar beak. A pollen chamber and a nucellar beak was present in each ovule. The seed was somewhat elongated or oval in shape and possessed two cotyledons. A linear tetrad also reported in the nucellar region of Cycadeoidea.



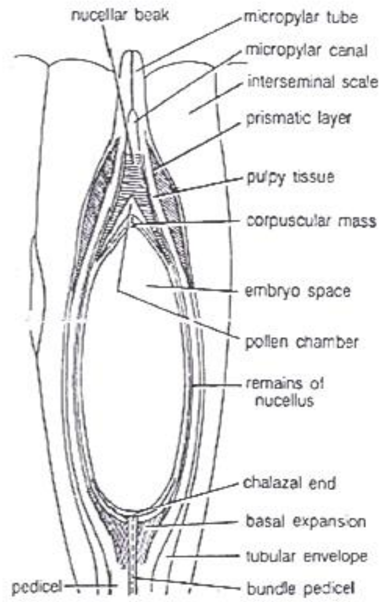


Fig. 3.10. Bennettitesgibsonianus. A female strobilus showing terminal seed with dicotyledonous embryos.

Fig. 3.11. Bennettitesmorieri LS. seed (after Wieland, 1905)

b. Williamsoniaceae

Occurrence Williamsonia belongs to family Williamsoniaceae of Bennettitales. It has been reported from Upper Triassic period but was more abundant in Jurassic. This was earlier discovered under the name Zamia gigas by Williamson (1870) but has now been named as Williamsonia. Professor Birbal Sahni (1932) described W. sewardiana from Rajmahal Hills of Bihar (India).

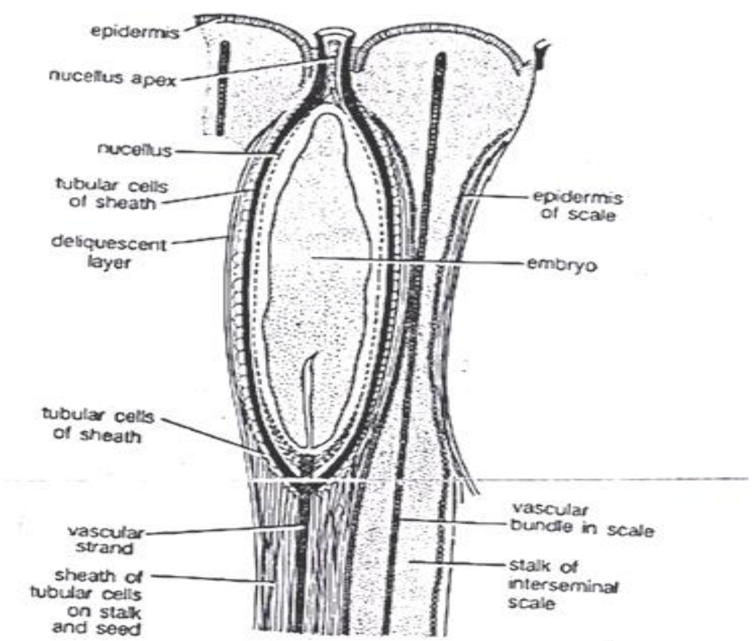


Fig. 3.12. Bennettesabianus. LS. seed along with two surrounding interseminal scales. (after Stopes).

External characters

Williamsonia resembled Cycas in appearance, and its best known species is W. sewardiana. A reconstruction of this species was published by Sahni (1932). The leaves of W. sewardiana were like that of Philophyllum. The plant had an upright, brancher and stout stem covered by persistant leaf bases. A terminal crown of pinnately compound leaves was present. Inthe stem genus Bucklandia, the leaf bases such as their shape, size and arrangement pattern are of taxonomic significance. Leaves in Williamsoniaceae show syndetocheilic stomata with rachis possessing collateral endarch vascular bundles. A distinct constriction was present at the base of lateral shoots.

Reproduction

The fructifications of Williamsonia were large and attained a diameter of about 12 cm. They were borne on a peduncle. Many spirally arranged bracts were present around the base of the floral axis. In W. gigas the cones were present among the crown of leaf bases while in W sewardiana they were present on the short lateral branches. Williamsonia plants were unisexual.

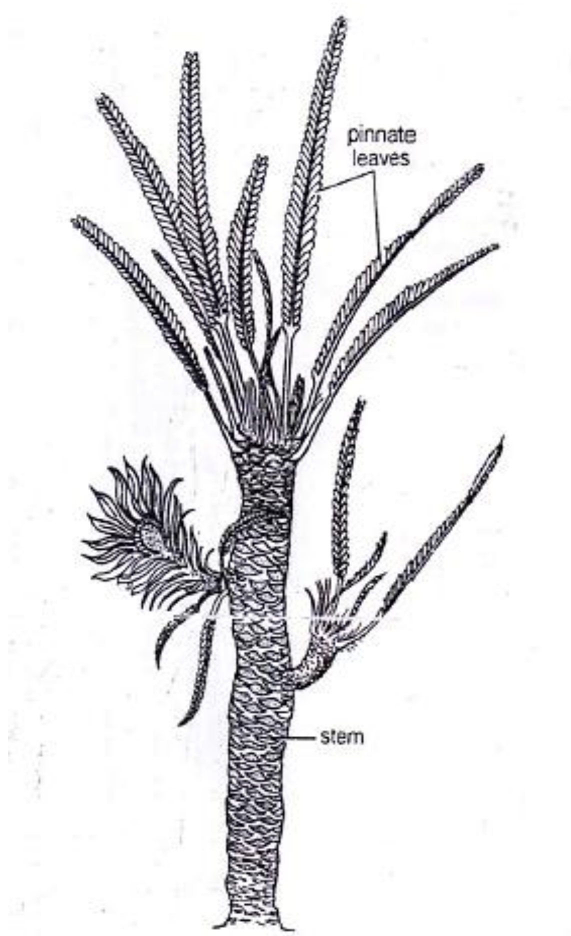


Fig. 3.13. Williamsonia sewardiana (after Sahni).

Female Flower: The term "flower" was used in Williamsonia instead of strobili. . The conical receptacle was surrounded by many perianin like bracts. The ovules were stalked.

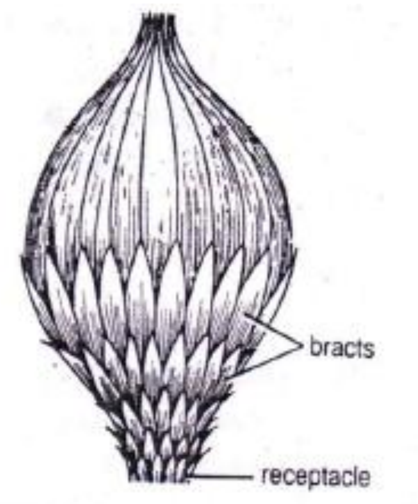


Fig. 3.14. Williamsonia gigas. A female flower bud (after Williamson).

Fig. 3.15. Williamsonia gigas. LS. female flower. (after Williamson)

The apex of the receptacle was naked and sterile. The nucellus was surrounded by a single vascularise integument, which was fused with the nucellus. The nucellus had a well-marked beak and a pollen chamber. In young ovules the micropylar canal was long and narrow. In mature ovules the canal widened because of the formation of nucellar plug and disappearance of interlocking cells. In the apical part of endosperm observed 2 or morearchegonia.

Male Flower Out of several known male flowers of Bennettitales some have been described to belong to Williamsonia. Male flowers consisted of a whorl of microsporophylls, which were united to form a more or less cup like structure. In majority of the species the sporophylls were unbranched but in some species, they were also pinnately branched.

Williamsonia santalensis was discovered from Upper Gondwana (India). One of the branches of microsporophyll was fertile while the other was sterile. The fertile part had finger like structures called synangia. Each synangium had two rows of chambers enclosing microsporangia. The entire male flower attained a length of about 20 cm. while a single microsporophyll was about 10 cm long. The fertile branch of the bifid sporophyll possessed many purse-like capsules, in each of which there were present many monocolpate pollen grains (Harris, 1969).

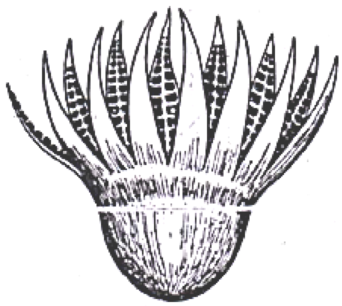


Fig. 6.16. *Williamsonia whitbiensis*. Pollen-bearing organs. (after Nathorst).

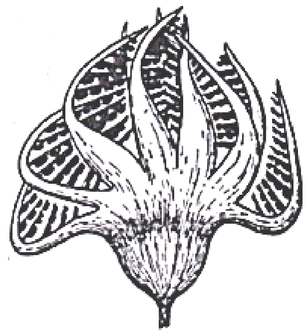


Fig. 6.17. *Williamsonia spectabilis*. Pollen-bearing organs. (after Thomas).

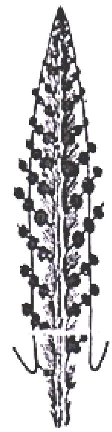


Fig. 6.18. *Williamsonia spectabilis*, showing upper side of one lobe of pollen-bearing organs. (after Nathorst).

SAQ.

1. Williamsoniaceae was first discovered by ....
2. Bennettiales are also known as...................

3.4 PENTOXYLALES

Discovery

This group has been discovered and named as "Pentoxyleae" by well known Indian Palaeobotanist Professor Birbal Sahni (1948). This is a group of some fossil plants described from Rajmahal Hills in AmraparaDistrict of Eastern Bihar (India) revealing their existence in Jurassic Period. While Pentoxyleae exhibits certain characteristics, not shown by members of any other group of gymnosperms. This also shows a combination of features characteristic of the Bennettitales, Cycadales and Coniferales. Lam (1932) suggested that Pentoxylae should be given a rank equivalent to Bennettitales and Cycadales in the Gymnospermous classifications. Sporeme(1965) has treated this group as an order under the name "Pentoxylales". Stems, leaves and male and female reproductive organs of this group have been described under followingnames.

Stems: Pentoxylon and Nipanioxylon

Leaves: Nipaniophyllum

Pollen-bearing organs: Sahnia

Seed-bearing organs: Carnoconites.

General characters

1. Extinct Mesozoic plants found in Jurassic period.

2. Although the exact habit of these plants is not clearly established, these were probably shrubsor very small trees.

3. Long and short shoots were present on these plants.

4. Short shoots had spirally arranged leaves and terminally located reproductive organs.

5. Leaves were thick, simple, lanceolate, and had diploxylic leaf trace.

6. Stomata were formerly thought to be syndetocheilic, but now they are considered to be haplocheilic.

7. Leaves possessed open venation.

8. Stems were polystelic.

9. Wood of Pentoxylon was pycnoxylic and resembled Araucaria.

10. Ovules were sessile.

11. 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.

12. Male reproductive organs or microsporophylls form whorl of branched microsporangiophores.

13. The microsporangiophores were fused basally into a disc-like structure.

PentoxylonSahnii

Pentoxylonsahnii and Nipanioxylonguptai are the stem genera of "Pentoxylene". The stems of Pentoxylonsahnii attained a diameter from 3mm to 2 cm. The stem has always been reported in association with the leaves called Nipaniophyllum. Presence of five steles in a cross section of the stem has been the main reason for giving the name Pentoxylon to the genus. Many short lateral shoots or dwarf shoots were also present on the stem.

Five steles occupied greater part of the stem in a cross section. 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 appeared eccentric. Primary phloem and primary xylem were present towards outer and inner sides of the cambium. Six steles have also been observed. The number of steles varied along the length of the stem. There were present five much smaller bundles just alternating with the main bundles of the stem i.e. five steles. Each such bundle had a large amount of secondary wood. These were probably the leaf trace bundles. Medullary rays of the main steles were uniseriate, and they lacked ray tracheids, wood parenchyma and resin canals. The secondary wood resembled greatly with that of Araucaria. Uniseriate or biseriate bordered pits were present on the radial wall of tracheids.

Fig. 3.19. Pentoxylonsahni. T.S. stele. (after Sahni)

Nipanioxylon

This stem genus of Pentoxyleae was discovered from the village Nipania and hence named Nipanioxylon. Village Nipania is in Rajmahal Hills, near Dumarchir in the Amrapara district (Santhal Parganas) in Bihar (India). Nipanioxylon differed from Pentoxylon in possessing larger number of vascular bundles (steles) and less developed secondary growth in the stem. Nipanioxylon resembled Pentoxylon in other details.

Nipaniophyllum

The leaves have been described under the name Nipaniophyllumraoi. They were found attached with the shoots or Pentoxylonsahnii. They were originally described under the name Taeniopteris. They were present on the short lateral shoots . Each leaf was simple, petiolate, strap-shaped, and possessed a well developed midrib with many parallel lateral veins. Branching has not been observed in lateral veins. Like cycads, the leaf traces had centripetal and centrifugal xylems, thus exhibiting diploxylic condition. The presence of syndetocheilic stomata was found in Nipaniophyllumbut the presence of Cycadaleantype of haplocheilic stomata was also been observed. The arrangement of stomata was foundanomocytic as in Cycads and most other gymnosperms. Vascular bundles in Nipaniophyllum were mesarch.

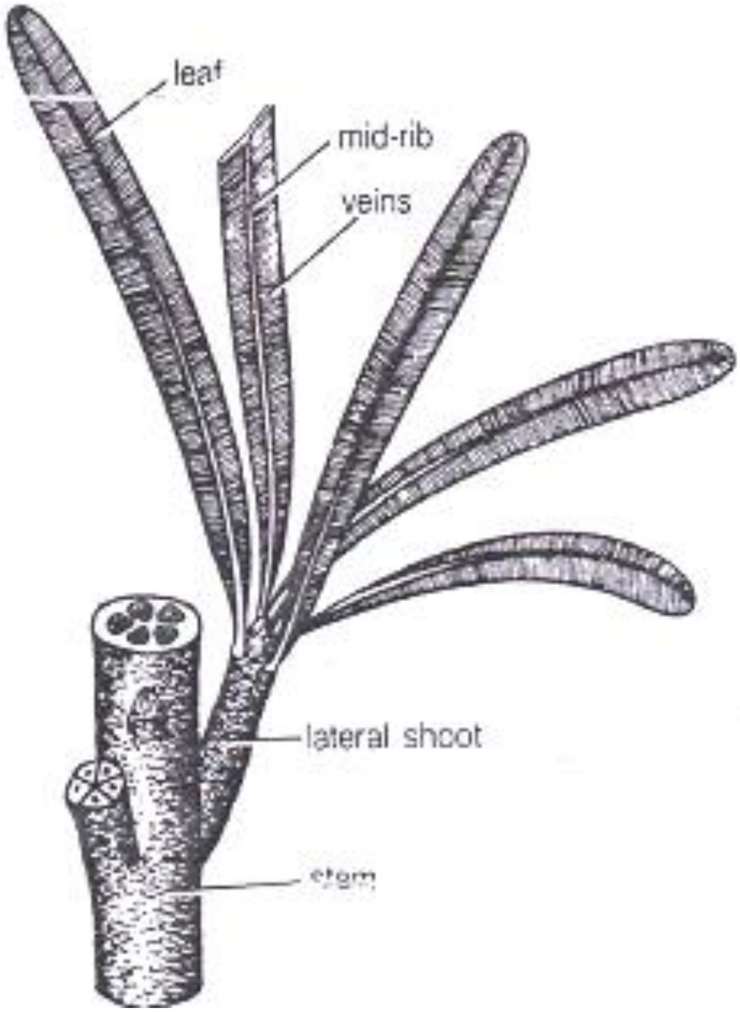


Fig. 3.20.Pentoxionsahnii. Reconstruction of stem and leaves (Nipaniophyllumroai) after Sahni

Carnoconites

The female cones or seed bearing organs have been described under the name Carnoconiies. Seed bearing organs were forked and found attached terminally on the lateral dwarf shoots. They were mulberry like, and attained a length of about 1.8 cm in Carnoconites compactum and 3 cm in C. laxum. They were, however, narrower in C. laxum. About 20 sessile ovules were seen attached on the receptacle, and there were no interseminal scales. Any sporophyll like structure was also not reported. Inspite of these facts Sahni (1948) used the word 'cone' for these structures. The ovules were covered by a single integument. The nucellus was free from the integument.

SahniaNipaniensis

The probable microsporangiate or male organs of Pentoxyleae were named as Sahnianipaniensis by Vishnu-Mittre (1953). They were present terminally on the shoot, and fused uasally in a shallow

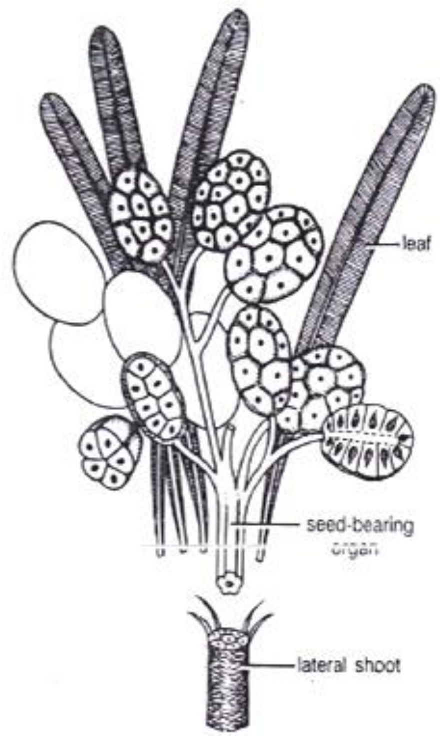


Fig. 3.21Carnocontes compactum. Female cones. (after Sahni).

disc. Vishnu-Mittre 1953) reported as many as 24 such pollen bearing organs. Each microsporophyll possessed many pear shaped, unilocular sporangia. The terminal position of the sporophyll was also occupied by a sporangium. Several monocolpate and boat-shaped pollen grains were present in each microsporangium. The sexine of the pollen wall is homogeneous while its nexine is present in the form of thin dark zone. In the region of aperature, the sporodermis highly folded.

Fig. 3.22. Sahniapaniensis. econstructionof male "flower". (after

Fig. 3,23Sahnienpaniensis. A detached microsporophyll (after

Vishnu-Mittre). Vishnu-Mitre)

AFFINITIES AND SYSTEMATIC POSITION OF PENTOXYLALES

The correct phylogenetic placing of the Pentoxylales was a most fascinating problem. While in their seed attachment they are clearly Coniferophytes, and they also have a coniferous type of secondary wood, their stomatal structure is fundamentally bennettitalean, the vascular anatomy of their leaves is truely cycadean. The general anatomy of the stem is unique. Pentoxy leaeoccupy a unique and rather isolated position.

If characters of stems, leaves, and male and female reproductive organs are compared, Pentoxyleae exhibits close affinities with Cycadales. The group (Pentoxylales) "should thus be given an equal rank amongst the Bennettitales and the Cycadales".

Affinities with Cycadales

The two groups (Pentoxyleae and Cycadophytes) resemble each other in (i) possession of direct leaf trace in Pentoxyleae and seedlings of some cycads, (ii) leaf traces anatomy in showing diploxylic nature of their vascular bundles, (ii) haplocheilic stomata, (iv) vestigial polystaly in the seedling stages of some modem cycads, (v) nature of wood and pittings, (vi) possessing more or legs similar kind of pollen grains, and (vii) structure of their seeds and peduncles.

However, vascular bundles in Pentoxylon are not arranged in the Cycadean manner. There is also no similarity between the polystelic condition of Pentoxylon and mature modern cycads.

Affinities with Conifers

Some of the characteristics in which Pentoxylales resemble with conifers, include the presence of (i) pycnoxylic wood, (ii) tracheids with circular bordered pits arranged in uniseriate or biseriate manner, (ii) uniseriate wood rays, and (iv) dimorphism in the stems of Pentoxylonsahnii and several conifers.

However, the general anatomy of the stem of Pentoxylales is not at all coniferous as mentioned also by Sahni (1948). Pentoxylales are totally stachyospermous (ie. both the male and female organs were bome on stems, rather than on leaves) while coniferales are partly phyllospermous and partly stachyospermous.

Affinities with Medullosaceae

Pentoxylales also resemble with members of family Medullosaceae of PalaeozoicPteridospermales (e.g. Medullosa) in possessing a polystelic primary vasculature in their stems. The secondary wood of Pentoxylon was pycnoxylic, character also encountered in some species of Medullosa. The two groups also resemble each other in their mode of branching as well as nature of their steles. Coniferous type of pittings were present in the stems of Pentoxylon and some species of Medullosa.

Affinities With Bennettitales

There are some resemblances between Pentoxylales and Bennettitales:

1. Presence of syndetocheilic stomata, in addition to haplocheilicones
2. Diploxylic nature of the vascular bundles.
3. Whorled microsporangiophores.
4. Superficial resemblances between male flowers of both the groups.
5. The manner in which the ovules were borne in Pentoxylales was similar to that of Bennettitales. However, the interseminal scales, found in members of Bennettitales, were absent in Pentoxylales.
6. Stachysporous nature of their male and female organs, ie. instead of leaves, these organs were bome on the stems.
7. Both the groups share several common characters in their dwarf shoots.
8. Presence of direct leaf trace also brings the two groups quite close to each other.

The polystelic condition of the stems of Pentoxylon and Nipanioxylon has no similarity with that found in Bennettitales. In Pentoxyleae the sporangiophores were erect, radial structures without any sterile part. They were spirally branched and possessed sac-like unilocular microsporangia. On the other hand, in Bennettitales these structures were completely different. They had circinate dorsiventral pinnate sporophyll with a sterile and synangium-bearing portion.

Features Unique to Pentoxylales

The mulberry like female cones or infructescences of Pentoxylales (Carnoconites compactum) with over twenty sessile ovules attached to a central receptacle is a unique feature of this group. These infructescences had neither any interseminal scales, nor anything that could be called a sporophyll, a unique feature again. The sporangiophores of Pentoxylales had spirally arranged branches and the sporangia were unilocular as well as terminal.

3.5 SUMMARY

i. Plants were shrubs or small trees.

ii. Branches were of two types. Long shoots and dwarf shoots.

iii. Leaves were spirally arranged.

iv. Wood is similar to that of a conifer.

v. Leaf and pollen grains are like that of cycads and cycadeoids and ovulate ones not reported in any other gymnosperm.

vi. The development of secondary wood is exocentric.

vii. The venetion was open or reticulate.

viii. The reproductive organs were unisexual and born terminally on short branches.

ix. The ovules are sessile.

x. The members of this group are unique combination of characters of Bennettiales, Cycadales and Coniferales.

xi. A few characters are peculiar to the group itself.

3.6 TERMINAL QUESTION

Q.1 Give an account of the strobili of Cycadeoidales. How do they differ fromthose of the Pentoxylales?

Answer...
....
....
....

Q.2 Discuss the Affinities of the Bennettitales.

Answer...
....
....
....

Q.3 Compare the general Characters of Cycadeoidacea, and Williamsoniaceae.

Answer...
....

....

....

Q.4. Write short notes on

A. Williamsonia

B. Fructifications of Williamsoniaceae

C. Cycadeoidea

D. Bennettitales remains from India

E. Affinities of Bennettitales

Q.5 Differentiate between

A. Leaf cuticles of Cycadales and Bennettitales

B. Caytonia and Williamsonia.

Q.6 Mention the characteristic features and affinities of Pentoxylales.

Answer...

....

....

....

Q.7 Write an essay on Pentoxylales and discuss its affinities.

Answer...

....

....

....

3.7 ANSWERS

SAQ.

1. Birbal sahni
2. Cycadeoideales

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U.P.Rajarshi Tandon Open University, Prayagraj

PGBY-106 (N)
Gymnosperms and Palaeobotany

2
Block
Coniferopsida

BLOCK INTRODUCTION

Block-2Coniferopsida

This is the second block of gymnosperms and paleobotany. This block is about class coniferopsida. Coniferopsida commonly known as conifers. This is a class of cone bearing seed plants that includes familiar tree species like pine, spruce, and cedar. They are characterized by their needle like leaves and reproductive structures called cones. Conifers play a significant role in ecosystem and are economically important for timber, paper and resin production. This block includes following six units.

UNIT-4 This unit covers the general account of order Cordaitales.

UNIT-5 This unit covers the general account of order ginkgoales.

UNIT-6 This unit includes the distribution and evolutionary history of conifers. It also includes some fossil families like labachiaceae, voltziaceae and palissyaceae.

UNIT-7 This unit provides the knowledge about some living genera of conifers like pinaceae, araucariaceae and toxidaceae.

UNIT-8 This unit includes the knowledge of family cupressaceae, cephalotaxaceae and podocarpaceae.

UNIT-9 This unit covers the knowledge about the order taxales and some of its genera like taxus, torreya,palaeotaxus,autrotaxus,pseudotaxus and amentotaxus.

UNIT-4 CORDAITALES

Structure

4.0 INTRODUCTION

The Cordaitales represent the most ancient and primitive order of the class Coniferopsida. They appeared in the Devonian period. They were at their peak of development during the carboniferous period. They were the only specimen of the Coniferopsida in that period. they succeeded by the Ginkgoales and the Coniferales in the Mesozoic era. The Coniferales went on spreading and dominating the world and become the most dominant gymnosperms. The Ginkgoales and Coniferales have both independent connections with the Cordaitales. The fossil conifers are represented by three families: Lebachiaceae, Voltziaceae and Palissyaceae. The Lebachiaceae originated at the time of the Carboniferous period and disappeared in the Middle Permian period of the Palaeozoic. At the same time the Voltziaceae started appearing and continued up to the Jurassic .

This evolutionary history of the Coniferopsida began in the Palaeozoic and passed through Mesozoic to the Coenozoic. During the Permian of the Palaeozoic the world had only one super-continent called the Pangaea. This super-continent started dismantling during the Permian and by the end of the Triassic it had splitted into two continents known as the Northern Laurasia and the Southern Gondwana Land. These continents started accumulate during the Coenozoic (65 million years ago) and reached the position in which we observe them today. The significant feature of the Coenozoic was the collusion of Indian sub-continent and creating the Himalayas.

Cordaitales fossils have been reported from Europe,North and South America, china,Australia and Africa during devonian and permian.Cordaitales are represented in India in the form of impression of leaves,petrified wood and seeds.

Objectives

1. To know about distribution of cordaitales.
2. To know the distinguishing features of cordaitales.
3. To learn about the classification of cordaitales.
4. To understand the external and internal structure of cordaitaceae.
5. To know the affinities of cordaitales.

4.1 CLASSIFICATION

The PalaeozoicCordaitales are an collection of interesting plants that reveal the historical background of the most dominating group gymnosperms. This intresting group of gymnosperms was named after the early 19th century palaeobotanist called Corda. Grand Eury and Renault brought it into recognition in the year 1870. This order has been divided into three families: (1) Cordaitaceae, (ii) Eristophytaceae and (iii) Poroxylaceae. The order is represented in India by 4 genera and 26 species. They all were discovered from the Upper Gondwana.

4.2 FAMILY CORDAITACEAE

External Characters

The members of this family formed the world's first great forests in the Carboniferous period. They included tall trees, (upto at least 30 metres in height) that grew in dense stands. The stems attained a diameter of 65 centimetres or a little more. This diameter is comparatively small with respect to their height. Because of this they show slender appearance. The branching was lateral and restricted only to the top of the tree.

The leaves appeared on the branches and were spirally arranged, petiolate, simple, subulate, spathulate or grass-like with entire margins and acute apices. The venation was parallel. The leaves showed considerable variation among the members of the family and were put under the type genus Cordaites. Based on the differences among the leaves of Various Cordaitaceae, the genus Cordaites has been sub-divided into three sub-genera:

Sub-genus: 1. Eu-Cordaites, in which the leaves were spathulate with obtuse apices. They reached up to a metre in length and about 15 cm broad. This sub-genus includes the forms that have been fully explored.

Sub-genus: 2. Dory-Cordaites, the leaves were lenceolate with pointed apices

Sub-genus: 3. Poa-Cordaites. The leaves were grass-like and reached a length of 50 cm and about a centimetre wide.

The leaves were encountered in the form of compressions. The parallel venation was identifiable to a series of dichotomies. The leaves were thick at their regions of attachment and then tapered proximally. The roots were also discovered and were named Ameylon. They arose from the base of the stem and were repeatedly branched.

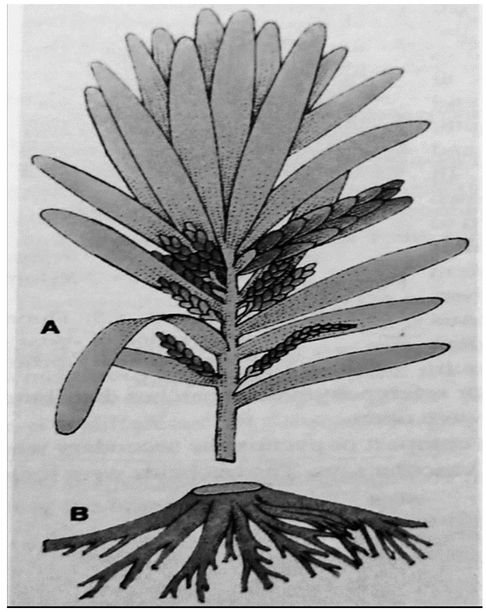


Fig. 4.1 Reconstruction of cordaites sp.

Anatomy

Stem

The cordaitaleanstems have also called as Mesoxylon, Cordaites, Metacordaites, Parapitys, Coenoxylon, Mesopitys, Cordaicladus and Artisia. In Cordaites the stem has a large cortex with sclerenchymatous patches scatteredbetween the parenchyma. The secretory sacs were also present. The pith casts reveal it to be wide and extensive and peculiar in being discoid. The characteristic feature of the pith is the presence of large air chambers separated by diaphragms. The pith casts disclose the pith to be transversely septate at the margins but the petrified material disclose the diaphragms to be incomplete. So that a transection shows two or three large air cavities and many smaller ones. The names Artisia and Sternbergia were given to the casts showing chambered pith. The primary xylem forms a narrow zone around the pith and consists of large number of endarchprotóxylems. In Mesoxylon, the xylem is mesarch.

As a result of secondary growth compact or pycnoxylic secondary wood is formed, which are, traversed by narrow or uniseriate vascular rays. The tracheids were long and narrow. The vascular pitting was primarily restricted to the radial walls. The bordered pits were hexagonal in outline and occurred usually in uniseriate rows. Biseriate, triseriate to alternate and crowding arrangements were not uncommon. Metaxylem also showed some scalariform pitting. It is believed that in Mesoxylon the leaf traces were mesarch and this condition extended downward to only some distance into the cauline system, but most of the cauline bundles had endarch xylem. In Cordaitesiowensis the first formed secondary wood had bordered pits multiseriately arranged but in the later formed wood the arrangement was uniseriate. The wood resembles the modern coniferous family Araucariaceae. The large pith and extensive cortex are cycadalean characters. The phloem showed sieve tubes and phloem parenchyma. Presence of phloem fibres is not confirm.

The stem named Dodoxylon also belongs to Cordaitales. It was first named and described by Dawson from Canada and Eastern United States. Later many species were discovered from France, England, Saxony, Brazil and South Africa. Presence of chambered pith in the stem of some species confirms their incorporation in the order.

Leaf Traces

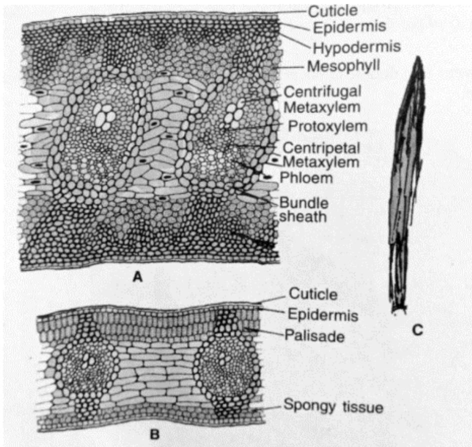
The cordaitean leaf traces were either single or double at their point of origin . In Cordaites, the strands were endarch whereas in Mesoxylon they were mesarch. During their course through the cortex they are sub divided. Two traces supplied each leaf. The two traces arose from a single protoxylem group. The leaf traces have been linked to those of Ginkgo, but there is a difference. The branch traces were also double at the point of their origin and they fused together before entering the branch base.

Roots

The roots in cordaitales (Ameylon) were usually triarch, exarch and protostelic. Most of the petrified specimens also showed the presence of periderm around the secondary cylinder. Secondary wood in the root was considerable. Another root genus is Premnoxylon. It was also exarch with the number of xylem pores varying between two to seven or even greater, in various specimens. In this genus the root pith had sclerenchymatous patches and the secondary xylem formed a distinct ring from that of the primary xylem. The root cortex was divisible into an outer and an inner cortex. Periderm was present in the outer cortex. The inner cortex had some cells with dark contents and were infected with mycorrhizic fungi.

Leaves

The leaves reveal characteristic xerophytic internal structure. The leaves had a distinct epidermis on the upper and lower surfaces (bifacial). The epidermal cells were thick walled. The sclerenchymatous hypodermis occurred in the form of distinct patches on both sides in C. angulostriatus whereas in C. rhobinervis it formed a continuous layer interrupted by distinct sclerenchymatous bundle sheath extensions. In C. lingulatus only sclerenchymatous bundle- sheath extensions were present. There was a clear distinction into palisade and spongy parenchyma in C. lingulatus. The vascular bundles were mesarch in all the species. The bundles were surrounded by a distinct sclerenchymatous bundle-sheath. The stomata were arranged in distinct bands along the entire length of the leaf. The guard cells were surrounded by 4-6 subsidiary cells. Cuticular ridge and papillae were present in the subsidiary cells that were lying besides the guard cells.



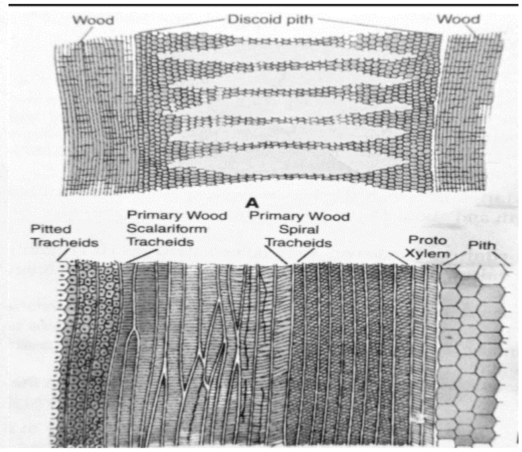


Fig.4.2v.s of cordaites leaf   Fig.4.3 L.S of stem showing sec.growth

Reproductive Organs

The fructifications of Cordaites are known under the form generic name Cordaitanthus (Cordaianthus). The fructifications occur among the leaves on the stem. They have loose inflorescences or compound strobili. Each fructification was borne on a vegetative shoot and consisted of an axis. Axis bore spirally arranged bracts with axillary reproductive shoots. it may be dwarf shoots or short shoots. The compound strobili were unisexual.

Male Strobilus

Male strobilus is also known as microsporangiate short shoot. Each dwarf shoot has a central axis with large number of spirally arranged scales. The scales at the proximal end of strobilus or dwarf shoot were sterile whereas those near the apex or the distal ones were fertile. Firtile scales possessed 4 or 6 or many microsporangia or pollen sacs. The microsporangia were elongate and finger like structures. Each microsporangiumis separately vascularised. These fertile and sterile appendages bore no axillary structures and are also termed as microsporophylls. The vascular strand that supplied the sporophylls or the appendages were mesarch and forked dichotomously.

