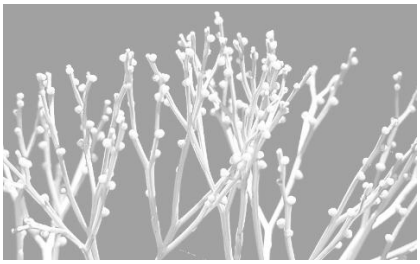


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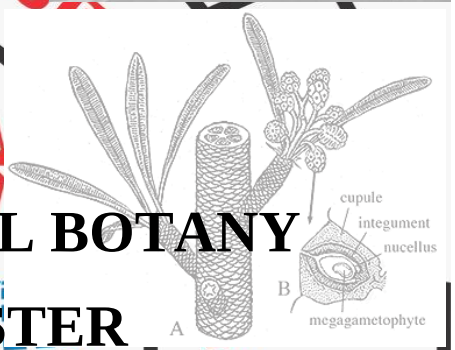


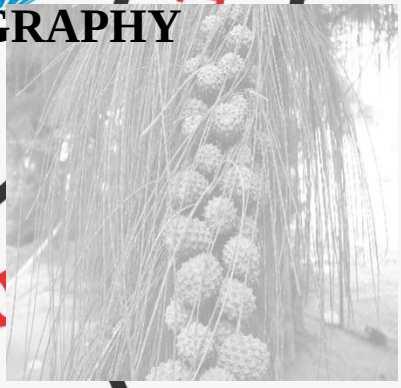
A MANUAL OF PRACTICAL BOTANY

II BSc.THIRD SEMESTER

PTERIDOPHYTES, PALEOBOTANY, ENVIRONMENTAL BIOLOGY AND PHYTOGEOGRAPHY

2019-2020






DEPARTMENT OF BOTANY

BOTANY PRACTICAL MANUAL

II B.Sc-III Semester

CBCS Scheme: Paper-III

PTERIDOPHYTES, PALEOBOTANY, ENVIRONMENTAL BIOLOGY AND PHYTOGEOGRAPHY

Laboratory Instructions

- Do not forget to carry laboratory apron, observation book and other required accessories.
- Handle equipments, microslides, glasswares, chemicals and specimen bottles with proper care.
- Report breakages / damages to the batch incharge or laboratory assistants.
- Keep the laboratory clean and tidy.

PRACTICAL PAPER III

PTERIDOPHYTES, PALEOBOTANY, ENVIRONMENTAL BIOLOGY AND PHYTOGEOGRAPHY

Total Units - 13

1. Identification and classification of Pteridophytes members included in theory : **4 units**
   - *Psilotum*
   - *Lycopodium*
   - *Selaginella*
   - *Marsilea*
2. Paleobotany – study of specimens and slides (Fossil material/ slide) **1 unit**
   - *Rhynia*
   - *Cycadeioidea*
   - *Pentoxylon*
3. Ecological Adaptations - Study of one example for each adaptation: (Specimen and slides) **2 units**
   - Xerophytes (*Nerium, Cassuarina*)
   - Hydrophyte (*Jussiaea*)
   - Halophyte (*Rhizophora*)
   - Epiphyte (*Vanda*)
   - Parasite (*Cuscuta*)
4. Estimation of Chloride and dissolved oxygen content in the given sample **2 units**
5. Study of Quadrat method in Ecology and studying soil sample and analysis of soil sample for structure (texture), pH etc. **3 units**
6. Marking of vegetational types of Karnataka on Karnataka map and Phytogeographical areas of India. **1 unit**
7. Submission of 5 permanent free hand sections (both Pteridophytes and Ecological Specimens).

PRACTICAL QUESTION PAPER III

PTERIDOPHYTES, PALEOBOTANY, ENVIRONMENTAL BIOLOGY AND PHYTOGEOGRAPHY

Time: 3 hours **Max marks: 35**

1. Identify and classify specimen **A and B** giving reasons. **2X3 = 6 marks**
2. Identify the slides **C, D and E** with reasons and diagrams. **3X3= 9 marks**
3. Comment on slide/ specimen/ photocopy/ photograph of **F** **1X3 = 3 marks**
4. Identify and comment on ecological adaptations of **G and H** (Vegetation pattern of Karnataka). ☐☐ **= 5 marks**
5. Estimate the oxygen or Chloride content of the given sample **I** **4 marks**
6. Class records and slide submission **5+3 = 8 marks**

SCHEME OF VALUATION

1. Pteridophytes – (A and B - Identification and classification- **1** mark, Reasons - **2** marks).
2. Pteridophytes - (C, D and E- Identification -**1** mark, Reasons – **1** mark, Diagram – **1** mark).
3. Fossil material – (F- Identification -**1** mark, Comment- **2** marks).
4. Specimens/ Slide/ Map – (G and H- Identification -**1** mark, Comment- **1.5** marks).
5. Estimation – (Conducting- **2** marks, Principle, Procedure and results- **2** marks).
6. Submission of 3 permanent slides of Pteridophytes and Ecological specimens, Class records (Marks : **5+3 = 8 marks**).

CONTENTS

Sl. no	Experiments	Page no.
01.	Pteridophytes:	1 – 14
	• *Psilotum*	1 – 3
	• *Lycopodium*	4 – 6
	• *Selaginella*	7 – 10
	• *Marsilea*	11 – 14
02.	Paleobotany:	15 - 19
	• *Rhynia*	15 - 16
	• *Cycadeioidea*	17 - 18
	• *Pentaxylon*	19
03.	Ecological Adaptations:	20 - 25
	• Xerophytes (*Nerium, Cassuarina*)	20 – 21
	• Hydrophyte (*Jussiaea*)	22
	• Halophyte (*Rhizophora*)	23
	• Epiphyte (*Vanda*)	24
	• Parasite (*Cuscuta*)	25
04.	Determination of dissolved chloride and oxygen in water (polluted and unpolluted) samples.	26 - 28
05.	Vegetation of Karnataka and Phytogeographical areas of India.	29 – 33 34 - 36
06.	Soil analysis – pH, Porosity, Water holding capacity, Adsorptivity, Capillary flow, texture and different types of soil.	37 - 42
07.	Study of population frequency by quadrat method.	43 - 44

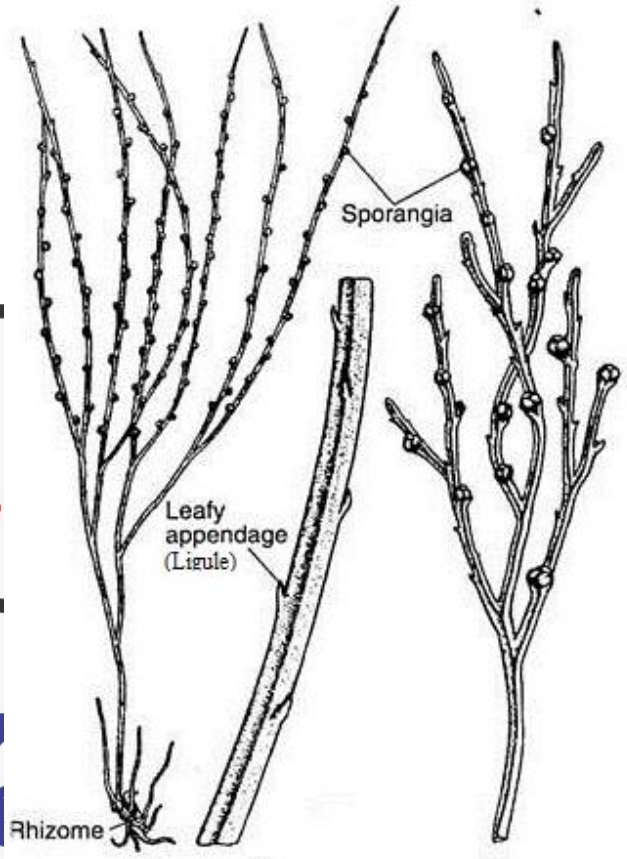
Psilotum

SYSTEMATIC POSITION:

Division: Psilophyta
Class : Psilotopsida
Order : Psilotales
Family : Psilotaceae
Genus : *Psilotum*

INTRODUCTION:

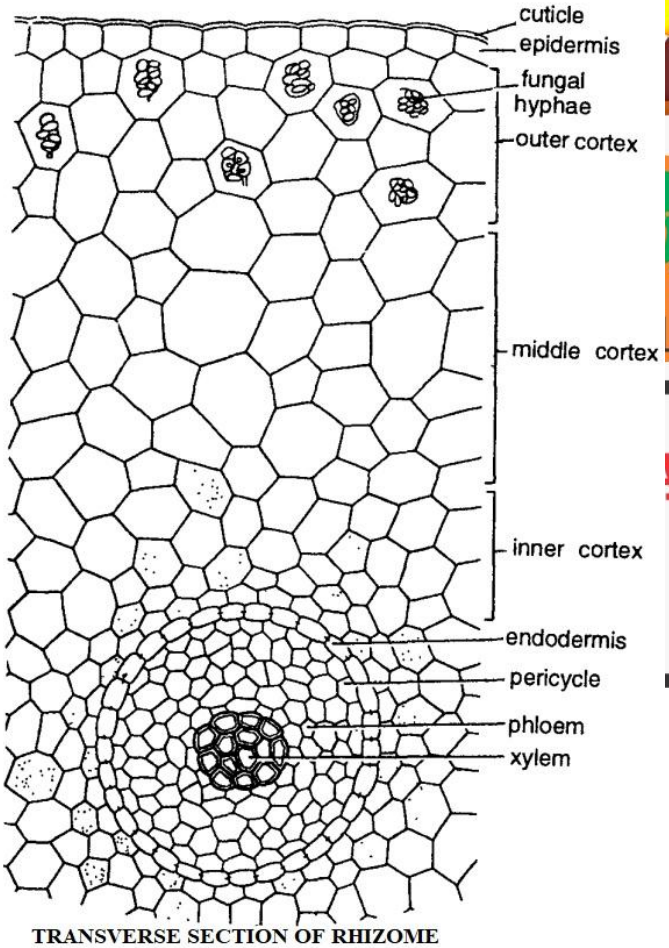
The genus *Psilotum* is distributed in tropical and sub-tropical regions in both eastern and western hemispheres. Some plants are cultivated in gardens for practical curiosities. There are two species- *Psilotum nudum* and *Psilotum flaccidum.* The aerial branches may reach a height of 75 – 100 cms in favourable habitats. *P. flaccidum* is mainly epiphytic growing on tree ferns. *P. nudum* is predominantly terrestrial and grows in humus at the base of trees and crevices of rocks.



Psilotum nudum : A. A sporophyte plant, B. An enlarged part of stem showing scaly appendage. C. A fertile twig

HABIT STRUCTURE:

1. It is a slender, dichotomously branched, perennial herb.
2. The main plant body is sporophyte and it is differentiated into underground rhizome and aerial erect shoot system. The rhizome generally consists a mycorrhizal fungus.
3. The rhizome is prostrate, dichotomously branched body with 2- 3 celled rhizoids on its surface.
4. The aerial shoots of epiphytic plants are commonly pendant and those of terrestrial plants are erect, green, slender dichotomously branched, multi angular in lower part and triangular in ultimate branches.
5. The aerial shoots bear small, scale like leaves which remain irregular in distribution. The leaves are without veins.
6. The terminal branches bear sexual reproductive bodies called synangia, each synangia at the axil of bifid scale leaf.



TRANSVERSE SECTION OF RHIZOME

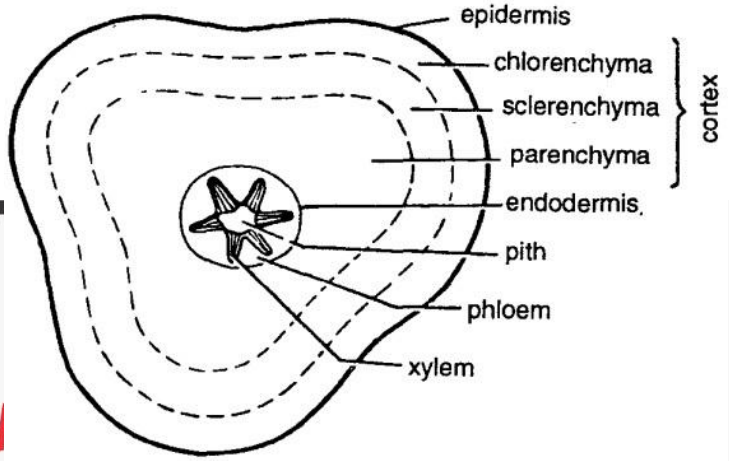
ANATOMY OF RHIZOME:

T/S of rhizome shows the following regions like epidermis, cortex and stele.

Epidermis is the outermost, continuous, with single layer of cutinised cells.

Cortex is present below epidermis. It is divided into three regions – outer, middle and inner cortex. The outer cortex is composed of parenchymatous cells with fungal association. Middle cortex is thick composed of parenchymatous compactly arranged cells with starch grains. The inner cortex composed of oxidised products of tannins called phlobaphene.

Stele is protostelic where the xylem is exarch present at the centre surrounded by phloem and single layered pericycle.



T.S OF AERIAL BRANCH (OUTLINES)

ANATOMY OF STEM:

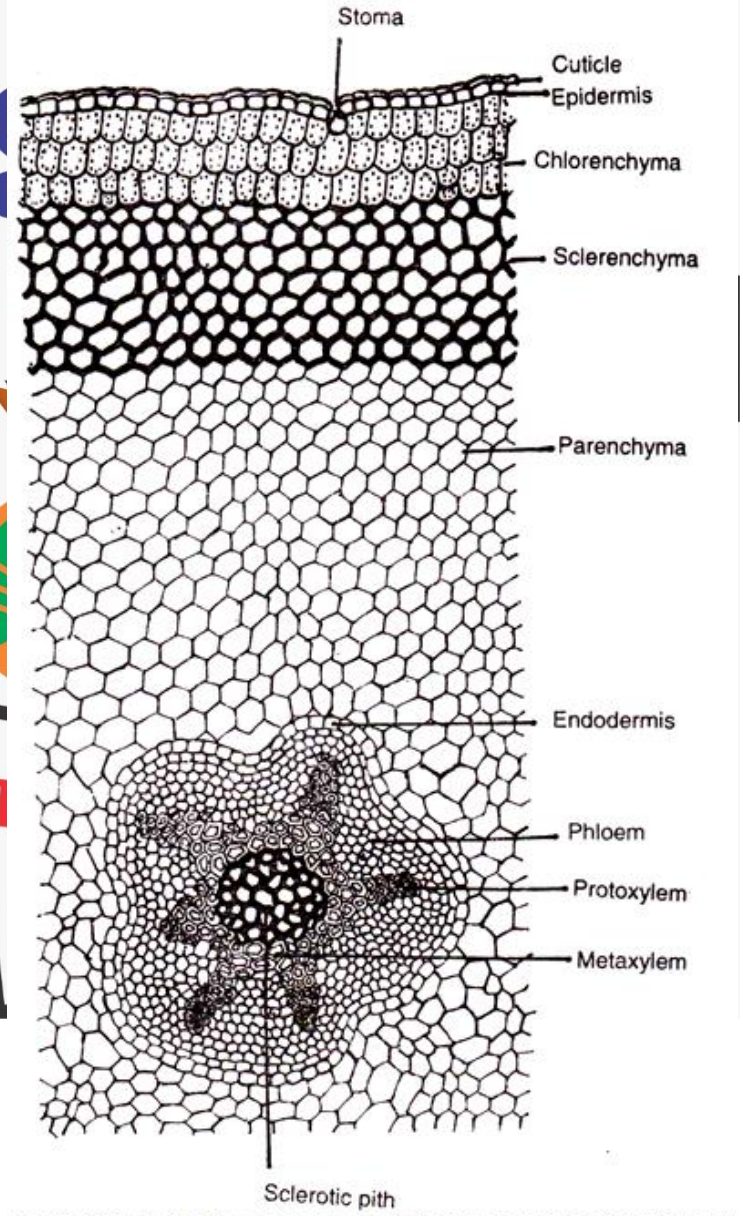
T/S of aerial stem show the following three regions like epidermis, cortex and stele.

Epidermis is the outermost single layer of cells. The outer surface epidermal cells are surrounded by thick cuticle. Some stomata are distributed here and there.

Cortex is present below the epidermis and it is differentiated into three zones: outer chlorenchymatous, middle sclerenchymatous and inner parenchymatous layer. The innermost cortex layer of cells is the endodermis having caspanan strips on their radial walls.

Stele is the inner core of the stem. At the basal region it is actinostelic protostele, at middle region it is siphonostele and the terminal region it is protostele.

The siphonostele consists of central sclerenchymatous pith and it is surrounded by star shaped exarch xylem. Phloem is present between xylem and endodermis. There is no distinct pericycle or an ill-defined pericycle is observed.



TRANSVERSE SECTION OF AERIAL STEM SHOWING ACTINOSTELE

REPRODUCTIVE STRUCTURES:

Structure of Synangia: Synangia is a trilobed asexual spore producing reproductive body present at the axil of bifid scale leaf on terminal branches of shoot system. It is covered by 3 – 5 layered jacket cells. It is formed by fusion of three sporangia consisting of three locules, where a number of haploid homospores are present. The wall cells have thickened considerably, except along one vertical line running from distal end to the base of each sporangium. These are the lines of dehiscence along which the synangium opens. There is no true tapetum. The spores are bean shaped with reticulate walls.

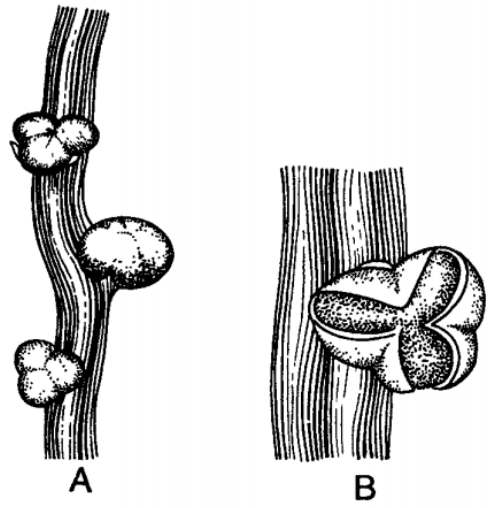
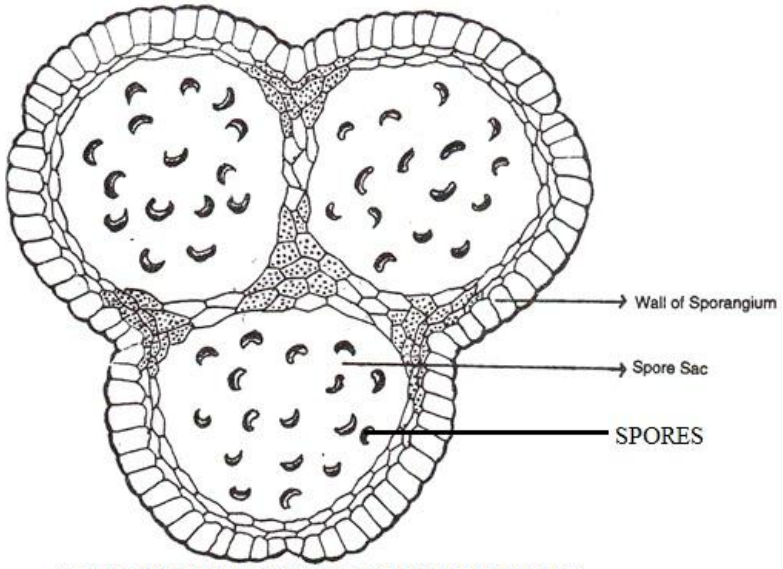


Fig. 6. ***Psilotum***. **A.** Aerial branch with synangia, **B.** A single synangium.

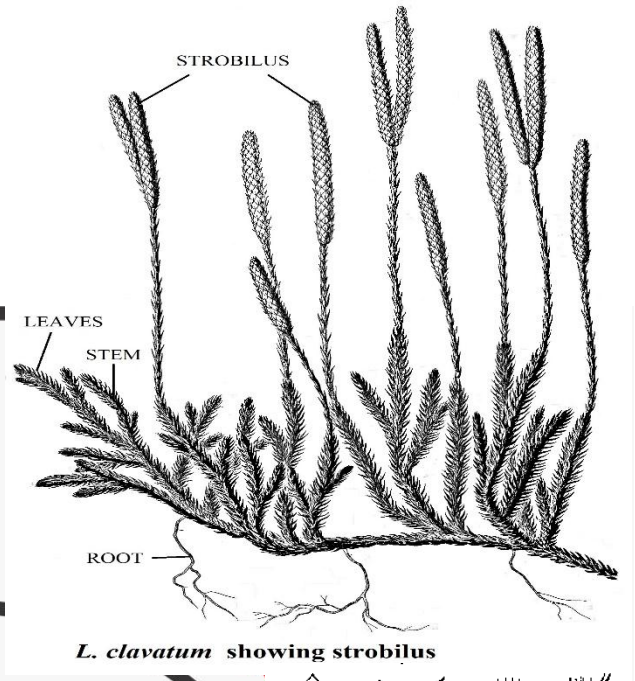


T.S OF MATURE SYNANGIUM WITH SPORES

Lycopodium

SYSTEMATIC POSITION:

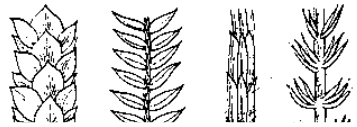
Division: Lycophyta
Class : Eligulopsida
Order : Lycopodiales
Family : Lycopodiaceae
Genus : *Lycopodium*



L. clavatum showing strobilus

INTRODUCTION:

Lycopodium is also called "club moss". It includes about 400 species. Some important ones are *L. phlegmaria, L. cernuum, L. clavatum, L. selago, L. complanatum*. They are widely distributed over the earth's surface. Usually they grow in shady places, rich in humus and other organic matters. *L. phlegmaria* is an epiphytic form.


Leaf arrangement in *Lycopodium:* B: *L. refescens, C: L. volubile,* D: *L. complanatum,* E: *L. cernuum*

HABIT STRUCTURE:

1. It is a perennial herb, some are prostrate growing and some erect in habit.
2. The main plant body is sporophyte and it is differentiated into root, stem and leaves.
3. Roots are dichotomously branched, which are developed from basal part of the stem in erect form and lower surface in prostrate forms.
4. Stem is long, slender and unbranched upto a certain height in erect forms and unequally dichotomously branched at terminal regions.
5. The leaves are small, simple, sessile, eligulate and spirally (or) whorlly arranged on stem, measuring around 2 – 10 mm. Each leaf contains only midrib without lateral veins.
6. The spore producing club shaped bodies are called strobili and developed on the apex of the aerial shoot.

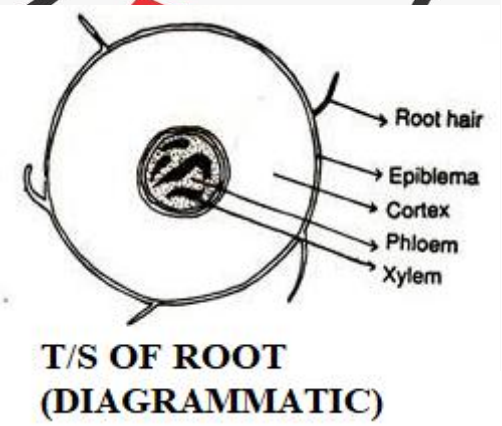
ANATOMY OF ROOT:

T/S of root shows an epidermis, cortex and a stele.

Epidermis is single layered and consists of thin walled cells. Many of the epidermal cells give rise to unicellular root hairs, which lie in pairs.

Cortex is several layered thick, the cells of the outer region of the cortex usually consists of thick walled cells and inner region of cortex consists of thin walled loosely arranged cells. Endodermis separates the cortex from the stele.

Stele is thin, usually diarch xylem present at centre and it is crescent shaped but in some species it appears tetrarch in condition in some portions. Xylem surrounded by phloem and a layer of pericycle.



T/S OF ROOT (DIAGRAMMATIC)

ANATOMY OF STEM:

T/S of stem is wavy in outline and shows the following three regions called epidermis, cortex and stele.

Epidermis is the outermost single layer of cells with cutinised outer walls. Stomata are present in the epidermis. Hence epidermis isn't continuous but interrupted.

Cortex is quite broad and is differentiated into outer, middle and inner cortex.

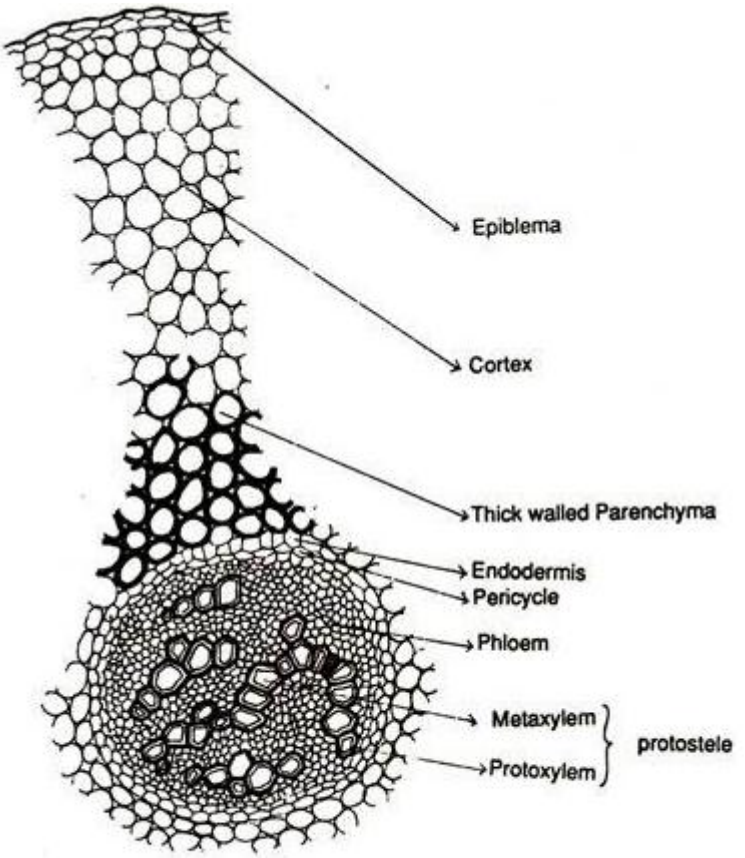
In *L. cernuum*, outer and inner cortex are parenchymatous and middle cortex is sclerenchymatous.