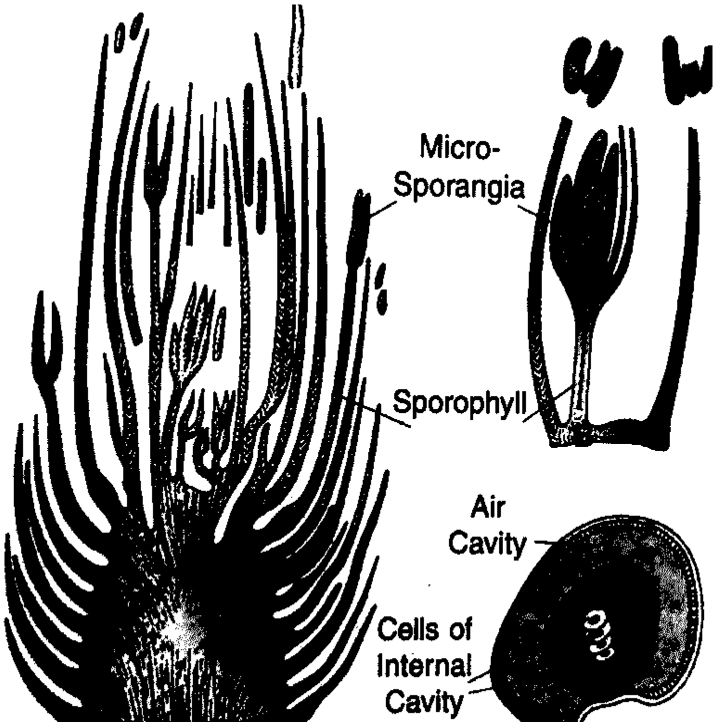


Fig. 4.4 Male reproductive organ

The microsporangia had a single layered wall enclosing large number of pollen grains or the microspore. The microspores had an air cavity enclosed by the exine. This is the saccus. The intine enclosed a central cavity which contained cellular remains of microgametophytes. The cavity of the germinated microspore is occupied by a row of peripheral male prothallus cells and a row of central spermatogenous cells. Each spermatogenous cell divided into two spermatozoids that were multiciliated. These were liberated into the trough like archegonial chamber. Pollen tubes have not been found.

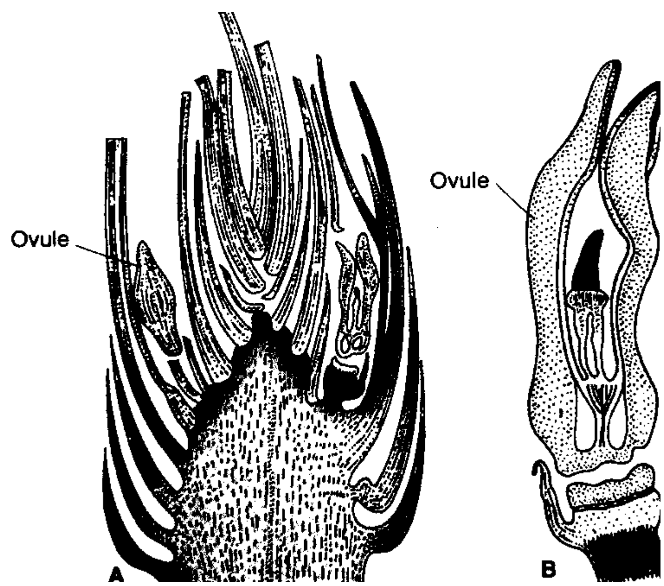


Fig. 4.5 A. L.S of female strobilus, B.L.S of ovule

Female strobilus

The organisation of the megasporangiatestrobilus is similar to microsporangiate dwarf shoot. They arise as lateral outgrowths from the inflorescence axis and each have a central axis with spirally arranged appendages. The basal or proximal ones were sterile whereas the distal ones were fertile and bore one to three ovules terminally.

In Cordaitanthuspseudofluitans, the distal fertile sporophyllswere elongated. They bore two to more terminal ovules that were more or less pendulus and flattened. The fertile appendages later grow and project beyond the shortshoot.

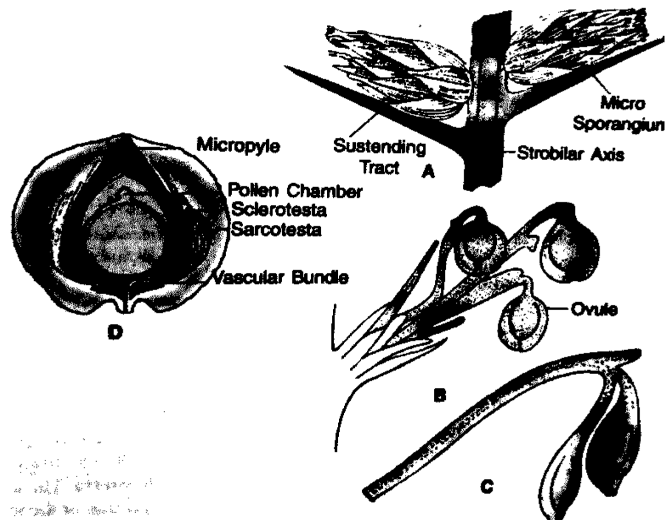


Fig 4.6A.Short shoots, B.Megasporangiate short shoot,

C. Single magasporophyll, D.L.S of ovule

The ovules were bilaterally symmetrical. It enclosed within a single, two parted integument which completely free from the nucellus. A distinct pollen chamber was found containing germinated pollen grains. The ovules appeared heart-shaped from the broad side. The single median bundle entered the sporophyll and divided into three just below the ovule. The central vascular strand continued up to the base of the nucellus.

These ovules are bilaterally symmetrical and the integument is free from the nucellus and consists of two or three distinct layers of tissues: (1) sarcotesta or the outer fleshy layer. (ii) sclerotesta or the middle stony layer, and (ii) endotesta or the inner narrow and fleshy layer.

The female gametophyte in most of the ovules encroaches upon the nucellus integument. It develops a characteristic endosperm beak which supports the nucellar beak and is called the tent pole as in Ginkgo biloba. The archegonial necks open into a distinct archegonial chamber which surrounds the tent pole.

4.3 FAMILY- POROXYLACEAE

This family is represented by a single genus Poroxylon. Seeds of this genus are put under the form genus Rhabdospermum. This family is of Permocarboniferous origin. The genus Poroxylon is of singular interest because it shows certain characteristics in which it resembles the pteridosperms. It also shows some characters of Cordaitales. It bridges the gap between these two orders. It resembles the pteriodosperms in the following respects -

1. Poorly developed secondary wood.
2. The secondary xylem rays were 3 cells wide.
3. The primary xylem was exarch.
4. The pith was wide.
5. The cortex had bands of sclerenchyma like those of Lyginopteris.

It resembles the Cordaitales in the following respects.

1. The leaves were simple and up to 1 metre long.
2. The cordate base of the seeds (Rhabdospermum).
3. The nucellus was vascularised.
4. The leaves were parallel veined.
5. Presence of a conical pollen chamber at the apex of the nucellus.
6. The ovule was bilaterally symmetrical.
7. The nucellus is free from the integument.

4.4 FAMILY-ERISTOPHYTACEAE

This family includes the form genera Eristophyton, Endoxylon and Bilingea. These genera were formerly placed under the family Calamopiryaceae, but Lacey (1953) pointed out that they have pycnoxylicwood and should therefore be included under the Cordaitales.

Some characters are given below

1. Only stems of these genera are well known.
2. The leaves and reproductive organs are not known and hence their taxonomic position remains unsettled.
3. In Eristophyton the primary vasculature consisted of five distinct vascular bundles arranged around the large and conspicuous pith.
4. They were quite free from the secondary wood but during their course outward as leaf traces they came to touch the secondary cylinder.

5. The strands were mesarch at this stage but during their course downwards they lost their centripetal wood and became endarch.

6. In Endoxylon the strands remained endarch throughout.

7. In Bilingea the pith was mixed and contained groups of tracheidal elements.

Their features suggest that like the Poroxylaceae this family also has certain pteridospermous and some cordiatalen characters.

SAQ.

Fill the appropriate word

1. The coniferopsida has been divided into................[four, three]

2. In cordiates the secondary xylem is.........[manoxylic, picnoxylic]

4.5 AFFINITIES OF THE CORDAITALES

The Cordaitales are the oldest plants of the true Coniferophytes. It constitute an interesting group of fossil plants that reached a high state of development as early as the Palaeozoicera. These highly developed features include:

1. The development of simple leaves with parallel venation.

2. The secondary wood was pycnoxylic and had uniseriate rays.

3. The development of definite strobilar arrangement of the reproductive structures.

4. The reproductive structures were unisexual.

5. The ovules and seeds were bilaterally symmetrical.

This group can also be regarded as an assemblage of fossil gymnosperms that combined the characters of most of the other fossil and living gymnosperms.

Resemblances with Cycads

They resemble the cycads in the following points:-

1. Their xerophytic habitat and aerial stems.

2. The stems had large pith.

3. The leaf had abundant sclerenchyma and showed xerophytic characters.

4. The ovule was surrounded by a single integument with three distinct layers.

5. Vasculature of the ovule is almost similar in both the groups.

6. Both have simple and large seeds.

7. The spermatozoids were motile.

These primitive characters seem to be inherited by both groups from a common ancestor. They differ from the cycads in possessing pycnoxylic wood, simple leaves, leaves parallel veined, straight leaf traces and compound strobili.

Resemblances with Ginkgoales

The Cordaitales resemble the Ginkgoales in the following respects:

1. Presence of double leaf traces in both, but there is a little difference regarding the origin of leaf traces. In the Cordaitales the two traces originate from the same protoxylem group, whereas in the. Ginkgoales they originate from separate groups of protoxylem.
2. Presence of motile spermatozoids.
3. Presence of an endospermic beak in the mature ovules.

Resemblances with Pteridosperms

The Cordaitales resemble the pteridosperms in the following features:

1. Both have stems with wide pith.
2. The tracheids have multiseriate pitting in many cordaitales.
3. The vascularisation of the ovule and its general structure is similar in both the groups.
4. The xylem is centripetally developed in the primary wood.
5. Both have double leaf traces.
6. The internal structure of the leaf is also similar in the pteridosperms and the cordaitales.
7. Their seeds lack embryos.

Resemblances with the Coniferales

The points of resemblances with the Coniferales can be listed as below:

1. Both include tall trees that are branched.
2. The leaves are simple and parallel veined.
3. Presence of sclerenchymatous hypodermis in the leaves of both the orders.
4. The wood is pycnoxylic in both.
5. They resemble the Araucariaceae in possessing multiseriate bordered pits on the tracheidal walls and absence of resin ducts.
6. The ovules are bilaterally symmetrical and have two parted integuments.

Resemblances with Ephedra

1. In Cordaitanthus and some species of Ephedra, the microsporophylls are laminate or flattened.
2. Both bear sporangia at the apex of the sporophylls.

3. The number of sporangia at each tip varies from 1 to 6 in both the groups.
4. In some species of Cordaitanthus, the number of ovules is reduced from three to two to one.
5. The leaves have parallel venation.
6. Each leaf is supplied with two leaf traces.
7. Pycnoxylic secondary wood.
8. The tracheids are long and narrow with tapering ends.
9. The stomata are haplocheilic.

4.6 SUMMARY

1. The plants of Cordaitales were tall trees with slender and branched stems.
2. The leaves were simple, paddle-shaped.
3. The leaves were spirally arranged.
4. The venation of the leaves was parallel.
5. The secondary xylem was pycnoxylic.
6. The strobili were unisexual and compound structures, that consisted of sterile and fertile appendages.
7. Megasporophylls bore four ovules.
8. The male appendages bore 4-6 microsporangia terminally.
9. The seeds were bilateral.
10. The stems were monopodial in habit.
11. Presence of an endospermic beak in some ovules.
12. The nucellus and the integument are free from each other. The nucellus is vascularised.

4.7 TERMINAL QUESTIONS

Q.1 Give a general account of the order Cordaitales. Discuss its affinities.

Answer...
....
....
....

Q.2 Discuss the affinities of Cordaitales.

Answer...
....

....
....

Q.3 Discuss the fructification of corditales.

Answer...
....
....
....

Q.4 What are corditales ? Describe the anotomy of corditales.

Answer...
....
....
....

Short Answer Type

Q.5 Write notes on

[a] Poroxylaceae

[b] Eristophylaceae

[c] Female strobilus

4.8 ANSWERS

SAQ.

1. **Four**
2. **Picnoxylic**

UNIT- 5 GINKGOALES

Structure

5.0 INTRODUCTION

The class ginkgopsida includes a single order ginkgoales.The order Ginkgoales is today represented by only one living member, ie. Ginkgo biloba.It was very abundantly represented in the world by several species of about 16 genera during the Triassic period of Mesozoic age. 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 Carriere 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". 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 .ie. Ginkgo biloba. Ramanujam (1976) reported that a few recrods of this order are known from Late Palaeozoic of India. These include Ginkgophyton, Psygmophyllum and Rhipidopsis.

Objectives

1. To understand the meaning of ginkgoales.
2. To know the general chracteristics of ginkgoales.
3. To know the classification of the ginkgoales.
4. To understand the phylogeny of ginkgoales.

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

5.1 GENERAL CHARACTERISTICS

Some general characteristics of Ginkgoales are undermentioned

1. Tall, well branched trees with short and long shoots. However, some earliest fossil memberswere without short and long shoots.
2. Wood is pycnoxylic.
3. Leaves are large, feathery and fan-shaped or strap-shaped. They are often deeply divided.
4. Dichotomous venation is usually present in the leaves.
5. Unbranched, catkin-like male organs are axillary in position.
6. Male organs bear microsporangiophores.
7. Each microsporangiophore possesses 2-12 pendulous microsporangia.
8. Spermatozoids are motile and contain spiral bands of flagella.
9. Ovules are terminal in position on branched or unbranched axillary axes. They are 2-10 innumber.
10. Seeds are large sized.
11. Each seed contains a fleshy outer layer and a middle stony layer.

5.2. CLASSIFICATION

Formerly, Ginkgo was included under Coniferae but Engler placed it under a new order Ginkgoales. Florin (1936) included various other genera in Ginkgoales, such as Baiera, Ginkgodism, Ginkgoites, Czekanosia, Stephanophyllum, etc. But the validity of some of them has been questioned as to whether they belong to Ginkgoales or not. Spome (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 ,Eremophyllum, Ginkgoites, Sphenobatera and Windwardia).*

Fig. 5.1. Baiera gracas, a bilobed leaf. Both the lobes show repeated dichotomy.

TRICHOPITYACEAE

Family Trichopityaceae is represented by the single species Trichopitysheteromorpha. It was first reported in 1875 from the Lower Permian of southern France. According to Florin (1949), it wasthe earliest member of Ginkgoales. Inspite of the fact that Trichopitys shows clearginkgoalean affinities, it differs in several characters from almost all other genera of Ginkgoalesand hence has been placed in a separate family Trichopityaceae.

The fertile shoot of Trichopitysheteromorpha had several ovules borne on branching structures. These branching structures were subtended by dichotomously branched leaves. Instead of flat, the leaves were almost circular in outline. Differing from the ovules of Ginkgo, the ovules of Trichopitys were reflexed and resembled with those of some Cordaitales (e.g. Cordaitanthuspseudofluitans). Male organs perhaps had clusters of microsporangia attached on the branching tips of a bifurcating axis. Several such bifurcating axes were borne on short shoots.

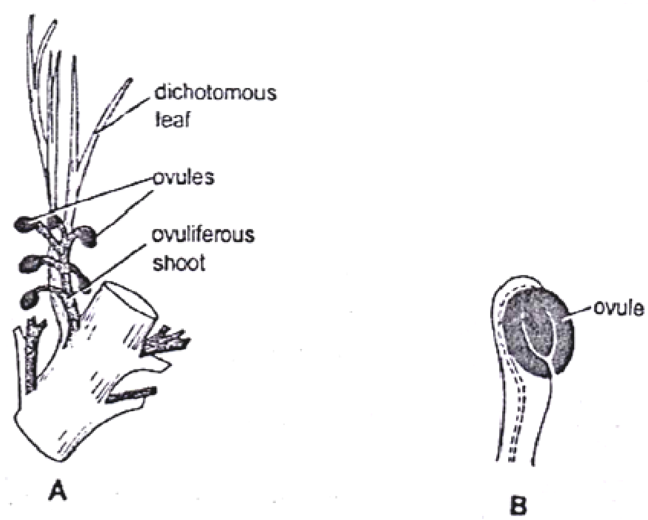


Fig. 52. Trichopitysheteromorpha. A, Two ovuliferous short shoots in the axil of dichotomous leaves; B, A reflexed ovule.

Ginkgoaceae

Some life history details of Ginkgo biloba, the only representative of family Ginkgoaceae, are mentioned below.

5.3. GINKGO (MAIDEN-HAIR TREE)

Distribution Ginkgo biloba is a tall slender and beautiful tree. It is commonly called Maiden hair Tree because its new leaves resemble very much like those of Adiantum (called maiden hair fern) both in form and venation. It is the oldest living seed plant. It is cultivated for its edible seeds in some parts of China and Japan. Though, Chamberlain (1935) mentioned that it is doubtful whether Ginkgo exist today in the wild state but Sporne (1965) has stated clearly about Ginkgo biloba that "if it occurs naturally anywhere, is restricted to a small and relatively inaccessible region in South China". Li (1956), however, mentioned certain evidences that Ginkgo still exists in the wild state in South-eastern China, along "the north western border of Chekiang and south eastern Anhwei". In China and Japan it is grown as a sacred tree in temple gardens. It is cultivated in the United States as a shade tree. It is also successfully cultivated in some gardens of Europe, America and India.

Fig. 5.3. Ginkgo biloba, a profusely branched tree

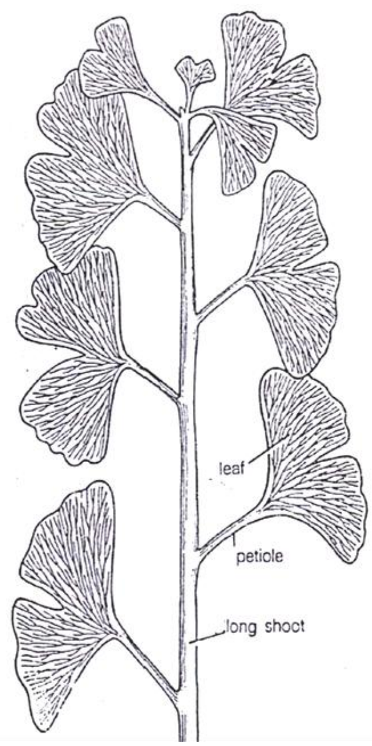


Fig. 5.4. Ginkgo biloba. A long shoot bearing deeply lobed leaves.

Nomenclature*The name 'Ginkgo'* was first proposed in 1690 by Kaempfer, a European botanist, and the same name was adopted by Linnaeus (1771). Due to the frequently notched character of the fan shaped leaves, the name "biloba" to the species was, however, proposed by Linnaeus (1771). According to Moule (1944) and Thommen (1949) the correct spelling should be Ginkgo. Li (1956), however, used and advocated for the word Ginkgo and opined that maiden hair tree has been designated correctly as Ginkgo and "certainly will be known as such forever". In fact, the tree was formerly known as Salisburiaadiantifolia but later the name was changed to Ginkgo*biloba.*

Ginkgo A Living Fossil

Ginkgo is known to have occurred in rocks as old as Triassic or even much earlier. Fossils of its leaves have been identified in the Permian and probably also in the Carboniferous. Ginkgo biloba occurs even today. It is therefore, referred as living fossil by the botanists. It may sure somewhat circular also be referred as the oldest living seed plant..

Morphological Features

The plant body of Ginkgo biloba is sporophytic, and the sporophyte resembles several conifers in general habit. The trees have a pronounced excurrent habit of growth and attain a height up 'to 30 metres. A very irregular pattern of branching is shown by Ginkgo trees. The branches are dimorphic i.e. bear long shoots which are of unlimited growth with scattered leaves and dwarf shoots which are short branches of limited growth. Long shoots elongate rapidly, sometimes as much as 50 cm in a year. Dwarf shoots grow rather slowly. A dwarf shoot of 2-3 cm length may be several years old. Sometimes there is no clear cut distinction between two types of shoots, and the dwarf shoot may convert into a long shoot while the latter may sometimes convert into a dwarf shoot for a year or two and then revert back into a long shoot. The foliage leaves, present on the long shoots, are deeply lobed while those on the dwarf shoots are not so deeply lobed and sometimes more or less entire . The differences in the growth pattern of long and dwarf shoots may be due to the quantities of auxin produced in the apical meristems.

Ginkgo biloba possesses a long tap root system. The roots are branched and penetrate deep into the soil.The *foilage leaves* are simple,large, petiolatewith wedge-shaped or fan-shaped expanded apex and narrow base.

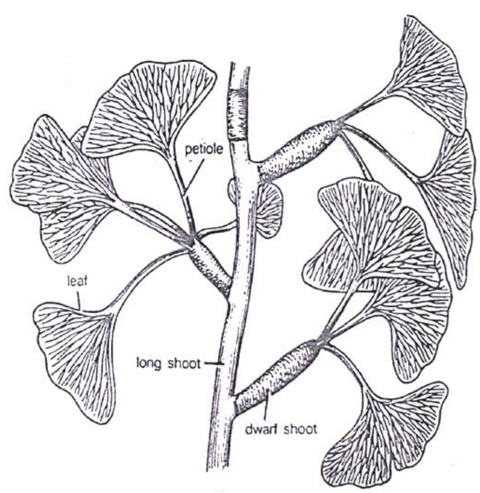
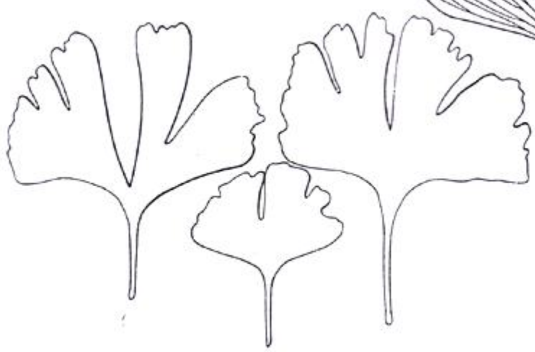


Fig. 5.5 Ginkgo biloba. A long shoot bearing dwarf shoots.

They resemble Maiden hair fern (Adiantum) and by this they can distinguished among gymnosperms. The leaves are bilobed, and hence the name 'biloba' was suggested to the species by Linnaeus . The leaves with many lobes are also present invariably on the tree. The leaves of the long shoot and seedlings are deeply bilobed whilethat of the dwarf shoot are not so deeply lobed and may be sinuate or even entire. They may bepale yellow, golden yellow or dark green in colour. A typical dichotomous type of venation is present in the leaves.



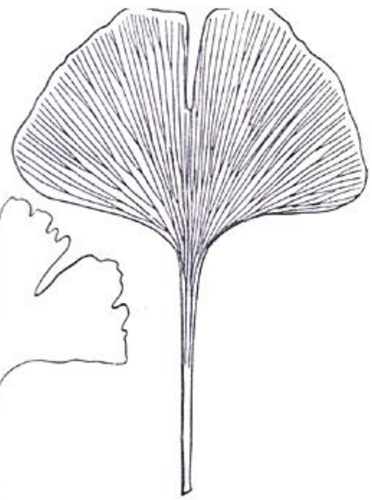


Fig. 5.6. Ginkgo biloba. Leaves showing many lobes. (after Chamberlain, 1935)

Fig. 5.7. Ginkgo biloba. A mature foliage leaf showing dichotomous venation.

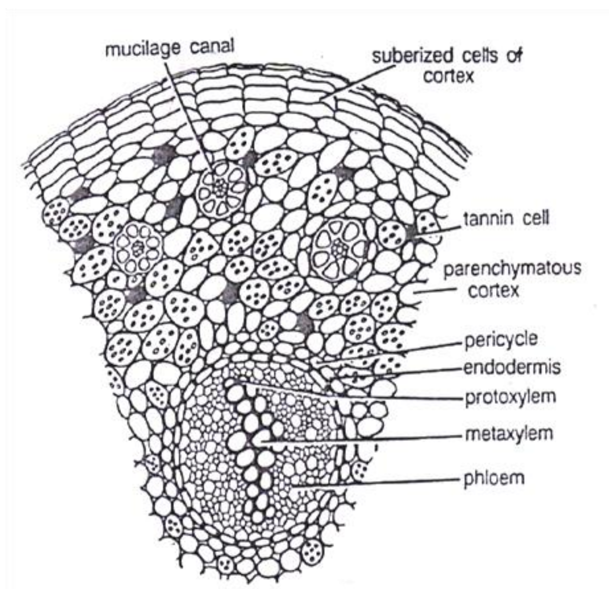


Fig. 5.8 Ginkgo biloba. T.S. young root.

Foliar epidermis also exhibits some distinguishable characters in Ginkgo biloba. The epidermal cells are rectangular over the veins while polygonal in outline in between the veins. The leaves are hypostomatic (i.e. bear stomata only on the lowersurface of the leaf). A few stomata on the upper surfaceof the leaves on long shoot also observed, thus makingthem amphistomatic. Stomata remain surrounded by 4-6 subsidiary cells with finger like outgrowths over arching the guard cells.

Anatomy

Root: In transverse section the roots are somewhat circular in outline. Mature roots are surrounded by phellogen or suberized cells of cortex. A large portion of the young root is occupied by multilayered, thin walled cortex which contains several tannins- filled cells and calcium oxalate crystals. Mucilage canals are also prominently visible in young roots, a layer of endodermis and unilayered pericycle are clear. Mature roots, however, lack such a distinction. Diarch condition is clearly visible in the young roots. Xylem is exarch. It remains separated by the phloem strands. Sometimes the roots also show triarch condition. **Stem**: The young stem (long shoot) is more or less cicularin outline and remains surrounded a single-layered, thickly cuticularized epidermis made of brick shaped cells. Epidermisis replaced by periderm in the older stems.

Inner to the epidermal layer is present a well-marked region of parenchymatous cortex. It contains mucilaginous canals, sphaeraphides and many tannin-filled cells. Cortex is comparatively less extensive in long shoots than dwarf shoots. Endodermis and pericycle are not well marked in long shoot. Several conjoint, collateral, open and endarch vascular bundles are arranged in a ring in very young stem.

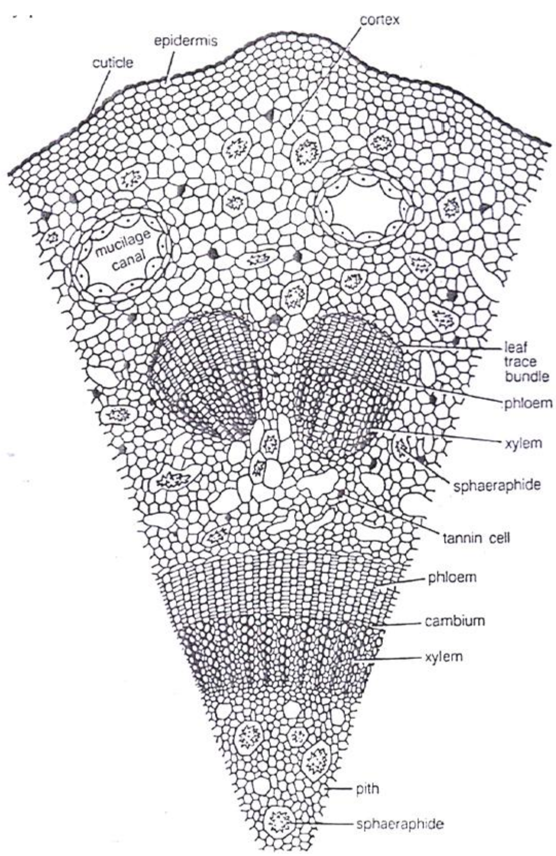


Fig. 5.8 Ginkgo biloba. T.S. young stem (Long Shoot).

Stem Two leaf traces, one for each leaf, are given out. After the secondary growth, the vascular cylinder of the stem becomes an endarch siphonostele with no parenchyma in the wood except that of uniseriate medullary rays. Protoxylem has spiral thickenings while bordered pits are present on the radial walls of the metaxylem tracheids. Sieve tubes and phloem parenchyma constitute the phloem.

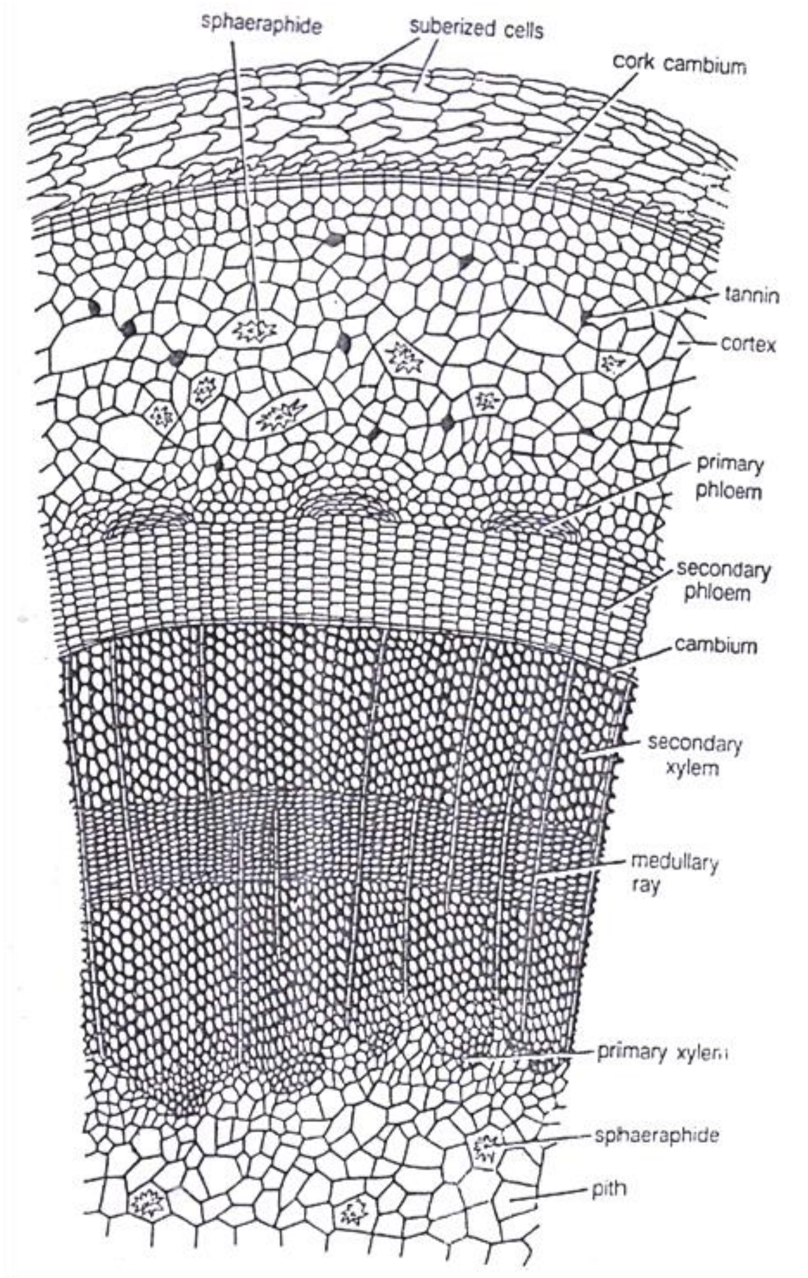


Fig. 5.10 Ginkgo biloba, T.S. old stemshowing secondary tissue.

A narrow pith, containing mucilage canals and sphaeraphides, is present in the centre of long Secondary Growth in Stem: Cork cambium cuts periderm towards outer side and secondary cortex towards inner side. Periderm replaces the epidermis. Mucilage canals are absent. A single ring of cambium remains active throughout and cuts secondary phloem towards outer side and secondary xylem towards inner side. Crushed patches of primary phloem towards outer side and primary xylem towards inner side are present. Secondary phloem consists of sieve tubes and phloem parenchyma. Secondary xylem consists of tracheids. well defined annual rings are also seen. Study of the tangential longitudinal sections of long and dwarf shoots shows that uniseriate medullary rays are 1-3 cells in height in long shoot while 1-15 cells in height in dwarf shoot . One or two rows of bordered pits are present on the radial walls of the tracheids. Pits are circular in outline and have a clear torus. Bars of Sanio are also present. Bars of Sanio do not occur in primary wood. Trabeculae of Sanio, which cross the lumen of the tracheids, are also present.

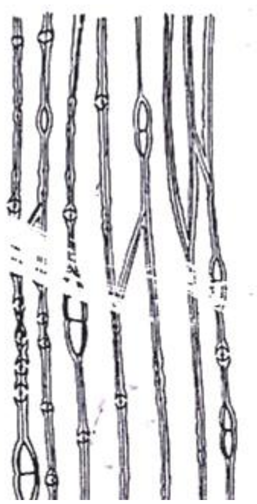


Fig.5.11. Ginkgo biloba. **T.L.S. long shoot showing uniseriate medullary rays of 1-3 cells in height. (modified fromChamberlain, 1935).**

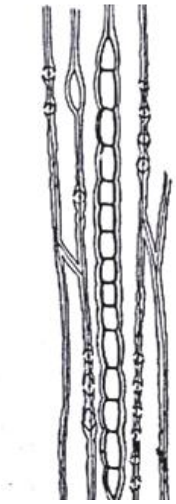


Fig. 5.12. Ginkgo biloba. **T.L.S. dwarf shoot showing uniseriate medullary rays of 1-15 cells in height. (modified from Chamberlain, 1935).**

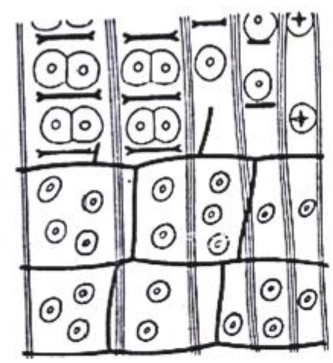


Fig. 5.13. Ginkgo biloba. L.S. mature wood showing pittings and Bars of Sanio.

Leaf: A layer of epidermis is present on upper as well as lower sides of leaf. The epidermis is thickly cuticularised and consists of rectangular to polygonal cells. Haplocheilic type of stomata restricted only to the lower epidermis, are present. Some stomata presenton the upper epidermis of the leaves on long shoots of male plants only. Mesophyll is present in between the two epidermal layers. It is not well-differentiated into palisade and spongy parenchyma.The leaves of long shoot, however, show a distinct palisade region. Many mucilage canals or secretory canals and a few tannin-filled cells are also present in the mesophyll region.

Vascular bundles of the vein have an indistinct mesarch structure. Each vascular bundle may be surrounded by a sclerenchymatous bundle sheath in mature leaves.

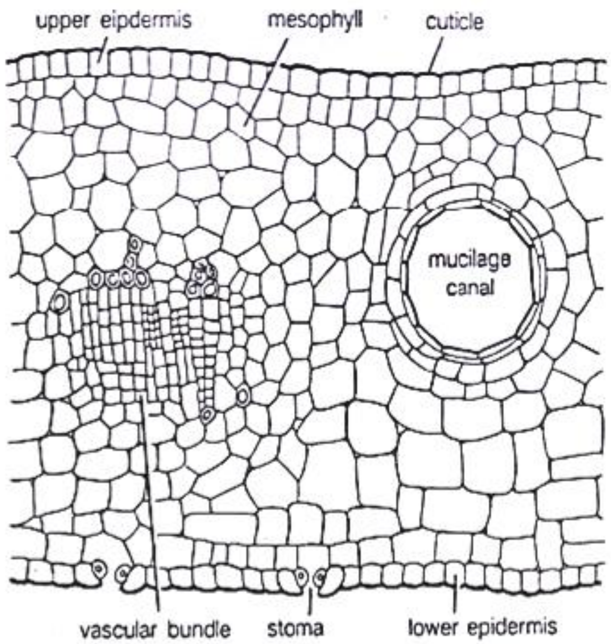


Fig. 5.14. Ginko biloba. T.S. young leaf.

4. Petiole: The petioleremains covered by a layer of thicklycuticularized epidermis, the continuityof which is broken by stomata. Innerto the epidermis is present a few hypodermal layers. Few mucilage canals, tannin filled cells and sphaeraphides are irregularly distributed in the cortex. The petiole is supplied by a pair of endarch vascular bundles. It remains surrounded by a sclerenchymatous bundle sheath. Protoxylem has spiral thickenings. Cambium is clearly visible. Uniseriate rays are present in thexylem. These are continuous withthose of the phloem.

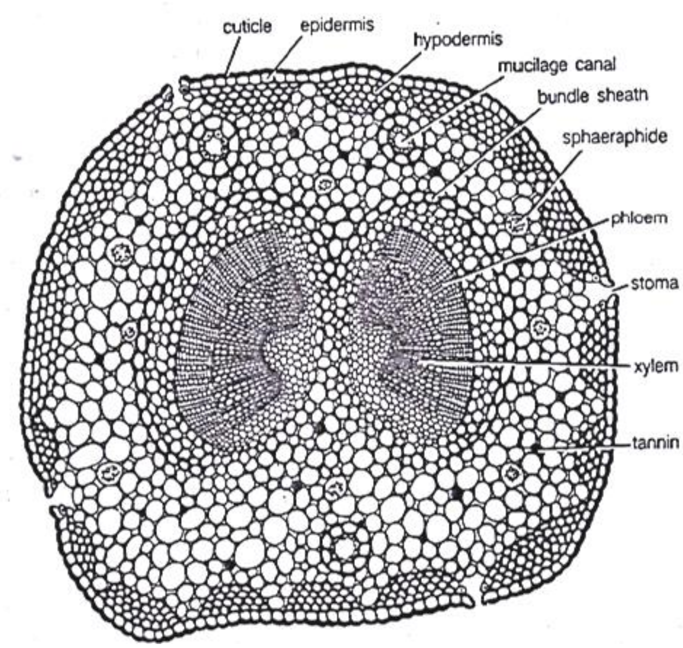


Fig. 5.15. Ginko bioba. T.S. petiole.

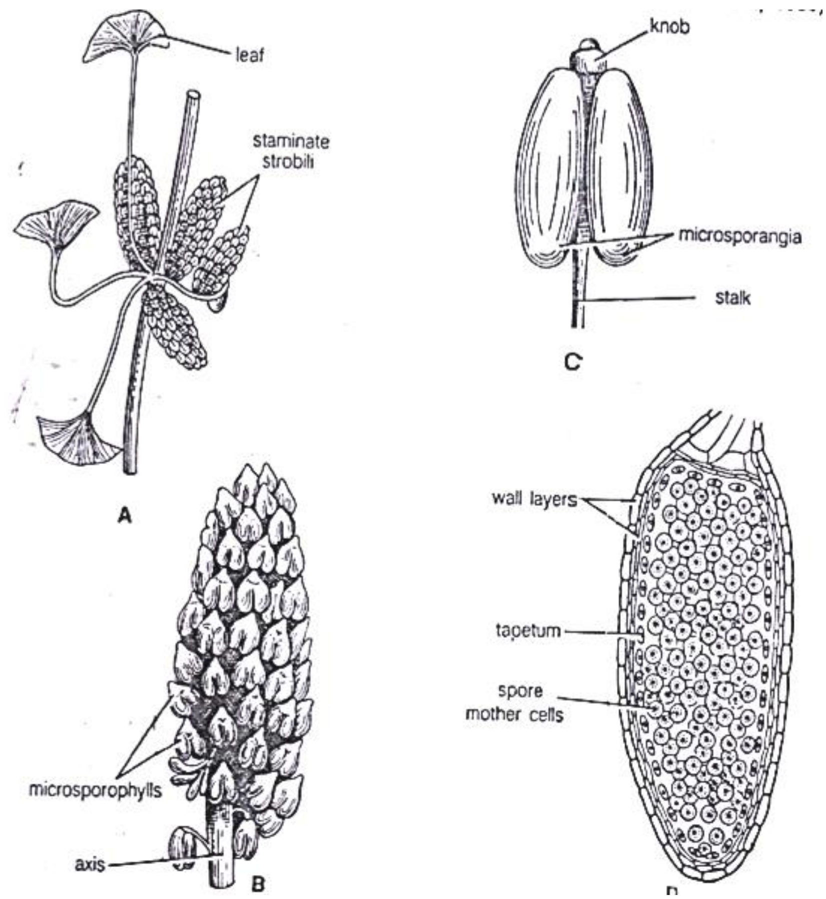


Fig. 5.16. Ginkgo biloba. Male reproductive structures. A, Showing a dwarf shoot with male strobili; B, A single male strobilus; C, A microsporophyll; D, A microsporangium.

Reproductive Structures

Ginkgo biloba is dioecious. Male and female plants are however, difficult to be differentiated when young. Reproductive bodies of Ginkgo are most primitive among living seedplantsexcept some Cycadales.

Male Strobilus*:* Male or microsporangiate fructifications develop in catkin-like clusters on the dwarf shoots of male trees. Each male strobilus contains several microsporophylls arranged loosely on a central axis. Each microsporophyll has a long stalk terminating into a hump or knob. It contains two pendant microsporangia. According to some workers this terminal knob represents an abortive sporangium. A mucilage duct is present in the knob. Rarely more than two sporangia are present in a microsporophyll. Each sporangium is a tubular structure surrounded by many layers. The outermost layer of sporangial tissue differentiates into a tapetum. The sporogenous cells of the sporangium undergo reduction division and form many haploid microspores.

Microsporangium*:* It is of eusporangiate type, i.e. single archesporial cell divides by a periclinal wall forming primary wall cell and primary sporogenouscell. The former develops into wall of microsporangium while the latter develops into sporogenous tissue. Sporangium dehisces by means of a longitudinal slit.

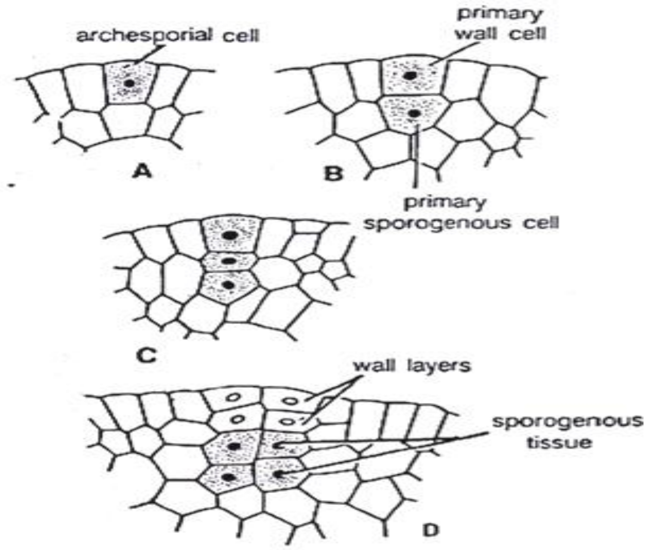


Fig. 5.17. Ginkgo biloba. Development of microsporangium.

Female Strobilus: *The female strobili develop in groups in the axil of leaves or scaly leaves* present on the dwarf shoots. These are much reduced structures, each having a long stalk or peduncle. Itbifurcates apically. Each bifurcation usually bears a single ovule. Out of the two sessile ovules one generally aborts earlier. Rarely, three, four or more ovules on a peduncle are also observed. At the base of each ovule is present a fleshy cup-like structure called ring or collar. The leaves surrounding the ovules do not show their bilobed character

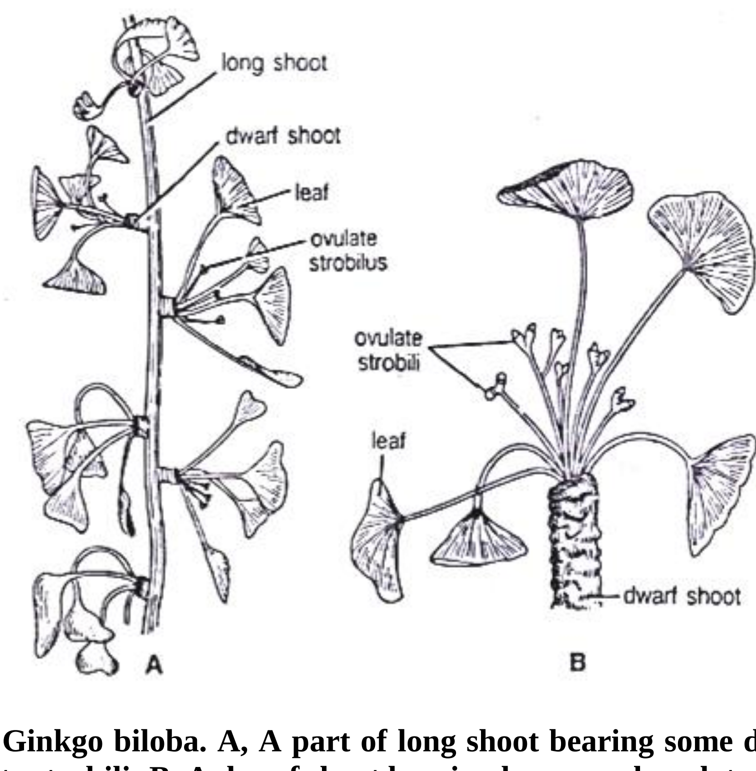


Fig. 5.18. Ginkgo biloba. A, A part of long shoot bearing some dwarf shoots and ovulate strobili; B, A dwarf shoot bearing leaves and ovulate strobili.

The development of ovule, megasporogenesis and structure of the mature ovule is similar to that of Cycas. There is a thick integument consisting of three layers, i.e., outer fleshy, middle stony and inner fleshy layers.

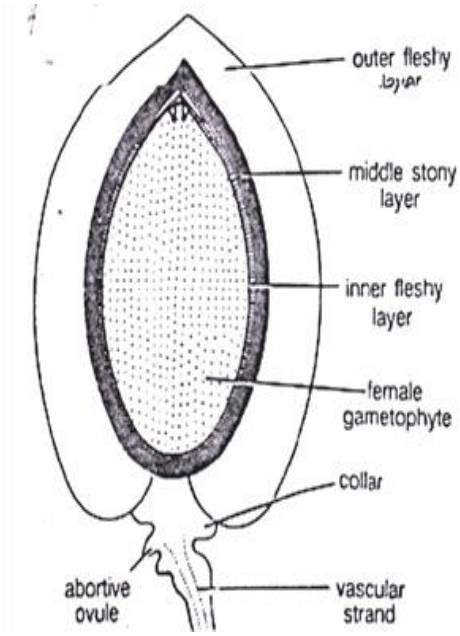


Fig. 5.19. Ginkgo biloba. L.S. of an ovule shortly after pollination.

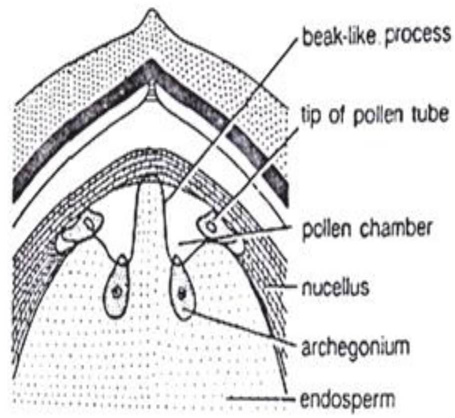


Fig. 5.20. Ginkgo biloba. L.S. micropylar region of the ovule.

A major difference between Ginkgo and Cycas is that the integuments of Ginkgo do not have any noticeable vascular supply. Each ovule has a large and prominent nucellus. Free apex of the nucellus breaks down into a pollen chamber forming the nucellar beak. Deep in the rucellus tissue a functional spore mother cell becomes prominent. The spore mother cell develops into a tetrad, of which only the innermost megaspore remains functional and develops into female gametophyte. The vascular supply of the ovule is well developed. Two vascular strands enter the inner fleshy layer and reach up to the free part of the nucellus without branching, Outer fleshy layer lacks any prominent vascular supply.

Gametophytes

Male Gametophyte : Major aspects of the development of male gametophyte of Ginkgo biloba are similar to that of Pinus. Male gametophyte starts developing in situ, i.e. within the sporangium. Pollen germination starts with a diffuse swelling of tube cell. Tube cell becomes very elaborate with a proximal unbranched tube and a much branched haustorial system.

Microspore is the first cell of the male gametophyte. Each microspore is a rounded structure having thin intine and thick exine layers. A centrally located nucleus contains one or two nucleoli and ramains surrounded by dense cytoplasm. An unthickened portion, called pore, is also present in each microspore. It is a region where exine is not covering the intine.

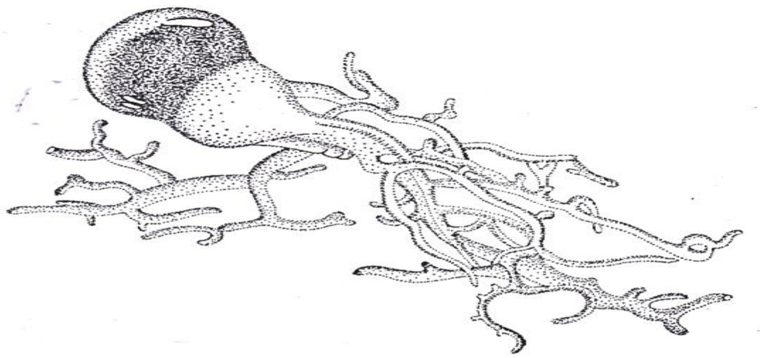


Fig. 5.21. Ginkgo biloba. Stereo computer image showing hyphae-like outgrowth of pollen tube.

Two unequal cells are formed by the first mitotic division in the microspore. These are called 1st prothallial cell and inner cell. The 1st prothallial cell is smaller than that of inner cell. The inner cell again divides forming a 2nd prothallial cell and an antheridial initial By this time the 1st prothallial cell starts to degenerate. The antheridial initial then divides forming a generative cell near the 2nd prothallial cell and a tube cell . The tube cell does not divide any further. This is the 4-celled stage of the male gametophyte and the microspores are dispersed by wind at this stage.

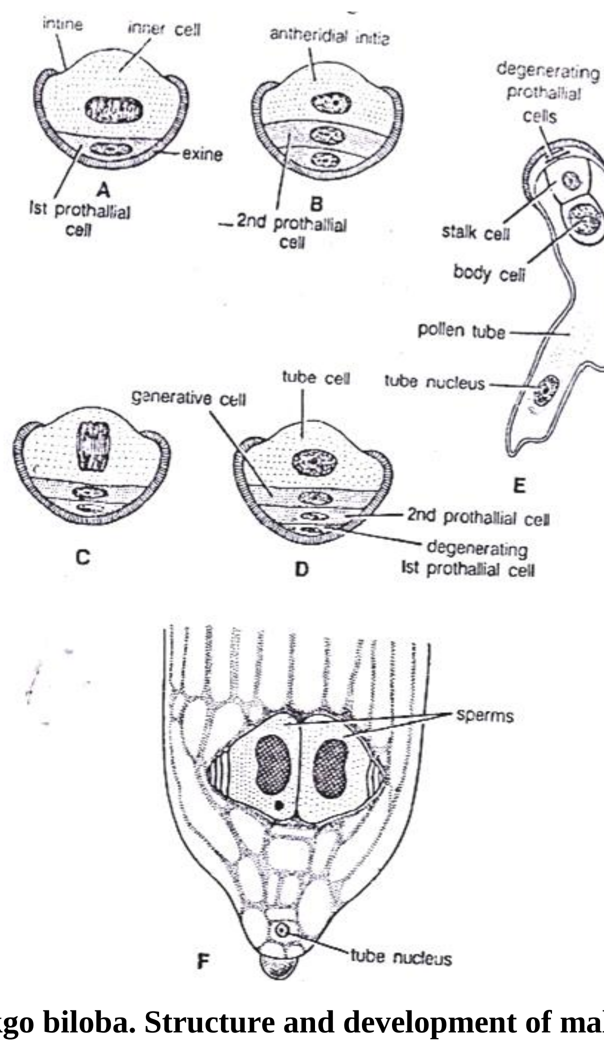


Fig. 5.22 Ginkgo biloba. Structure and development of male gametophyte.

At the time of pollination the ovule secretes a mucilaginous substance. Further development of the male gametophyte takes place in the pollen chamber.In pollen chamber the generative cell of the 4-celled young male gametophyte divides into a stalk cell, which is close to the 2nd prothallial cell, and a body cell. Now the intine protrudes out near the pore and functions as a pollen tube. The pollen tube swells up and advances towards the archegonia by protruding into the nucellus.

Just before fertilization the body cells divides into two, and the wall formation is at right angle to the base of pollen grains. These two cells function as sperms or male gametes .

Female Gametophyte: Out of the four megaspores formed from the megaspore mother cell, only the lowermost remains functional and the remaining three degenerate. The nucleus of the functional megaspore migrates towards the micropylar end and divides into two followed by a number of free nuclear divisions forming hundreds of free nuclei. A large vacuole is present in the megaspore at this stage. Now the wall formation starts and progresses from the periphery towards the centre. During wall formation first the anticlinal walls are formed followed by the vertical walls. Each cell generally contains one nucleus but in some cells 2-3 nuclei are also seen. Due to more rapid cell divisions on the micropylar end a pole like structure develops. This is called tent pole . The female gametophyte possesses abundant chlorophyll .

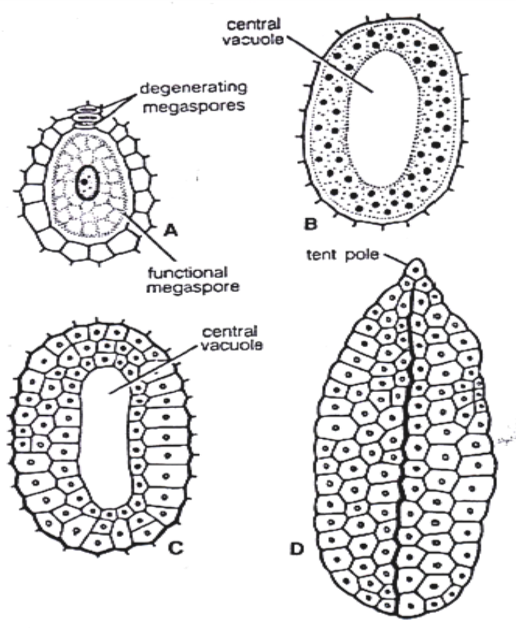


Fig. 5.23. Ginkgo biloba. Development of female gametophyte.

The *development of archegonium* starts from the cells towards the micropylar end of the female gametophyte. Each archegonium possesses a short neck made up of only four cells and a small venter having a central cell. The central cell later on forms a ventralcanal cell and an egg cell. Only two cells are present in thearchegonial neck.

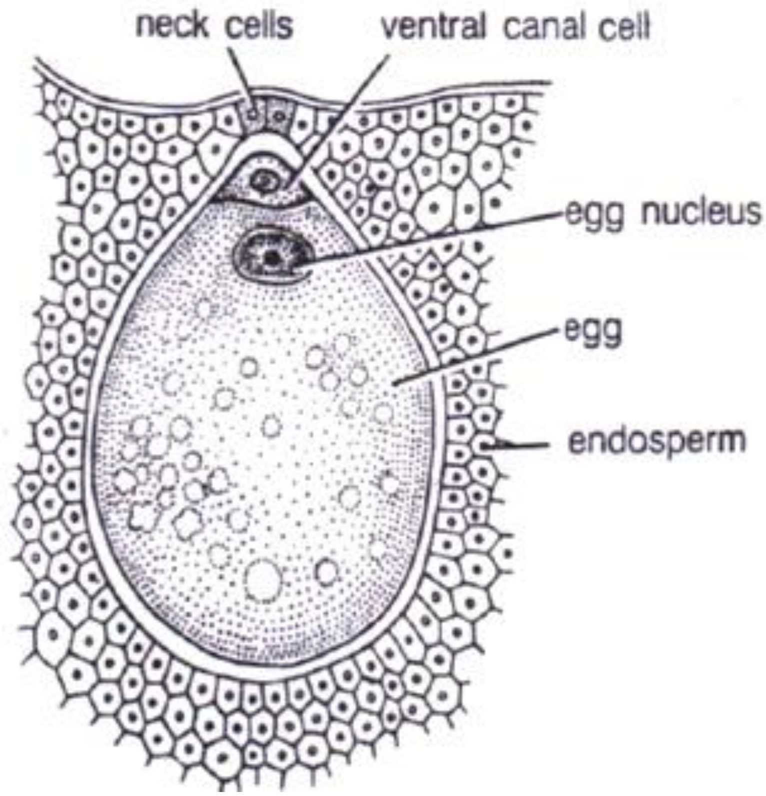


Fig. 5.24. Ginkgo bilobe. A mature differentiation. The tube ruptures releasing the sperms archegonium.

Ultrastructural study of the female gametophyte of Ginkgo biloba has been shows four zones based on food reserves. These are (1) lipid zone (2) starch proteolipid zone with large vacuolate cells (3) starch zone made of large vacuolate cells with peripheral cytoplasm, and (4) deep or central zone with very little reserve contents.

Fertilization: The pollen tube reaches upto the neckof the archegonium just after its (archegonium)and the other contents in the archegonial chamber. A sperm passes through the neck of the archegonium, comes in contact and fuses with the egg nucleus.

SAQ.

Fill in the blanks.

1. Ginkgo is also called.................tree.
2. Ginkgoales have ....and.............shoots.
3. In ginkgo ovules are ....in position.

Embryogeny

The zygote becomes enlarged and starts dividing by many free nuclear divisions just after fertilization. The nuclei are distributed irregularly. The cell wall formation starts just after a few divisions of the nucleus and soon a proembryo is differentiated. Three types of larger chalazal cells chalazallarger of cells are clearly differentiated in the proembryo. The cells towards theend are smaller in size with dense cytoplasm, followed by another zone of comparativelycells, which do not possess such a dense cytoplasm. Elongated cells are present in theuppermost zone. There is no differentiation of suspensor in the embryo. The development of thecotyledon starts from the lowermost zone soon after the differentiation of these zones. Roots, stem and cotyledons are soon differentiated. Generally, five leaves are present in the mature embryo. Out of these five leaves the first two are decussate with cotyledons while the remaining leaves are irregular in arrangement in embryo and seedling. The germinationof the seed is of hypogeal typeand quite similar to that of Cycas. A strong tap root develops soon and the seedling bears many bilobed leaves, which is characteristic of Ginkgo biloba. Soon a mature plant, with many more leaves develops. The majorpart of the growth of embryo takes place when the seed is detached from the tree and is lying on the ground.

Economic Importance of Ginkgo

Ginkgo biloba tree is treated as a sacred plant in China and Japan and worshipped by the people. It is regarded as "Holy Tree" by Buddhist monks and nuns because of its tall, strong andmajestic appearance. It is grown as an ornamental plant in gardens in several countries. In autumn, the greenleaves turn yellow, showing a magnificient autumn scenery. The endosperm of its roasted seeds is edible, but seeds may prove fatal if taken in large quantity. When the outer skin off, its apricot-like seeds is peeled off or decayed. The left kernel is called "White Fruit, Ginkgo is, therefore, also named "White fruit tree". The kernel is also used as food and Chinese medicineas well. If it is taken raw, it functions as detoxicating and asthma-curing medicine. They are highly resistant to pathogenic infections, specially of bacteria and fungi, so their wood isof much commercial importance. It also possesses a strong capacity of resistance to air pollutionby smoke and poisonous gases. Since an unpleasant odour is emited from the ripe seeds of female plants not trees, male trees are largely preferred and grown as shade trees in China, Japan and United States.*Ginkgo*trees grow and develop very slowly. It is said that the tree planted by grandfather willbear "fruit" at the time when his grandson grows up. Therefore, it is also known as "grandfather grandson tree". An extract of leaves of G. biloba is useful in the treatment of cerebral insufficiency and vertigo.

Fossil Members of Ginkgoaceae

Sphenobalera, Ginkgoites, Baiera, Arctobalera, Windwardia and Eretmophyllum are thefossil members of Ginkgoaceae. All fossil members of Ginkgoaceae resembled Ginkgo biloba and were possessed long and and short shoots. The leaves of Windwardia and Arctobatera were strap-shaped with few veins while that of Eremophyllum fan-shaped with several veins. The leaves of Batera and Ginkgoites resembled greatly with that of Ginkgo biloba in shape and also had a distinct petiole. Petiole was absent in the leaves of other fossil Ginkgoaceae genera. Leaves of Sphenobaiera were circular in outline dichotomously branched and resembled Trichopitysheteromorpha of family Trichopityaceae of Ginkgoales. All fossil Ginkgoaceae leaves had strictly dichotomous open venation.

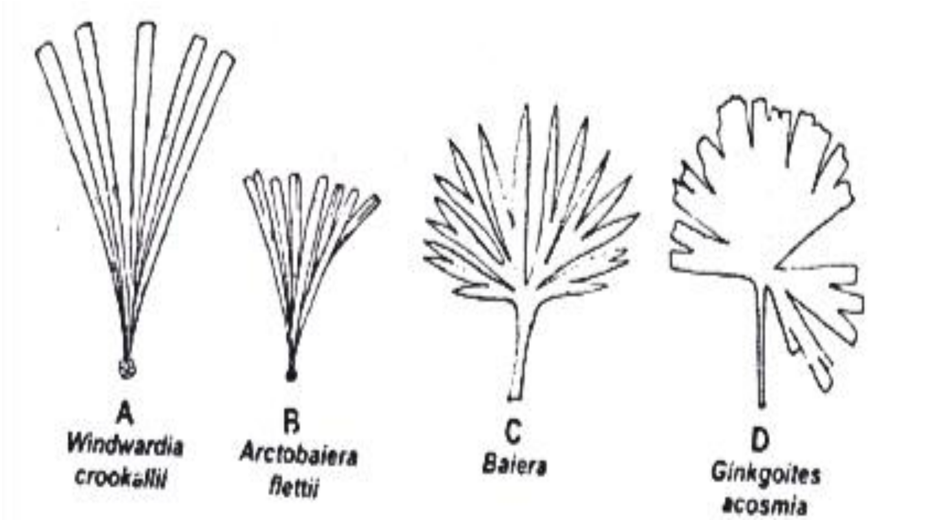


Fig. 5.25 A-D D. Leaves of some fossil Ginkgoaceae. A, Windwardiacrookal B, Arcobalerafletti; C, Baiera D, Ginkgotesacosmia.

5.4 PHYLOGENY OF GINKGOALES

Some of the striking peculiarities of Ginkgo biloba, the only living representative of Ginkgoales,include (i) bilobed, fan-shaped leaves with dichotomous open venation, (ii) ovule bearing a collarat the base, (iii) microsporangiophore bearing a hump-like outgrowth at its apex, (iv) presence oftentpole at the tip of female gametophyte, and (v) absence of suspensor in its embryo.Inspite of these characteristics, Ginkgoales resemble in some or other aspects with Cordaitales, Pteridospermales, Filicales, Cycadales and even Coniferales.

Resemblances with Cordaitales

(i) Presence of double leaf trace, (ii) endospermic beak in the mature ovule, and (iii) the probable motility of the spermatozoids of the members of both Ginkgoales and Cordaitales are some of the resemblances between these two groups.

Resemblances with Pteridospermales

(1) Presence of leaf gap in the stem, (ii) dichotomous open venation in the wedge-shaped leavesof Ginkgo and pinnules of some seed ferns (Pteridospermales), (iii) a distinct pollen chamber.

5.5 SUMMARY

- Gikgoales are tall,well branched trees with short and long shoots.
- Ginko biloba is the only living genus of ginkgoaceae. It is native to China and Japan.

- Leaves are large fan-shaped and venetion is open to dichotomous.
- The plant is diocious.Male organs are axiliary in position and bears micro sporangiophores .
- Ovules are terminal in position and seeds are large in size.
- The root is tap root type and it is penetrates deep into the substatum .
- Inflorescence is catkin type .
- Microsporangia show longitudinal dehisence and ovule is sessile.

5.6 TERMINAL QUESTIONS

Q.1 Ginkgo is a living fossil Why? Describethe distinguishing features and interrelationships of Ginkgoales.

Answer...
....
....
....
....

Q.2 Ginkgo is a living cordaite. Discuss this statement..

Answer...
....
....
....
....

Q.3.Give the general characters and classification of Ginkgoales.

Answer...
....
....
....
....

Q.4. Write short notes on:

A. T.S. ovule of Ginkgo.

B. Morphology of the female strobilus in Ginkgo.

C. Fossil members of Ginkgoales.

5.7. ANSWERS

SAQ.

1. maiden hair
2. short,long
3. terminal

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UNIT-6 CONIFERALES-1

Structure

6.0 INTRODUCTION

Coniferales are the dominant forest makers of the world. They 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 born on ovuliferous scales in the axils of bracts arising from the axis of cone.

Objectives

1. To know the distribution of conifers.
2. To undrstand the evolution of conifers.
3. To learn about the families of conifers.
4. To know about Lebachiaceae,VoltziaceaeandPalissyaceae families.

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 (Pseudotsugadouglasit), 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, terpentinecanada-balsam, etc.

Plant body is sporophytic and the sporophytes are richly branched trees or shrubs. One species Juniperus horizontalis is prostrate. They are generally evergreen and xerophytic but genera such as Larix, Metasequoia and Taxodium are deciduousa massive fleshy layer in the ovules, and collar at the base of the ovules in Ginkgo and cupule in ovules of some Pteridospermales are some of the characteristics showing resemblance between Ginkgoales and Pteridospermales.

6.1 DISTRIBUTION OF CONIFERALES

Coniferales are a large group of cone bearing seed plants. They are distributed in temprate regions and high altitudes of tropics. Their growth habbit varies from tall trees as in sequoia to miniature forms of dacrydium which are only some centimeters.

The living conifers show a wide range of geographical distribution. Some genera are widespread and some are restricted to particular areas. Conifers were differntiated by the jurassic period of the mesozoic era. In India the conifers are distributed in the himalayas and connecting ranges of himanchalpradesh, kashmir, assam and burma. Conifers form predominant flora 16 genera and 53 species are found in india. Northeastindia has highest diversity of gymnosperms. Pines are distributed in the mountaneous areas like bhutan, northindia, nepal, pakistan, sikkim and southern part of tibbat. Conifers are the dominant plants over the northern hemisphere. The narrow conical shape of northern conifers helps them sheds snow.

Pinacae is spread over six indogenous genera distributed in Himalayas. These genera are Abies, picea, larix, cedrus, pinus, and tsuga. A. pindrow grows in western himalayas from Afganistan to Nepal.A. spectabilis occurs in eastern himalayas apart from western and central himalayas. In western himalayas it grows upto 4,250 meters whereas in sikkim and bhutan it is upto 2,700meters. this species is found 2,7750 meters in Darjiling.Deodar grows in western himalayas from Afganistan to garhwal between 1,200-3,300 meters and between 1,800-2,600 injaunsar, kullu, manali, hazara, kashmir, chamba, ranikhet, nainital, mussoorie, and shimla. Deodar occur in abundance at the karnauli valley in Nepal.Pinus is well distributed in India with six species, P. roxburghi, P. insularis, P. wallichiana, P. gerardiana, P. armandii and P. merkusii. P. roxberghi is the most useful of all indian pines and found abundant in valley of western himalayas.

Taxodiaceae is represented by five genera. Metasequoia, taxodium, cryptomeria, and cunninghamia are exotic and taiwania are found in indian neighbourhood. Metasequia was introduced first time at forest reasurch institute dehradun and was then transplant at liyod botanical garden darjeeling.

cupressceae is represented by six genera. These are cupressus, thuja, juniperus, chanaecyparis, callitiris and libocedrus. Cupressus and chamaecyparis are regarded as indigenous. Thuja, callitris, and chamaecyparis are exotics and libocedrus found abundant in India.

Podocarpaceae comprises a single genera podocarpus and four species growing in India. P. neerifolia occurs in eastern himalayas and in assam, sikkim, eastward to khasia, bangladesh, burma and andman island.P. llichiana is found in western ghat at nilgiris southwards in tamilnadu.

Cephalotaxaceae comprises single genus cephalotaxus with two species in India. C.manni grows in eastern himalayas, khasi, jaintia hills and naga hills.

Araucariacea has two exotic genera grown in India. These are agathis and araucaria. Agathis was inroduced at liyod botanical garden, darjeeling and A. robusta was at forest research institute dehradun.

Taxales has only one genera taxus baccata. It grows in eastern and western himalayas, khasi jaintia hills, naga hills and manipur.

Ginkgoales has only one genera ginkgo biloba. It has been introduced and cultivated at dehradun, nainital and darjeeling.

Gnetales has two families gnetaceae and ephedraceae represented by gnetum and ephedra. These are widely distributed in manipur, nefa, golaghat, khasi jaintia and sibsagar. G. ulva is found in western ghat near khandala, kanara and coorge.

6.2 EVOLUTIONARY TRENDS

Conifers are thought to be most close related to the cordaitales. Corditales are the extinct plants of carboniferous. The reproductive structure of corditales are found similar to conifers. The most primitive conifers belong to walchian conifers, which were small trees. The range of conifers increases during early permian due to increasing aridity. Walchian conifers were gradually replaced by advanced Voltzelean. They were called transition conifers. Conifers were dominant land plants of the mesozoic. Modern group of conifers were emerged from voltziales. It happened in late permian through jurassic. Conifers becomes major decline in the late cretaceous corresponding to the explosive adoptive radiation of flowring plants**.**

Resemblances with Filicales

A few points of resemblances between Ginkgoales and ferns include

(1) the similarities between the primary xylem, secondary xylem and periderm of Ginkgo and some ferns (Ophioglossum and Botrychium).

(2) dichotomous open venation in their leaves.

(3) multiflagellated and motile spermatozoids.

(4) presence of ventral canal cell in the archegonia in some of their members.

Resemblances with Cycadales

Some of the resemblances between Ginkgo and Cycadales are -

(1) Presence ofmultiflagellated spermatozoids.

(2) welldeveloped nucellar beak and pollen chamber.

(3) haustorial nature of pollen tube.

(4) presence of large egg, massive female gametophyte and well-developed venter.

(5) endoscopic embryo with two cotyledons.

(6) seed with thick and well developed integument.

(7) hypogeal type of seed germination.

Inspite of these above mentioned similarities, there are several major differences between Ginkgoales and Cycadales which put them quite apart from each other. They differ from each other in the (1) general structure of their male and female reproductive organs, (ii) vascular supply of their ovules, (ii) development of their male gametophytes, (iv) branched (Ginkgoales) and generally unbranched (Cycadales) nature of their stems, (v) simple (Ginkgoales) and compound (Cycadales) nature of their leaves, (vi) presence (Cycadales) or absence (Ginkgoales) of circinate venation in their leaves, etc.

Resemblances with Coniferales

Ginkgo has several characteristics in common with many members of Coniferales. Florin opined that all Ginkgoales, Coniferales, Cordaitales and Taxales belong to the same natural group named as Coniferopsida All these four orders of Coniferopsida constitute parallel lines of evolution and separated from each other in the Upper Devonian or Carboniferous times according to Florin. Some major characteristics common to both Ginkgoales and Coniferales are listed below:

1- General appearance of tree is cone like, branched stem with two types of branches, ie long shoots and dwarf shoots.

2- They are found from Carboniferous to the present times

3- Their growth habit varies from extremely tall trees as in Sequoia (Taxodiaceae)and 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 ontheir 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. foilage leaves and scaly leaves. They are generally arrangedspirally and only in opposite or whorled manner. Foliage leaves are filiform, needle-like and called needles.

10- Plants are either monoecious or dioecious.

11- Reproductive organs are unisexual cones.

12- The sporophylls are generally arranged in the form of cones.

13- The microstrobili or male cones are simple and cotain many scales like microsporophylls.

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

15- The male gametes are non-motile.

16- The female cone or megastrobili consist of many sterile bract scales and fertile ovuliferousscales.

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 showthe phenomenon of polyembryony.

21- Seeds are endospermic and winged with hard testa.

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

SAQ.

Q.1. Conifers wood are ....[pycnoxylic, manoxylic]

Q.2. Reproductive organs in conifers are ....[unisexual,bisexual]

Sporne (1965) has divided the fossil conifers into three families; [1]Lebachiaceae, [2]Voltziaceae and [3]Palissyaceae)

1. Lebachiaceae: *Family of extinct genera including Lebachia, Ernestiodendron, Walchia, Walchiostrobus, Carpentiera and Buriadia.*

2. Voltziaceae: *Family of extinct genera including Pseudovoltzia, Voltziopsis and* Ullmannia.

3. Palissyaceae: An extinct family including Palissya and Stachyotaxus.

6.3. LEBACHIACEAE

General characteristics

Members of this fossil family 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

Ernestiodendron and Walchia was very regular, quite characteristic and resembled with that of the present-day Araucaria. The main branchesin these three genera were arranged in whorls of 5 or 6 on the trunk. The leaves were scale like. In L. piniformis the megasporangiate strobilus is 6 to 7 cm long. It consists of central axis with several spirally arranged and closely imbricated bracts with bifid tips. Each bract bears a dwarf shoot in its axil. This shoot consists of short axis with spirally arranged scales and a short stalk bearing a terminal ovule. Inlebachia the megasporangiate strobilus is compact and bears spirally arranged appendages.