In *L. clavataum*, the outer and inner cortex are sclerenchymatous and middle cortex is parenchymatous.

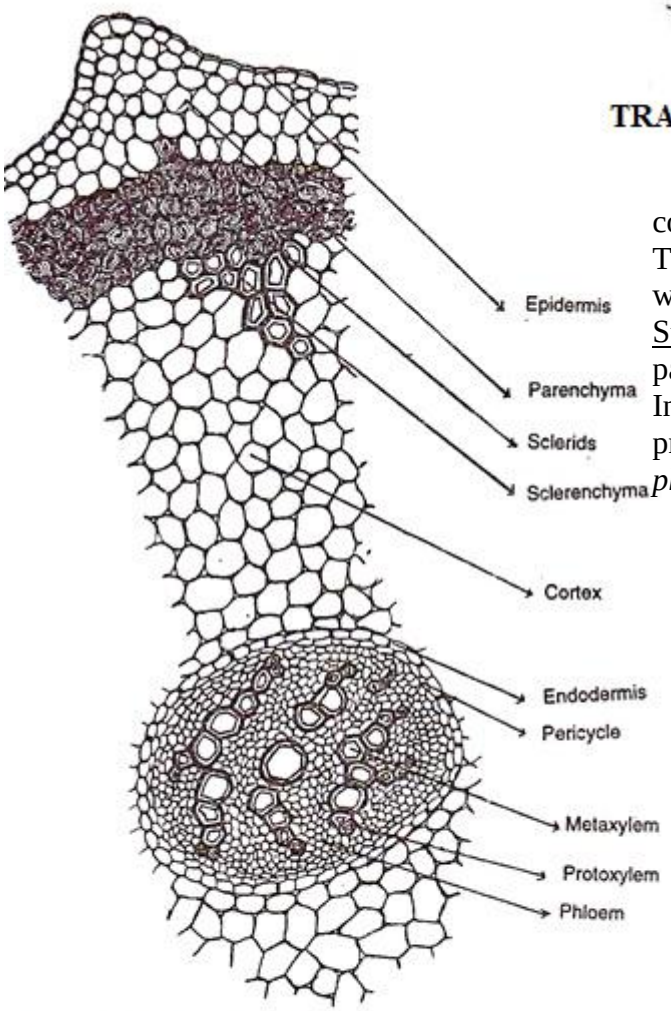
The innermost layer of cortex is endodermis, the radial walls of endodermis have casparian strips.

Stele is protostelic surrounded by single layer of parenchymatous pericycle.

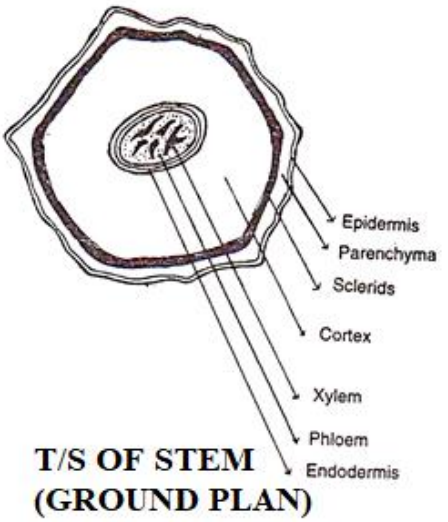
In *L. cernuum*, it is mixed protostele, plectostelic protostele in *L. clavatum* and actinostele in *L. phlegmaria.*



TRANSVERSE SECTION OF ROOT
(Cellular)



T/S OF STEM
(A PORTION ENLARGED)



T/S OF STEM
(GROUND PLAN)

ANATOMY OF LEAF:

1. The epidermis is single layered. The stomata are equally distributed on both the sides.
2. The leaf has a single vascular strand which is concentric with xylem in the centre and surrounded by phloem.
3. The cells between the epidermis and the vascular strand form spongy parenchyma or cholerenchyma.

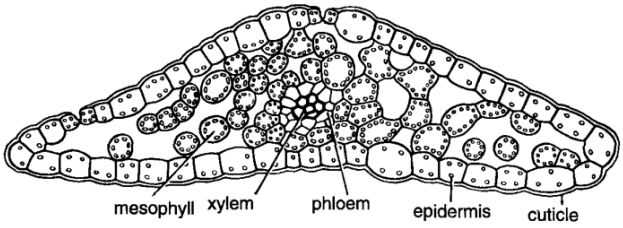
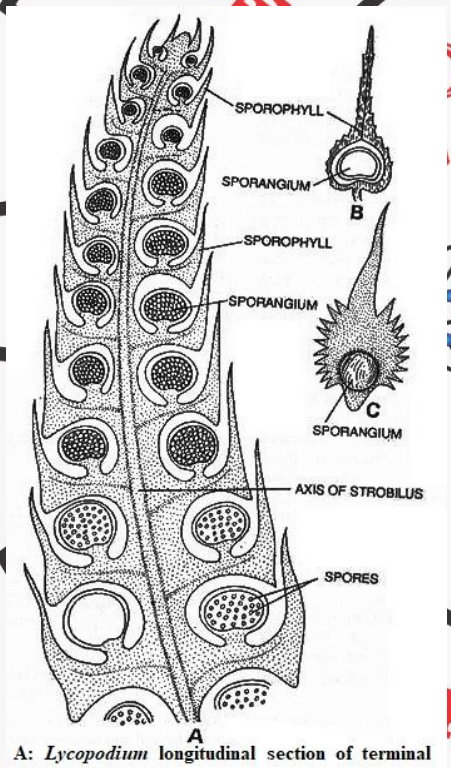


Fig. 5. ***Lycopodium.*** T.s. leaf.

REPRODUCTIVE STRUCTURES:

Structure of strobilus: It is an asexual spore producing body present at the apex of the stem.

1. It consists of a number of spirally arranged sporophylls on central axis.
2. Each sporophyll bears a single stalked kidney shaped sporangium at axil on dorsal surface.
3. Inside the sporangium a number of haploid homospores are present which are formed by meiotic division.
4. The spore chamber is surrounded by 3 – 5 layered sporangial wall, inner most layer is tapetum.

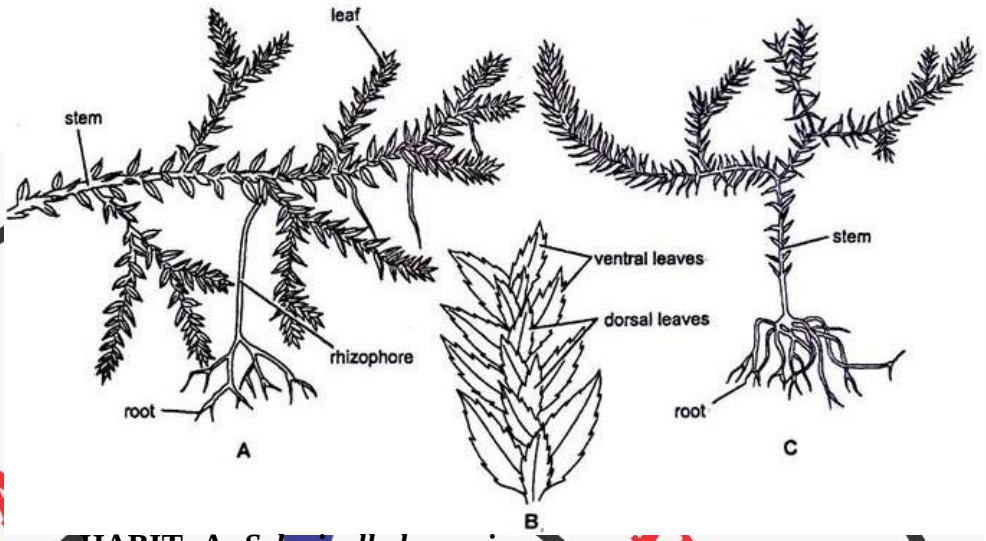


A: ***Lycopodium*** **longitudinal section of terminal position of strobilus.**
B: Sporophyll with sporangium of ***L. clavatum***
C: sporophyll with sporangium of ***L. cernuum***

Selaginella

SYSTEMATIC POSITION:

Division : Lycophyta
Class : Ligulopsida
Order : Selaginellales
Family : Selaginellaceae
Genus : *Selaginella*



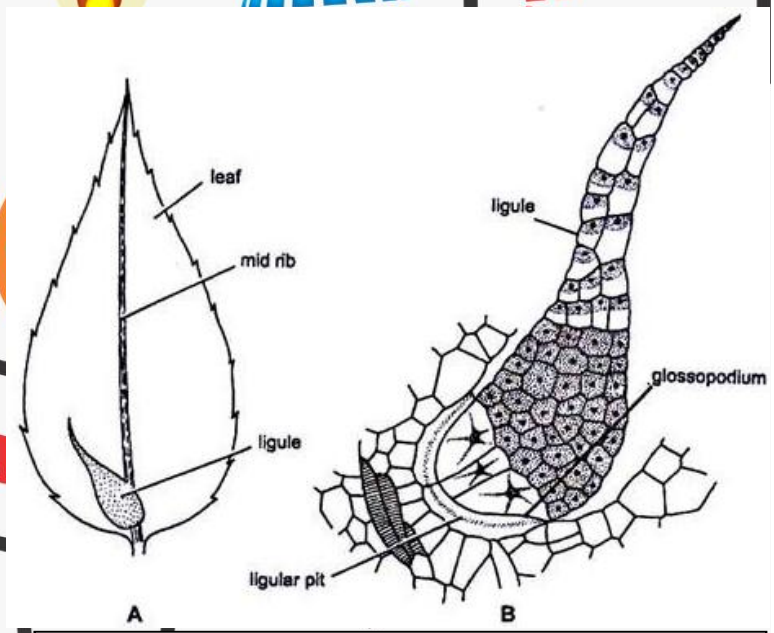
HABIT: A: *Selaginella kraussiana*
B. A branch of *S. kraussiana* showing leaf arrangement
C*: *Selaginella spinulosa

INTRODUCTION:

Selaginella is commonly called "spike moss". It includes about 700 species some important ones are *Selaginella kraussiana, S. spinulosa, S. rupestris, S. lepidophylla* etc., usually they are distributed in the rain forest of tropical countries where the ground is humid with shady habitat.

HABIT STRUCTURE:

1. It is a slender, perennial or annual herb. The main plant body is sporophyte. The plant body is differentiated into root, rhizophore, stem and leaves.
2. The roots are adventitious dichotomously branched present at the apex of the rhizophore.
3. Rhizophore is a long, slender cylindrical leafless structure developed from the region of branching of stem in prostrate form, whereas in erect forms they are raised at from lower part of stem.
4. Stem is soft, slender, erect or prostrate and bears rhizophore and leaves.
5. Leaves are small, heterophyllous, sessile, ovate and ligulate with mid rib.
6. In homophyllous forms, leaves are only one type arranged spirally on stem. In heterophyllous forms, the leaves are two types arranged in four rows on stem. The smaller two rows of leaves on dorsal side and larger two rows of leaves arranged on ventral side of stem.



A: Leaf with a ligule B: vertical section of Ligule

ANATOMY OF THE ROOT:

1. The section is almost circular in outline.
2. The tissues are differentiated into epidermis, cortex and stele.
3. The epidermis is single layered and its cells are tangentially elongated. Few of these cells give rise to the root hairs.
4. Cortex may either be made of parenchymatous (thin walled) cells or the outer layer of cells may form a sclerenchymatous (thick walled) hypodermis.
5. The stele lies in the centre. It is protostelic, monarch and exarch.
6. Endodermis is one layered and generally indistinct.
7. Pericycle is one to three layered.
8. Xylem forms only one group. Protoxylem is situated towards the periphery.
9. Phloem surrounds the centrally located xylem.