They were spirally arranged 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 modem conifers. In Carpentieria, 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.

Lebachia, Ernestiodendron and Walchia were monoecious, i.e. both male and female cones developed on one and the same plant. In Lebachiapiniformis the male and female cones were present singly at the tips of the ultimate branches. In some other species, however, the female cones were borne only 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 microsporophylls were spirally arranged. Each microsporophyll had an unforked apex and two microsporangia. 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 dorsiventrally in Walchia, and mostly on the abaxial side in Lebachia. In L. elongatus 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 Ernestiodendronfiliciforme. The sterile appendages were absent in this species. Several sterile and fertile appendages were present in Walchiostrobus. In some of its species reflexed ovules were present. The integument was bilateral in its symmetry.ie. 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.

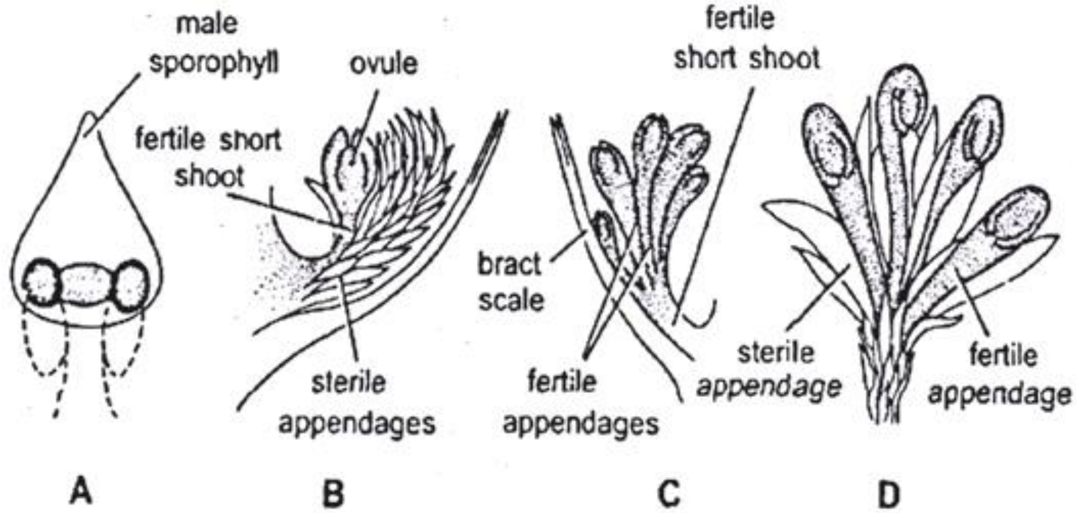

Fig. 6.2. A, A male sporophyll of Lebachiahypnoides: B, Fertile short shoot and bract scale of Lebachia elongatus: C, Bract scale and fertile short shoot in Ernestiodendronfciforme; D, Fertile short shoot of Walchiostrobus

6.4. VOLTZIACEAE

General Characteristics

1. Voltziaceae is a family of fossil conifers represented by three genera, viz. Voltziopsis, Pseudovolizia and Ullmannia.

2. These members were present luxuriently 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 Pseudovoltzialiebiana had three fertile appendages and five sterile appendages if observed from the adaxial side. Each fertile appendage had a single reflexed ovule.

6. In Ullmanniabronnii, the fertile dwarf shoot had only one fertile appendage (having a single reflexed ovule) and only one spathulate sterile appendage. Spome (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 Pseudovolizia".

7. In Voltziopsisafricana the ovules were exect and the fertile dwarf shoot had five sterile and five fertile appendages.

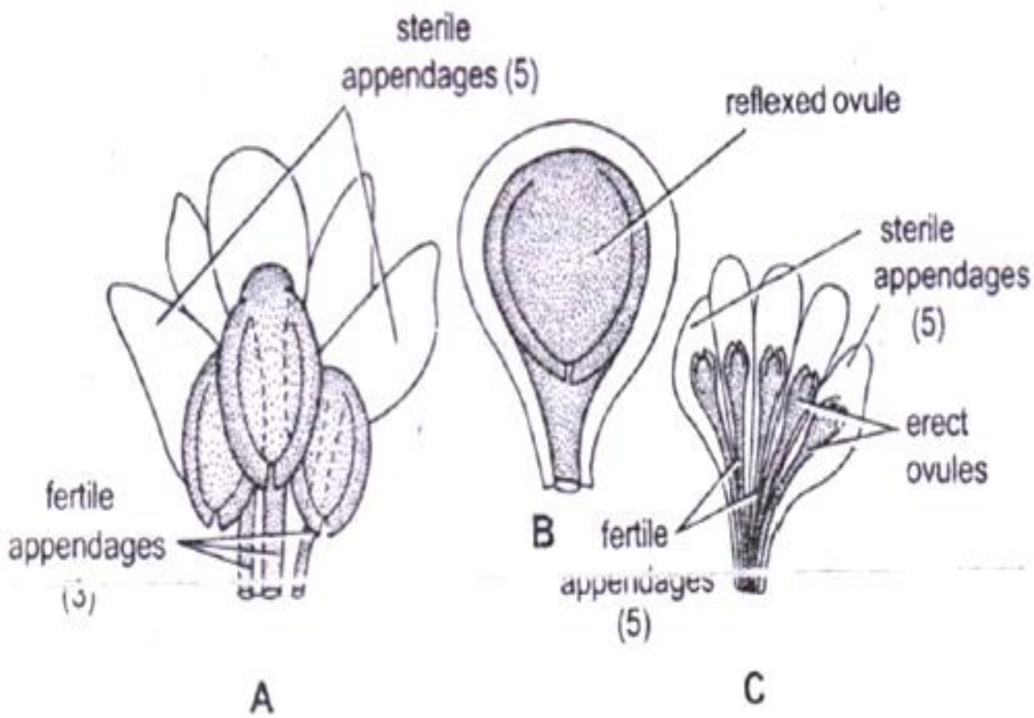

Fig. 6.3. A, Fertile dwarf shoot of Pseudovozialebiana as seen from the adaxial side; B, Fertile dwarf shoot of Ulmanniabronni; C, Fertile dwarf shoot of Voltziopsisafricana.

6.5. PALISSYACEAE

General Characteristics

1. This is also a family of extinct Coniferales represented by two Mesozoic genera, viz. Palissyaand Stachyotarus.

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 Mesozoicera 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 sterileportion.

4. Palissyasphenolepis 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), Stachyoiatus of this family resembles closely with theCephalotaxus of family Cephalotaxaceae of modem

Coniferales, particularly in the arrangement of ovules on the fertile dwarf shoot.

6.6. SUMMARY

1. Conifers are woody perennials. They show two types of branches ,long shoots and dwarf shoots.
2. Leaves are dimorphic having scales and needle like leaves.
3. The roots are tap root type associated with mycorhiza.
4. The wood is pycnoxylic and xylem fibres and xylem parrenchyma are found absent,
5. Reproductive organs are male and female cones.
6. wind pollination is found.
7. Embryo may be di or polycotyledonous.
8. Lebachiaceae, voltziaceae, and palissyaceae families are extinct families.

6.7 TERMINAL QUESTIONS

Q1. Give an account of distribution of coniferales in india.

Answer..
....
....
....
....

Q.2 Briefly discuss the affinities of coniferales.

Answer..
....
....
....
....

Q.3 Write short notes on

a. fossil conifers

b. lebachiaceae

c. voltziaceae

Q.4 Give a brief account of the fossil conifers.

Answer..
....
....

....
....

Q.5 Classify the order coniferales and name at least one member of each family.

Answer...
....
....
....

6.8 ANSWERS

SAQ.

1. Picnoxylic
2. Unisexual

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UNIT-7 CONIFERALES 2

Structure

7.0 INTRODUCTION

The living conifers include 52 genera and 570 species. They are distributed mainly in temperate regions. They are tall, dignified and graceful trees with foliage. Their branches presenting a magnificent cone-like appearance. All are woody perennials. They range in size from the tallest trees of californian Sequoia sempervirens and Sequoia gigantea that reach a height of 100 metres. Some species of Juniperus grows completely prostrate. Abies pindrow and A. spectabilis grow in India at 8,000 to 14,000 ft above sea level. Majority of the species of Pinus grow upto 120 ft tall and vary in diameter from 2-5 it. Cedrus deodara grows in India upto 12,000 feet above sea level and reaches a height of 175 ft it and a diameter of 6 ft.Tsuga canadensis, Phyllocladusmachomanoides, Cupressus, Juniperus, and Taxus grow from 40-80 feet tall and vary in diameter from one to three feet. Pinus roxburghii forms extensive forests along steep slopes in the western Himalayas at 1.500 meters to 2,000 meters and grows in height from 23-35 meters. P.insularis forms forests in the Khasi hills, Naga hills and in Manipur at 800 to 1,600 meters and grows upto a height of 25 meters. Pinus wallichiana grows both in Western and Eastern Himalayas . It grows as tall as other species of Pinus in India. Podocarpus neriifolnis and Cupressus funiberis also grow in the central Himalayas at an altitudinal range of 800-950 meters above sea level. They are medium sized trees. Cryptomeria japonica is a small japanese tree that forms pure stands in Khasi and Jaintia hill in Eastern Himalayas. Cephalotaxusgriffithii, & Biota orientalis also grow in Eastern Himalayas. They are small trees .

Objectives

1. To learn about the some general characters of coniferales.

2. To understand the morphology and anatomy of family Pinaceae, Araucariaceae, Taxodiaceae.
3. To know about the reproductive structure of Pinaceae.
4. To know about the reproduction in Araucariaceae and Taxodiaceae.
5. To understand the embryogeny in Pinaceae, Araucariaceae and Toxidiaceae.

7.1 GENERAL CHARACTERS

The living conifers are believed to have been differentiated by the Jurassic period of the Mesozoic era. The Pinaceae and the Araucariaceae are believed to be slightly older. The Cephalotaxaceae and the Cupressaceae probably came into existence in the Upper Jurassic or the Lower Cretaceous periods. Metasequoia is the oldest extant conifer. This family came into existence in the upper Cretaceous of the Mesozoic. Family Voltziaceae originated in the Upper Permian period of Palaeozoic era. The distribution of the modern conifers clearly suggests their being an ancient group. The earliest conifers are included in the family Lebachiaceae that originated in the Early Permian and were in existence before the Coredaitales became extinct. The conifers reached their climax in the mid Mesozoic times.

The leaves in the conifers vary from scale leaves to linear to broad types and show xerophytic characteristics. The conifers are branching woody plants that have two types of branches: (1) the dwarf shoots, and (2) long shoots. Similarly there are two types of leaves: (1) scale leaves; and (2) green foliage leaves. The root system is branched tap root system infected with mycorrhizic fungus. The mycorrhiza may be ectotrophic or endotrophic. The roots in Podocarpaceae possess root nodules. Pneumatophores have been reported in Taxodium distichum.

The secondary wood is pycnoxylic with uniseriate or biseriate secondary medullary rays. Resin canals are found in the cortex, pith and even in the xylem of leaves, stems and roots. The leaves may be spirally arranged, opposite or whorled. The reproductive organs are unisexual and form compact cones or strobili. The female cones are compound structures with a central axis bearing spirally arranged bract scales. The ovuliferous scale bears many or two ovules. The male cones are compact, simple structures with a central axis having spirally arranged microsporophylls. Each microsporophyll bears many or two microsporangia containing winged or wingless pollen grains. The spermatozoids are non motile. The embryo has two to many cotyledons. Polyembryony is commonly found. The seeds are endospermic.

7.2 FAMILY: PINACEAE

The family Pinaceae (Abietaceae) with 9 genera and 145 species is the predominant conifer of temprate to colder zones. The bracts and the ovuliferous scales are distinct in the female shoot.

The family has been classified into three sub families as follows:

1. Sub family: Abietoideae ,genus;Abies
2. Sub-family: Laricoideae; genus.Larix
3. Sub-family: Pinoideae; genus.Pinus

Morphology

Pinus is beautiful tree having pyramidal appearance. The main stem is erect, woody, and covered with scaly bark which peels off. The branches are of two types, long shoots and dwarf shoots. Each long shoot arises as lateral bud in the axil of scale leaf. The long shoots,when fall off, leaves a scar on the stem.The dwarf shoots are born on long shoots and arise in the scale leaves. Dwarf shoot bears two opposite leaves called sprophylls. The leaves on dwarf shoots are of two types, needle like foliage leave and scaly leaves.

Two types of root system is found,long root and dwarf root. Long root forms the main root system. The primary leaves appears soon after germination and functions as foliage leaves. The secondary leaves are needle like and born on short shoots. The main tree is monoecious.Male and female cones are on separate branches. Each male cone consist of central axis on which the microsporophylls are spirally arranged. The female cone borns in pairs and consist of central axis having magasporophylls. The bract and ovuliferous scales together form a seed scale complex. The ovules are inverted with the micropyle facing the axis of the cone.

Anatomy

In root anatomy the outer layer is epidermis followed by starch filled cortex. The endodermis is single layered with casparianstrip. It is followed by 5 or 7 layered pericycle. Pitted thickening is found. The pith cells are rich in starch.Secondary growth is found. T.s of stem shows ridges and furrows. Epidermis is found above the parenchymatous cortex. Vascular tissue are arranged in ring. Resin duct with thin walled ,unpitted, unlignified epithelial cells are found. The cambium produces secondary xylem inside and secondary phloem towards outside. The secondary xylem consist of tracheid with bordered pits. The cork cambium differentiate in first or second layer of cortex. It cuts cork on the outer side and secondary cortex towards inner side. Anatomically, the dwarf shoot resembles the long shoot. The collateral and open vascular bundles are separated by parenchymatous madullaryrays. The pith and cortex are parenchymatous.

In t.s of leaf or needle the outer epidermis layer can seen. Below the epidermis mesophyll cells are found. The epidermis is formed of single layer of isodermal lignified cells covered by cutin. The mesophyll is chlorenchymatousinterupted with resin ducts. Single layered hypodermis is found. The endodermis is single continuous layer of barrel shaped cells, chloroplast is not found in endodermis. The endodermal cells are devoid of casparianstrips. The pericycle is parenchymatous ineterspesed with transfusion tracheids. The vascular bundles consist of protoxylem and metaxylem. A cambium is present in the vascular bundles. It cutts secondary phloem but no sacondaryxylem. The stomata are sunken. The walls of subsidary cells and guard cells are lignified.

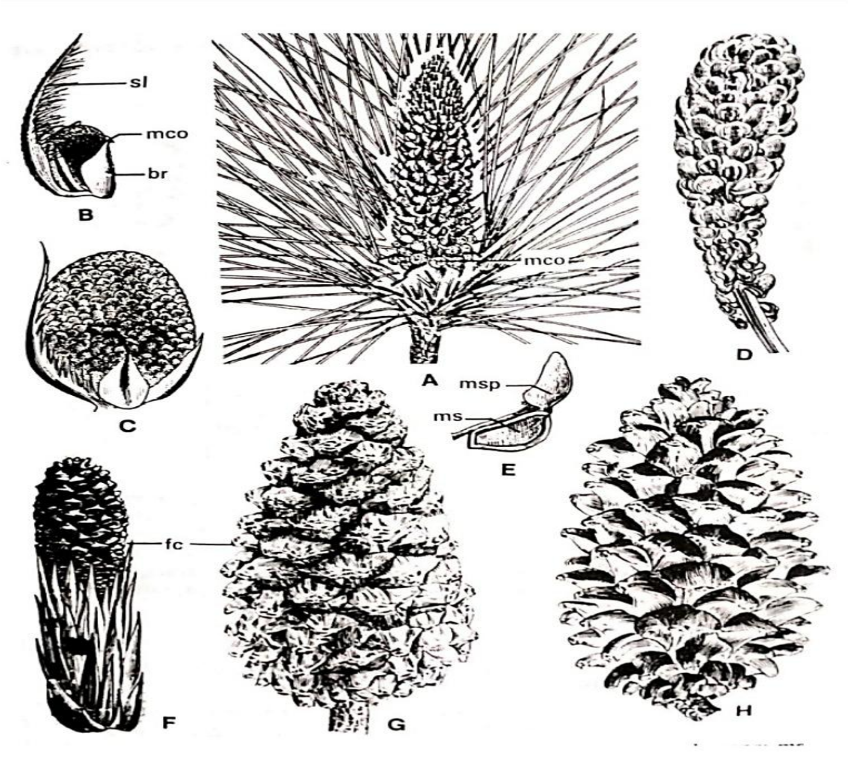

Fig.7.1A.Cluster of male cone, B-D.development of male cone ,

F-H.development of female cone.

REPRODUCTIVE STRUCTURES

Female Cones

These are composed of a number of spirally arranged bracts. The ovuliferous scales bear two ovules each, on their adaxial or upper sides. The bract scales in Larix and Pseudotsuga are trifurcate at their apices. The bract scale develops first. The ovuliferous scale or the cone scale arises later in its axil. The bract scales may be free or fused to varying degrees with the ovuliferous scales. The ovules are sessile and inverted with their micropyles directed towards the cone axis.

Megasporangium and Megasporogenesis

The ovule has a single integument (unitegmic) that has the usual three layers (outer fleshy, inner fleshy, and middle stony). The integument is two lipped at the micropyle and is fused to the nucellus for a part of its length except most of the upper portion. The nucellus is thick and well developed (carassinucellate). The nucellus is also called the megasporangium. In Larix decidua the micropyle develops into a stigma like outgrowth that catches the pollen grains.

In Pinaceae (Pinus wallichiana, Cedrus deodara, etc.) a deep seated cell in the nucellus tissue differentiates as a megaspore mother cell. In P. roxburghii a hypodermal archesporial cell differentiates and divides into an outer primary parietal cell and an inner sporogenous cell. The sporogenous cell functions as the megaspore mother cell. It undergoes reduction division to form three or four haploid megaspores. In Pinus roxburghii the mother cell forms a linear tetrad of haploid megaspores. The one towards the chalazal end is functional, whereas the upper three degenerates.

Female Gametophyte

The functional megaspore enlarges and without undergoing any resting period its nucleus divides and forms 512 free nuclei. In Cedrusdeodara the megaspore undergoes a resting period of 4 months before starting free nuclear division. In Pinus roxburghii and P. wallichiana the megaspore nucleus divides into a few free nuclei and then undergoes a resting period. The number of free nuclei in P. roxburghii is 2,500. The functional megaspore in Keteleeriaevelyniana has been observed to possess a two layered membrane. It grows along with the megaspore. During free nuclear stage the megaspore is surrounded by a distinct spongy tissue. It disappears after the female gametophyte has completely developed. After the free nuclear division wall formation starts. It is centripetal.

The archegonia develop from the superficial cell of the female gametophyte at the micropylar end. Their number varies in the different genera. At maturity. The neighbouring gametophyhtic tissue grows upwards to form a sunken area called the archegonial chamber. The archegonium consists of a short neck and a large venter. The neck is composed of varying number of neck cells but does not enclose a neck canal. The venter has a small ventral canal cell. It may degenerate before fertilization or may persist for some time after fertilization.

At maturity cytoplasm of the egg develops. A number of proteid vacuoles or para-nuclei also appear in cytoplasm of the egg and they have been observed to increase in size along with the increase in size of the egg. They have a nutritive role to play and start dwindling in size and number as the zygote starts dividing. They disappear completely when the suspensor starts elongating. The female cones take the place of long shoots and take two years to complete their development.

Microsporangium and Microsporogenesis

The microsporangiate cones bear a spiral sequence of microsporophylls. Each with a variably developed sterile distal flap and a pair of elongate microsporangia that usually dehisce by a longitudinal split. Rarely oblique and transverse dehiscence has also been observed. The male cones take the place of short shoots and are aggregated together in Pinus.

The mature sporangium has a wall made up of two to six layers of cells. Tapetum is present. In Pinus roxburghii it originates from the innermost wall layer and becomes binucleate at maturity. The tapetum and all the wall layers, except the outer layer or the epidermis, degenerate during meiosis and maturation of the microspores. The epidermal cells undergo significant changes and develop tanniferous contents. Their walls develop bands of thickenings and thick cuticle develops on the outer tangential walls.

The microspores in Pinaceae possess two wings. The young microspore has a three layered exine (outer ectine, middle mesine and inner entine) and an intine whose outer layer is well developed whereas the inner layer does not develop in young grains but in mature grains, it is recognisable as a pectocellulosic layer.

The microspores are uniaperturate. The pollen grains start germinating within the microsporangium and are shed either at 4-celled stage or 5-celled stage .

Male Gametophyte

Before pollination the nucleus of the microspore divides twice by periclinal walls and cuts off two prothallial cells and an antheridial cell. Its latter divides by a perichial wall to form a small generative cell and a large tube cell. In Pinus and Pseudotsuga the semigerminated pollen grains are released from the microsporangium and further germination takes place on the nucellus. In Abies, Cedrus, Picea, Larix, Pseudolarix and Keteleeriaevelyniana the generative cell divides periclinally to form a stalk cell and a body cell. Pollen is released in a five celled stage.

Pollination

It is anemophilous. The nucellus secrets a pollination drop which contains sucrose, glucose and fructose. In pinus the winged pollen orientates itself in the pollination drop in such a manner that its germinal furrow is in contact with the nucellus. The pollination drop dries and the semigerminated pollen is retracted back to the nucellar region or the lateral sides of the micropyle tube. The nucellus grows and comes in contact with pollen grains. Thesemigerminated microspores rest on the nucellus before starting to germinate again. The period of dormancy is variable. It is 9 months in Cedrus, 3 months in Keteleeriaevelyniana, 3 weeks in Pseudotsuga and a few days in Picea. In pinus it is one year. After pollination the generative cell divides periclinally into the stalk cell and the body cell. The pollen tube also appears by the growth of intine through the germ furrow. The tube nucleus migrates into the pollen tube. Soon after pollination and later the stalk cell and the body cell also migrate into the tube. About a week before fertilization the body cell divides into two non motile male gametes. The male gametes are unequal in size. At this stage the pollen tube contains two male gametes, tube nucleus and stalk nucleus. The last two start degenerating. A single pollen tube fertilizes only one archegonium in Pinus.

Fertilization

The pollen tube reaches the archeogonial neck and penetrates through it by crushing its cells and releases all its contents into the venter of the archegonium. The pollen tube grows down to the egg and then bursts, and releases the male gametes. After that the following steps can be seen.

- The appearance of a receptive vacuole.
- The migration of functional male nucleus towards the egg cytoplasm.
- The male nucleus approaches the receptive vacuole and sinks into it.
- The fusion of the male and the female nuclei.
- The dissolution of the double membranes separating the paired male and female nuclei.
- The chromatin material in each nucleus condenses and ultimately distinguished into short and thick chromosomes.

- The establishment of a diploid nuclear condition of the zygote.

Embryogeny

The zygote enlarges and its diploid nucleus divides twice to form four free nuclei. These nuclei migrate to the chalazal end of the archegonium. In Pinus the four nuclei divide again and arrange themselves in two tiers of four nuclei each. The lower one is enclosed by walls all around whereas the upper one is free from walls at their distal end. These two tiers divide to form four tiers of four cells each. The cells of the suspensor tier elongate considerably and push the terminal embryonal cells deep into the endosperm tissue. The primary and secondary suspensor cells elongate considerably and ultimately split apart longitudinally into 4 parts each carrying an embryonal cell at its tip.

Of all the embryos differentiated by various types of polyembryony only one reaches maturity. After seed formation the female cones turn brown in colour and become woody. The seeds develop wings that are formed from the adaxial surface of the ovuliferous scale. The wing is not a part of the seed. The cones may persist after the seeds have been shed or may fall down.

SAQ.

Fill in the blanks

1. The pollengrain of pinus is................[Winged, Nonwinged].
2. Chilgoja is the seed of ....[Pinus gerardiana, Pinusroxburghii].

7.3 FAMILY: ARUCARIACEAE

General characters

The family is represented now by two genera, Araucaria with 16 species and Agathis with 20 specie. The arucaria is dioecious whereas the agathis is monoecious. The leaves may be linear or broad and are spirally arranged. All species are evergreen and do not show shoot dimorphism. The bract scale and ovuliferous scale are intimately fused in Agathis. In Araucaria the tip of the ovuliferous scale is free which forms the ligule. The ovules have only one archegonium. The integument of the ovule is free from the nucellus right up to its base. The ovules are orthrotropus and crassinucellate.

Morphology

The tree of this family is about 40m tall, evergreen, having columnar trunk with horizontal branches. The buds are distinct, and covered with opposite foliaceous scales. The young shoots are green and bear soft, yellowish green leaves. The leaves are spirally arranged. Leaves are long, petiolate, thick, broad and having parallel venation.

In araucaria the branches cover the young plant from base to tip and in older trees the lower portion of the stem is devoid of them. The plants may be monoecious [agathis] or dioecious [araucaceae]. The young cones are covered with scales. Microsporophylls are spirally arranged on the cone axis. The female cones are large stalked, and solitary occur on the upper branches of the tree.

Fig.7.2 Araucaria

Anatomy

In root the epidermis is followed by multilayered parenchytamouscortex. Endodermis is single layered found above the pericycle. Pericycle is 5 to 7 layered. Resin ducts are found in pericycle. The root is diarch with small parenchymatous pith. Secondary growth is found. Secondary xylem tracheids has pits on their radial walls and parenchyma cells are tanniferous and solitary. The secondary phloem consists of phloem fibres, sieve cells and parenchyma. The phloem rays are found continuous with the xylem ray.

In a transversed section of a young stem of agathis there is thick cuticularized epidermis is found. Below epidermis parenchymatous, multilayered cotex occurs which are filled with tannin. There are two rings of resin ducts, one below the epidermis and other associated with vascular bundles. The vascular rays are homogeneous. Inaraucariaceae the secondary xylem consists of tracheid and few solitary parenchyma cells. There is no resin canals in the wood. Secondary phloem consist of sieve cells, parenchyma, tannin filled cells. The young stem of araucaria shows isodermal, taninferous and cutilarised epidermis with sunken stomata. The spongy tissue consist of large, parenchymatous cells with intercellular spaces.

The leaf of agathis is dorsiventral. The upper epidermis is consist of cuticularised and rectangular cells. Tanninferous cells are found in epidermal layer. The hypodermis has stone cells. Stomata are found on both surface.

Vascular bundle and resin ducts are found in alternate. Each vb is surrounded by bundle sheeth. The xylem consist of tracheids and phloem consist of sieve cells.

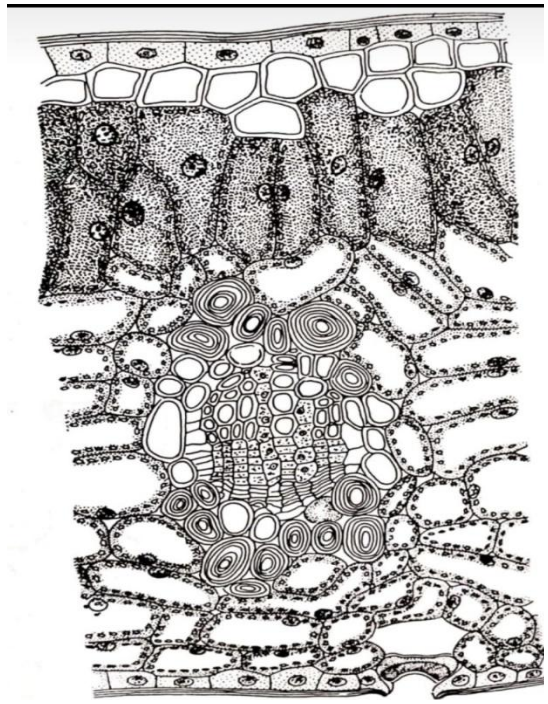

Fig 7.3 V.S of leaf Agathis robusta

Repruductive structures

Male gametophyte and microsprogenesis

The male cones are about 30 cm in length and consist of a central axis. Each microsporophyll bears microsporangia on their abaxial surface. The pollen grains are wingless. There is no pollination drop mechanism. Pollen grains fall on the ovuliferous scale. They send out pollen tubes that grow towards the micropyle.

The Araucariaceae are unique in producing manyprothallial cells. At first the microspore nucleus divides periclinally into two prothallialcells, further to produce many prothallial cells. The antheridial cell divides into a tube cell and generative cell. The latter divides into a stalk cell and a body cell. The cell walls of the prothallial cells, tube cell and stalk cell break down and release their nuclei into the pollen tube. The body cell divides to produce two equal male gametes. There is only one archegonium. The male gametes are unequal.

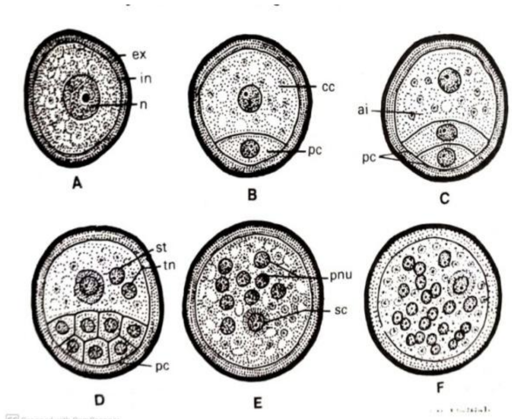

Fig .7.4 Development of male gametophyte

Megasporogenesis and female gametophyte

Out of the three of four megaspore mother cells, only one is functional and undergoes meiosis to form a linear row of 3 megaspores. The chalazal one is functional and undergoes free nuclear division followed by wall formation. The archegonia have a two or more celled neck, a ventral canal nucleus and an egg cell. The functional megaspore increases volume and its nucleus divides mitotically to form free nuclear gametophyte. Female gametophyte enlarges and nuclei become arranged in a thin layer of cytoplasm around a big central vacuole. The gametophyte takes more than a year to complete its free nuclear phase. At the mature gametophyte stage, the spongy tissue and other layers are absorbed. The nucellus becomes very thin except the micropylar end. Archegonia devolops at the micropylar end. The youngest archegonia found near the tip of gametophyte and older found away from it. The archegonia initial divides into large central cell and a small neck cell. The central cell nucleus divides into egg nucleus and ventral canal nucleus. Gametophytic cells that surround the archegonial become densely cytoplasmic and have prominent nuclei and jacketlayer. The pollen tube pierces the mature archegonium and releases male gamete. The male gamete sinks into cavity of female nucleus. The nucliarmembracme fuse and forms zygot.

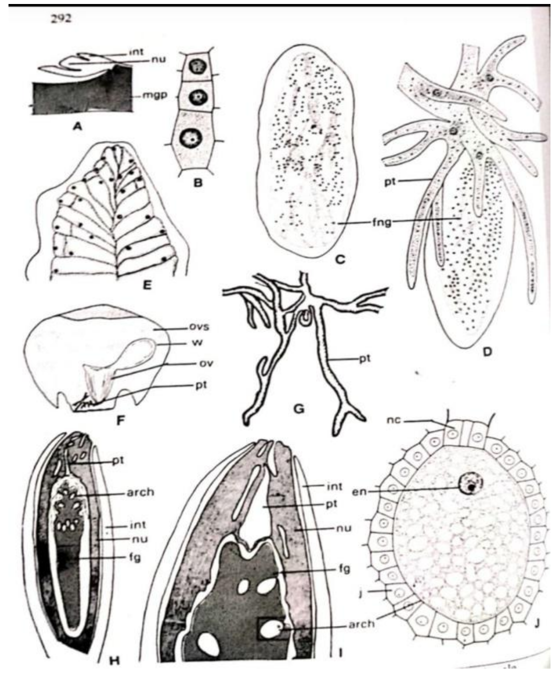

Fig .7.5; Development of female gametophyte

Embryogeny

The zygote nucleus undergoes free nuclear divisions to form thirty-two (Araucaria) or sixty four (Agathis) free nuclei. These nuclei are grouped together in the centre of the egg cell. Walls are laid down. Group of two tiers of cells is surrounded by a jacket on all sides. The upper cells of the jacket elongate to form the suspensor, whereas the cells towards the chalazal end behaves as cap cells. The suspensor cells may elongate and divide and grow out of the archegonial necks. The upper tier of the central two tiers divides periclinally and form an upper tier of secondary suspensor cells, and the lower tier of embryonal cells. The latter divide and develop into the embryo. Embryo has two cotyledons. There is no cleavage polyembryony. In the mature seed there is 2 cotyledons in embryo. Emryo is surrounded by endosperm, nucellus and the seed coat.

7.4 FAMILY: TAXODIACEAE

This family includes 10 genera and eighteen species. Some members of this family Sequoia gigantea and S. sempervirens are the largest and oldest trees of the world .Metasequoia is the oldest living tree. The trees of this family are monoecious that vary in size from small to gigantic size. The leaves are spirally arranged or rarely opposite. The leaves may be scale-like or broad. In Taxodium Metasequoia, Sequoia, Cryptomeria, Glyptostrobus and Athrotaxis produce two types of branchlets. one type is persistent and other deciduous and falls along with the leaves. The strobili are small and retain their cone-like appearance. Bracts and ovuliferous scales are free when young, but become fused in mature cones. The number of ovules varies from 2 to 9 on each ovuliferous scale and microsporangia also vary in number from 2 to 9 on each microsporophyll. The pollengrains are wingless. The number of cotyledons varies from 2 to 5. The male gametophytes lack prothallial cell. The female cones are solitary and terminal. The male gametes are equal in size. The archegonia occur in closed groups on archegonial complexes.

Morphology

In Taxodium there are two types of branchlets: (i) persistent branchlets with axillary buds and (ii) deciduous branclets that are devoid of axillary buds. Metasequoia also bears deciduous branchlets that are shed along with the leaves. In Sequoia the lateral branchlets bear linear leaves that are about 2 cm long whereas the long shoots bear lanceolate leaves. The deciduous branchlets in Cryptomeria japonica bear awl shaped leaves. In Sciadopitysverticillata the photosynthetic organs arise in pseudo whorls of 10 to 30 leaf like structures that resemble a pair of pine needles fused throughout their length and about 12 cm long. These structures arise in the axils of scale leaves and have been described as cladodes.

Anatomy-

The stem of taxodium is circular in outline. The outer most layer is called epidermis. Below the epidermis four to five layercortex is found. Cotex is made of parenchymatous cells with intercellular spaces. Group stone cells are seen in the cortex. The xylem elements are represented by elongated tracheids with spiral thickenings. Vascular rays are seen in xylem and in the phloem. The pith is small and consist of parenchyma and fibres. Resin cells are not found in young stem but in the older stem they are found in concentric rings. The secondary phloen is made up of sieve cells, parenchymatous cells and fibres. Sieve cells are long and narrow.

In the leafe of taxodium a thick cuticle is found. The epidermal cells are long, thick walled with clear nuclei. Stomata are found on both abaxial and adaxial surfaces. The mesophyll is differentiated into palisade and spongy parenchyma. The palisade is single layered and contains chloroplast. The spongy parenchlyma cells are isodiametrice with intercellular spaces. Below this layer hypodermis is found. There is no bundle sheath found.

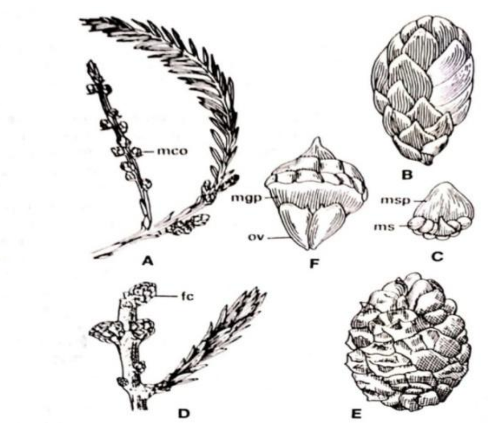

Fig 7.6; Taxodium mucronatum; **A**.Twig of male cone,**B**.Mature male cone, **C**.Microsporophyll**,D**.Twig of female cone**,E.**Mature female cone**,** **F**.Megasporophyll bearing ovule.

Microsporogenesis and Microgametophytes

The microsporangiate cones are found on tasseloid branches as in Taxodium and resemble pinaceous cones in their general morphology. The number of microsporangia per sporophyll varies. It may be from two to seven or nine. The microsporangia have a three layered thick wall with tapetum, the innermost layer. A mature sporangium has a single wall layer whose walls develop fibrous thickenings. It acts as endothecium. The sporangium develops from a group of hypodermal meristematic initials that appear on the abaxial side of the microsporophyll. Sporangium has archesporial cells and divide periclinally into outer parietal layer and an inner sporogenous layer. The cells of parietal layer divide by periclinal walls to form a three layered sporangial wall. The sporogenous cells divide in all directions to form a growth of microspore mother cells that undergo reduction division to form tetrads of microspores. The tapetum and inner wall layers degenerate during spore formation and maturation. The microspores are uni-aperturate. In Cryptomeria japonica the apertural area is marked by a papillate projection. They are usually spheroidal and devoid of wings.

The microspore nucleus divides before pollination into a generative cell and a tube cell. There are no prothallial cells in Taxodiaceae. At this stage the grains are released and pollination takes place. Such two celled pollen grains have been reported in Cryptomeria. In other genera e.g. Athrotaxis, Cunnighamia, Metasequoia, Taxodium and others the pollen is shed at two celled stage. later during the pollen tube growth, the generative cell divides, producing a stalk cell and a body cell. The stalk cell loses its cytoplasm and moves ahead of the enlarging body cell. The tube nucleus is the first to move into the pollen tube.

The pollen tube penetrates directly into the nucellus, and reaches the megaspore membrane. In Sequoia it reaches before archegonial development. The body cell divides before fertilisation, into two equal male gametes. In Taxodiaceae a single pollen tube may fertilise two archegonia.

Megasporangium and Megasporogenesis

The megasporangiate strobili are solitary terminal and consist of a central axis. It has spirally arranged bract scales that bear axillary seed ovuliferous scales. In most genera the axillary fertile complex consists of a single ovuliferous scale bearing from 2-7 ovules. In Cunninghamia the female cone axis grows beyond into a distal vegetative extension. In Cryptomeria japonica the mature ovuliferous scale is fan shaped. and appears as a "small hump". The integument grows around the nucellus. In the beginning the growth of the integument is unilateral but later its growth is uniform. At this stage one or two hypodermal archesporial cells appear in the nucellus and divide to form outer parietal cells and inner sporogenous cells. The parietal cells later merge with nucellar tissue, and the sporogenous cells divide to form a group of such cells.

In a mature ovule the integument is free from the nucellus right upto its base. The micropyle is wide open. Out of the group of sporogenous cells only one cell enlarges and acts as the megaspore mother cell. The megaspore mother cell undergoes reduction division to form a row of three cells. Meiosis-I forms two haploid cells. Of these the upper does not divide and the lower undergoes

Meiosis-II resulting in the formation of a linear tetrad of 3 haploid cells. Sometimes the upper nucleus divides but there is no wall formation and is therefore binucleate (Cryptomeria). Usually the lowest megaspore in the tetrad functions and enlarges to develop into the female gametophyte. In Sequoia, however, all the megaspores are functional and a number of young megagametophytes can be seen in the nucellus. This genus has several megaspore mother cells.

Female Gametophyte

The functional megaspore enlarges in size and its nucleus undergoes free nuclear divisions followed by centripetal wall formation. A distinct archegonial chamber is formed after the development of archegonial complexes. All the archegonia in a complex are surrounded by a Jacket. The ventral canal nucleus and the egg nucleus are not separated by a wall. The ventral canal nucleus is epheimeral and degenerates before fertilisation. ToxodiumCunninghamia and Sciadopitys also have a definite but ephemeral ventral canal nucleus. The egg nucleus in Cryptomeria lies in the upper part of the archegonium.

Fertilisation

The neck of the archegonium begins to degenerate just before fertilisation. The archegonium has dense cytoplasm and a prominent nucleus above the vacuole, which becomes smaller. One or both the male nuclei may enter and fertilisation takes place in the centre of the archegonium. The cytoplasm around the fusing nuclei is dense and shows starch grains. Vacuoles now appear in the upper part of the zygote. The vacuole in the lower part starts disappearing.

Embryogeny

Four types of embryogeny have been reported in the family Taxodiaceas. These types are:

1. Usual taxodian type found in Taxodium, Taiwania, Cryptomeria, Cunningham etc.

2. Sequoia sempervirens type.

3. Sciadopitys type.

4. Athrotaxistype.

In the first type the zygote nucleus undergoes 3 divisions and forms eight nuclei. These nuclei organise into two tiers of four cells each. The upper of these two divides again to form three tiers of 4 cells. In Cryptomeria there are two or three cells in the embryonal tier whereas there are 5 or 6 cells in the open tier. The cells of the upper tier soon degenerate. The prosuspensor cells elongate and push the embryonal cells out of the archegonium. The embryo cells also start dividing. The suspenor cells then separate from each other. This is the cleavage polyembryony. The embryo cells may or may not divide transversely into an upper primary suspensor cell and a lower embryonal cell. In Sequoia sempervirens the first division of the zygote nucleus is followed by wall formation thus forming two cells. These cells divide to form a primary suspensor cell and embryonal cell. There is thus no free nuclear stage and no tier system in the proembryo stage.

7.6 Summary

1. The shoot apex does not show any distinction into tunica and corpus layers.
2. Presence of central mother cells in the shoot apex.
3. The tracheids in the wood have multiseriate pitting.
4. The medulary rays are homogenous and have no resin ducts. They have no pits on radials as well as tangential walls. The heterogenous rays according to fossil evidence appeared late and are hence regarded as advance.
5. The female cone is well developed and larger in size.
6. The bract scale is free from the ovuliferous scale.
7. The pollen grains are winged.
8. The male gametophyte has several male prothallial cells enclosed within the microspore.
9. The number of free nuclear divisions is large in the early embryogeny and this condition persists for a longer period.
10. There is no cleavage polyembryony in primitive forms.Polyembryony as an advanced character.
11. The number of chromosomes is high in primitive forms.
12. The spiral arrangement of the leaves is primitive as compared to the opposite and whorled arrangements.
13. The haplocheilic type of stomata are primitive as compared to the syndetocheilic type.

7.7 Terminal questions

Q.1 Give an account of morphology and reproductive structure of family taxodiaceae.

Answer...
....
....
....
....

Q.2 Describe the reproduction and embryogeny in family pinaceae.

Answer...
....
....

....
....

Q.3 Describe the morphology and reproduction in family araucariaceae.

Answer...
....
....
....
....

Q.4 Short answer type

[a]Female reproductive structure in taxodiaceae

[b]Embryogeny in pinus

[c] Reproductive structure in araucariaceae

[d]Anatomical structure of pinus plant

Answers

SAQ

1. Winged

2. Pinus gerardiana

UNIT 8Coniferales-3

Structure

8.0 Introduction

Conifers are distributed mainly in temperate regions and high altitude of tropics. They are tall woody perennial and graceful trees with foliage leaves. Conifers were differentiated by Jurassic period of the Mesozoic era. Coniferales have evolved from a group of extinct plants. The primitive confers show both primitive and advanced features. Podocarpaceae is the most primitive members of conifers. The cupressaceae is the most advanced family. The root system is branched tap root type and infected with mycorrhizicfungus. Podocarpaceae root possess root nodules. The secondary wood is picnoxylic with secondary medullary rays. Resin canals are found in the cortex, pith and in the xylem of leaves, stems and roots. Some conifers exhibit two types of branches, long shoot and dwarf shoots. Dimorphism of leaves is shown by presence of scales and foliar leaves. The wood is picnoxylic. Reproductive organs are found in unisexual strobili. Pollengrains are dispersed by wind. The embryo has two to many cotyledons. The seeds are endospermic.

Objectives

- To know about the some important characters of conifers.
- To understand the morphology and anatomy of family cupresseacea, cephalotaxaceae and podocarpaceae.
- To know the reproductive studies of family cupresseacea, caphalotaxaceae and podocarpaceae.

8.1 Family Cupressaceae

It is the largest family of the order. It includes twenty genera and 148 species. Half of them are restricted to the northern hemisphere (Thuja, Biota, Cupressus, Juniperus, etc.) and the other half to the southern hemisphere (Calitris, Libocedrus, Popuacedrus etc.).

Morphology

The sporophytes are small or large trees, most of which are cultivated as ornamentals and some as commerical sources of wood. Tree is evergreen, tall with pyramidal appearance. The bark is thin, fibrous, and brown in colour. The leaves are small and may be scale like or linear. The arrangement of leaves is either opposite or whorled except in Juniperus and Actinostrobus, where the leaves are spirally arranged. There is no shoot dimorphism. The sporophytes may be monoecious or dioecious. The megasporangiatestrobili are small and may be dry (Thuja, Biota Cupressus) or fleshy (Juniperus) at maturity. The ovuliferous scales may overlap (e.g. Thuja) or may be valvate (Cupressus). The ovuliferous scales are slightly larger than the bract scales. There is a high degree of fusion between the bract scale and the cone scale. The number of ovules varies from 3-20. The ovules are mostly erect. The female cone has as single cone scale with a single ovule. The ovules appear to alternate with the cone scales because they are borne laterally.

Anatomy

Epidermis is found as an outer layer in t.s of stem. Cortex and pith are narrow in structure and consist of parenchymatous cells. Annual ring can be seen after secondary growth. Xylem cylinder is found more thicker than cortex, secondary phloem and periderm. Secondary phloem is consist of sieve elements, phloem fibers, phloem parenchyma and resin ducts. Sieve cells are confined to the radial wall. The resin canals are bounded by resin ducts and fibres. Phloem fibers occur as alternative with rings of parenchyma and resin cells. Phloem rays are found as uniseriate, thin walled and pitted. The trachieds of secondary xylem are narrow and long.

In t.s of leaf the epidermis is found covered with cuticle. Hypodermis is thick walled, single layered and discontinuous at some places. Mesophyll is differentiated into a layer of elongated cells and spongy parrenchyma. The palisade cells are found at lower surface of leaf and contains chloroplast in large amount. The spongy tissue is composed of large irregular cells with intercellular spaces. Single vascular bundle is found with resin canal.

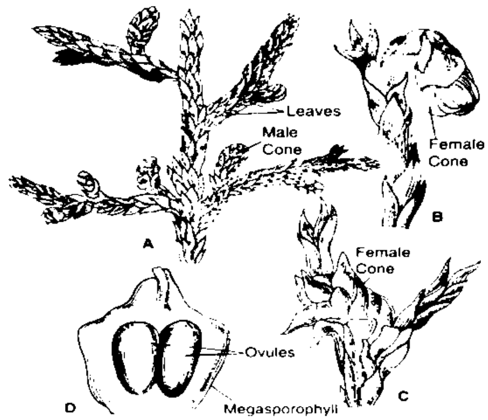

Fig.8.1;.Biotaorientalis; A.branch bearing male cones,B-Cfemale cones on curved branches;D.megasporophyl bearing ovules.

Microsporogenesis and male gametophyte

The microsporangiate strobili are small and consist of central axis with microsporangiophores arranged in whorls. The microsporangia are nearly spherical and develop from a group of 2 or 3 hypodermal cells. The young sporangium consists of an outer wall layer, a middle layer and a tapetum. It encloses a group of mother cells that divide meiotically to form several tetrads of microspores. Each microsporangiophore bears 2-6 spericalmicrosporangia. The pollen grains are wingless. There is a well developed pollination drop mechanism. The male gametophytes lack prothallialcells. The pollen grains may be released in one celled stage or in a two celled stage. The two celled stage consists of a generative cell and a tube cell. The male gametes are equal in size.

In Cupressus sempervirens the body cell divides into 4 to 11 male gametes. In Callitris both the male gametes are functional. A single pollen tube may branch and enter two archegonia or it may remain unbranched and enter only one archegonium. The pollen grains that are dispersed by wind are caught in the pollination drop, which then starts diminishing in size. Strassberger (1892) observed that in Juniperus the pollen tube sends several prolongations to several archegonia of the group. Each prolon- gation has a definite pit at its top. In majority of Cupressaceae, pollination, fertilisation and seed development occur within the same season. The spore tetrads may be isobilateral or tetrahedral.

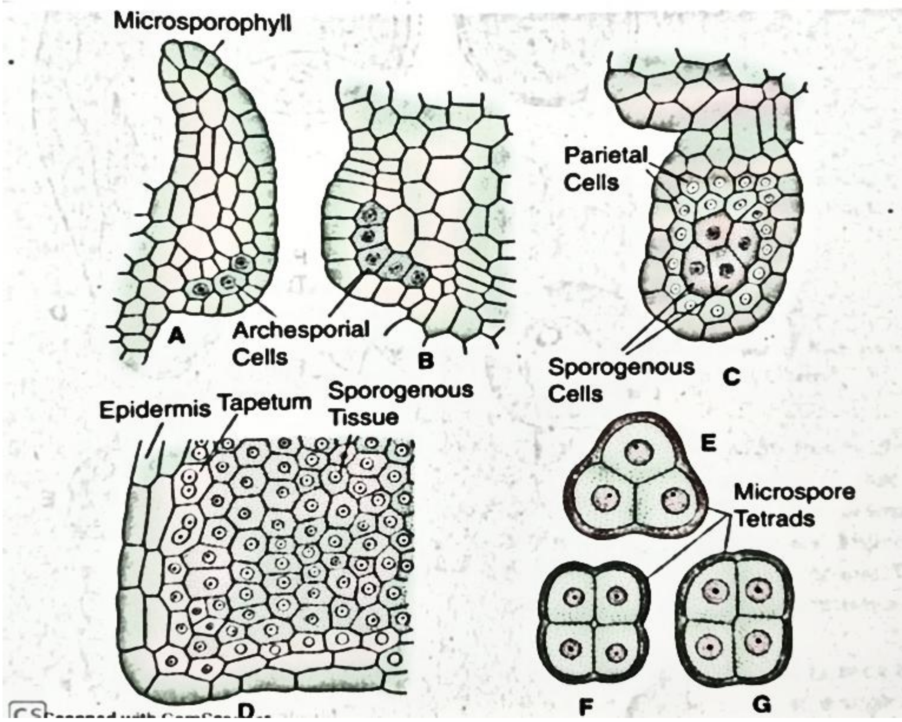

Fig.8.2; Biota orientalis, Microsporogenesis

Megasporogenesis and Female gametophyte

In young ovules the integument is 3 to 4 cells thick at the base and only one layer thick at the micropylar end. After pollination the cells of the integument lining the micropyle, elongate radially and close the canal. The nucellus shows differentiation of archesporial cells quite deep in its tissue almost near its chalazal end. The number varies from two (Biota) to six or ten (Cupressus sempervirens). The archesporial cells divide repeatedly to form group of sporogenous cells. One distinguishes itself as megaspore mother cell. In Biota this mother cell divides meiotically and form a linear tetrad of three cells. In Thuja, reported a tetrahedral tetrad of megaspores. Mehra and Mallotra (1947) reported tetrahedral, L-shaped, T-shaped and linear tetrads in Cupressus sempervirens. The functional megaspore is surrounded by a distinct spongy tissue.

The nuclei are arranged in a peripheral cytoplasm with a big central vacuole. Wall formation is centripetal. The enlarging gametophyte almost completely consumes the nucellus. The archegonia occur in groups and form a micropylar, lateral or chalazal complex. Widdringtoniacupressoides has 25-100 archegonia in a complex that is lateral in position and deep seated. In Cupressus funiberus there are 14 to 17 archegonia in a micropylar complex. In Biota orientalis the archegonial neck has a single tier of 4 cells. Widdringtonia the neck cells degenerate before fertilisation. The central cell divides into a ventral canal nucleus and an egg before fertilisation.

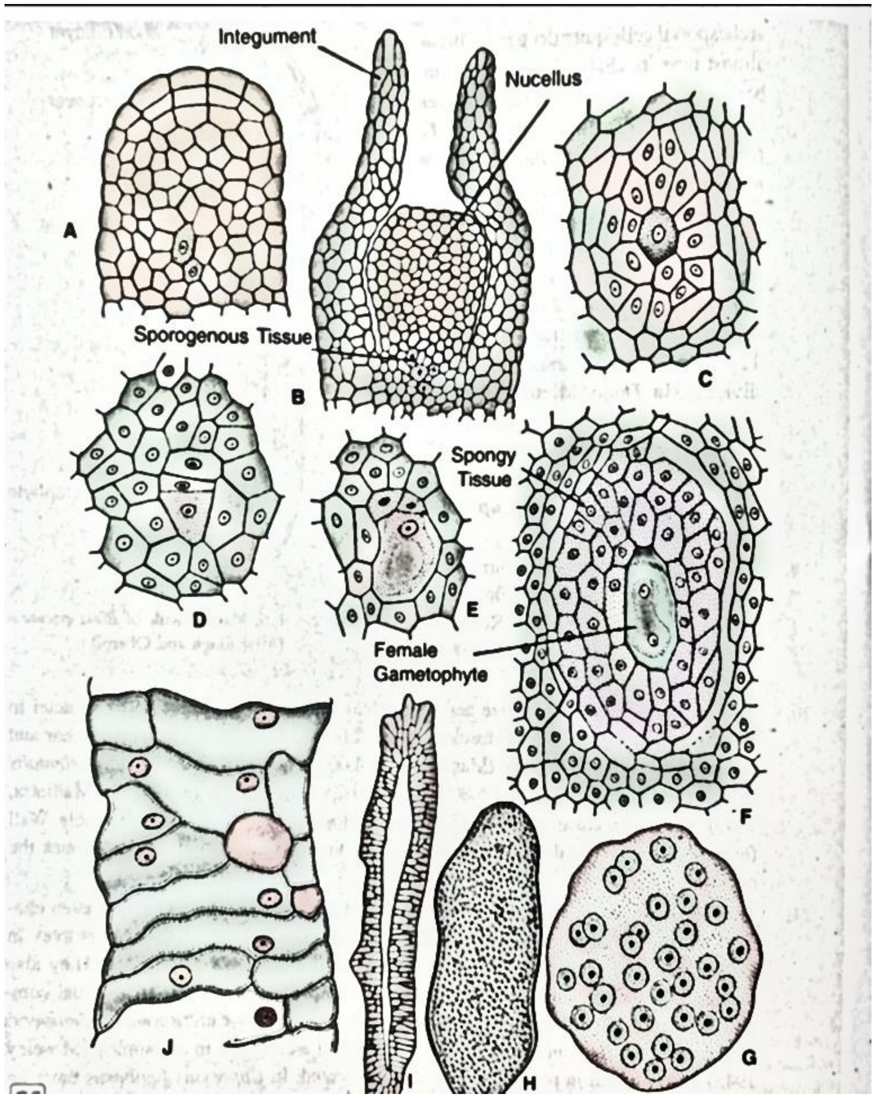

Fig.8.3; Development of female gametophyte in Biota orientalis

Embryogeny

During embryo development the zygote nucleus divides into eight free nuclei in Biota. Wall formation results in a lower tier of 4 embryonal cells and an upper tier of 4 cells. The cells of the upper tier divide again into a middle prosuspensor tier and an upper open tier. Tetrahedral, isobilateral or even T- shaped arrangement of the four primary embryonal cells are found insome species. The prosuspensor cells elongate and push the embryonal cells out of the archegoniate complex. Later the primary embryonal cells divide transversely to cut off an upper tier of suspensor cells and a lower tier of embryonal cells. After that suspensor cells start elongating and cleavage takes place. So, cleavage polyembryony is there in Biota and Cupressus. In Thuja there is no cleavage polyembryony.

A proembryo with four large and two or three small cells is formed as a result of another division. The lower four cells divide again to form upper long suspensor cells and lower small embryonal cells. The suspensor cells elongate and separate.

The four embryonal initials divide into suspensor cells and embryonal cells. The mature embryos have two cotyledons.

SAQ.

Fill in the blanks

1. Largest family of coniferales is............[cupressaceae,podocarpaceae].

2. pollen grain of cupressaceae are..............[.winged,wingless].

3. Secondary wood is ....in conifers.[manoxylic,picnoxylic].

8.2. FAMILY: CEPHALOTAXACEAE

Morphology

This family is represented by six species of Cephalotaxus. they grow in the subtropical forests of Japan, Central China and in the Eastern Himalayas. The plants are dioecious and are either shrubs or small trees with spirally arranged flat leaves. In C.drupacea the leaves are arranged in a decussate and bifurcate manner and remain on the tree for at least few years. Numerous scale leaves covers the winter buds. The male tree of this species bear short and unbranched lateral shoots that are closely covered with scale leaves. They arise in the axils of foliage leaves of newly developed branches and bear male cones in the axils of upper scale leaves.

The megasporangiate strobili arise singly in the axils of lowermost two to four leaves on a young branch of the female tree. Each megasporangiate strobilus has a short stalk and is small in size. They appear green when young ,and become reddish at maturity. It has a central axis that bears 5 to 7 pairs of opposite and decussate bracts. The central axis is fleshy in nature. Each bract bears two ovules in its axil. The lowermost pair of bracts is sterile. A small ridge like outgrowth which represents a secondary axis is present between the two ovules of each bract. The ovules are green when young but become red in colour later.

The male cones arise in compact clusters of 6-8 cones in the axils of upper scale leaves of the short lateral shoot of the male tree. The microsporangiate cones are sessile and have short central axis that bears 15-20 spirally arranged microsporophylls. Each microsporophyll bears three or four abaxial microsporangia. A sporophyll consists of a short stalk and a distal sterile flattened region which points outwards and upwards. The microsporangia are pointed towards the cone axis.

Anatomy

The stem has ribbed outline due to long leaf base. Epidermis is covered with thick cuticle. Cortex is made up of thin walled cells. Resin duct is found in the centre of young stem. Secondary growth is normal type. The phloem fibre occurs in single layered rings. Growth ring can be seen in secondary xylem. Tracheids are long with uniseriate bordered pits on radial and tangential walls. Xylem parenchyma is resinous. Xylem rays are uniseriate.

Leaf is dorsiventral. The epidermis is covered with thick cuticle. Hypodermis is absent. The mesophyll is differentiated into thick walled palisade and thin walled spongy parenchyma. Well defined endodermis is present. Stomata occurs in numerous lines. Below the phloem resin duct is present.

Root is diarch with exarch protoxylem. The cells of the cortex are loosely arranged and contains starch. The vascular tissues after secondary growth are similar to stem.

Microsporogenesis and male gametophyte

The microsporangia arise from two to four groups of archesporial cells. they are distinguished on the abaxial side of the microsporophyll near its base. They develop into 2 or 4 microsporangia. The archesporial cells divide periclinally into an outer primary parietal layer and an inner primary sporogenouslayer. The former divide anticlinally as well as periclinally to form a 4-layered thick wall. The primary sporogenous cells divide repeatedly to form a group of sporogenous cells. The inner wall layer differentiates into tapetum that is of glandular type and whose cells become binucleate at the mother cell stage. The sporogenous cells develop into microspore mother cells which undergo meiosis to form tetrads of microspores. During these changes the tapetum and inner wall layers are absorbed and only outermost wall layer persists. Its cells become highly cutinised and develop fibrous thickenings. Some cells of the outer wall layer of the epidermis facing the sporophyll stalk remain unthickened and help in dehiscence.

The microspores are small and spherical structures with a centrally located nucleus. It has a thick intine and a thin exine. The nucleus divides to form a small lenticualrantheridial cell and a large tube cell. The prothallical cells are absent. Pollen grain is wingless. The pollen grains are released at this stage. The pollen grains are carried by wind and are caught in a pollination drop which dries and sucks them in. They deposited on the top of the nucellus. A short and broad pollen tube develops and starts penetrating the nucellus. The tube nucleus migrates into the pollen tube whereas the antheridial cell divides periclinally into a stalk cell and a body cell. Both of them move into the pollen tube and reach near the tube nucleus. The pollen tube reaches the tip of female gametophyte that already contains the mature archegonia. The pollen tube comes in contact with the archegonial neck and swells at its tip. At this stage the body cell nucleus divides into two male nuclei. The male nuclei separate from each other and are released. The archegonial neck degenerates and the pollen tube cross through it to reach the archegonial venter. It bursts there and releases both the male nuclei into the egg cytoplasm.

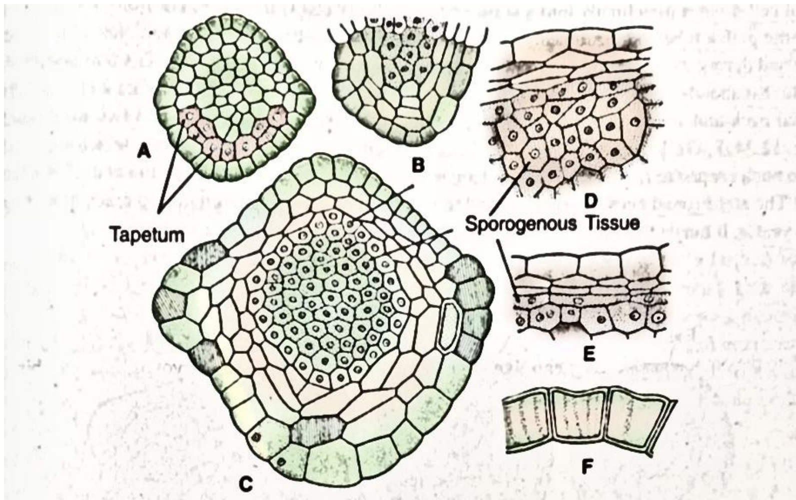

Fig.8.4; Cephalotaxusdrupaceae, Showing Microsporogenesis

Megasporogenesis and Female gametophyte

A small outgrowth arises in the axil of a bract scale and grows as a shoot apex. It grows into the secondary axis. The two ovules arise as lateral protuberances from this secondary axis. The youngest ovule has a well developed integument bordering a tissue containing three to six hypodermal archesporial cells. They later divide periclinally into outer primary parietal cells and inner sporogenous cells. The former divide and redivide to form the massive nucellus that pushes the sporogenous cells down towards the chalazal end. It gets crushed during free nuclear stage of female gametophyte. One of the sporogenous cells enlarges and functions as megaspore mother cell. It undergoes meiosis to form a linear tetrad of megaspores, out of which the lowermost is functional and enlarges and undergoes free nuclear division to form many nuclei. Wall formation is centripetal and leads to the formation of a well developed oblong gametophyte whose cells are filled with starch grains and oil globules.

The archegonial neck is usually two celled but may show two tiers of cells. There is no neck canal cell. The venter is elongated and has a pointed chalazal end. Its cytoplasm becomes vacuolated and filled with many irregular and darkly staining bodies. The central nucleus divides into a ventral canal nucleus and an egg nucleus. No wall faomation takes place between them. The archegonia are separated by 2 to 4 wall layers of the gametophyte and do not form groups.

The pollen tube reaches to the tip of the archegonium and enters through degenerating neck cells. The ventral canal nucleus disappears before fertilisation and egg nucleus moves to the archegonial base. The male and female nuclei fuse together, their membranes dissolve at the point of contact and their chromatins approach each other and later merge.

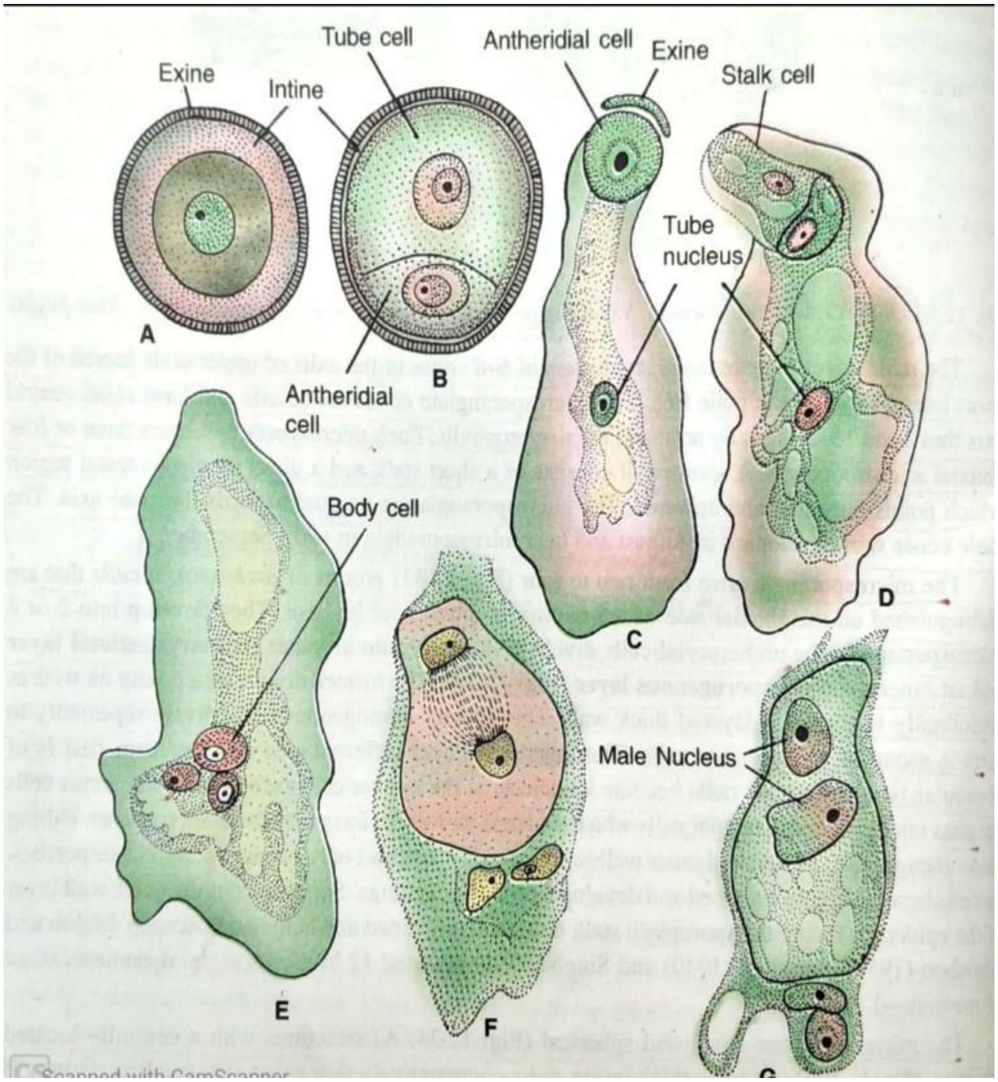

Fig.8.5; Cephalotaxusdrupacea;Male gametophyte

Embryogeny

The zygote nucleus divides into 16 free nuclei. The first division of the zygote nucleus is internuclear. That arrange themselves into 4 tiers of cells namely, (i) rosette tier, (ii) suspensor tier: (iii) embroyonal tier; and (iv) cap cells. The cap cells do not form any tier but are the lowermost cells of the embryonal tier. There is a cavity in the centre of the female gematophyte. It develops by the degenration of cells and progresses towards the chalazal end. The embryonal cells are pushed into this cavity. Later the cap cells degenerate and their place is taken by enlarging embryonal cells. The embryonal cells may divide once to form secondary suspensor cells above them. They grow further and push the embryonal mass. The embryonal cells divide to form a massive embryonal tissue. The prosuspensor cells degenerate after the formation of secondary suspensor cells. There is no cleavage polyembryony. The seed contains a thick seed coat and an immature embryo. The embryo attains maturity after the seed have fallen to the ground.

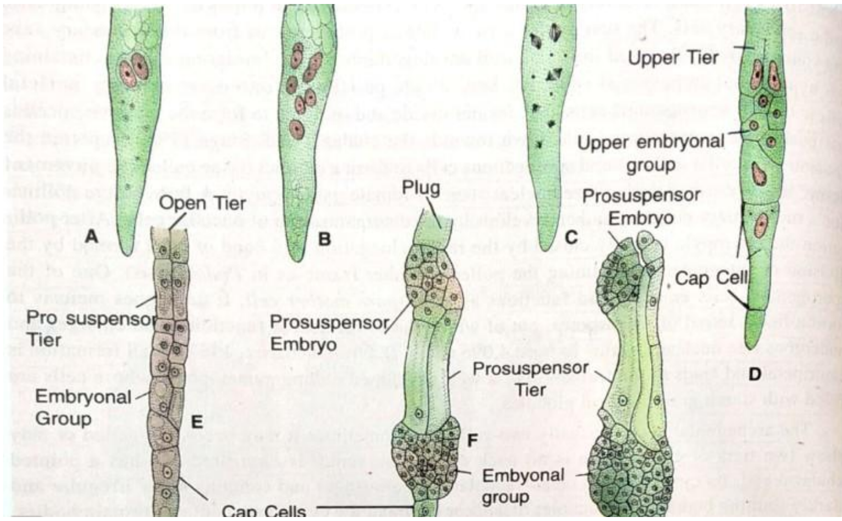

Fig.8.6; Embryogeny in cephalotaxusdrupacea

8.3. FAMILY: PODOCARPACEAE

The Podocarpaceae include seven genera and approximately 150 species. This family shows a greater range of morphological characters.

Morphology

The sporophytes are small or large trees, and some are shrubs. Some species of Dacridium are only a few inches hight. Some species of Prodocarpus grow as tall as 60 metres. Podocarpus ustus is reported to grow as a partial parasite on the roots of Dacridium taxoides. The leaves are spirally arranged except in some species of Podocarpus they are opposite or sub opposite. The leaves may be scale like, needle-like, linear or broadly lanceolate. There is no shoot dimorphism except in Phyllocladus where the dwarf shoot is a flattened fusion product called the cladode. It is the main photosynthetic organ. In Microcachyrustoo the leaves are opposite and decusate.Themicrosporangiate cones are long and bear spirally arranged microsporophylls that bear two microsporangia each. The male cones are usually axillary in position and in some cases new strobili arise from the bases of older ones. The trees may be monoecious or dioecius.

The pollen grains are winged in all genera. Only Saxegotheca has wingless pollen. In Pherosphaera and Microcachyrus the pollen grains have three wings, whereas in all other genera there are two wings.

Anatomy

The stem has grooved outline due to broad leaf bases. The epidermis is covered with cuticle and followed by parenchymatous cortex. In older stem some epidermal cells contains tannin. The vascular bundles are collateral and open.Resin canal is present outside each vascular bundle. The pith is parenchymatous and contains resin cells. Secondary growth forms secondary xylem and secondary phloem. The phloem consist of sieve cells, parenchyma, fibres and uniseriate rays. The wood shows growth ring. The xylem is consist of tracheids, parenchyma and rays. The xylem rays are homogeneous and uniseriate.

Resin canals are not found in wood. Cork cambium is formed in the outer layers of the cortex which produces cork cells towards outside.

The leaf may be isobilateral or dorsiventral. The leaf epidermis is covered with thick cuticle. The hypodermis is two to four cell layers wide around margins. Mesophyll consist of palisade and spongy tissue.Fibres and sclereids are interspersed in the mesophyll. Single collateral vascular bundle is found. The xylem is composed of tracheids with bordered pits on their radial walls. The phloem shows sieve cells and fibres. Transfusion tissue are present in the leaf. Parenchyma cells and tracheids running parallel to the lamina constitute the accessory transfusion tissue.