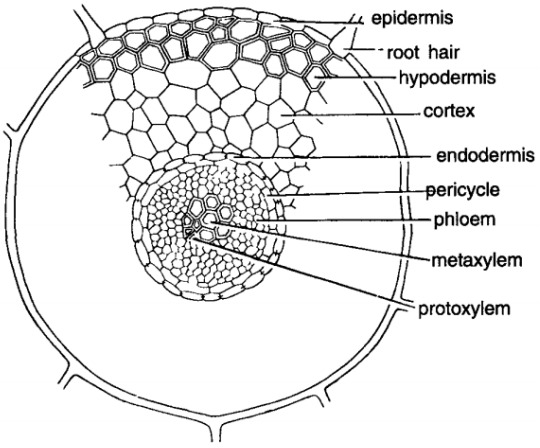


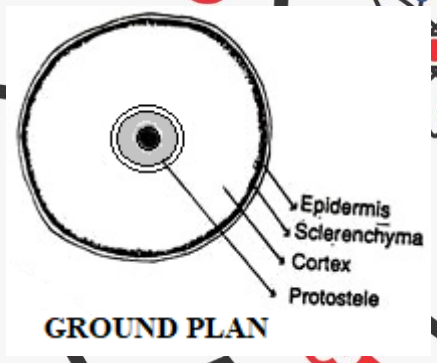
Fig. 5. ***Selaginella***. T.s. root (a part cellular).

ANATOMY OF RHIZOPHORE:

Rhizophore is positively geotropic, colourless, leafless structure bearing cluster of adventitious roots at tips. The T/S of rhizophore consists of a single layer of cutinised epidermis, cortex and stele. The cortex is differentiated into outer sclerenchymatous and inner parenchymatous region. The innermost layer is endodermis. The stele is protostelic where the xylem is present at the centre surrounded by phloem and a layer of pericycle.

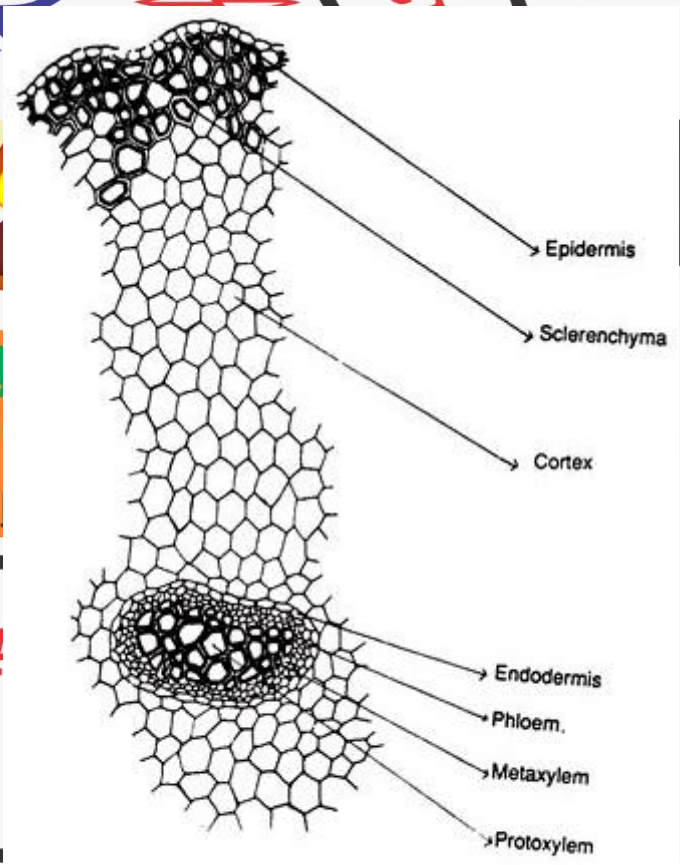
T/S OF STEM:

The transverse section of stem shows the following three regions: epidermis, cortex and stele.

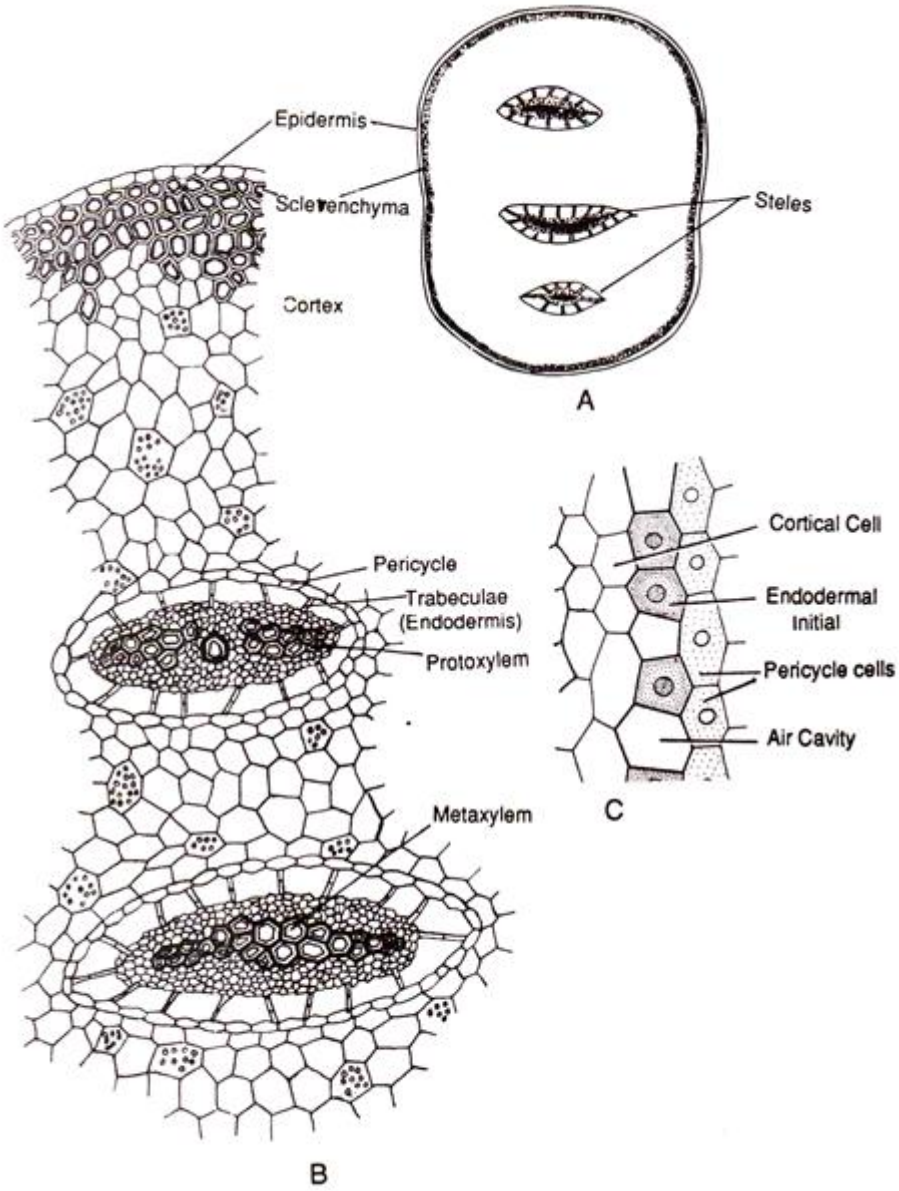


GROUND PLAN

Epidermis is a single layer of cells. The outer walls are cutinised. Cortex is present below the epidermis and it is differentiated into three zones. The outer zone consists of 2-3 layers of sclerenchymatous cells and the inner zone consists of many layers of parenchymatous cells. The cortex is separated from the stele by air cavities because the endodermal cells are arranged radially in air cavities and contact with the stele. The radially arranged endodermis is called trabaculae. The stele is mono, di or polystelic. Each stele is haplostelic protostele. The xylem is diarch and exarch. It is surrounded by phloem and a layer of pericycle.



TRANSVERSE SECTION OF RHIZOPHORE
(A SECTION ENLARGED)



TRANSVERSE SECTION OF STEM
A. GROUND PLAN
B. A SECTOR ENLARGED
C. DEVELOPMENT OF TRABECULAE

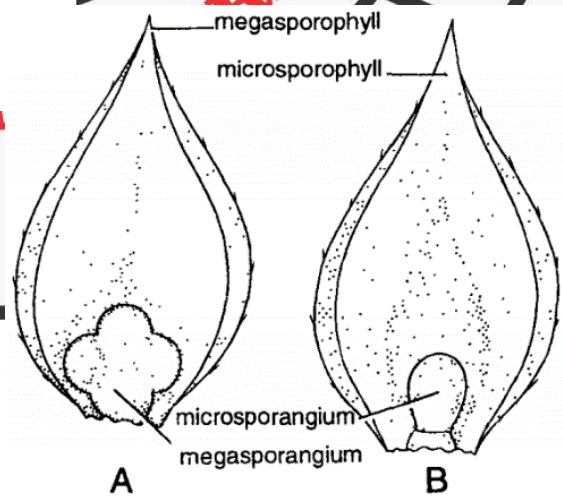


Fig. 10. ***Selaginella.*** Adaxial views of sporophylls showing sporangia; **A.** Megasporophyll, **B.** Microsporophyll.

STRUCTURE OF STROBILUS:

1. It is the fertile asexual spore producing body formed at the stem apex.
2. It is quadrangular and consists of a number of spirally arranged sporophylls.
3. The sporophylls are two types namely: mega sporophylls and micro sporophylls.
4. The arrangement may vary from species to species. In some species, strobili may bear only one type of sporophyll or both types.
5. Micro sporophylls consist of microsporangium on adaxial surface just near the axis region. Matured microsporangia appear red or yellow in colour.
6. Microsporangium is oval shaped body bounded by two layered wall and inner single layered tapetum. At the centre it contains numerous small haploid microspores, which are formed from microspore mother cell by meiosis.
7. Megasporophylls consist of megasporangium on adaxial surface just above the axils region through short stalk.
   Megasporangium is four lobed body bounded by two layered outer walled and single layered tapetum. Mature megasporangium appear green or whitish yellow colour. It contains four large haploid megaspores, which are formed from megaspore mother cell by reduction division.
8. Thus, *Selaginella* is regarded as a heterosporous form.

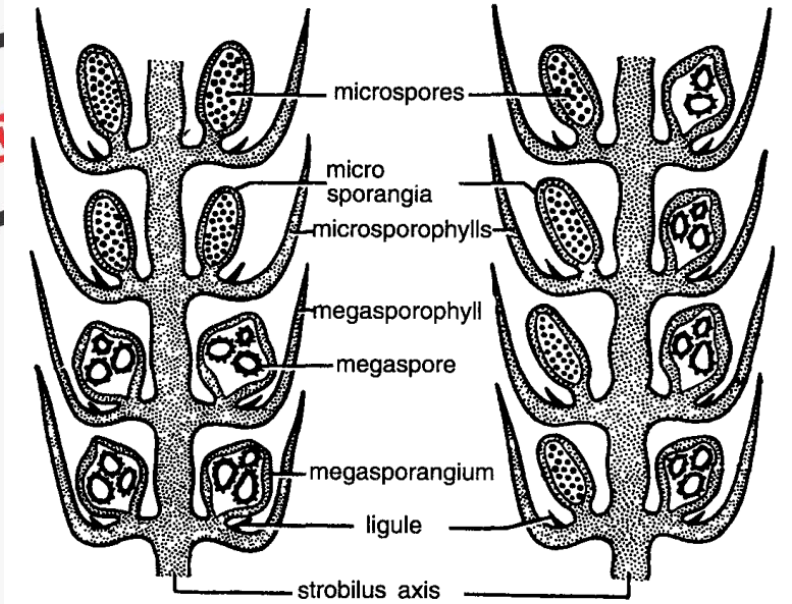


Fig. 11. ***Selaginella.*** L.s. strobilus showing different positions in which megasporangia and microsporangia occur.

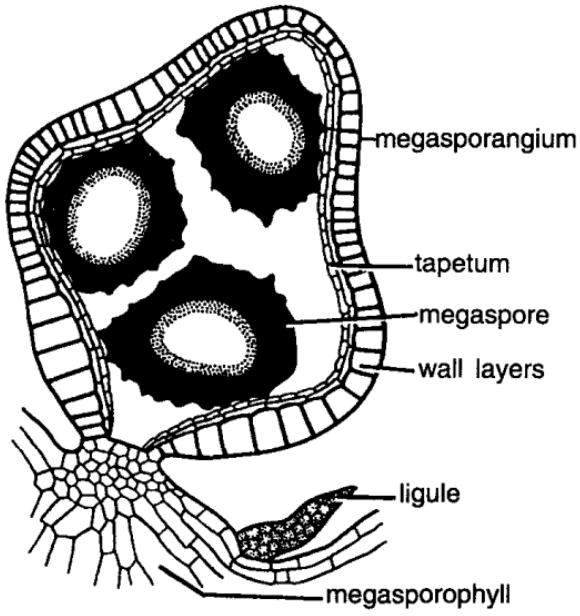


Fig. 12. ***Selaginella.*** L.s. megasporangium.

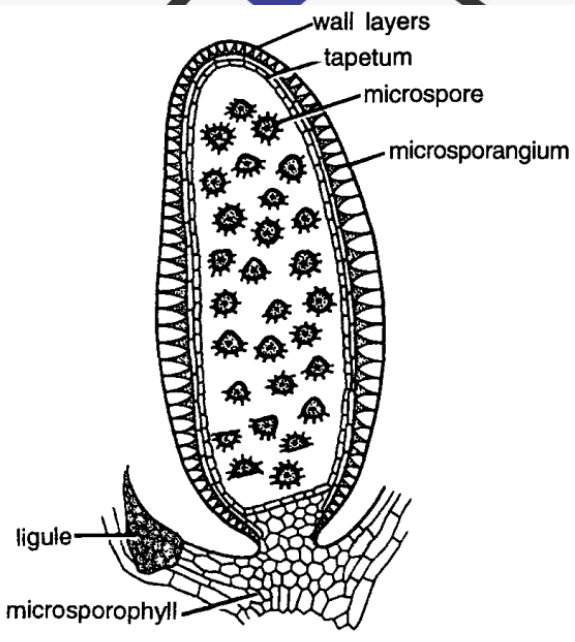
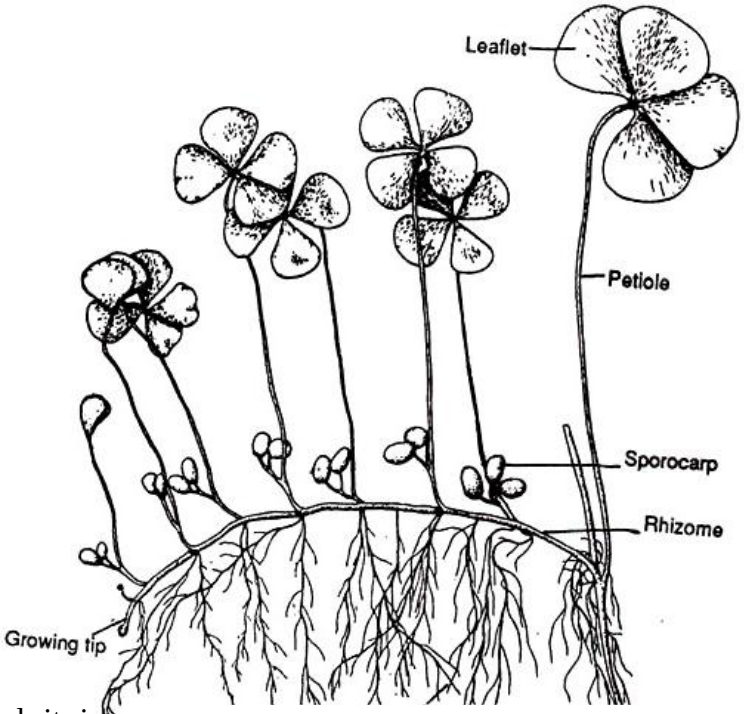


Fig. 13. ***Selaginella.*** L.s. microsporangium.

Marsilea

SYSTEMATIC POSITION:

Division : Filicophyta (Pterophyta)
Class : Leptosporangiopsida
Order : Marsiliales
Family : Marsiliaceae
Genus : *Marsilea*



Habit of *Marsilea quadrifolia*

INTRODUCTION:

Commonly known as "water fern". Marsilea are generally aquatic or amphibious or few are xerophytic or extremely xerophytic plant.It is represented by about 53 species. Distributed mainly in warmer parts of the world. Some important species are *M. hirusta, M. minuta, M. quadrifolia, M. rajasthanensis*.

HABIT STRUCTURE:

1. The main plant body is sporophyte and it is differentiated into rhizome or stem, roots and leaves.
2. The rhizome is long, slender, branched and subterranean.
3. Adventitious roots are formed from lower surface at different nodal regions of rhizome.
4. Leaves are tetrafoliate, compound, alternately arranged on the upper surface of the rhizome.
5. Each leaf consists of a long, cylindrical petiole and four obovate leaflets at its apex.
6. Each leaflet shows dichotomous venation.
7. The young leaves show circinate vernation.
8. At the base of old leaves petiole, the spore producing bodies called sporocarps are present.

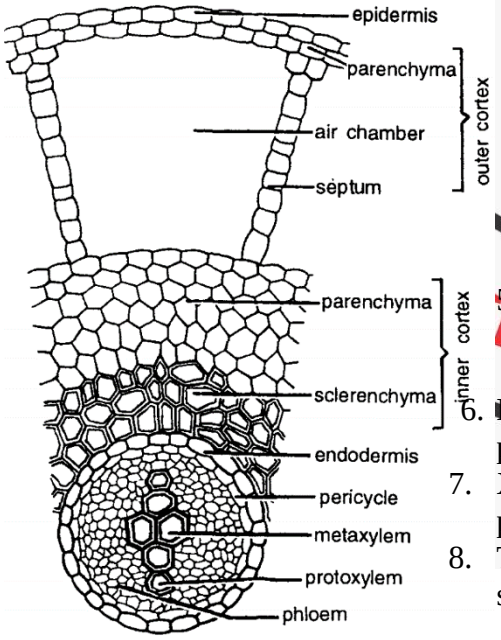


Fig. 3. ***Marsilea.*** T.s. root (a part cellular).

ANATOMY OF THE ROOT:

1. The outline of the section appears almost circular.
2. The epidermis is single layered with tangentially elongated cells.
3. The cortex is differentiated into an outer and an inner cortex.
4. The outer cortex has many air chambers separated by radial septa.
5. The inner cortex has either all the parenchymatous cells or some of the cells towards the inner side may become thick walled and sclerenchymatous.
6. Endodermis is single layered. It is followed by one layered pericycle. These surround vascular bundle.
7. Xylem is diarch and exarch xylem. It is situated in the centre. The protoxylem elements are situated opposite one another.
8. The phloem has smaller cells and forms two bands, one on either side of the xylem mass.

ANATOMY OF RHIZOME:

T/S of rhizome shows the following three regions like epidermis, cortex and stele.

Epidermis is a single layer with thick walled cells and without any stomata.

Cortex is differentiated into outer, middle and inner regions. In outer cortex there are 2 – 3 layered compactly arranged outer parenchymatous cells and inner loosely arranged parenchyma cells with large air chambers. The middle cortex consists of 2-3 layered compactly arranged sclerenchyma cells. The inner cortex consists of 2 to many layered compactly arranged thin walled parenchyma cells. The innermost layer of inner cortex is the outer endodermis.

Stele is an amphiphloic siphonostele. It consists of central xylem ring and it is surrounded by phloem, single layer of pericycle and endodermis both towards inner and outer side. The central region of stele is occupied by thin walled parenchymatous or thick walled sclerenchymatous pith.

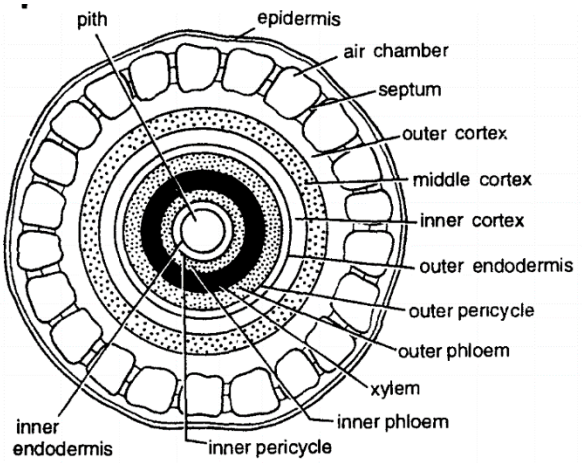


Fig. 4. ***Marsilea.*** T.s. rhizome (diagrammatic).

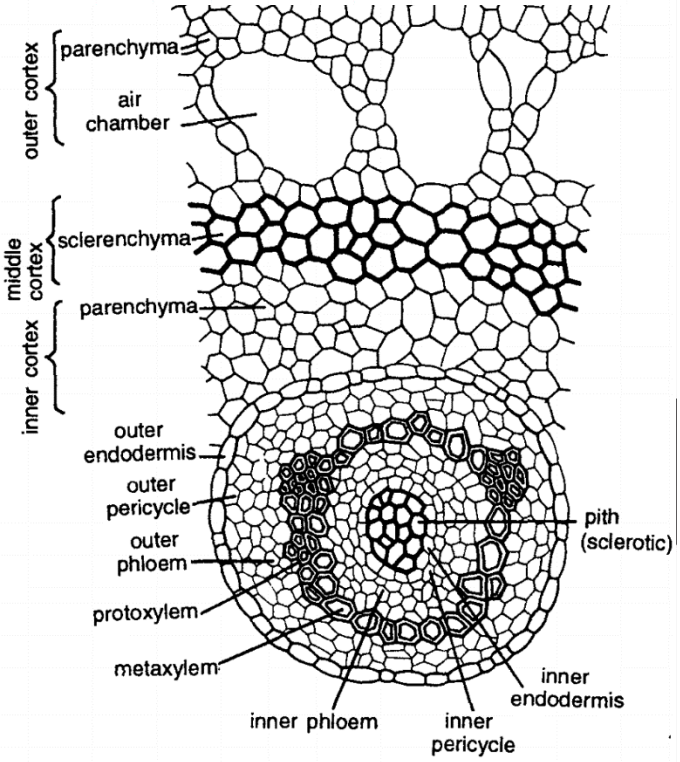


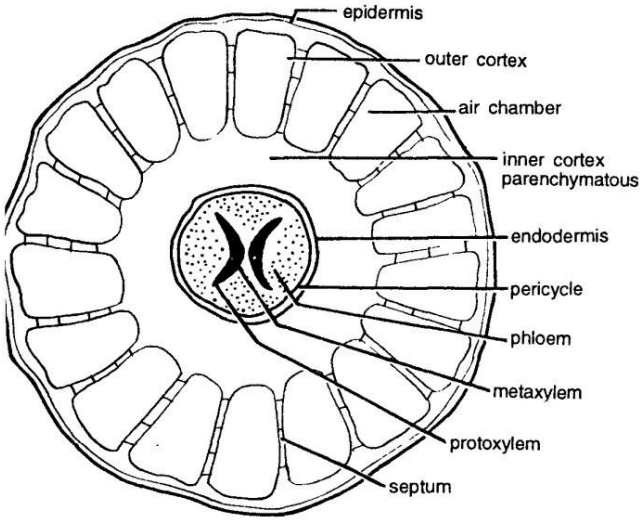
Fig. 5. ***Marsilea.*** T.s. rhizome (a part cellular).

T/S OF PETIOLE:

The T/S of petiole shows the following regions like epidermis, cortex and stele.

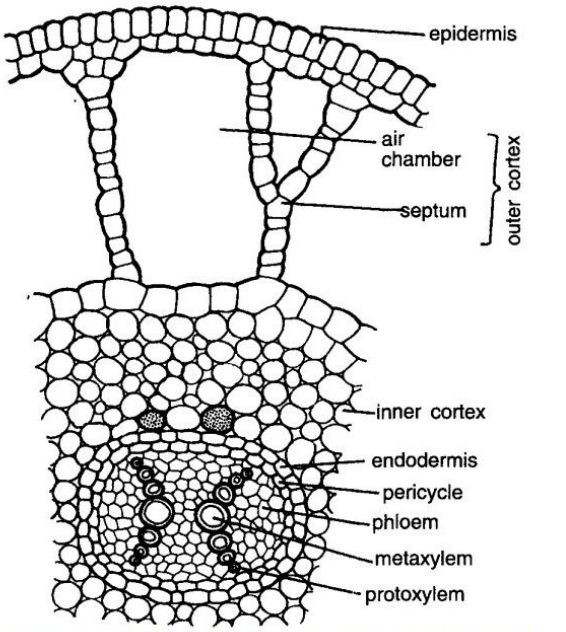
Epidermis is the outermost layer with compactly arranged cells.

Cortex is divided into two regions like the outermost region composed of a number of air chambers and they are separated by radially arranged single row of cells called septa. The inner region of the cortex consists of loosely arranged parenchymatous cells and they contain starch and tannins. The innermost layer of cortex is endodermis and it encircles the stele.



TRANSVERSE SECTION OF PETIOLE (GROUND PLAN)

Stele displays a protostelic structure. V- Shaped xylem is present at the centre and surrounded by phloem and a layer of pericycle. The two arms of V are separate and curve away from each other. The protoxylem is present at either end of the arm of V and the metaylem is present at the middle of the arm.



TRANSVERSE SECTION OF PETIOLE (A SECTION ENLARGED)

ANATOMY OF LEAFLET

1. The section shows an upper and lower epidermis, mesophyll and a vascular bundle.
2. The stomata are found on both upper and lower epidermis if the plant is terrestrial but they are found only on upper epidermis if leaves float on water surface.
3. Mesophyll is differentiated into palisade and spongy parenchyma.
4. Palisade is arranged in one layer near the upper epidermis. Spongy parenchyma is located near the lower epidermis. It is loosely arranged to form large air spaces and is called aerenchyma.