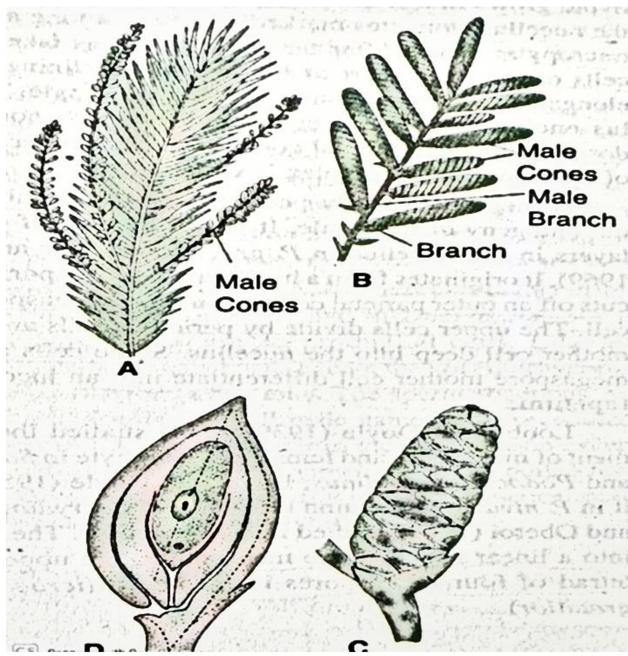

Fig 8.7;Podocarpus;A.shoot with male cone,B.male branch bearing male cone ,C.single male cone,D. L.S of ovule

Microsporogenesis and Male gametophyte

The development of the microsporangium is eusporangiate. The microsporangia arise as a small hump like structres on the abaxial side of the sporophyll. They enlarge and forms sac like structure. Three or four hypodermal archesporial cells differentiate in each microsporsngium and divide to form sporogenoustissue. The innermost layer differentiates into tapetum. The tapetum is of glandular type. As the microspores differentiate and mature, all the wall layers and tapetum disorganise, except the outermost layer that acts as endothecium.

The microspore nucleus divides to form two prothallial cells and an antheridialinitial. Theprothallial cells divide into three or four cells. Theantheridial initial divide into antheridial cell and tube cell. A mature pollen grain cintainsspermatogenous cell, prothallial cell, stalk cell and tube nuclei.

Megasporogenesis and female gametophyte

The megasporangiate strobili generally appear unstrobiloid in appearance. It may have one to four or sometime nine bract scales with their axillary complexes. The ovuliferous scale is folded around the ovule and enclosed it completely or partially. The female cones in P. spicatus and Dacrydium franklinii look like loose or lax spikes. The ovules may be erect or anatropous. A single integument projects a litele above the level of the nucellus and forms a wide micropylar opening in the young ovule.

A megaspore mother cell differentiates early in the ontogeny of the ovule. It lies at a depth of 4 or 5 cell layers in the nucellus in P. gracilior. It originates from a hypodermal archesporial cell that cuts off an outer parietal cell and an inner megaspore mother cell. The upper cells divide by periclinal wlls and push the mother cell deep into the nucellus. Some cells around the megaspore mother cell differentiate into an inconspicuous tapetum. The megaspore mother cell divides meiotically into a linear row of three megaspores. The upper cell remains undivided. The megaspore enlarges and undergoes free nuclear division to form coenocytic female gametophyte. Wall formation is centripetal and takes place by alveoli. The archegonia occur in groups of 20 to 25. In P. andinus the archegonia are long and pointed at their lower ends. In P. gracilior and Pusumbarensis the archegonia are oval with rounded base. The archegonia have a short neck of 16 cells arranged in a single tier in Podocarpus. Ventral canal nucleus is ephemeral in most cases. The nucleus of the central cell divides to give rise to a small ventral canal nucleus and egg nucleus. The egg nucleus is surrounded by dense cytoplasm.

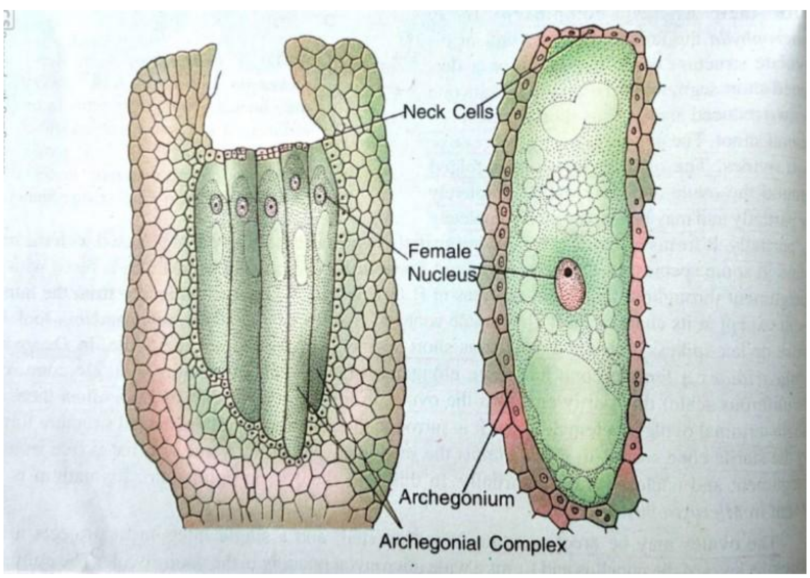

Fig.8.8 Female gametophyte of Podocarpus gracilor

Fertilisation

Pollination is anemophilous. In most species winged pollen grains are found. The mechanisms are similar to Pinaceae. In Saxegothaea the wingless pollen grains fall on the cone scale. The nucellus grows rapidly and bulges out of the micropyle. The pollen tubes grow and penetrate into it. In this genus there is no pollination drop mechanism.

In Podocarpus gracilior the pollen tube generally enters the archegonium laterally. The neck cells do not separate and undergoes degeneration. The pollen tube exerts pressure on the archegonial wall and penetrates through it to liberate its contents into the egg cytoplasm. The functional male nucleus and its cytoplasm are the only structures that enter the egg but in rare cases some other contents may also be seen in the archegonium. The male and the female nuclei fuse together in the upper part of the archegonium. During their fusion the nucleoli disappear and the nuclear membrane disappears at the point of contact leading to complete fusion.

Embryogeny

Zygote nucleus is enveloped by a dense and nonvacuolated cytoplasm. In Podocarpus gracilior the zygote undergoes five free nuclear divisions to form 32 free nuclei. Wall formation results in the formation of two tiers. The lower tier consists of 9-12 embryonal cells whereas the upper open tier contains 15-22 cells. The embryonal cells are arranged in a single tier. The cells in the upper open tier divide transversely followed by a wall formation. The suspensor cells elongate and push the embryonal cells into the gametophyte. Later cap like structures appear at the tips of embryonal cells. The binucleate embryoal cells undergo another nuclear division and wall formation takes place to distinguish tetrads of cells. This is called an embryo tetrad stage.

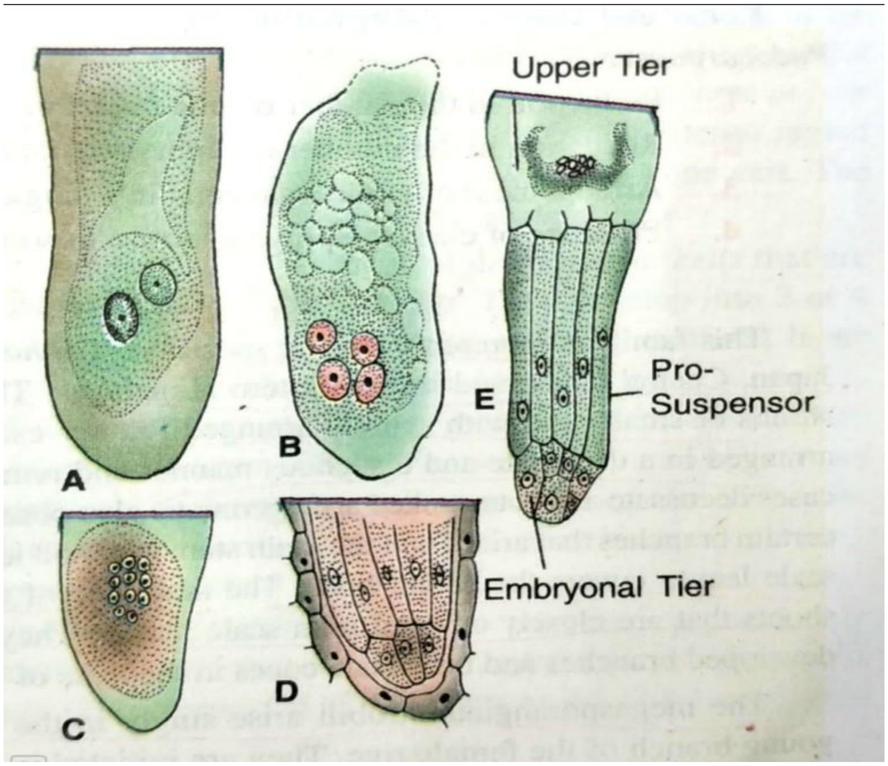

Fig .8.9; Embryogeny in Podocarpus gracilior

8.4. Summary

All are woody perennials.

Leaves are small and may be scale like.

Arrangement of leaves are either opposite or whorled or spirall.

Shoot domorphism is not found.

Sporophyte may be monocious or dioecious.

Fusion is found between bract scale and the cone scale.

Ppllengrain are winged and pollination takes place by wind.

The ovule may be erect or anatropous.

8.5 Terminal Questions

Q.1. Describe the morphology and anatomy of cupressaceae family.

Answer...
....
....
....
....

Q.2 Write detailed account of morpholpgical and anatomical characters of family cephalotaxaceae.

Answer
....
....
....
....
....

Q.3 .Write about the reproductive structure of podocarpaceae.

Answer...
....
....
....
....
....

Q.4 .Write short note on following.

[a] megasporogenesis in cephalotaxceae

[b] fertilization and embryogeny in podocarpaceae

[c] microsporogenesis and male gametophyte

[d] anotomy of cephalotaxceae family plant

Q. 5 Objective type

[1] Cryptomeria is a member of family

a .pinaceae

b.cuprecaceae

c. araucariaceae

d. podocarpaceae

[2] Resin canal in the conifers is an example of

a. intercellular space

b. schizogenous cavity

c. lysigenous cavity

d. big vacuole

8.6. Answers(objective)

[1]cupressacese [2] schizogenous cavity

SAQ . 1.Cupressaceae 2.Wingless 3. picnoxylic

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UNIT- 9 TAXALES

Structure

9.0 Introduction

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. There was Professor Birbal Sahni (1920), a well- known Indian botanist, who suggested that Cephalotaxus, Taxus and Torreya should be treated Taxales. Florin (1948) has opined that Cephalotaxus should not be included under taxales but under coniferales because it is a true Conifer. According to Florin (1948) Taxales include *six genera*, *namely Taxus, Austrotaxus, Pseudotaxus (-Nothotaxus), Torreya,* Amentotaxus and Palaeotaxus. Palacotaxus is the only fossil genus of the family. Sporne (1965) also followed the same classification. According to Turrill (1959), out of the total 19 speciesof Taxales, 7 species belong to Taxus, and one each to Austrotaxus and Nothotaxus, 6 species to Torreya and four to Amentotaxus. Ramanujam (1976) mentioned that the order Taxales is poorly represented in the fossil flora of India.

Objectives

1.To understand the general characters of taxales.

2.To know the morphology and anatomy of taxus.

3.To learn about genera torrey,palaeotaxus and autrotaxus.

4.To learn about genera pseudotaxus and amentotaxus.

9.1 General Characters

1. The sporophytic plant body consists of evergreen, slow growing, profusely branchedshrubs or small trees.

2. Theleaves 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. Microsporangiophores are arranged in the form of small cones.

8. On each microsporangiophore 2-8 pollen sacs are present on a scale-like or peltate disc.

9. Prothallial cells are absent in the male

10. The ovule is solitary and borne terminally on a dwarf shoot.

9.2 Internal Structures

Stem: In transverse section the stem is irregular in outline and resembles Pinus in structure. It is surrounded by a thickly cuticularised single layered epidermis. Inner to the epidermis is parenchymatous cortex having some tannin-filled cells. It is followed by endodermis and sclerenchymatous pericycle. The young stem shows a ring of conjoint, collateral, open and endarch vascular bundles enclosing a distinct pith in the centre. The protoxylem consists of spiral tracheids, and the phloem contains sieve cells with sieve plates and phloem parenchyma. Companion cells are absent.

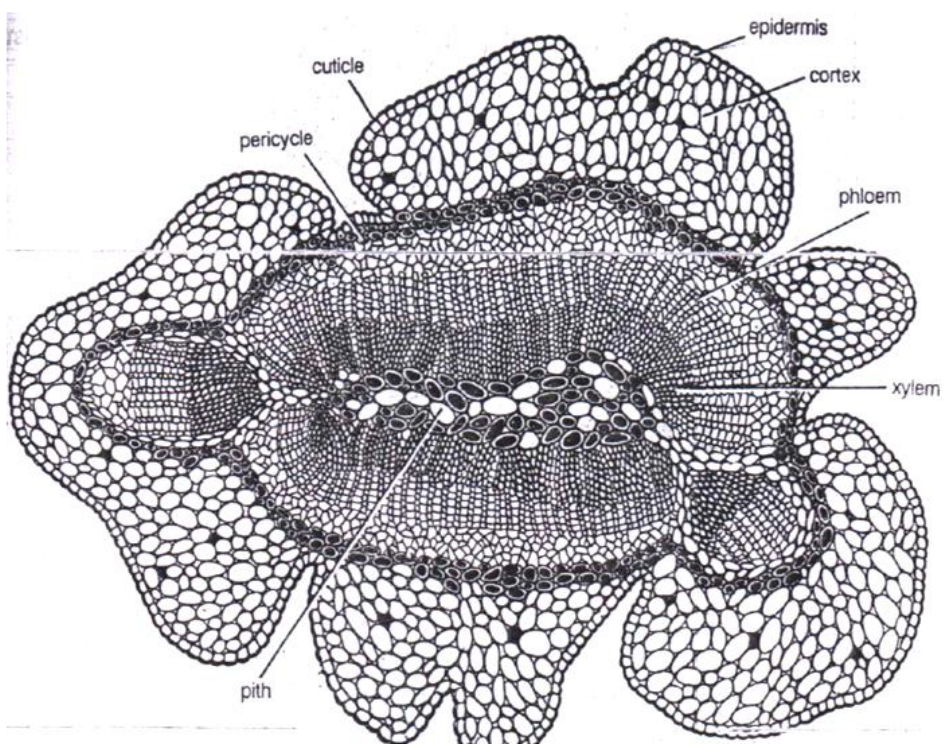


Fig. 9.1. Taxus baccata. T.S. stem (Young)

The cambium is persistent and develops a thick vascular cylinder due to secondary growth. The cambium cuts secondary phloem towards outer side and secondary xylem towards inner side. The secondary wood is devoid of resin canals and wood parenchyma. Its tracheids show uniseriate bordered pits only on their radial walls. The tracheids also show spiral thickenings. The medullary rays are uniseriate and homogeneous but in Taxus baccata they are sometimes biseriate. The wood is strong and dense. Duetothe presence of tertiary spirals the wood is elastic in nature. Phellogen may develop in the older stems showing extrastelar secondary growth.

Root: Except that of the absence resin canals, the root anatomy of Taxus resemblesvery much with that of Pinus. The root is diarch.

Leaf: The leaf is dorsiventral. It shows xerophytic characters.

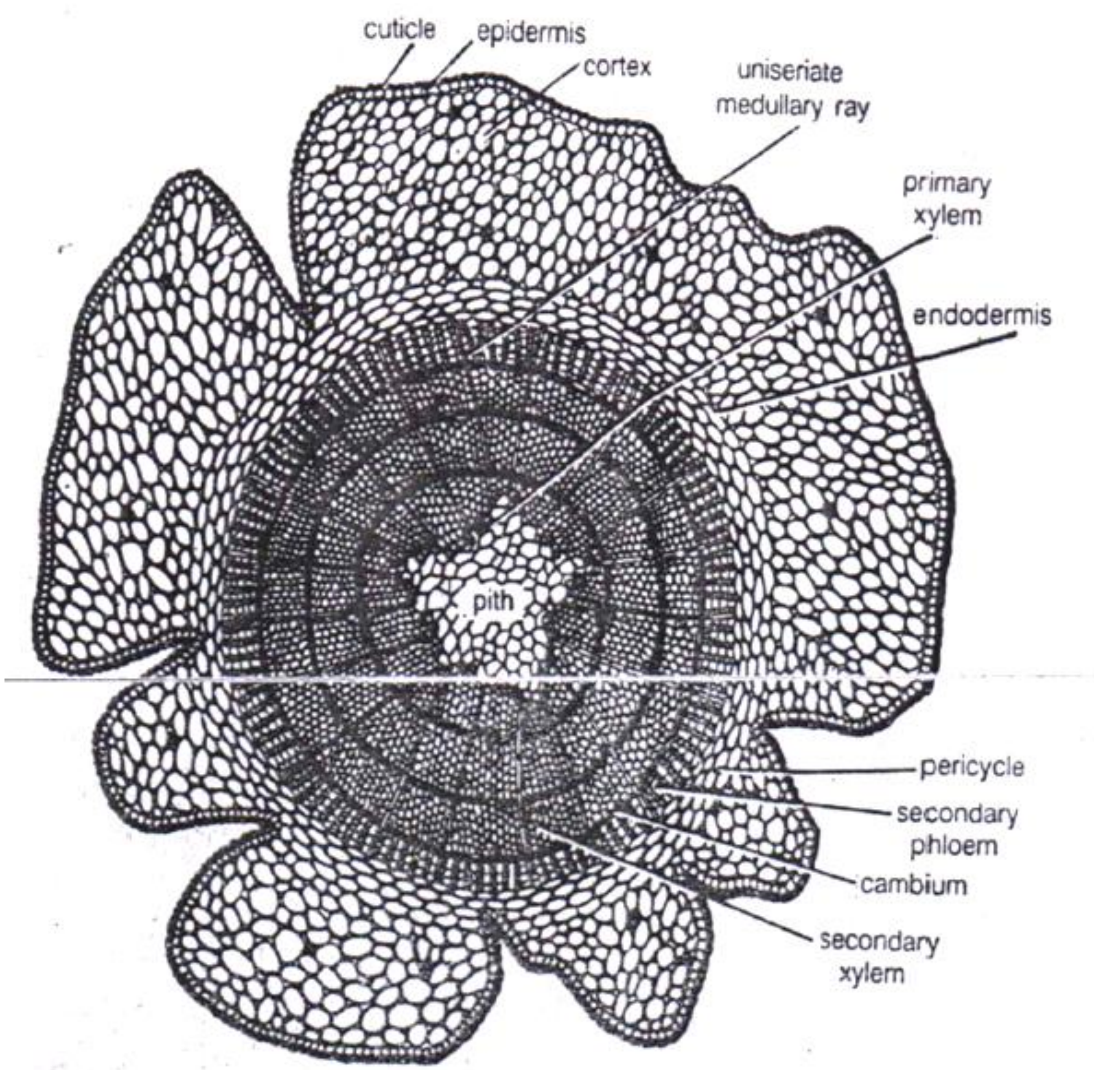


Fig. 9.2. Taxus baccata. T.S. stem (old) showing secondary growth.

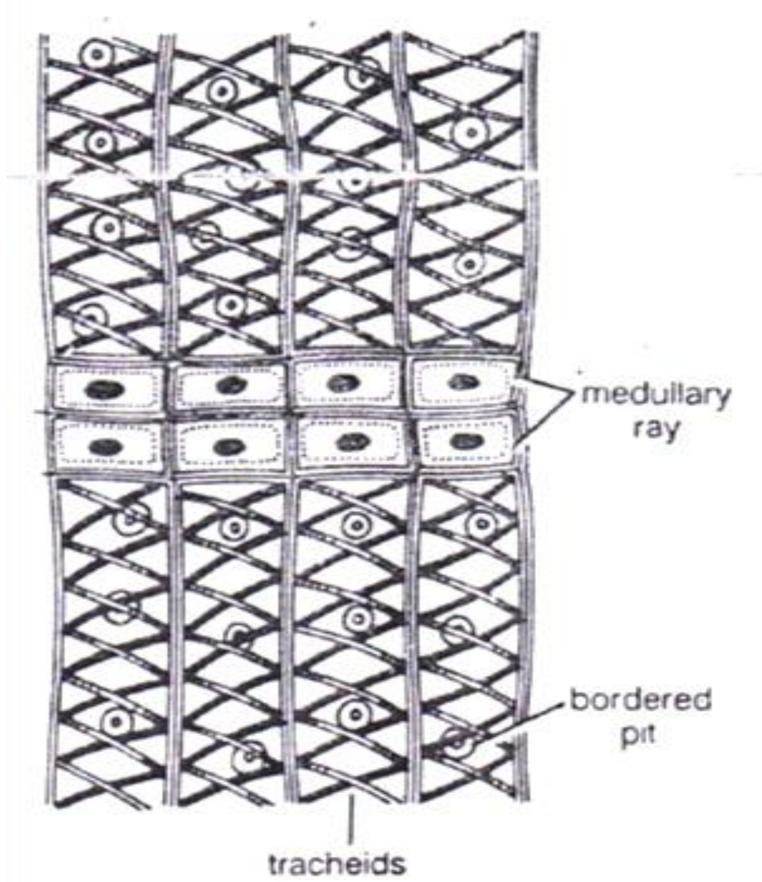


Fig. 9.3. Taxus baccata. R.LS wood showing biseriste medullary rays and spiral thickenings on the tracheids.

Upper and lower epidermal cells are rectangular in shape and thickly cuticularized. The cuticle is comparatively thinon the lower surface. The stomata are of sunken type and restricted only to the lower epidermis. They are haplocheilic in development. The mesophyll is differentiated into palisade and spongy parenchyma. The palisade is generally two layered. Only one vascular bundle is present. It contains phloem towards the lower side and xylem towards the upper side.

The xerophytic characters of the leaf include the presence of thick cuticle, sunken stomata, transfusion tissue and differentiation of mesophyll into palisade and spongy parenchyma.

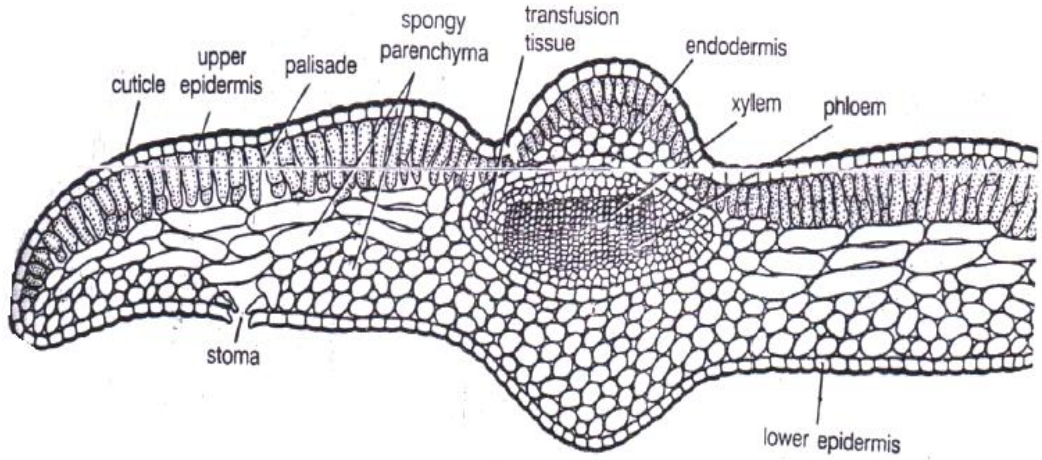


Fig. 9.4. Taxus baccata. V.S. Leaf

9.3 Reproduction

Taxus is usually dioecious, but occasionally monoecious trees are also reported. The reproductivestructuresbecome prominent on the plant in February-March. The male and female plants do notshow any distinction in their vegetative organisation, and the differentiation between them can bemade only when the plants are in the flowering or fruiting stage. Vegetative reproduction in Taxus is not known.

Male Strobilus or Male Flower

The 'male flowers' or 'male strobili' are usually yellowish in colour and develop in the axil of foliage leaves. Each strobilus contains a number of overlapping sterile bracts. Some of the bracts towards the tip of the strobilus are replaced by stamens ormicrosporangiophores. Each stamen is shortly-stalked and has a peltate disc bearing 4-8 pendant microsporangia. The microsporangia surround the stalk completely. The axis of the male strobilus contains. a broad apex which is consumed in the formation of a stamen. The microsporangia in the young male strobilus are compactly arranged but at maturity they get loosened and undergo dehiscence. The presence of peltate microsporangiophores is one of the most remarkable features of Taxus. A mature microsporangium remains surrounded by an epidermal layer followed by two wall layers and sporogenous tissue. The outermost sporogenous cells differentiate into a tapetum.

The sporogenous cells start to behave as microspore mother cells which undergo meiosis and form microspores or pollen grains. The microspores remain arranged isobilaterally or tetrahedrally for quite sometime.

The development of microsporangium is of eusporangiate type and is identical with that of Pinus. Four to eight archesporial cells develop hypodermally. They divide and form wall layers and sporogenous tissue. In Taxus canadensis the microsporangium develops from one or rarely two hypodermal archesporial cells.

Each microspore remains surrounded by two layers, ie. intine and exine. It is uniaperturate, spheroidal and contains a mass of cytoplasm and a centrally located nucleus.

Female Strobilus or Female Flower

The female strobili in Taxus are so highly reduced that they hardly appear as cones or strobili. They arise in the axils of leaves early in the season and mature in the next season.

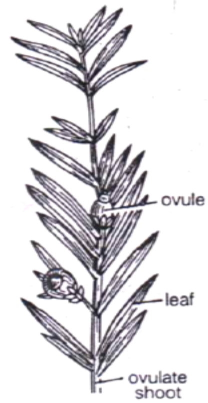


Fig. 9.5. Taxus baccata. An ovulate shoot

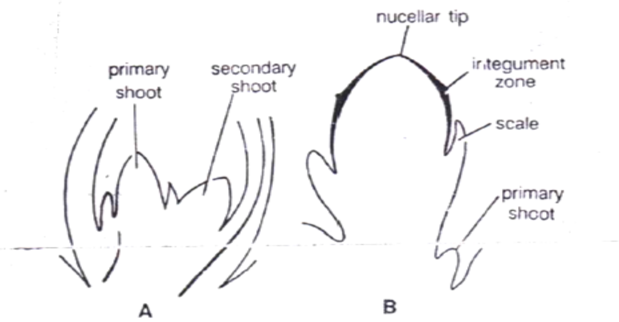


Fig. 9.6. Taxus baccata Development of ovule (only two stages).

Each female reproductive organ consists of a short primary axis having scaly leaves or bracts arranged in opposite decussate manner. A short secondary axis develops from the axil of upper three scaly leaves. This secondary axis bears a few pairs of scaly leaves and a terminal ovule. According to Dupler (1920) the primary axis functions only as a vegetative branch of limited growth bearing the reproductive secondary axis.

Ovule: The ovule is somewhat rounded or oval in shape and orthotropous. A single thick integument is present. Integument is free from the nucellus right up to its base forming a long micropyle. The integument is differentiated into outer fleshy, middle stony and inner fleshy layers. Two vascular strands enter the integument from the base of the ovule and reach up to its top.

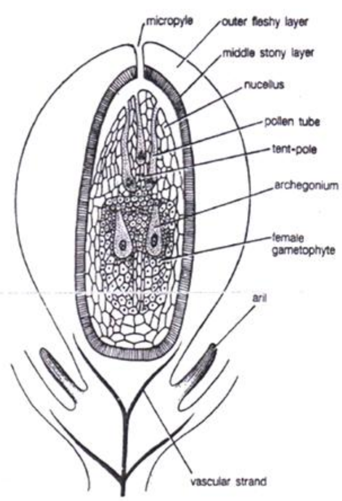


Fig. 9.7. Taxus baccata. A female strobilus with terminal ovule.

Fig. 9.8. Taxus baccata. V.S. ovule.

A ring like outgrowth develops from the base of the integument. It surrounds the entire ovule. It is called 'aril' or 'cupule. Aril is green and saucer-shaped when young but at maturity, it is red and cup shaped. The aril also receives two vascular bundles but they are very minute and rudimentary. Pollen chamber and nucellar beak are absent in Tarus. The apex of the female gametophyte changes into a flask-shaped structure called tent-pole. The tent-pole disappears in the later stages. Generally, upto 10 archegonia develop in the female gametophyte but sometimes as many as 25 archegonia may appear.

In the young ovule an archesporial initial develops hypodermaly in the nucellus. It divides periclinally forming an outer parietal cell and an inner primarysporogenouscell. The latter divides again to form many sporogenous cells, of which generally one or more start to behave as megaspore mother cells. The megaspore mother cell divides meiotically to form four megaspores which remain arranged in a linear tetrad. Generally, the lowermost megaspore remains functional and the remaining three degenerates. The functional megaspore nucleus divides, redivides and develops ultimately into a multicellular gametophyte.

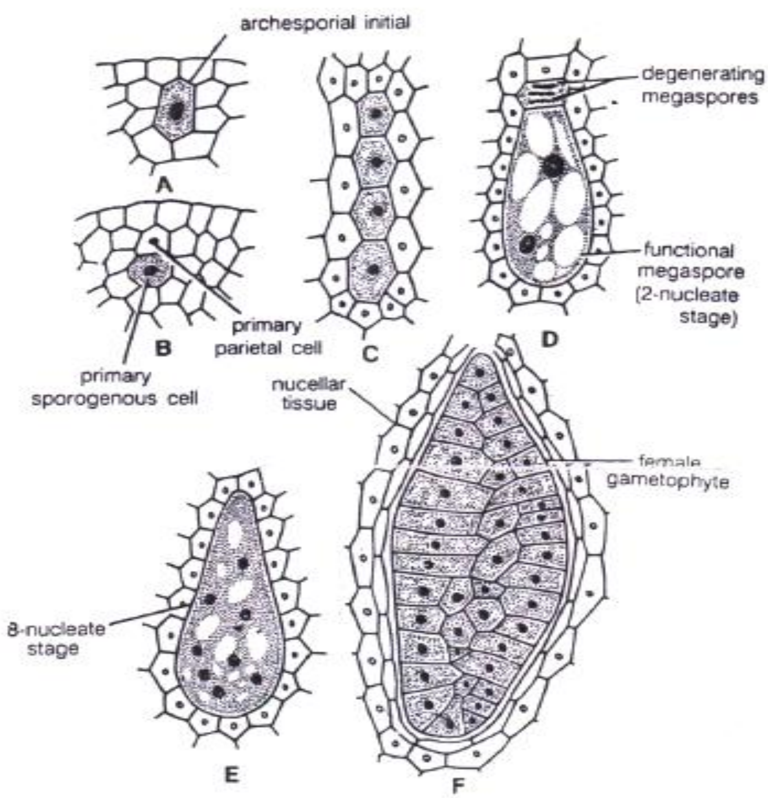


Fig. 9.9 A –F. Taxus candensis showing development of female gametophyte

Morphological Nature of the Aril: The morphological nature of the aril has been quite controversial. Strasburger (1872) considered aril as an expansion of the axis. Sinnott (1913) compared the aril of Taxus with that of the epimatium of Podocarpaceous ovules while Jager (1899) considered aril as the second integument. According to Dupler (1920) the aril is equivalent to an outer fleshy layer in Taxus.

Gametophyte

Male Gametophyte: A microspore develops into a male gametophyte. It is uninucleate at the time of shedding. Dispersal of the microspores takes place by wind. A few microspores are taken up to the micropyle by the wind, where they are caught. Taxus canadensis showing development of female pollination drop. At the time of germination, the microspore nucleus divides and forms a tube cell and a generative cell. The exine ruptures and the intine comes out to form a pollen tube. The tube nucleus moves towards the tip of the pollen tube. The generative cell divides soon into a stalk cell and a body cell . In the later stages two unequal male gametes are formed by the division of the body cell. The pollen tube reaches upto the archegonial neck by penetrating the nucellus. The prothallial cells are absent in Taxus.

Female Gametophyte: The functional megaspore develops into the female gametophyte. It enlarges in size and its nucleus divides by many free nuclear divisions to form as many as 256 nuclei. In Taxus baccata only 128 free nuclei are formed. A central vacuole develops and thus the free nuclei become parietal in position. There is a centripetal wall formation as in Pinaceae and ultimately the whole of the tissue becomes cellular. Certain archegonial initials are differentiated towards the micropylar end of the cellular female

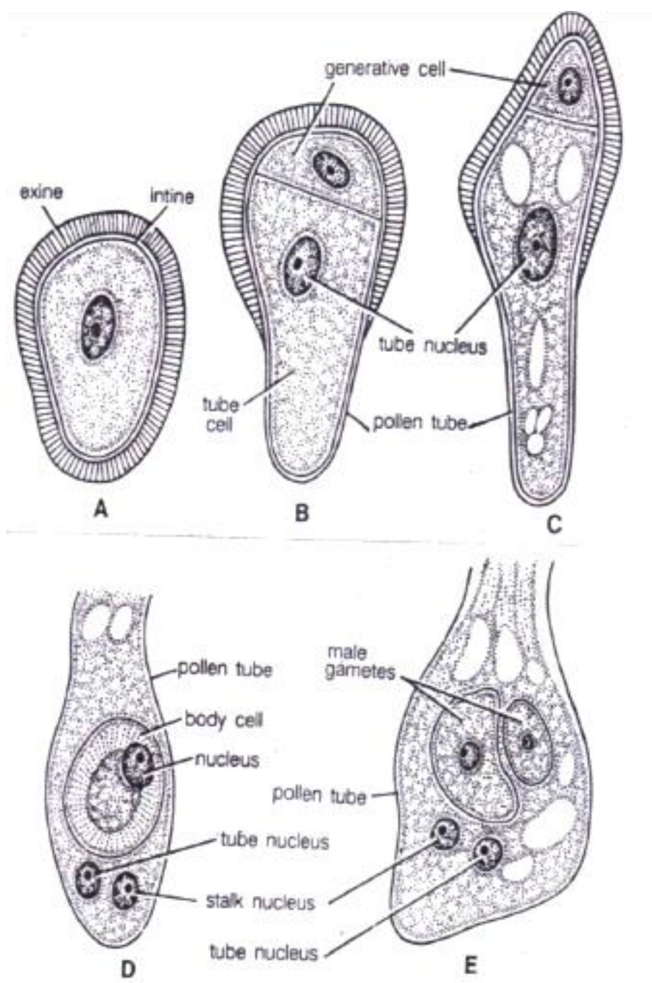


Fig. 9.10. Taxus canadensis. Development of male gametophyle

gametophyte. The development of archegonium in Taxus is similar with that of Pinus. Each archegonium contains 2 to 4 neck cells and a large venter containing an egg nucleus. There is no venter canal cell. The cytoplasm of the egg cell contains both small and large cytoplasmic inclusions and a zone of mitochondria and lipid globules near the nucleus .

Fertilization:

The tip of the pollen tube present near the neck of the archegonium, bursts and both the male gametes, along with stalk nucleus and tube nucleus, are liberated into the archegonial venter. The functional male nucleus and the egg nucleus fuse and result in the formation of a zygote. The other three nuclei (i.e. stalk nucleus, tube nucleus and smaller male cell) degenerate. As there are several archegonia in the female gametophyte, several eggs may be fertilized, resulting into a simple polyembryony But ultimately only a single embryo attains maturity.

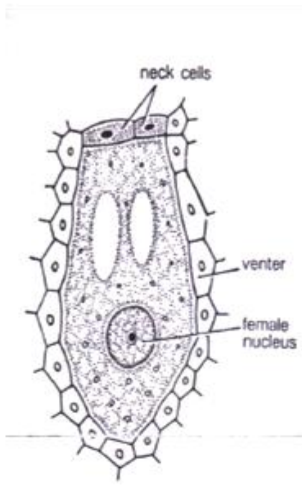
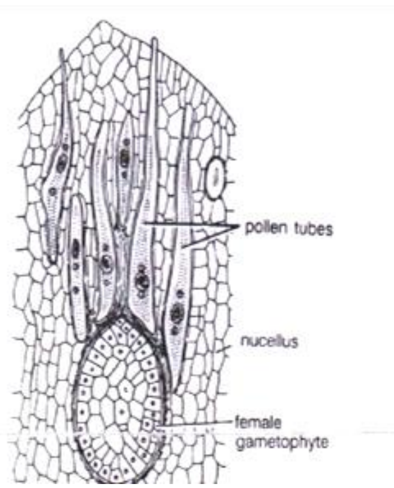


Fig. 9.11. Taxus baccata. A mature archegonium



9.12. Taxus canadensis. Nucellus showing even pollen tubes

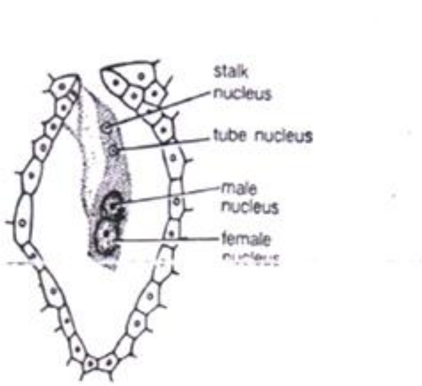
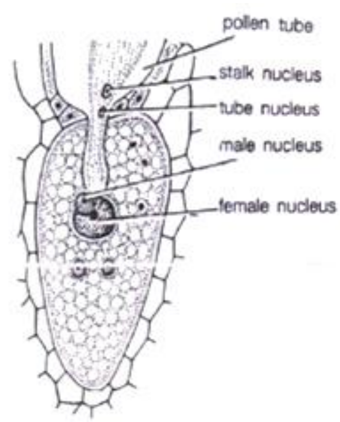


Fig. 9.13. Taxus baccata. An archegonium under the process of fertilization.