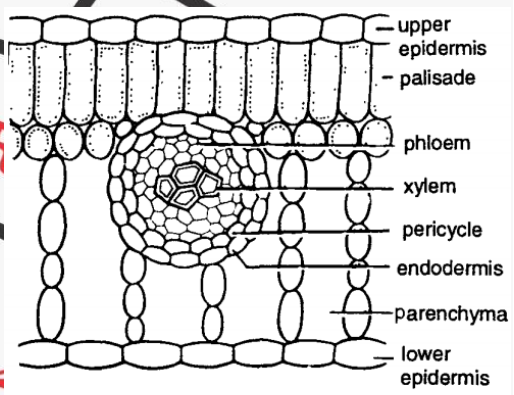


Fig. 8. ***Marsilea.*** T.s. leaflet (a part cellular).

5. There are many vascular bundles. Each bundle is concentric with centrally located xylem surrounded by phloem.
6. The distinct epidermis is present just outside the vascular bundle.

REPRODUCTIVE STRUCTURES – STRUCTURE OF SPOROCARP:

1. Sporocarp is the bean- shaped asexual spore producing structure attached to the basal part of the petiole on a short stalk.
2. Each sporocarp has two teeth like projections at the junction of peduncle with the sporocarp body are called tubercles. It is bisporangiate type it consists of two valves enclosing two rows of sori on either side of gelatinous ring. Each sorus enclosed by a thin inducium and consists of receptacle, it is ridge like and bears along its top a row of short stalked megasporangia and around its side by many long stalked microspoarangia.

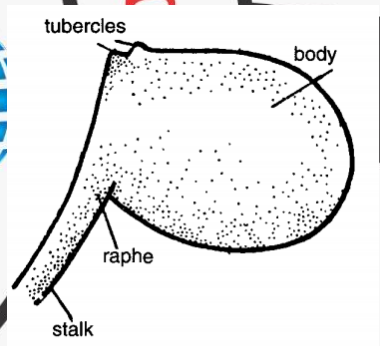


Fig. 9. ***Marsilea.*** A single sporocarp.

3.Megasporangia produce megaspores and microsporangia produce microspores, hence *Marsilea* is regarded as a heterosporous form.

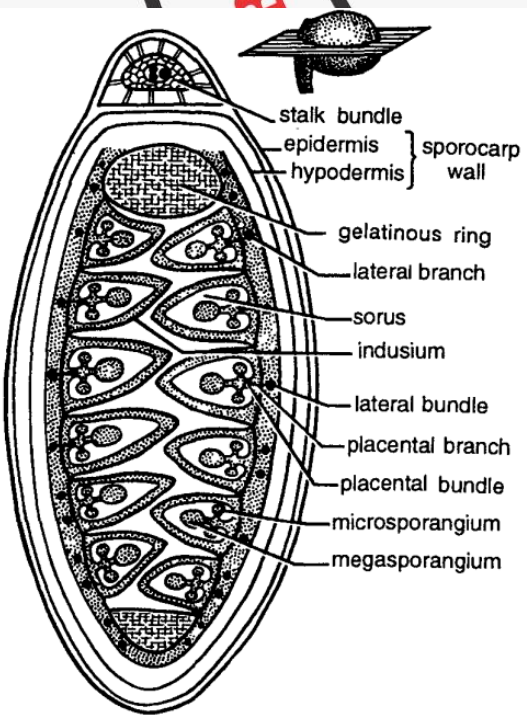


Fig. 14. ***Marsilea.*** H.L.s. sporocarp.

H.L.S OF SPOROCARP:

It shows the following regions: The wall of the sporocarp is the outermost region it is three layered, the outermost layer is called epidermis and inner two layers are called hypodermis with palisade like cells. The gelatinous ring is visible at two sides as gelatinous mass.

There are two alternating rows of sori present. Each sorus shows receptacle with single megasporangium at the apex and two microsporangia at the base, these are surrounded by two layered inducium.

V.T.S OF SPOROCARP:

It shows the following regions:

The outer region is the wall of the sporocarp and made of three layers. The outermost layer is epidermis and innermost layer is a two layer of hypodermis- consists of palisade like cells; the vascular bundle present at the dorsal end of sporocarp and extending to ventral end. The gelatinous ring is visible at two sides below the wall. The two sori are appearing and covered with inducium and the inner side attached to the placental ridge towards outside. Each sorus shows two microsporangia one each at dorsal and ventral sides. Few megasporangia are arranged along the placental ridge.

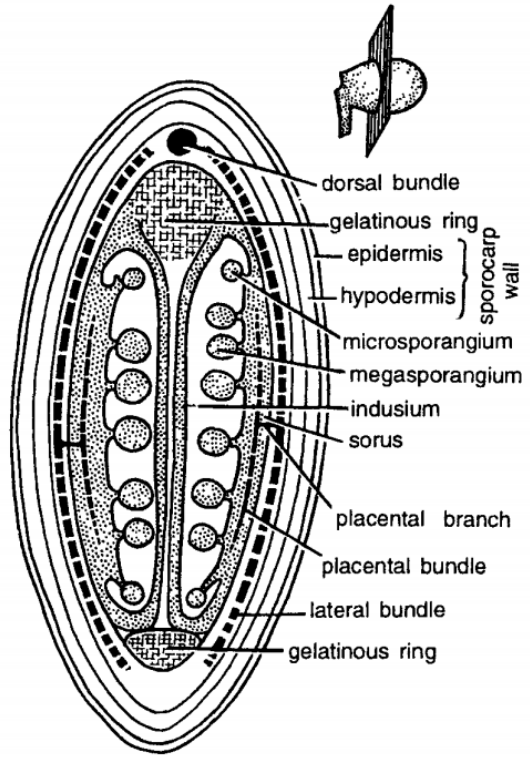


Fig. 11. *Marsilea.* V.T.s. sporocarp.

V.L.S OF SPOROCARP:

VLS of sporocarp show the following regions: the gelatinous ring appears as complete ring around the sori. Sori are arranged in few (6-12) rows in the plane of section either micro or mega sporangium are visible. If the section is perfectly median, then only megasporangia are visible. If the section is slightly away from the median line then only microsporangia are visible.

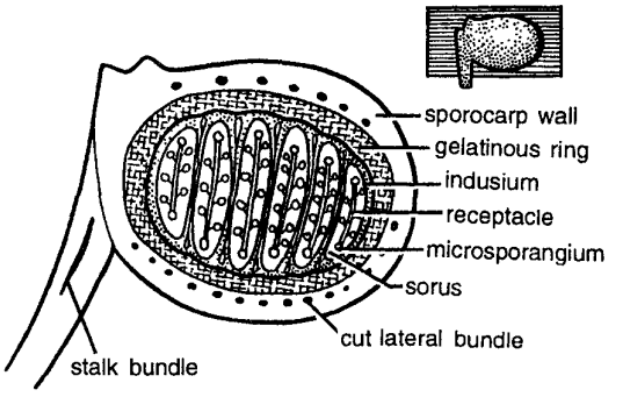


Fig. 12. *Marsileal.* V.L.s. sporocarp showing microsporangia.

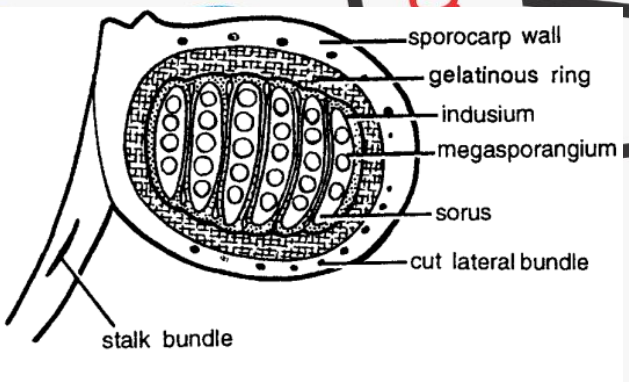
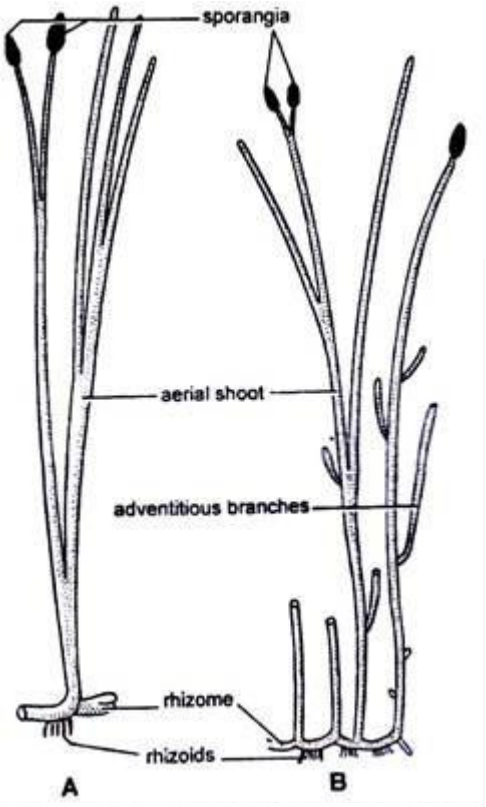


Fig. 13. *Marsilea.* V.L.s. sporocarp showing megasporangia.

PALEOBOTANY

Rhynia

- Class : Psilophytopsida
- Order : Psilophytales
- Family : Rhyniaceae
- Genus : *Rhynia*



A: Habit of *Rhynia.major*,
B:* Habit of *Rhynia gwynnevaughni

INTRODUCTION:

1. *Rhynia* is a fossil member (not found living in the present age), discovered from Rhynie chert Beds (or upper Devonian era) in Aberdeenshire of Scotland, by Kidston and Lang in 1917.
2. The two species *R. major*, about 40-50 cms in height and *R. gwynne-vaughani*, about 20 cms in height, found at this station, were well preserved, hence their form and structure are well known.
3. The plant grew in swampy marshes.

HABIT STRUCTURE:

The plant body *Rhynia* was herbaceous sporophyte. It consists of subterranean, cylindrical and dichotomously branched rhizome and uprightly dichotomously branched aerial leafless shoot with gradually tapering. While in case of *R. gwynne-vaughani* many adventitious branches were present on the aerial shoots. There were no roots. Unicellular rhizoids were borne in patches, on underside of the rhizome.

The reproductive structures called sporangia were borne singly on apices of some of the aerial shoots.

INTERNAL STRUCTURE OF *Rhynia*:

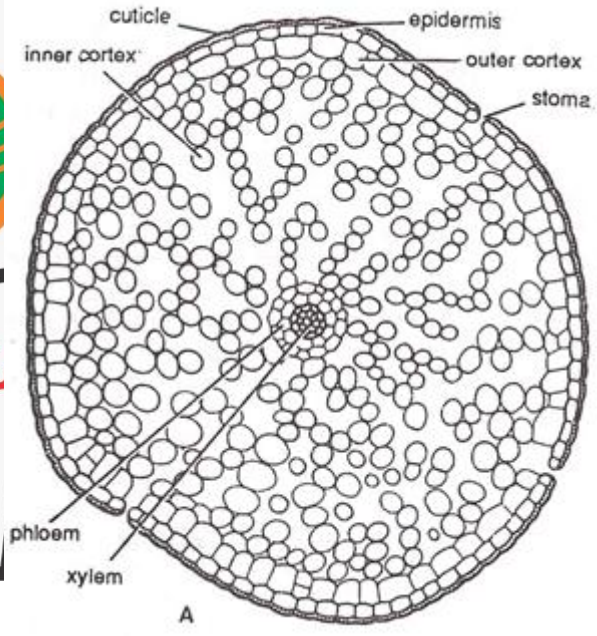
Transverse section (T.S.) of Aerial shoot and Rhizome: Anatomically, the aerial shoots and rhizome are almost similar and were internally differentiated into epidermis, cortex and stele.

Epidermis:

It was the outer-most surrounding layer. It was one cell thick and covered by thin cuticle. In aerial shoots it was interrupted at certain places by stomata but stomata were absent in rhizome.

Cortex:

Epidermis was followed by cortex. It is differentiated into outer cortex and inner cortex. The outer cortex was only 1-4 cells thick, thin walled and without intercellular spaces. The inner cortex is composed of spherical shaped loosely arranged parenchymatous cells and its cells had chloroplast. It is thought that this was the chief photosynthetic region of the plant. The endodermis and pericycle layers were absent.



A: T/S of Rhizome or Stem

Stele:

The centre of the aerial shoot/rhizome was occupied by stele. The stele was a protostele (haplostele). The xylem was made up of annular tracheids and there were no sieve plates in phloem.

Reproductive Structures of Rhynia:

The sporangia was nearly oblong in shape, broad at the base and pointed at the apex. They were 12 mm long and 4 mm in breadth in *R. major* and 4 mm long and 1 mm broad in *R. gwynne - vaughani*.

A longitudinal section (L.S.) of sporangium shows that it had a five cells thick wall. The outermost layer was 1 cell thick cuticularized epidermis. It was followed by 3 cells thick middle layers of thin walled cells. The inner-most layer was 1 cell thick tapetum. The wall was surrounding a spacious sporangial cavity which was without columella and contained large number of spores. The spores were of same size and measured upto 60 µ in diameter.

It means that Rhynia was homosporous. In many specimens the sporangium contained tetrahedral tetrads of spores which suggest that they were formed by reduction division and the plant bearing them represented the sporophytic generation.

There was no special mechanism of sporangium dehiscence. The liberation of spores seems to have taken place by disintegration of the sporangial wall. Nothing definite about the gametophyte of Rhynia is known.

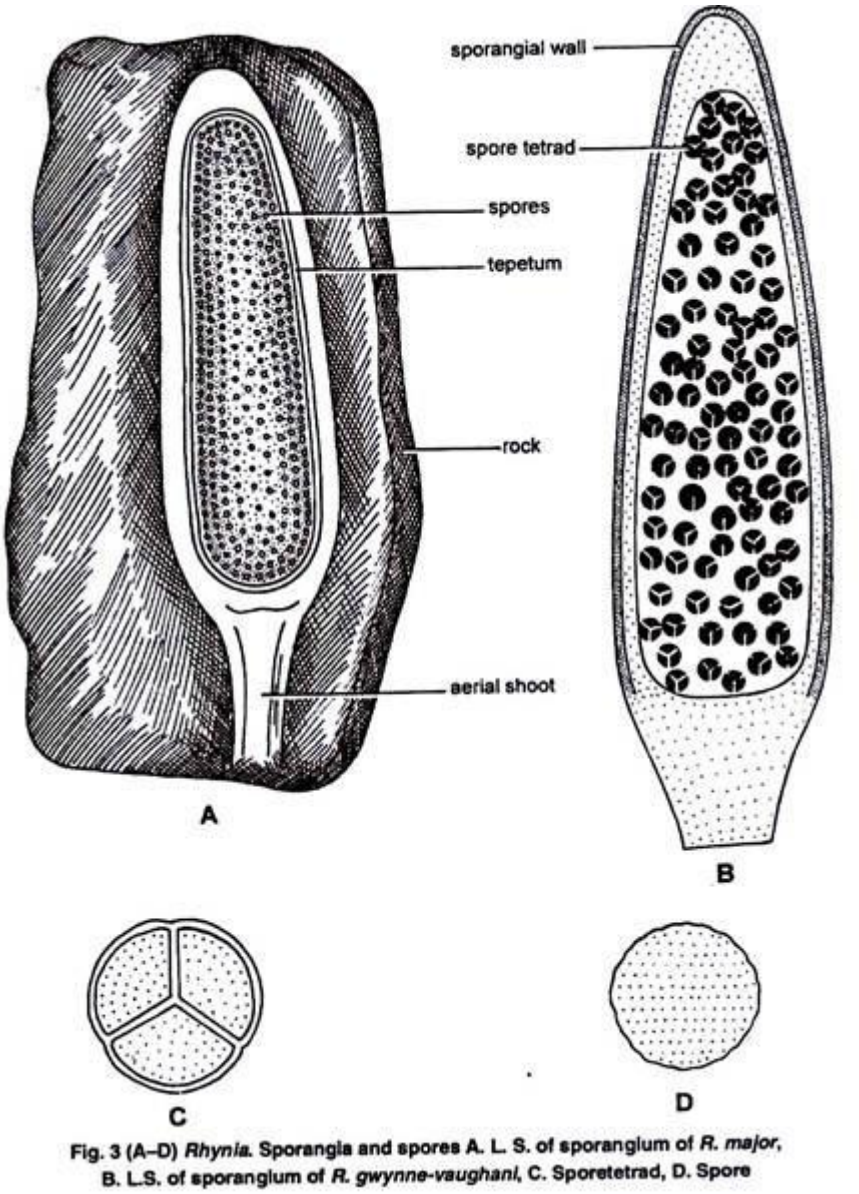
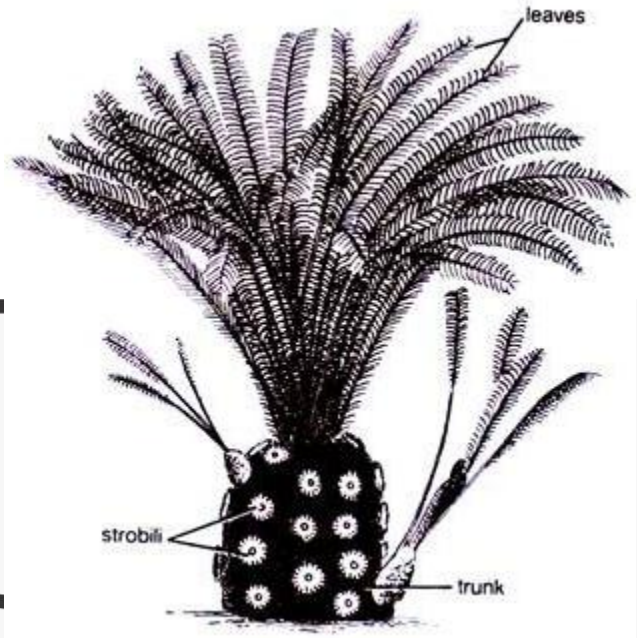


Fig. 3 (A–D) *Rhynia*. Sporangia and spores A. L. S. of sporangium of *R. major*, B. L.S. of sporangium of *R. gwynne-vaughani*, C. Sporetetrad, D. Spore

Cycadeoidea

- Class : Cycadopsida
- Order : Cycadeoideales
- Family : Cycadeoideaceae
- Genus : *Cycadeoidea*



External features of *Cycadeoidea dacotensis*

INTRODUCTION:

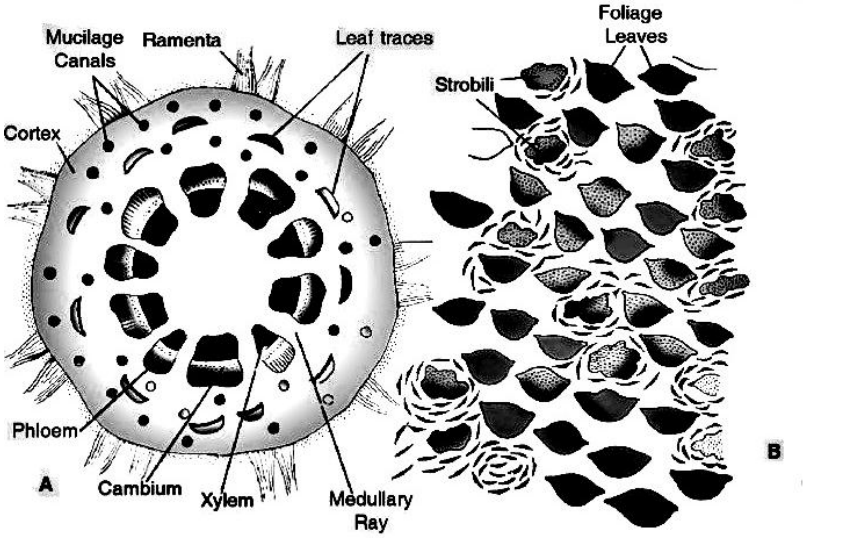
The plant Cycadeoidales were also called Bennettitales. The name derived from the name of J. J. Bennet, a British botanist. These groups of plants were abundant in the Jurassic period and they were a good food for dinosaurs.

HABIT:

The Cycadeoidea trunks were short, stout, spherical to sub-spherical and un-branched or branched.

The trunk 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 OF CYCADEOIDEA: T/S OF STEM



(A—B). *Cycadeoidea* sp. A. T.S. stem showing primary structure; B. Tangential section of a trunk.

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.

The secondary xylem and the secondary phloem were traversed by secondary medullary rays.

Cambium was clearly visible.

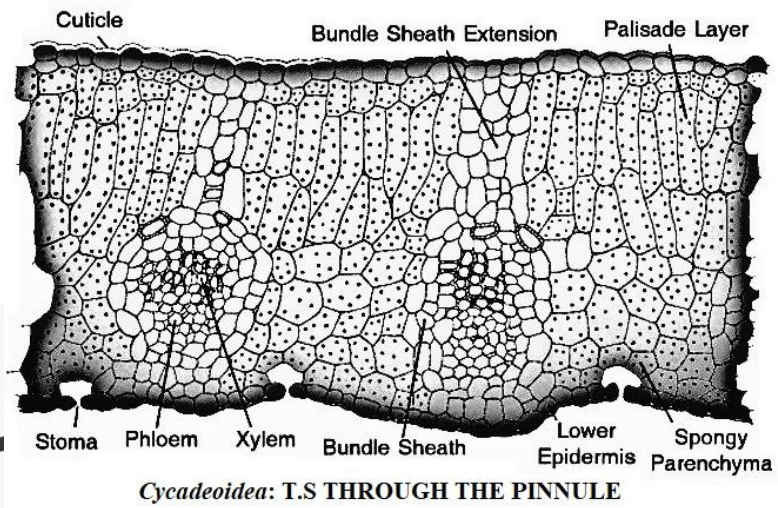
A leaf trace developed singly from the primary vascular strand.

LEAVES OF *Cycadeoidea:*

The leaves in Cycadeoidea (Bennettites) were large pinnate and showed xerophytic features. The vascular bundles in petiole and leaflets were mesarch with a strong sheath of sclerenchyma around it.

The plant *Cycadeoidea* was bisporangiate. Sporophylls were borne at the axillary position on the tip of the stalk or peduncle (known as dwarf branches). Sporophylls were completely surrounded by the

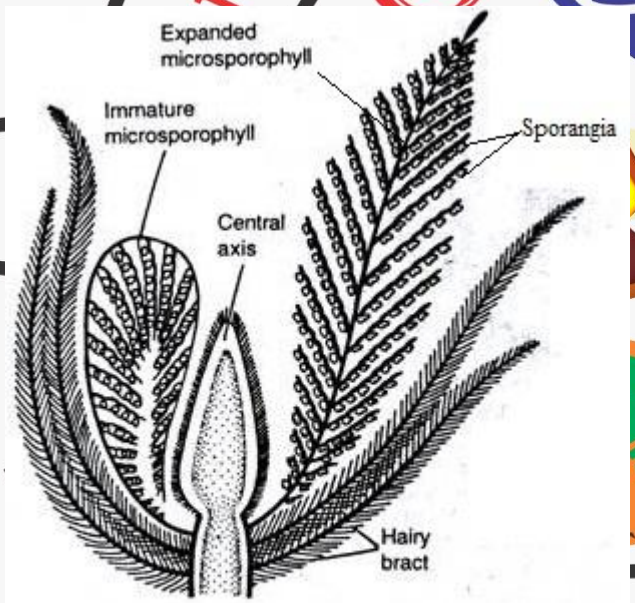
imbricately arranged branches. The sporophylls were of two types: microsporophylls arranged whorlly below the megasporophylls. The sterile bracts were present between micro and mega sporophylls.



Cycadeoidea: T.S THROUGH THE PINNULE

Each microsporophyll had a simple stalk and twenty slender pinnae, they were arranged in two rows. Sporangia were present on under surface of the pinnae. Each sporangium had two pollen sacs. Micro sporophylls or stamens were present in folded condition in young stage and then they became elongated as they became matured.

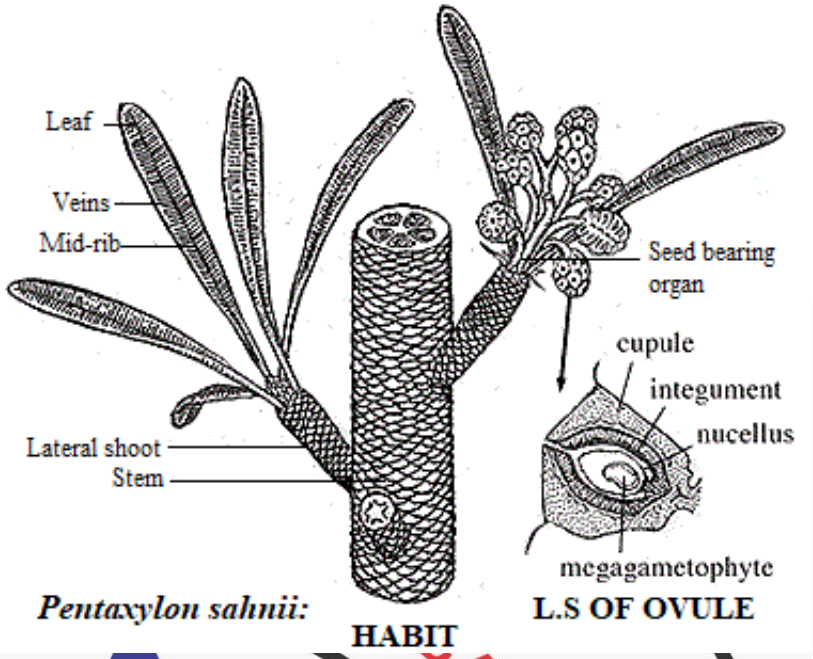
Mega sporophylls are arranged whorlly on the cone shaped receptacle above the microsporophylls. Each megasporophyll had simple stalk and one ovule was present at the tip in fertile sporophylls. The fertile sporophylls had flattened tips without ovules. The central mega sporophyll stood vertically upwards and they were longer in length.