9.14. Taxus baccata Bursting of pollen fusion of male and female nuclei.

Embryogeny

The zygotic nucleus divides to form 16 to 32 nuclei. Only 16 free nuclei are formed in Taxus baccata according to Sterling (1948). Cell formation starts and soon the complete structure becomes cellular. A few cells at the tip of this proembryo develop into the embryo while the cells above it elongate and form suspensor. The embryo gradually absorbs all the endosperm on development, and the seed thus becomes non endospermic. The fully mature embryo is orthotropous and dicotyledonous. Only one embryo matures in one ovule.

Seed Taxus seeds are covered by a three-layered seed coat. The outermost layer is thin, brown and detaches soon. The middle layer is hard and stony while the innermost layer is fleshy. The mature seeds are covered by a red coloured aril. The aril serves to attract birds and help in dissemination.

The germination of seed is hypogeal. The seed germinates into a seedling possessing two cotyledonary leaves. The foliage leaves arise in the coming year. The cotyledonary leaves are larger than the normal foliage leaves.

CytologyIn Taxaceae, the basic number of chromosomes is x-12 (eg Taxus). In Torreya and Amentotaxus, however, the basic number of chromosomes is x-11.

9.4 Economic Importance of Taxus

Besides its cultivation as an ornamental plant, the timber of Taxus baccata and some other species are used as heaviest of the soft woods. It is quite durable and used for making decorative veneers, turnery, flowers and posts. Several other types of decorative pieces are also made from its wood. Due to the presence of a toxic alkaloid (taxine) in the leaves, shoots and seeds, the entire plant of Taxus baccata is considered poisonous and also used in some countries as a fish poison. Its leaves also contain traces of ephedrine, and, therefore, used in bronchitis, asthama and epilepsy. Seeds of T.baccata are used as sedative.

SAQ.

Fill in the blanks.

1. Plants of taxales are........................[unisexual\bisexual].

2. The resin canals are ....in taxales.[present\absent].

3. Ovule of taxus is ....[terminal\axial].

9.5. Some Other Taxales

1. Palaeotaxus

It is the only known fossil representative of Taxales. Its fertile specimaen have been discovered from the rocks of the Triassic period of Mesozoic era. Plants had solitary terminal ovules which is 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. Aril was also present. Except at the top of the micropylar end, the ovule was enclosed by the aril.

2. 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 microsporangiophores. Each microsporangiophore 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 microsporangiophore terminates into a synangium formed by the fusion of 3 or 4 microsporangia.

3. Pseudotaxus(Nothotaxus) It is found growing these days in a small region of the forests of east China. It is also representedby only one species. Its male cones are also made of microsporangiophores similar to Austrotaxus but here the bracts are irregularly distributed. Each microsporangiophore of Pseudotaxus is actually a highly reduced male cone and therefore, the entire structure, formed by a group of microsporangiophores, is a compound structure.

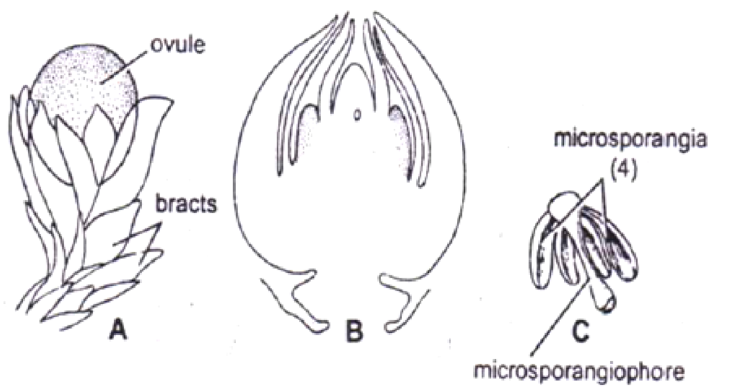


Fig. 9.15. A, A reconstructed female shoot of Palaeotaxusredivive, D. L.G. young ovule of Torreya taxifolia, C, A microsporangiophore of T. taxifolia.

4. 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 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 microsporangiophores are not peltate. They are dorsiventral, scale-like structures. Each microsporangiophore 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.

5. 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.

9.6 SUMMARY

1- The main plant body of taxales are sporophytic.They may be shrub or small trees.

2- Wood is pycnoxylic and elastic because of the presence of tertiary spirals on the walls of trachieds.

3- Plants are unisexual and the ovule is solitary and terminal .

4- Resin canals are not found.

5- The seeds are endospermic and dicotyledonous embryo.

6- Commonly known plants are taxus baccata which is evergreen tree and native to Europe.

7- Torreya taxifolia is large tree having secondary wood ,single vascular bundle in each leaf, tertiary spirals in tracheids and native to some east asian countries and USA.

8- Amentotaxus seed is found surrounded by its aril and several bracts.

9- Order taxales includes genera like taxus, palaeotaxus, psueudotaxus, amentotaxus, aurotaxus etc.

9.7 Terminal questions

Q.1 Explain the general characters of taxales.tell about some genera of taxales..

Answer..
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Q.2 Describe in brief the posotion of taxus in coniferales and explain the economic importance of this plant.

Answer..
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Q.3 Describe the male and female reproductive structure of taxales..

Answer...
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....

Q.4 Write short note on

a. male cone of taxus

b. palaeotaxus

c. psuedotaxus

c. economic importance of taxus

d. taxus leaf

9.8 Answers

SAQ

1.unisexual

2. absent

3. terminal

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PGBY-106 (N)

Gymnosperms and Palaeobotany

3

Block

Gnetopsida & Palaeobotany

Block-3

Gnetopsida and palaeobotany

This is the third block of gymnosperm and paleobotany. This block gives the knowledge about gnetopsida and palaeobotany. Gnetopsida is a class of gymnosperms, which are seed producing plants without flowers. This class includes the order gnetales, which consist of three extant families, gnetaceae, ephedraceae and welwitschia. They are uniqe among gymnosperms due to some morphological characteristics. This block includes three units.

UNIT.10 This unit covers the order gnetales and some plants like ephedra, gnetum, and welwitchia.

UNIT.11 This unit gives the knowledge of fossils, geological time scale and application of paleobotany.

UNIT.12 This unit covers the types of fossils, their method of preservation and reconstruction of fossils.

UNIT-10Gnetopsida

Structure

10.1 Introduction

Gnetopsida is a class of gymnosperms. These are seed producing plant without enclosed fruits. This group forms a link between gymnosperm and angiospers. They includes extraordinary morphology and diverse habit. They ressembles gymnosperm like in that their ovules are naked, born on cones and also resembles angiosperm like in that their ovules and micriosprangia are born on flower like fertile shoot. Gnetopsida include three extant genera, Gnetum, Welwitschia, and Ephedra. They exhibit some unique characteristics, such as vessel elements in their xylem and double fertilization, which is typically seen in angiosperm. Gnetopsida are a small but distinctive group within the plant kingdom. These are distributed in both Eastern as well as Western Hemisphere. Gnetum occurs in tropical forest regions of Africa, Asia, and Sauth America. Welwitschia covers an area of Africa and south west Africa. Welwitschia is a monotype genus. It includes only one species.

Objectives

1.To uderstand the class of gymnosperm gnetopsida.

2.To know about general characters of ephedra.

3.To know about morphology and reproduction of gnetum.

4.To undrestand about the family welwitchia.

10.2 Ephedra

The genus has been reported to occur from sub alpine Himalayas spreading form Western Tibet to Sikkim, Rajasthan and Punjab. Hooker recorded three species of Ephedrine, i.e., E,vulgarise, E.pachyelada and E.penduncularis from India and adjacent countries. There occurs a great variation in the number of species of Ephedrine occurring in India. At present six species are known to occur in India. E.foliate Boss is common in deserts of Punjab, Sindh and Rajasthan. E.intermediary Shrank is found in N.W. Himalayas Kashmir, Punjab, Himachal

Pradesh and Jaunsar. E.guardian Wall occurs in dry alpine and temperate Himalayas spreading from Kashmir to Sikkim. E.saxatilis Royale var. sikkimensis Florin occurs in Sikkim and adjacent countries. E.nebrodensis Tin is more common in Kashmir. E.regalia Florin grows well at ladakh and lahul. Species of Ephedrine occurring North West Himalayan region are all shrubby except E.foliate which is a climber.

External characters

Most of the species are woody shrubs, reaching a height of up to 2 metres. The plants are xerophytes. Root are long tap root type in xerophytes species. The stem is profusely branched. When young stem the branches are green. Occasionally the rhizome may also be present. It develops from maxillary bud and help in vegetative propagation. The stem is fistula. The nodes and Internodes elongate by the activity of a meristematic zone lying at the base. Each zone dries up at the end of growing season and causes the brittleness and shedding of branches. New maxillary shoots are given off in the next season. The apical buds of branches are provided with 4 to 5 undeveloped internodes covered by scales. Stem is photosynthetic phylloclade and apparently resembles Equisetum.

The leaves are very small, scale like and inconspicuous. They are cystic and usually arise in opposite and decussate manner. In a few species the leaves are arranged in whorls of three or rarely even four at each node. Each scale leaf possesses a thick midrib with a thin border which rarely bears any stomata. Scale leaves of a whorl are united at the base. Each leaf is supplied at the base by a double leaf trace. The venation is parallel. Foliage leaves are generally lacking. The leaves are deciduous. An curly abscission layer causes shedding of the leaf leaving a broad scar.

Internal characters

The anatomy of the root resemble a typical gymnosperm. It is diarchy or rarely tierce. The outer surface of the stem shows ridges and furrows. Epidermis is thick walled. It is covered by a thick layer of cuticle. At some places it is punctured by haplocheilic stomata. Each of which is sunken in a circular pit in the furrow between the ridges. Hypodermis is represented by a group of very thick walled cells lying under each ridge. The cortex is differentiated into an outer palisade layer and an inner spongy tissue. The cells of both palisade and spongy tissue possess chloroplasts and are provided with intercellular spaces. The innermost layer of the cortex represents well defined endodermis. It surrounds the end arch siphonostelic vascular cylinder. pericycle is not well demarcated.

Vascular bundles are collateral. The cambium occurs in between the xylem and the phloem. The primary cambium is persistent. Each internodal usually has two pairs of small bundles and four leaf bundles. Each trace is supplied with two leaf trace bundles. Thus there occurs a double leaf trace for each leaf as found in pteridosperms. The presence of scale like leaves with double leaf trace is an ancestral character. Pith is usually parenchymatous. Near the nodes pith is composed of strongly lignified cells which form a epidermal diaphragm accounting for the rapid separation of branches in these regions.

Secondary growth occurs as a result of activity of persistent cambium and causes the older stems to become greatly thickened. In course of the formation of secondary wood annual rings are formed. The young stems possess thin and uniseriate xylem rays. Xylem rays when mature become broad and multiseriate due to their vertical growth and fusion of adjacent rays. The tracheids have a single row of bordered pits with crassulae on both the radial and tangential walls. Stages of transition from tracheids to vessels occurring in old stems point out an independent origin of vessels. Presence of vessels is the most interesting feature resembling those of angiosperms. Vessels are large in size and are found in abundance in spring wood. They are scarce and small in autumn wood. New cells with large stellate crystals of calcium oxalate are also found. Phellogen arises outside the secondary phloem during the third or fourth year of growth of the plants. It results in the formation of periderm which displaces all the outer tissues.

The leaves are highly reduced and scaly. They do not exhibit well marked tissue differentiation. Single layered epidermis bears haplocheilic type of stomata. A layer of palisade lying just below the epidermis constitutes the greater part of the mesophyll. Air chambers occur in between the palisade and stomata. Embedded in mesophyll are two vascular bundles each of which is collateral and closed with the xylem on the adaxial side. The presence of well marked tunica layers in the shoot apices are reported .

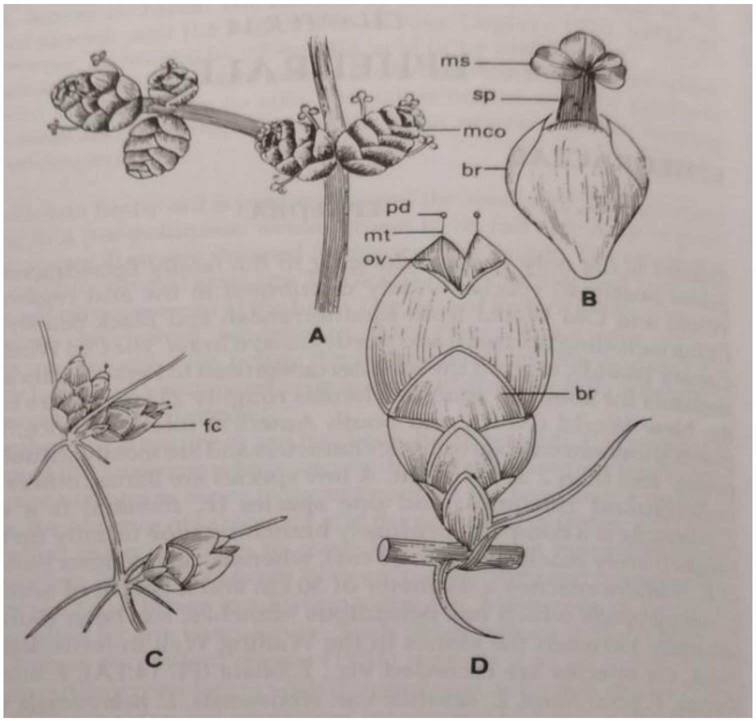

Fig10.1.Ephedrafoliasta;A.twig bearing cluster of male cones,B.male shoot bearing microsporangia,C.twig bearing female cone,D.female strobilus bearing ovule.

Reproduction

Most of the species are dioecious. Monoecious plants are also found sometimes. The sex organs are borne on unisexual compound strobilus which occur as small spikes at the nodes and resembles the inflorescence of angiosperms.

Male strobilus

The male strobilus arise in the axils of scale leaves at each node of the fertile branch of male plant. They arise in whorls of 2, 3 or 4. Each strobilus consists of a short central axis on which are borne 2 to 8 pairs of opposite decussate bracts. The lower 1 or 2 pairs of bracts are sterile. Solitary male flowers arise form the axils of fertile bracts. Usually a single male flower arises in the axil of a fertile bract. The compound male strobilus bearing male flowers is thus similar to an inflorescence. Each male flower is maxillary in position. It consists of a short axis. The microsporangiophore at its tip bears 1 to 8 micro sporangia (anthers). At its base each microsporangiophore is clasped by two anterior posterior thin bracteoles. These bracteoles are united at the base and possess no vascular tissue. The microsporangiophore is formed as result of fusion of a pair of microsporophylls. The number of microsporangia within a single male flower varies from 1 to 8. These are situated at the apex of microsporangiophore. Microsporangium possesses 2 to 3 loculi and is often called as synangia. Each loculi opens through a terminal slit to release the microspores. The pollen grains are shed in favourable season.

Female strobilus.

The female strobilus arise in the axils of scale leaves at each node of the fertile branch of female plant. They also arise in whorls of 2, 3 or 4 but are usually smaller in size than the male strobilus. Each strobilus consists of a central axis with 2 to 4 or more pairs of opposite decussate bracts. It is an elongated structure pointed at the apex. The pairs of the bracts are fused below so as to form cup like structures. Each female flower is maxillary in position. It consists of a short stalk and a megasporangium at its apex. The megasporangia consist of a centrally situated nucellus surrounded by an outer and an inner layer of integument. The ovule is bitegmic in nature i.e. with two layered integument. It is unique character among gymnosperms .

Microsporogenesis.

The development of the microsporangium is eusporangiate. The archesporial cells divide periclinally to form primary partial cells and the centrally situated primary sporogenous cells. Primary parietal cells divide periclinally and the resulting cells differentiate into a single cell thick wall layer on the outer side and tapetum on the inner side. Primary sporogenous cells ultimately form microspore mother cells. During the formation of microspores, the microspore mother cells undergo reduction divisions. The tapetal cells become 2 to 4 nucleate.

Megasporogenesis.

The archesporial cell or functional megaspore mother cell is hypodermal in origin .This divides repeatedly by periclinal divisions and cuts off several wall cells or parietal cells. Soon after the overlying epidermal cells of the nucellus also divide periclinally. The megaspore mother cell undergoes reduction division and forms a linear or T- shaped tread of four cells. The lowermost cell usually behaves as functional megaspore.

Male gametophyte.

The microspore represents the earliest stage of male gametophyte. Each microspore is a boat shaped and unwinged structure. Microspore possess an outer thick wall the exine and the inner thin wall the intine. The microspore nucleus divides and cuts off the first prothallial cell. The generative nucleus now gets surrounded by a cytoplast sheath and forms a naked cell that divides to form a stalk cell nucleus and a body nucleus. Both the stalk cell nucleus and the body cell nucleus remain in a common sheath of cytoplasm. The microspores are shed from the microsporangium at this 5 celled stage. On reaching the pollen chamber microspore germinates. Its exine ruptures and the intine elongates to form a pollen tube. Body nucleus divides to form two male gametes.

Female gametophyte.

The functional megaspore represents the earliest stage of female gametophyte. The functional megaspore divides by free nuclear divisions. First of all the megaspore nucleus divides and forms two daughter nuclei which lie in two opposite poles as a result of the development of a large central vacuole in the spore. A pair of nuclei divide to form four nuclei. These nuclei divide further and forms about 256 nuclei. The number of the archegonia within a single ovule varies from 1 to 3. Each archegonia develops from a single superficial initial at the micropylar end of the female gametophyte. The archegonial initial divides to form a primary neck cell and a central cell. The primary neck cell divides to form eight tiers of neck cells. The central cell divides and gives rise to a ventral canal nucleus and an egg nucleus.

Pollination.

Like other gymnosperms pollination is anemophilous. The 5 nucleate microspores or Pollen grains are carried on by wind in early spring when a pollination drop is excluded by the long tubular tip of the inner layer of the integument. The microspores are sucked in by the drying liquid into the pollen chamber. Microspores come in direct contact with the archegonia by developing pollen tubes. Germination of the microspores takes place only a few hours after they have entered the pollen chamber.

Fertilization.

The pollen tube pierces through the neck tissue of the archegonia and bursts apically. It makes free all the four nuclei into the egg where both the ventral canal and the egg nuclei are present. The nucleus of one of the male cells fuses with egg nucleus to form a zygote. The zygote nucleus undergoes free nuclear divisions to form an embryo. The seed contains two large cotyledons which remain embedded within the tissue of female gametophyte. The mature seed possesses three distinct protective covering.

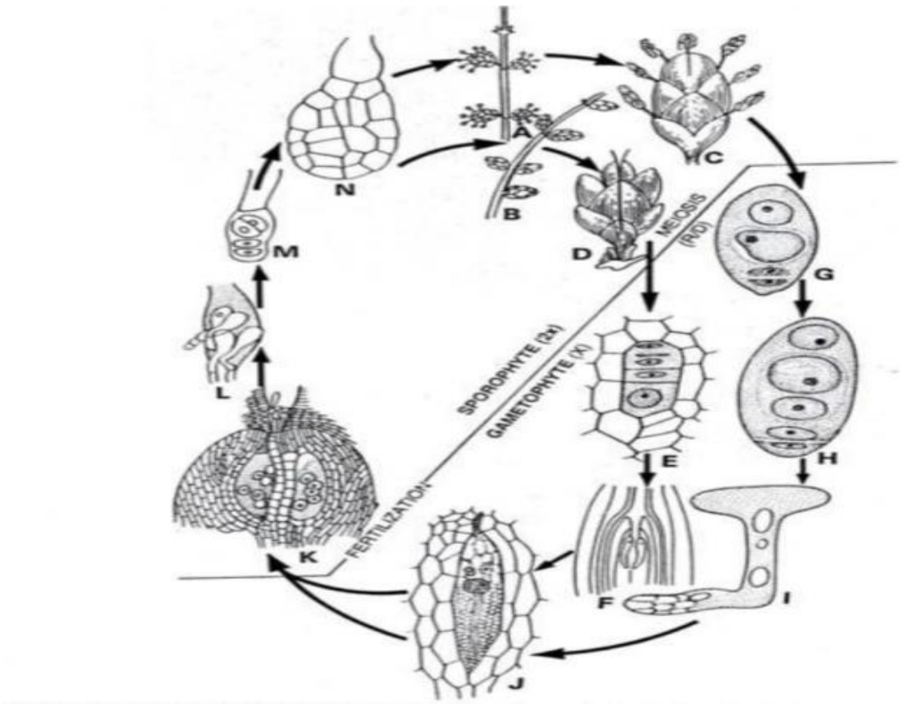

Fig10.2.Life cycle of ephedra

SAQ.

Choose the correct option

1.Ephedra pollen grains are shed at which stage

a.binucleate b.trinucleate

b.tetranucleate d.pentanucleate

2.Which of the following plant resembles equisetum

a.cycas b.pinus

c.gnetum c.ephedra

3.How many female cones develop on each node of ephedra

a.2-4 b.5-8

c.10-15 d.15-18

10.3 Gnetum

Gnetum with its about 34 species occurs in the tropical forest regions of Africa Asia and South America. The genus is not found in North America, Europe and Australia. In India according to Bharadwaj (1957) only five species of Gnetum

(G.gnomon, G.ula, G.Montana G contractor and G.long folium) are found and a sixth species (G.oblong) is found in Bangladesh.

External characters

Most of the species are trailing or vine like large lians (woody climbers). These are G.ula, G.Montanum and G.neglectum, but G.gnomon is a small sized woody tree. The lianas are devoid of the leaves on the basal parts of their stems. The twining species often in association with other tall plants reach a height of about 30-35 metres. The stem for the first 13 to 17 metres lacks leaves. G.trinerve is said to occur as a parasite on adjacent tropical trees of Cinchona. The most striking feature of gnetum is its general appearance in which it resembles very much with the angiosperms. There develops a tap root which later branches prolifically. The normal tap root persists only for four years. The roots do not go very deep in the soil. The stem is usually articulated with two types of branches, branches of limited growth (dwarf braches) and braches of unlimited growth. The leaves are indistinguishable from the leaves of an angiosperm in having a broad lamina leathery texture and reticulate venation. The arrangement of the leaves is in decussate pairs. They are exstipulate, shortly petiolate with a simple lamina. In the climbing species, the foliage leaves occur on the branches of limited growth. Scale leaves are found on the branches of unlimited growth as well as on the main shoot. However in G.scan dens the foliage leaves are borne on both types of branches.

Internal characters

The transverse section of a young root of Gnetum shows a diarch structure. The outermost layer is epidermis which is followed by a multilayered parenchymatous cortex. The cells of cortex are oval or polygonal and full of starch. Often cork cambium layer arises in the epidermis. There occurs a single layered endodermis around the pericycle. Two radially arranged vascular bundles are separated by parenchymatous tissue. The secondary growth is of normal type.

The transverse section of a young stem of Gnetum shows a ring of conjoint, collateral and endarch vascular bundles. The arrangement is similar to dicotyledonous angiosperms. The outermost layer is a well defined epidermis covered by a layer of cuticle. Epidermis possesses sunken stomata. The multilayered parenchymatous cortex is found impregnated with calcium oxalate crystals. Endodermis and pericycle like the root are not distinct. The vascular bundles are about 20 to 24 in number and are arranged in a ring. The xylem possess both tracheids and vessels. The tracheids are uniseriate with bordered pits. Phloem consists of sieve tubes, companion cells and phloem parenchyma. Phloem fibres are present in G. ula. Pith is broad, circular in outline and consists of thin walled rounded or polygonal parenchymatous cells. Secondary growth is a normal type.

The leaves are dorsiventral with upper and lower epidermis. On its upper side the epidermis possesses well developed cuticle. The stomata are distributed on the lower surface only. Stomata may be haplochelic or syndetocheilic type. The mesophyll consists of single celled thick palisade and spongy cells. The midrib is characterised by the presence of vascular strands arranged in the form of an arch followed by patches of stone cells on their lower sides. The vascular bundles are conjoint, collateral and endarch. The petioles are provide with transfusion tissues intermixed with the vascular bundles. Two larger groups of mechanical tissue occur on either side of the leaf.

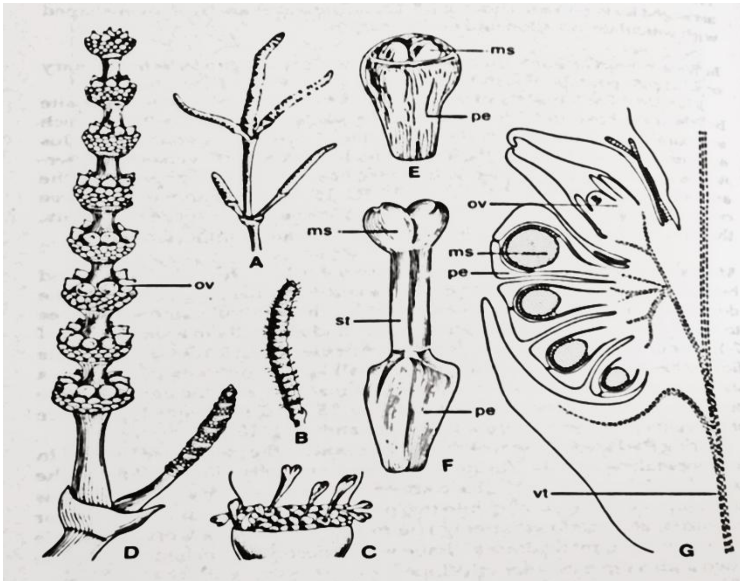

Fig10.3.Gnetum Ulva(reproductive organs)

Reproduction

Plants are usually dioecious. Reporoduction is sexual and the male and femal reproductive organs are often referred to as flowers which are organised to form inflorescence. Inflorescences are indeterminate. They arise in the axils of leaves. Inflorescences represent compound strobili and consist of long axis and flowers. The bracts fuse together and form a cup like structure called collar. The collars lie very close to each other because of suppression of internodes. The leaves usually fall before the strobili develop. Hence the branches bearing the strobili are leafless.

Male strobilus.

Each male strobilus normally possesses 10 to 15 cupules. The collars are arranged on the slender cone axis one above the other. Around the axis and just below each collar occur about 3 to 4 rings of flowers. Each ring possess 25 to 30 male flowers. Above the male flowers a single ring of about 10 to 15 imperfect female flowers with abortive oveules are situated. Collars, perianth and stalks of the male flowers possess branched or unbranched star shaped sclereids with narrow lumen and thickened walls. Laticiferous tubes also occur in these organs. Each male flower consists of a stalk with two unilocular anthers (microsporangia). When young each male flower is enclosed within a sheath like perianth which is apparently formed by the fusion of two bracteoles. Young microsporangia are enclosed within the anthers. At the time of the development of a microsporangium the tapetum is formed from the sporogenous tissue. When the microspores mature, all the cells between them disintegrate. The anthers dehisce longitudinally by slits to release the pollens.

Female strobilus.

The female strobilus is similar to male strobilus in its outward appearance and place of development. In the young female strobilus flowers remain hidden under the connate bracts. Like the male strobilus each female strobilus possesses a stout central axis growing between two bracts at the base. The collars are arranged one above the other each bearing a single ring of 4 to 10 flowers. Each female flower represents a single shortly stalked or sessile ovule. In the young strobilus all the ovules are alike but as the development proceeds, they show dimorphism i.e, with two types of ovules. The smaller ones degenerate and may fall off. Only a few ovules are able to mature into seeds. The female flowers are separated from one another by uniseriate hairs.

Microsporogenesis.

The young microsporangium shows usually two or more hypodermal archesporial cells which become prominent. These divide periclinally and form a multilayered archesporium. Archesporium is differentaiated into parietal layer and a mass of centrally situated sporogenous cells. The parietal layer divides further to form the wall layer and tapetum. The wall of the microsporangium soon becomes three layered: the outer single layered persistent epidermis, the middle layer and the tapetum. The cells of wall layer become flattened and the middle layer and tapetum disorganise leaving the epidermis. Epidermis shows fibrous thickenings and resembles those of the endothecium of angiosperms. In a mature anther the cells of the epidermis become radially elongated with outer walls thickened and cutinised. The sporogenous cells divide frequently and produce microspore mother cells.

Megasporogenesis.

The young ovule at the time of development differentiates two to four hypodermal archesporial cells in the nucellus. These archesporial initials divide periclinally to form primary parietal cells on the outer side and sporogenous cells on the inner side. Primary parietal cells along the nucellar epidermis divide repeatedly and form a massive nucellus. The sporogenous cells divide once or twice to form megaspore mother cells which arrange themselves in linear rows of 8 to 16 cells. The megaspore mother cells divide meiotically each forming two nuclei which separate apart but do not possess walls in between them. The second meiotic division results in the formation of a tetranucleatecoenomegaspore. In G.gnemon and G.ula a megaspore tetrad is never formed.

Male gametophyte.

The microspore has a spiny thick exine and a thin smooth intine. The microspores are formed in tetrads inside the microsporangium. Microspore nucleus devides to form a small prothallial cell and a larger cell. The nucleus of the larger cell divides to form two daughter nuclei, the tube nucleus and generative cell. Prothallial cell degenerates before germination of the microspore. The two unequal male cells are formed from the generative cell.

Female gametophyte.

The functional megaspore exhibits free nuclear divisions and appears more or less ovoid. It has four free nuclei aggregated in the centre, like other gymnosperms. A vacuole develops in the centre and causes the gametophyte to elongate and appear like an inverted flask. The vacuole now gets shifted twowards the upper part and the lower in the female gametophyte. After the microspores had reached to the pollen chamber the exine rutures and intine protrudes in the form of a pollen tube. Which may sometimes be branched. The generative nucleus didvides to form two non flagellate male cells or gametes. A very large number of microsopores germinate in the pollen chamber.

Fertillization.

With the entry of the pollen tube the egg nucleus beomes conspicuous and large. Sometimes it is 3 to 4 times larger than that of a normal vegetative nucleus. One to four pollen tubes are seen in a female gametophyte. Out of several tubes entering the female gametophyte, the one which is adjacent to egg pierces forcibly and reaches near the embryo sac. On coming in contact with the egg the wall of the pollen tube, at the pint of contact disorganises and the male gametes are released. Only one of them fuses with an egg to form a zygote.

The embryo

The zygote swell and exhibit free nuclear divisions to form two cells. One of them functioning as embryo and the other as suspensor. The tip nucleus of each primary suspensor divides into two. The upper remains in the tube as a persistent nucleus while the other is cut off by a wall and become the embryo initial. The embryo initial develops a number of elongated secondary suspensor cells towards the upper side and embryo towards the lower side. The mature seed is oval, elongated and green in colour.

SAQ.

Choose the correct option

1.Vessels are present in

a.Ginkgo b.Gnetum

c.Araucaria d.Zamia

2.Reticulate venetion is present in

a.Ginkgo b.cycas

c.Araucaria d.Gnetum

3.Development of stomata in gnetum is

a.syndetocheilic b.haplocheilic

c.both d.none

10.4.Welwitschia

External characters

Family Welwitschiaceae has only one genus Welwitschia. It has been considered as the most peculiar of all gymnosperms. The generic name Welwitschia, was given by Hooker (1863), in honour of its discovered Welwitsch. It is a monotypic genus with only one species W.mirabilis. The plant resembles a giant turnip or giant octopus . It reaches a diameter of more than one meter, with two large opposite strap shaped leaves. The part of the stem above the leaves has been referred to as the crown. The region between the crown and root refered as the stock. A perineum covers the whole body They grow very slowly. Welwitschia leaves are known to live longest in the plant kingdom.

Stomata are found on both surfaces of leaves. After the death of leaves the plant also dies. Leaves reach a length of nearly 3m and width of 1m. A series of ridges between the leaf and the stem apex is a special feature.

Internal characters

Root: The root of plant is diarchy. In older plant roots where secondary growth has taken place, there is cork and cells with fibres. The vascular boundles into the root form irregular concentric series of wood wedges which are separated by wide medullar rays. Wood wedges are in groups of 3-5 or even more. These wedges are larger towards the axis and smaller towards the periphery.

Stem: There is found a ring of collateral bundles in the main axis below the crown. Outside these bundles several incomplete rings of secondary vascular bundles are formed form accessory cambia in old stem. Two parallel series of bundles with their xylem towards inside found within the flanges of the crown. The vascular tissue appears as a cup shaped plate. they extends from one leaf groove to the other.

Each vascular bundle has its own cambium. Xylem and phloem in each ring is similar to that in polycyclic cycads. The bundles are long and narrow with straight rows of xylem cells to a certain distance when they become irregular. The phloem is consisting of sieve cells, parenchyma and aluminous cells. Vessels show single circular pores. These pores may be apical sub apical or lateral. The Secondary phloem consist of long narrow cells with prominent nuclei and sieve cells. The cortex is full of sclereids and the cork is produced from a phellogen.

Leaf: Leaf is isobilateral with epidermal cells on both the surfaces with heavy cuticle. The mesophyll shows palisade cells on both sides. The mesophyll cells are large in the centre. The palisade tissues in leaves consist of 3 or 4 layers of columnar cells. One of the most distinct character of Welwitschia leaf is the presence of numerous large, ramifying crystalliferous sclereids or spicular cells. These sclerieids also occur in root, stem and reproductive organs ,and also on scales. Crystals of calcium oxalate are embedded in the cell wall of sclereids. These sclereids contain flared pits. Gum canals are occasionally found between vascular bundles on the lower side near the phloem. Stomata occur on both the surfaces, more on the upper side.

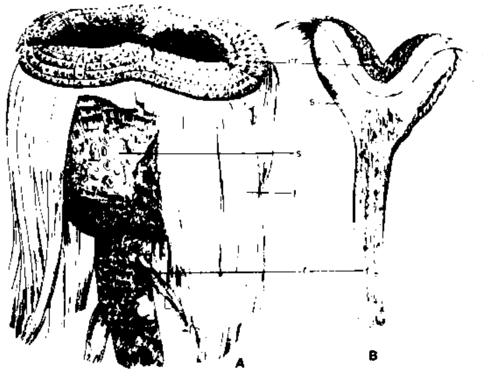

Fig10.4.Welwitschiamirabilis;A.showing the crown,stock and root,B.L.s of plant

Reproduction; Welwitschia is dioecious plant. Inflorescences arise in the leaf axil which are hidden in the groove. The ovulate, and the stamina cones or strobilus are compound and are borne in large numbers. The stalk is dichotomously branched.

Male cone: The male cone consists of opposite and decussate cone scales. Each male flower is bisporangiate and is subtended by a large cone scale. It consists of two lateral bracts and perianth of two parts, in decussate arrangement. These are followed by a whorl of six microsporangiophores. The cone scales and the perianth show a lager number of thick walledsclerenchymatous cells. Microsporangiophores are fused at the base into a cup like structure. Each microsporangiophore bears a synangium of three fused sporangia at the tip. The centre of the male flower is occupied by a sterile ovule with a single integument. There is a pair of minor bracts at the base of ovule.

Microsporogenesis and male gametophyte: The wall of young microsporangium consists of an epidermis, two tapetal layers, and sporogenous tissue. At the time of shedding the pollen grains are 3 celled and made of an ephemeral prothallial cell, a tube cell, and a spermatogenous cell. The pollen grain shed by vertical slit. They latter soon divides into two equal male nuclei. The sterile ovule has a nucleolus enclosed by a long and tortuous micropyle.

Female cone: The branching flower stalk bears numerous female cones. The young cones are green but become scarlet red at maturity. The female cones are simple because the flowers are not bisporangiate. The female flower consists of a central nucellus which is surrounded by two envelopes and two small lateral bract. The outer envelope is sometimes called perianth and the inner one is considered to be true integument.

Megasporogenesis and female gametophyte: A single megaspore mother cell differentiates in the nucellus. After meiosis there is no walls laid down, so that a tread of megaspores is not produced. A coenomegaspore is formed with four free nuclei. Thus The development is tetrasporic. All the four nuclei undergoes many nuclear divisions to form a thousand nuclei. Soon a large number of vacuoles appear and nuclei become randomly mixed up with the vacuoles. Walls are eventually laid down and forms two zones, a smaller micropylar zone and a larger chalazalzone. The upper micropylar consists of vacuolated cells. These grow upwards piercing the megaspore wall in to the nucellus. The prothallial ends become swollen, called fertilization bulb. In this swollen portion the fertilization takes place. The polyploidy nuclei undergo divisions and forms the actively growing endosperm. There is a thick megaspore wall which becomes thinner owing to trenching. A spongy tissue or nutritive tissue is absent. Any nucleus in the fertilization bulb may functions as egg and get fertilized.

Fertilization: Pollen tubes during their downward course comes in contact with fertilization bulb and release their male gametes inside this swollen portion. The fusion of male and female nuclei takes place in the fertilisation bulb resulting in the zygote. After division zygote forms embryo.

10.5 Summary

Gnetopsida is a class of seed plants that include the order gnetales.This group is characterized by unique features such as vessels elements in their xylem and compound pollen cones.The genera gnetopsida include gnetum,welwitschia and ephedra. Despite some similarities with angiosperm ,gnetopsida is distinct in its repruductive structures and has a long evolutionary history. Gnetopsida has vessel elements in their xylem, has double fertilization, and a covering over their seeds like angiosperms. Their leaves are also like angiosperms. They do not produce flower and seeds are not found inside the fruit.

10.6 Terminal Questions

Q.1 Describe the salient features of life cycle of ephedra.

Answer...
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Q.2 Give a comparative account of reproduction in gnetum.

Answer...
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Q.3 Explain embryo development in gnetopsida.

Answer...
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Q.4 Mention the salient features of the reproductive parts of gnetum.

Answer...
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Q.5 Explain the external and internal characters of gnetum .

Answer...
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Q.6 Describe the reproductive structures of welwitschia plant.

Answer...
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Q.7 Write short notes on following

a.Embryo development in ephedra

b.Mele and female gametophyte in gnetum

c.Fertilization in welwitschia

d.Angiospermiccharacterstics of gnetopsida

10.7 SAQ Answers

1.Pentanucleate

2.Ephedra

3.2-4

4.Gnetum

5.Gnetum

6.Both

UNIT-11 Paleobotany-1

Structure

11.1 Introduction

Palaeobotany is the study of the past life in the form of fragmentary fossil remains. It is a part of palaeontology, which is concerned with both plant and animal. The remains of past plants are called as fossils. The most convincing evidence of plant evolution is the fossil plant record which is helpful in the study of past plant life. The plants living today are the surviving members of the flora that flourished luxuriantly extending back through hundreds of million of years in the remote past. A fossil may be broadly defined as a record of former life. The word fossil came from the Latin word fodere which means 'to dig'. Thus in the original sense a fossil is something occurring in the earth and requiring to be dug out. These came to lie in the rocks as a result of slow and sudden changes that occurred in the earth parallel to the course of evolition of earth’s flora. Fossil plants are usually found in stratified rocks which are built up of sediments that accumulate in the bottoms of lakes, lagoons, seas, swamps, subsiding beaches and flooded valleys. These stratified rocks get exposed by the natural errosion and release the plant fossils. Man has also been obtaining them by means of drill holes mine shafts quarries and railroad and highway excavations. The preserved plants are usually fragmentary and the collections are scattered usually since the softer tissues decay the records have badly been curated, lost or destroyed.

Objective

1.To know about the paleobotany.

2.To understand the techniques of fossil study.

3.To know about geological time scale.

4.To understand the importance of fossil study.

11.2Techniques for studying fossils

There are several methods for the study of fossils. These are as follows:

1- **Thin ground section** This technique is applicable in case of petrifactions like fossilised woods and coal balls. Coal can also be studied by grinding thin sections. Thin sections are prepared from the petrified plant materials. Then they grinded till they attain the required thickness and become translucent, thus making the cellular frame work of the tissues clear.

2- **Film or peel techniques**The film or peel technique is a method by which serial sections can be taken out from petrified specimens. It is of most importance in case of small fragmentary materials and those which need serial studies. During the process first the surface of the material is incised with a mineral acid then a commercial acetate film or solution of nitrocellulose is spread over the incised surface and then it is peeled off when dried. The film transfer technique has also been used with excellent results on compressions particularly minerals with calcite, bituminous and anthracite coals and fine grained sediments. The film technique is more advantageous than the ground section because the former is more translucent, thinner, less expensive and quicker to prepare. But the ground section technique is most appropriate and ideal since it keeps the fossil structure in a unchanged condition. The only drawback in film technique is the trapping of small air bubbles which often interfere during high magnification under microscopes.

3- **Maceration technique.** It is commonly used in the cases of peat lignite and coal. During the process the specimens are treated with a mineral acid or other suitable reagent which separates large fragments or even complete organs of fossil plants from the rocks for microscopic importance. The techniques is immense importance in study of spores and pollen grains.

4- **Transfer technique.** It is most suitable for the study of compressions. In fossil plant transfers, structural features such as the venation, the nature of vascular elements and the structure of epidermis along with stomata may sometimes be observed. During the process the plant fragment is freed from associated rock and cemented to a glass slide. The exposed surface of the glass is coated with paraffin wax and then it is treated with some mineral acid to remove mineral matter. The specimen after being washed, dehydrated and mounted, is ready for the study. The process is slow, but causes least destruction to the fossil. Aithough the specimen is usually dense and blurred.

5- **Microtome method.** The specimen is kept for few weeks in hydrofluoric acid and potassium chloride. Then treated with a mixture of equal parts of phenol and 95% alcohol. Finally it is embedded and sectioned with microtome. Because of prolonged process of demineralising and embedding, the method has not received proper attention.

6- **Excavation technique**The specimens of plant fragments are removed with micro-bibratory machines or with a small hammer and steel needles. The process is slow and tedious. Sometimes it gives excellent results for the minute leaves and sporangiophores. Calamophyton were obtained by the excavation technique.

7- **Electron microscopy**The observations made by Wesley and Kuyper on the xylem elements of Lepidodendron were based on electron microscopy. The technique showed the presence of cellulose and lignin in the cell wall but is commonly not employed due to complex equipment and complicated procedure involved.

8- **X-ray radiography**The plant fossils when photographed by x -rays exhibit differential shadows corresponding the density. A shadow picture taken by a sensitised film (radiograph) can be used for their study. The technique was used by Darrah during his study of certain calcified seeds from coal balls.

9- **Chemical methods**The basic principle underlying is to identify the constituents of fossil plants. The method has proved valuable in tracing the presence of chlorophyll and haemoglobin in carbonaceous sediments and carotenoids in lacustrine moods from post Pleistocene lakes near Moscow. C 14 method is most valuable technique for the study of fossils.

Determining the age of fossils

Fossils formed in the past are embedded in earth layers of different ages. In a geologically undisturbed section of the earth’s crust the deeper layers are the older layers. High lying land erodes material which gradually piles up on low land and on the sea bottom. A deep layer today, therefore, was on the surface in the past and earth’s surface to day will be a deep layer in the future. Fossils embedded in successive layers thus provide a time picture of evolution. To be sure, the fossils lying deep, are normally not accessible but occasionally make their appearance by a canyon cutting river and earthquake fracture or a consequent breaking of earth’s crust.

The actual age of a rock layer is determined and excellent clocks are built right into the earth’s crust based on the radioactive substances. The rate of the disintegration and the end products of disintegration of these substances are accurately known. A given quantity of radium is known to decay in a certain span of time. When these are found together in one mass within a rock the whole mass presumably had been radium originally, when the rock was formed. One can then ascertain the time required for that much lead to form. This dates the rock with an error of about 10 percent of its total age.

11.3A Geologic Time Scale

Based on data obtained from fossil and radioactive clocks it has been possible for geologists to construct a geological time table indicating the age of successive earth layers and provide a calendar of earth’s past history. It is assumed that our earth is made about 4.6 billion years ago. Based on the different methods of the fossil study the chronological order of the history of the organic evolution was made and presented in the form of time scale. This time scale is known as Geological Time Scale. This geological time scale is divided into larger and smaller subdivisions. The time scale includes the history of the earth from time of its origin. This calendar consists of five successive main divisions of eras. The last three eras are subdivided into a number of successive periods. These divisions help chronical earth's history and evolution over millions of years.

Eon This is the largest intervals of geological time. Two or more geological eras form an eon, which is the largest division of geological time.

Era Eons are divided into smaller time intervals, knownaseras. Phanerozoic is divided into three eras; cenozoic, mesozoic, paleozoic.

Period Eras are subdivided into periods. Paleozoic is sub divided into permian, carboniferous, devonian, silurian , ordovician, and cambrian.

Epoch This is the smallest division of geological time. Epoch is the subdivision of periods.

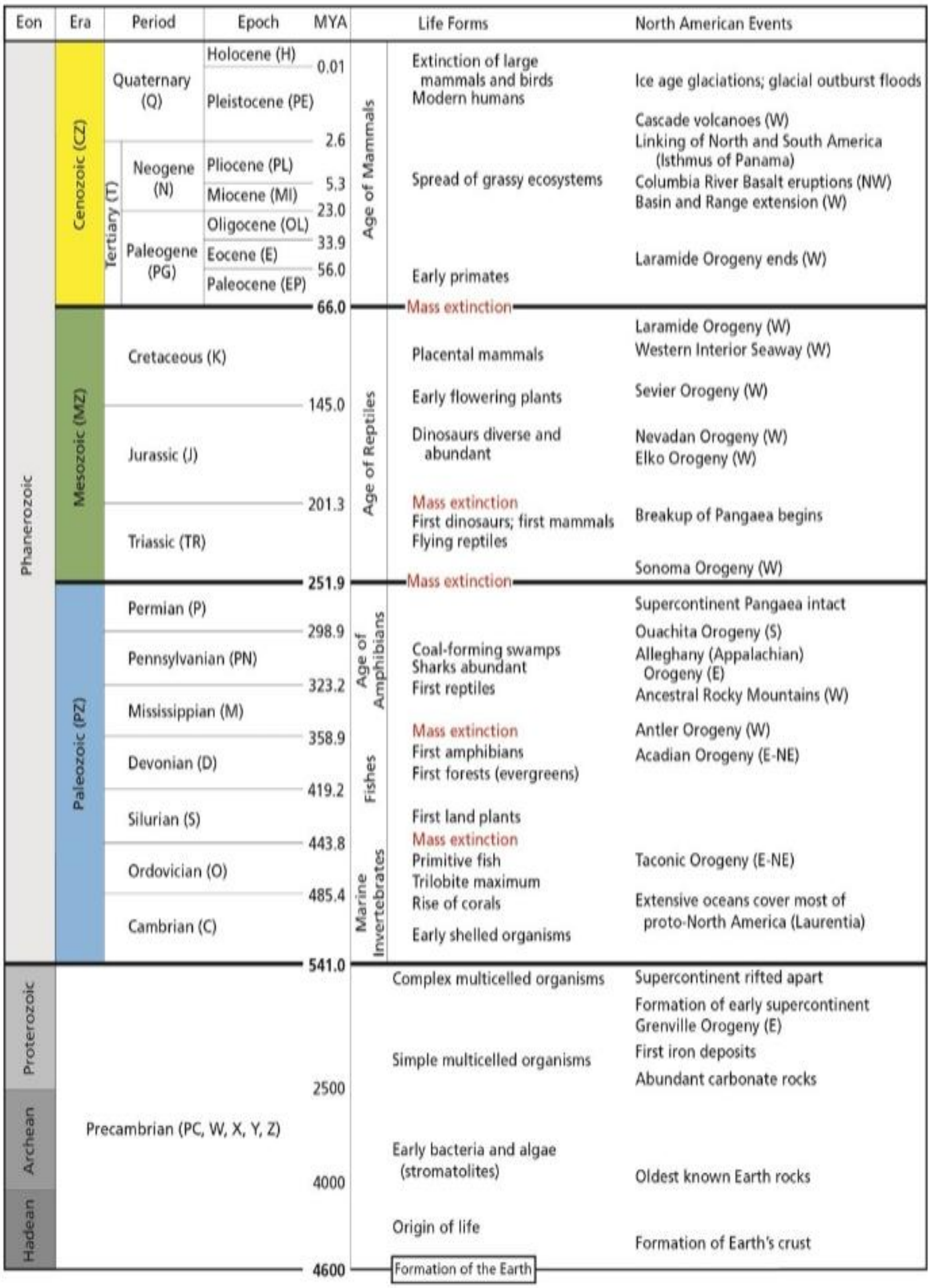

Fig.11.1-Geological Time Scale

11.4 Application of paleobotany

Paleobotany is the branch of botany in which we study about plant fossils. This branch deals with the identification of plant remains from geological context. It helps in biological construction of the plant environment and its evolutionary history. Fossil evidences helps to understand and to study the process of plant evolution. Fossil record helps to understand the origin of algae, fungi, gymnosperm and angiosperm etc. The knowledge of occurence of many plant groups can be used to understand relationship of environment of earth and plants on geological time. It is helpful in the natural classification of plants. Fossil plants can be used in the field of descriptive and comparative anatomy. Paleobotany is helpful in tracing the evolution and phylogeny of plants. Certain plants are resistant to decay, when they burried in mud or sand bacome transformed into fossils. These fossils are helpful in stydy of evolution. Fossils can be used for following purposes ;

1. **Fuel and gas exploration** Paleobotany provides useful information in the exploration of fossil fuel. Many plants inhabitated in paleozoic and mesozoic swamps acts as a source of coal and oils. The study of fossil plants has played an important role to understand the process of coal formation. By studing microfossils, we can determine the distance and direction of oil bearing ancient shore lines. Paleobotany provides the evidence for origin and evolution of plants.
2. **Evolutionary biology** By analyzing fossilized remains, researchers can trace the evolution of species over time,identifying transition forms and patterns of adaptation.
3. **Paleontological research** Fossil reconstruction helps scientists to study the anatomy, behavior ,and ecology of extinct species, contributing to our understanding of past ecosystems.
4. **Stratigraphy** Fossils assist in dating and correlating rock layers, helping geologists in establishing the chronological sequence of Earth history.
5. **Climate change studies** Fossilized plants and animals provide awereness into ancient climates, helping researchers reconstruct past environmental conditions and track changes over geological time.
6. **Biogeography** Fossils help in understanding the distribution of species in different regions throughout history, providing information about past land connections and barriers.
7. **Human evolution** Fossil reconstructions especially of hominins, contribute to the study of human evolution, helping scientists to understand our ancestor's physical characteristics and behavioral patterns.
8. **Biodiversity studies** Fossil data contribute to assessments of past biodiversity, helping conservation efforts by understanding historical species distribution and extinction events.

9. **Medical research** Comparative anatomy studies involving fossilized remains can offer perceptions into the evolutionary origins of certain traits and diseases.

10. **Educational purposes** Fossils serve as valuable educational tools, allowing students to learn about the history of life on earth and processes that have shaped it.

11.5 Summary

Paleobotany deals with the recovery and identification of plant remains from geological context. These are used for the biological reconstruction of past evolutionary history of plants. There are many techniques for the study of fossils. The history of the earth is divided into four eras. The first of these the precambrian era ended about 500 million years ago and characterised by the scarcity of fissils either of animal or plants. Thenpaleozoic era characterized by marinlife. After this mesozoic and caenozoic era comes. These eras are again divided in periods and then subdivided. Based on data obtained from fossil and radioactive clocks, it has been possible for paleobotanists to construct a geological time table. This scale provides a way to understand the vast expanse of Earth's history from its formation to the present day.

11.6 Terminal Questions

Q.1 What do you understand by paleobotany ? Describe the different techniques to study fossil.

Answer...
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Q.2 Write an essay on geological time scale.

Answer...
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Q.3 What are methods employed in the study of fossils ?

Answer...
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Q.4 Write the application of paleobotany.

Answer...
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Q.5 Write short note on

1. Thin ground section techenique
2. Maceration technique
3. Electron microscopy techenique

Q.6 Write note on the following

1. Eons
2. eras
3. Epochs

UNIT-12 Palaeobotany-2

Structure

12.1 Introduction

Any object connected with ancient organisms is considered as a fossil. Diatomaceous earth formed by the skeletons of billions of diatoms depositing on the sea bed, graphite used in lead pencils, different types of algal limestone's and even petroleum are to be considered as fossils. Sometimes certain minerals during their formation or crystallisation resemble some plants (algae). These are called as pseudofossils. Sedimentary rocks often play a key role, providing a stable environment for fossilization over millios of years. Pleontologists use careful analysis, comparisons with related species and advanced imaging techniques to reconstruct fossils accurately.

Objectives

1.To know the types of fossils.

2.To understand the process of fossil preservation.

3.To know about the form genera and organ genera.

4.To understand the reconstruction of fossils.

12.2 Types of fossils

The plants are preserved in earths crust in various ways. Various kinds of preservations require their own technique for study. According to the nature of fossilisation the fossils can be classified into the following types.

1- **Compressions** This is the most common kind of preservation, in which much of the organic matter of the plant is preserved with the impression of the plant. The organic matter retained on the surface may be a layer of the structure less carbon, although sometimes the cell pattern of the cutinised epidermis is retained. These are formed as a result of great vertical pressure of the sediments. The buried plants or plant parts are highly compressed due to the Weight of the sediments lying over them. Coal is usually considered to be a complex kind of compression formed by an extensive accumulation of the plant material that is gradual compressed in a basin of water. Differential pressure causes the variation in the kinds of coal. Black or bituminous coal of common usage in factories and our homes is resulted due to an excessive compression often as much as to produce only one foot thick layer of coal from a 15 feet thick half rotten free trunk branches and leaves.

The study of coal under reflected light by grinding thin sections or by maceration reveals the presence of cuticles wood fragments, bark fragments, making of leaves and resins. These include most of the familiar carbonisations as is evident from the fact that the largest percentage of coal was laid down around 250 millions of years ago in the carboniferous period. Compressions may be studied by film transfer or maceration.

2- **Impressions** These are the prints made by plants or plant fragments, which come in contact with a soft clay. When the sediments increase in thickness with entombed plant material, compression results and the less resistant and more compressible plant part is flattened to a mere fraction of its original thickness. A leaf falling on semi stiff clay, after its organic matter has decayed leaves the imprints of its form and veins. The plant material disorganises and leaves the impression. When clay gets converted into a rock, gives a superficial resemblance of the fragment preserved. These are often darker in colour than the surface of the rock below due to retain some of the organic material. Some of the specimens look extremely beautiful like paintings or bass relief of the actual twigs. The structures like stomata are clearly seen in very good preparations of well preserves specimens because of intact epidermis. No cellular details are left.

3- **Incrustations** Theseare the common type of fossils. In their formation the plant part gets covered up by sand or mud. Then the covering sediment of the mould becomes hard and the plant material inside rots away leaving hollow. The space formerly occupied by the plant which now is rearrested by a hollow gets filled up by some rock forming material. Furthermore, the inside as well as outside solidifies into the stone, from which the external part may be peeled off leaving an exact cast of the plant part showing all its surface features. Their mode of formation can be confirmed by obtaining moulds from clay or plaster of paris. These actually do not contain any of the original organic material of the plant or cellular detail. The surrounding material of the mould forms the incrustation while the rock material surrounded by incrustation is known as cast. They are valuable to palaeobotanists in reconstructing the external appearance of many kinds of plants. Casts of whole trunks stumps or seeds are usually formed when the plant part decays.

4- **Petrifactions (Mineralised plants.)** These are rarest type of fossils. They preserve both the external and internal structure, and sometimes substances of the original part. They are formed by involving a molecule by molecule replacement of the plant part by soluble minerals that eventually harden. These are rare and are the only means of transformation of the organic tissue into stone. Although the actual process of petrifaction is not very well understood. It is thought that the buried plant material absorbs mineral solutions like carbonyl sulphate, silicate phosphate etc. This infiltration is followed by precipitation so that calcium carbonate, magnesium carbonate iron sulphide, silica etc. get impregnated within the plant tissues. Although most of the organic material may get destroyed but at least some original cell wall compounds often remain and make the whole structure stone like. Vegetable fossil preserves every cell of the plant tissue. They can be used for obtaining fine sections by stone sectioning methods and studied for exact internal details under the microscope. Silicified woods bits of stems twigs seeds and sporangia and coal balls are some common examples of pretrifications.

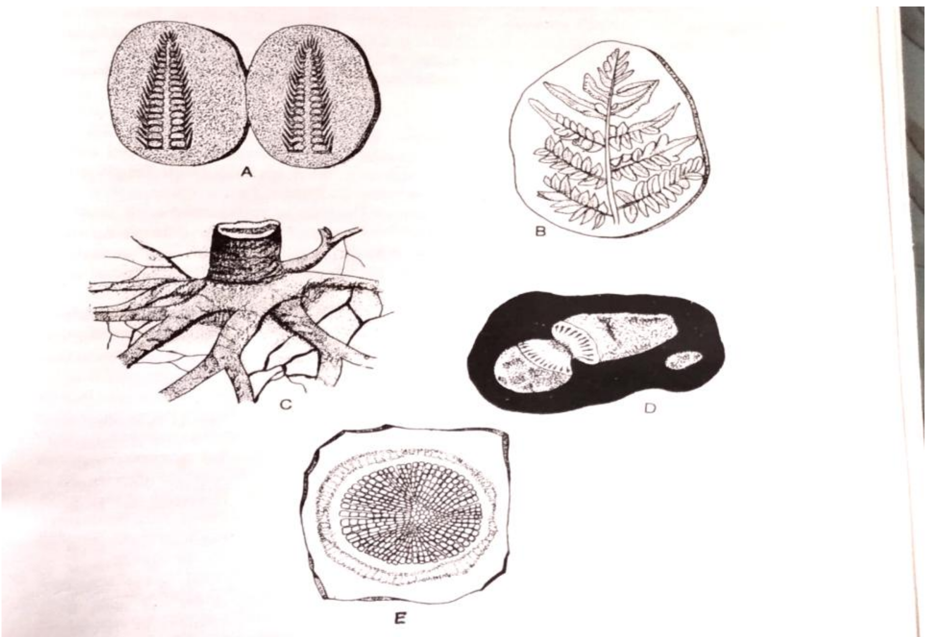

Fig. 12.1- Compression (Lepidodendron cone); B- Impression (Neuropterans leaf) C- Cost. (Stigmarian stump); D- Section of a coal ball showing T.S. of a metrification (Sphenophyllum stem); and E- Section of a mass of coal with petrified stems within coal balls.

Coal balls are irregular or sub spherical masses of mineral matter, usually of magnesium or calcium carbonates which vary in diameter (from a few mm to about 1 meter) and in weight (from 25 to 35 gm or more quintals). They occur in great numbers within chunks of coal. These are of localised occurrence and may be congregated in definite bands or in irregularly scattered pockets. Coal balls show petrified remains of a great number of plant parts representing the debris of past. Sometimes delicate parts remain intact in the coal balls so that the internal morphology as well as external morphology is clear.

5- **Compactions (Mummified plants)** These are the plants or plant fragments compressed by vertical pressure. Masses of plant fragments without intervening matrix, such as occurring in peat, lignite and coal, are large scale compactions. Occasionally in leathery leaves or tough fruits, the tissues are retained in a mummified condition. These can be embedded and sectioned for the microscopic studies.

6- **Ambers** These are the resinous excretions of certain fossil coniferous trees which flowed due to injuries caused by boring insects or decaying branches. These often dropped to the floor of the forest, gradually hardened and accumulated over long ages. Besides the insects and small animals, these enclose plant fragments some of which are well preserved and are ranked as fossils.

12.3 Methods of preservation

The process of fossilisation is going on in nature even now. The ancient plants or plant fragments are being turned into fossils or are being fossilised even since the sedimentary rocks began to deposit. It is essential for fossilisation that the whole organism be buried alive or soon after death without decay by bacteria, fungi and termites. Only a small number of plants become fossils because most of the plants either decay or are eaten away by animals. The suitable conditions for the fossil formation occur such as in swamp with very cold or acidic water and low oxygen supply, which stop decay of plants. Under these conditions fine sand or mud is deposited over the plant or plant part soon it has settled on the sea or lake bed. This deposit protects the plant body. A sediment containing plant body surrounded by the deposit is deeply buried. Through geological changes this sediment is compressed under weight of other sediments deposited on the top and reaches to a greater depth. Finally, it is converted into a sedimentary rock containing plant fragments which are preserved as fossils. The plant remains undergo several changes Besides swamps, falling volcanic ash and snow also help in fossilisation.

In most of the Indian Gondwana coal deposits, where the plant parts were carried down by riveres and got deposited in estuarine areas. After the plant material got sunk to the bottom of a lake or estuarine water, their remained has rare chances of decay by fungi and microbes. During the formation of the fossils the protoplasmic contents are the first to disappear, then the soft parenchymatous cells but the harder wood and other sclerenchymatous or cutinised tissues resist to the last. The first hazard during the formation of the fossils is decay caused by microorganisms and then comes the overlying pressure caused by heavy sedimentary rocks. The pressure first reduces the vacant spaces in or outside the cells and forces the watery substances sometimes also marsh gas and humid acids out. The kind of fossil depends upon the conditions for fossilisation. Despite all hazards some of the fossils retain their cellular structures beautifully.

Factors for preservation

For the fossilisation it is essential that a plant or plant part must be in a region where deposition is taking place or it must somehow be transported to a region where sedimentation is taking place. Another important requirement is the presence of some kind of water like fresh, brackish or marine. The kind of tissue constituting the plant body is an equally important factor. Plants having hard tissues are more liable to fossilisation than those with soft tissues. Various other factors acting upon the plant both before and during the process include the rapidity of burial and prevention of microbial or autolytic decomposition. These operate under such circumstances as fine grainedsediments burial in stagnant water, low amount of available oxygen, rapid infiltration by minerals and protection against high winds.

12.4 Theories of preservation

There are various views regarding the fossilisation and plant preservation. These are

Molecule by molecule replacement theory According to this theory the original substance of the plant body has been replaced molecule by molecule by the mineral in solution. There are some cases where the complete replacement has taken place. These replacements are due to complete hydrolysis or weathering of any type of original organic substance except the cell wall material (lignin and cellulose). The replacement is gradual and is supposed to the complete where lignin or cellulose remain. The organic substances gradually diminish due to chemical breakdown and molecule by molecule replacement by any mineral substances like iron pyrites, lime carbonate or silica. Inorganic matters with exception to water are perhaps unable to react chemically with wood constituents. Since cellulose is soluble only in a few reagents so the small quantity of silica acid in magnetic water cannot dissolve cellulose and lignin. In nature calcium carbonate replaces salt crystals. The process is brought about by the solution and replacement by comparatively simple organic compounds. The plant cell walls are made up of many substances which reacts with reagents.

Infiltration theory This theory is based on the fact that the mineral matters are precipitated and infiltrated in the cell walls. The buried plant or plant part undergoes partial disintegration and results in the release of free carbon. It produces the sulphides present in water and leads to the formation of carbonates of calcium, magnesium and iron. Finally silica and other compounds are deposited within the cell walls through infiltration and precipitation. The theory can be emphasised by the peel method of preparing thin section. The process is entirely dependent upon the presence of organic materials within the cell walls.

12.5 Form Genera and Organ genera

There are little chances that a large plant or a tree would get fossilised in its entirety. Most of the fossils are represented by their fragments. Sometimes the various fragments of the same plant are recorded from different places of the same locality or from different places. These bits of plant fossils are assembled and hypothetically reconstructed and made into form genus. The fragments of various plant parts are assembled on the basis of relationship between various plant fragments. Reconstruction of such form genus is made up of plaster of Paris. The common example of form genus is Williamson sewardiana, an Indian specimen, described by Sahni from Rajmahal and Jabalpur series (Lover and Upper Jurassic of Gondwana Flora).

Form genus is the artificial taxonomic category accepted for organism of uncertain relationships like in imperfect fungi. Form genera refers a group of fossil plants that share similar morphological characteristics. These genera are often defined based on the overall form of structure of the plant rather than specific reproductive features. These classifications are based on observable features such as leaf shape, arrangement etc. Form genera are particularly useful when the exact relationships between different fossilized plant species are challenging to determine due to incomplete preservation.

Organ genera refers to groups of plant fossils classified based on specific organs like leaves, stems, and roots, that share common characteristics. These classification helps scientists to understand the diversity and evolution of ancient plant life based on fossilized ramains. The fern genus Osmunda, known for its distinctive fern leaves. Genus Glossopteris recognized for its unique seeds.

12.6 Reconstruction of fossil

Very rarely does a scientist find a whole plant. Fossil reconstruction involves piecing together preserved plant remains to understand their original structure and characteristics. It helps in revealing evolutionary patterns and understanding the past ecosystem. By compairing these finding with extent plant structures, researchers can find information about morphology, anatomy, and reproductive features of ancient plant. Various techeniques are used for this purpose.

Methods of fossil reconstruction

1. **Physical Reconstruction** Directly assembling fossilized bones or other body parts to recreate the organism's skeletal structure.

2. **CTScanning**Non destructive imaging techeniques like computed tomography [CT] scans helps visualize internal structures without damaging the fossil.

3. **3D Printing** Creating physical replicas of fossils through 3D printing allows scientist to study and handle accurate copies of the original specimens.

4. **Digital Reconstruction** Using computer software to digitally reconstruct fossils based on scans, enabling scientist to manipulate and study the virtual models.

5. **Comprative anatomy** Comparingfossilized remains to the anatomy of living organisms helps conclude missing features and understand the overall structure.

6. **Isotope analysis** Examining isotopic compositions in fossils can provide insights into the organism's diet, habitat, and physiology.

Process of fossil reconsrtuction Fossils reconstruction typically involves several steps;

1. **Excavation** Fossils are carefully unearthed from sedimantary rock layers using tools like brushes and chisels.

2. **Cleaning** Once exposed, fossils are cleaned to remove surrounding rock and sediments, revealing the specimen.

3. **Documentation** Detailed notes and photographs are taken during excavation to record the fossil's context and orientation.

4. **Stabilization** Fragile fossils may require stabilization using consolidants to prevent deterioration.

5. **Transportation** Fossils are transported to a laboratory for further study, often encased in protective materials.

6. **Cataloging** Each specimen is assigned a unique identifier and cataloged to maintain an organized record of the fossil collection.

7. **Analysis** Researchers examine the fossil for anatomical details, taking measurements and noting distinctive features.

8. **Reconstruction** Missing parts may be reconstructed using other fossils or through digital modeling to complete the specimen.

9. **Mounting** If the fossil is to be displayed, it may be mounted in a way that accurately represents its natural posture.

10. **Research** Fossils contribute to scientific understanding through research, helping to reconstruct ancient environments and ecosystems.

12.7 Summary

Paleobotany is the study of past life of plants through fossils. The process of fossilisation depends on the environmental condition in which it takes place. There are many kinds of fossils. Compressions are the fossils found in sedimentary deposits. Impression fossils are the print formed by the plant or part plant on comming in contact with a soft clay. Incrustation, petrification and compaction are the other kind of fossils. According to molecule by molecule replacement theory, the original contentof the plant body got replaced molecule by molecule in a mineralized solution. The replacement is gradual and are due to complete hydrolysis. Infiltration theory is based upon the fact that the minerals are precipitated in the cell walls. Finally, by the process of infiltration and precipitation, silica and various other compounds get deposited within the cell wall.

SAQ.

Fill in the blanks

1.Williamsonia belongs to genus ....

2.In geological time scale, the age of gymnospers is known as the period

of.....................

12.8 Terminal Questions

Q.1 Describe the process of fossilization.

Answer...
....
....
....
....

Q.2 What do you understand by form genera and organ genera?

Answer...
....
....
....
....

Q.3 Describe the deffernt types of fossils.

Answer...
....
....
....
....

Q.4 Write about the reconstraction of fossils.

Answer...
....
....
....
....

Q.5 Write short note on

1. Petrifaction
2. Incrustation
3. Impression

SAQ Answers

1. bennittiales
2. triasic and jurassic

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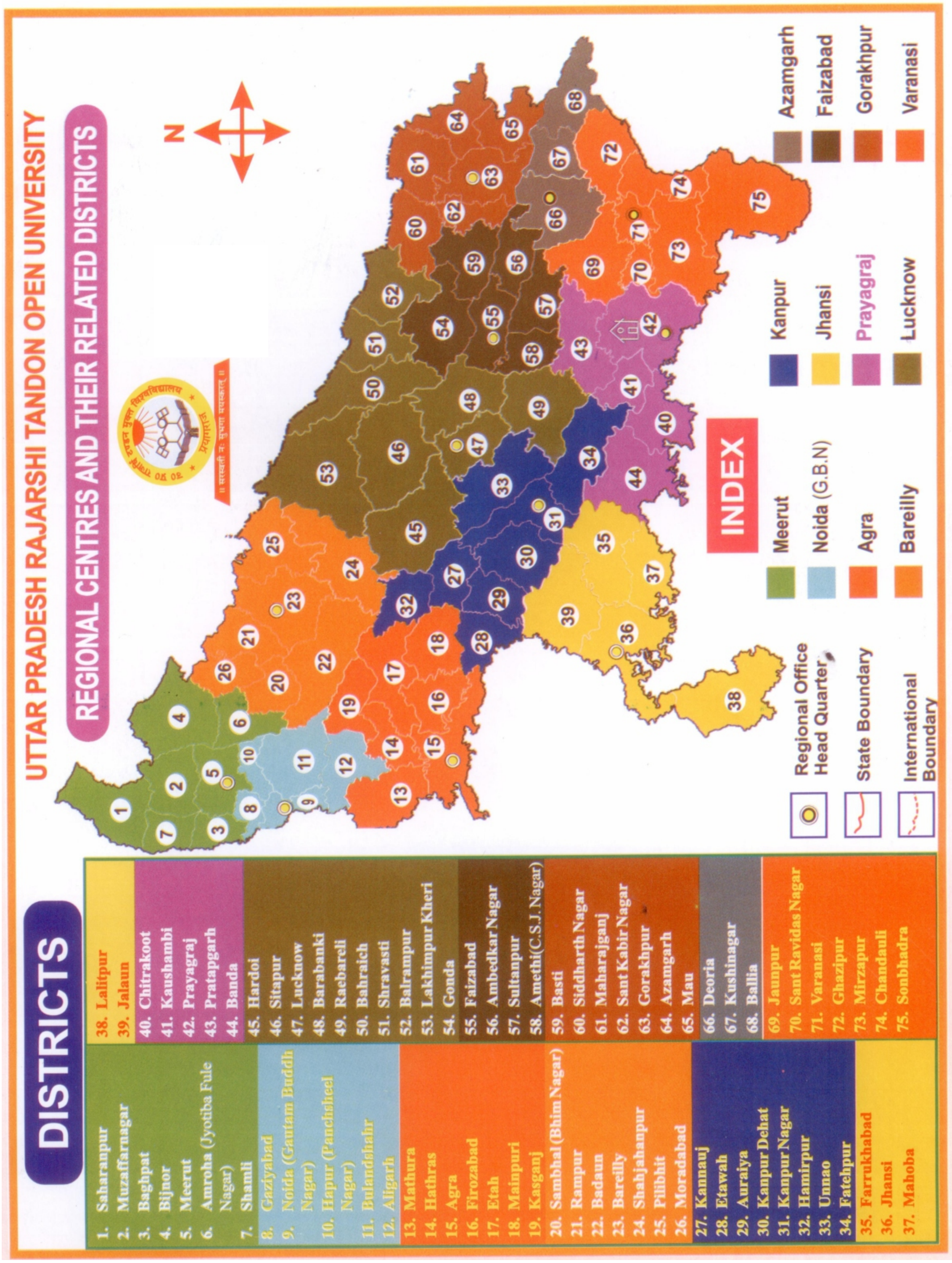

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