Apical portion with expanded and curved microsporophylls; the conical axis possesses female reproductive structures.

Pentoxylon

- Genus : *Pentoxylon*



INTRODUCTION:

The pentoxylales are a group of seed plants that lived during middle to late Mesozoic period. Stems, leaves and male and female reproductive organs of this group have been described under following names:
Stems: *Pentoxylon* and *Nipanioxylon*
Leaves: *Nipaniophyllum*
Pollen-bearing organs: *Sahnia*
Seed-bearing organs: *Carnoconites*.
They had long narrow leaves and wood in a characteristic five wedge pattern (penta – xylon) around the primary xylem.

HABIT:

The plant was probably a shrub or very small trees. The stem was dimorphic. Long and short shoots were covered with spirally arranged scale, foliage bases and terminally located reproductive organs.
Leaves were thick, simple, lanceolate, had diploxylic leaf trace and possessed open venation. The anatomy of stem revealed five to six steles which were closely aggregated. The stems of *Pentoxylon sahnii* attained a diameter from 3mm to 2 cm. 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.

Fig. 7.1. *Pentoxylon sahnii*. T.S. stele. (after Sahni)

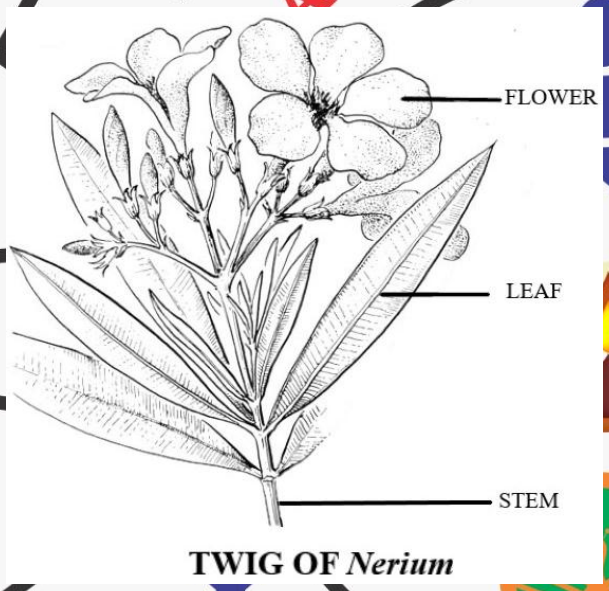
Primary phloem and primary xylem were present towards outer and inner sides of the cambium, respectively. The wood was pycnoxylic made of compact tracheids.
Ovules were sessile.
Female reproductive organs were like stalked mulberry, consisting of about 20 sessile seeds attached to central receptacle and surrounded by stony layer and then fleshy outer layer of integument uniting them.
Male reproductive organs or microsporophyll's form whorl of branched micro-sporangiophores.
The micro-sporangiophores were fused basally into a disc-like structure.

Ecological Adaptations in Plants:

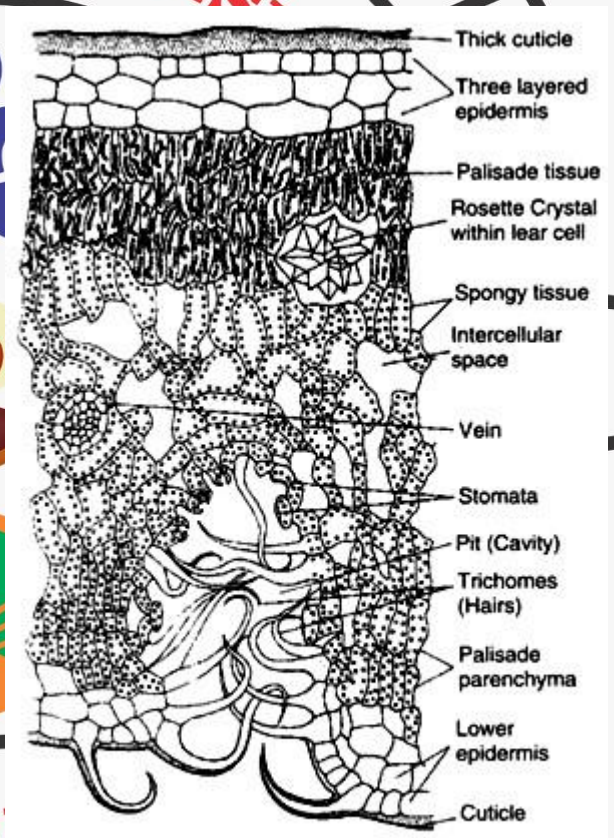
- **Xerophytic Adaptations:**
  Plants, which are growing in dry habitat are called xerophytes. They show some adaptations to live in xeric conditions.

A. ***Nerium***- is a non-succulent xerophytic shrub. It allows the following xerophytic adaptations:

1. Well-developed root system.
2. Leaves are narrow, thick, and leathery with glazed surfaces.
3. The T/S of leaf shows the multiple layered epidermis in dorsal side and coated with thick cuticle. Sunken stomata lined with hairs are present in lower epidermis.



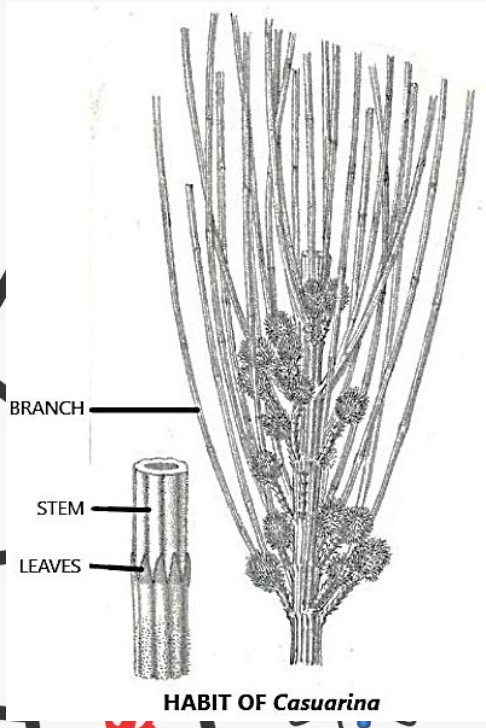
TWIG OF *Nerium*



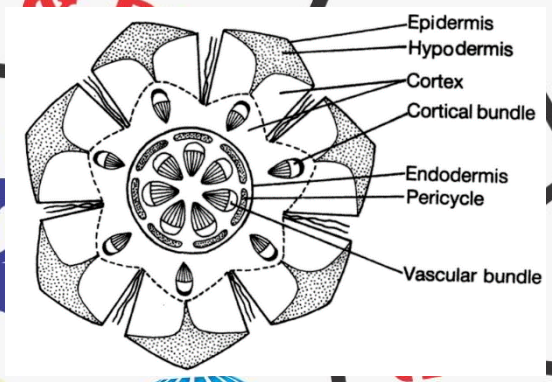
T.S OF *Nerium* Leaf

B. ***Casuarina***- is a perennial terrestrial non succulent xerophytic tree shows the following xerophytic adaptations:

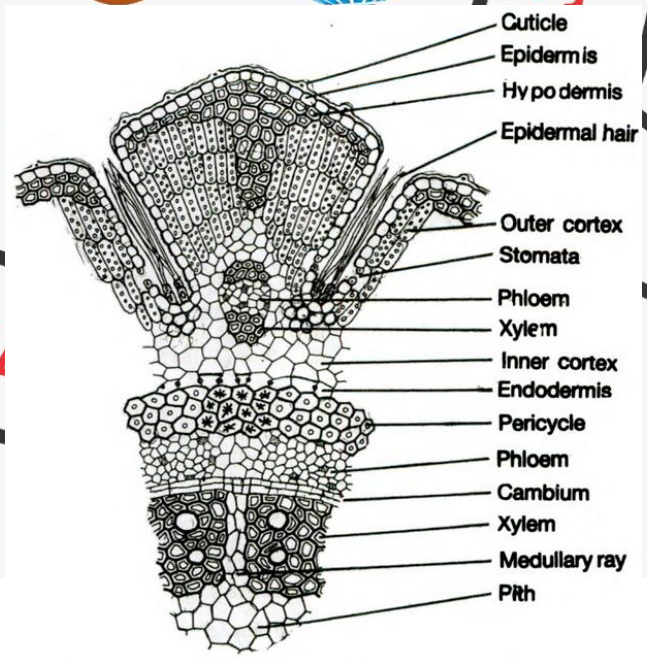
1. The stem are modified into needle like long, cylindrical, green photosynthetic structures called phylloclades.
2. Leaves are modified into small whorlly arranged membranous scales to reduce the rate of transpiration.
3. The T/S of stem shows thick cutinised epidermis, well developed sclerenchymatous hypodermis and a ring of vascular bundles.
4. The sunken stomata lined with hairs are present only in a groove of stem.



HABIT OF *Casuarina*



T/S OF *Casuarina* STEM (Ground Plan)



T/S OF *Casuarina* STEM
(A Portion Enlarged)

➢ **Hydrophytic Adaptations:**

The plants growing in water are called hydrophytes.

Jussiaea-

It is a free floating hydrophytic plant showing the following adaptations-

1. The root system is poorly developed, root hairs and root caps are present.
2. Balloon like floating roots are developed from the floating stem. They help in floating of stem on the surface of water.
3. The T/S of stem shows the epidermis layer and it is non cutinised. Well-developed aerenchyma tissue with large air spaces are present in cortex of stem and roots help in giving buoyancy and respiration.
4. Stomata is absent.
5. Poor development of mechanical tissues (avoid breakage or damage during water currents ex:- xylem and sclerenchyma).

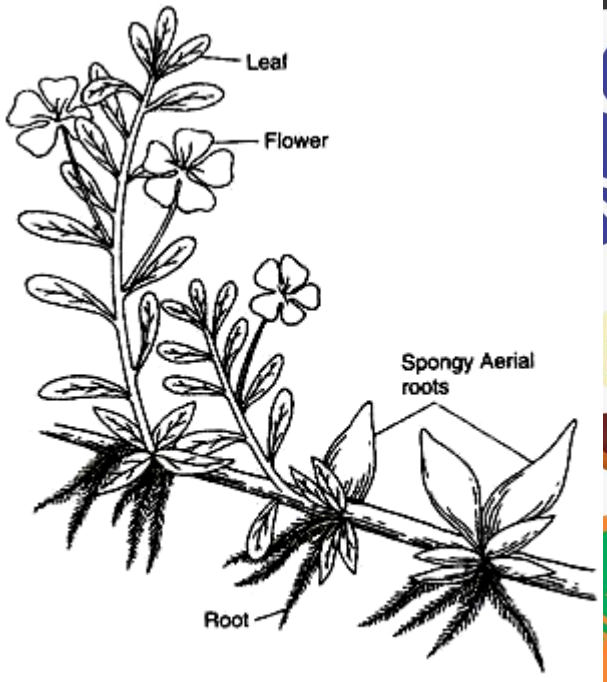


Fig. 8.7. *Jussiaea repens* showing spongy respiratory roots.

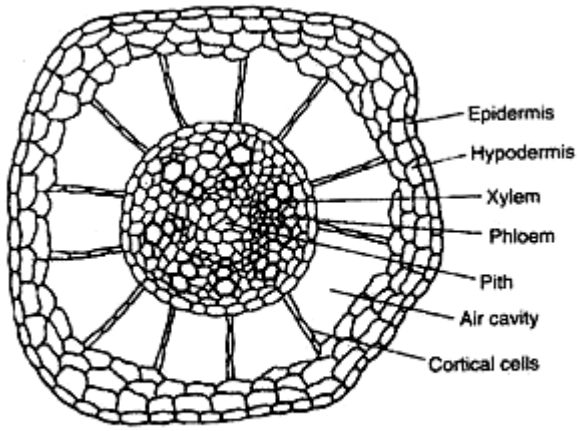


Fig. 8.16. T.S. of stem of *Jussiaea*.

➢ **Halophytic Adaptations:**

The plants growing in saline habitat (near sea shores) are called halophytes. In this place salts of NaCl, $MgSO_4$ and $MgCl_2$ are abundant. In order to survive they develop structural and physiological adaptations.

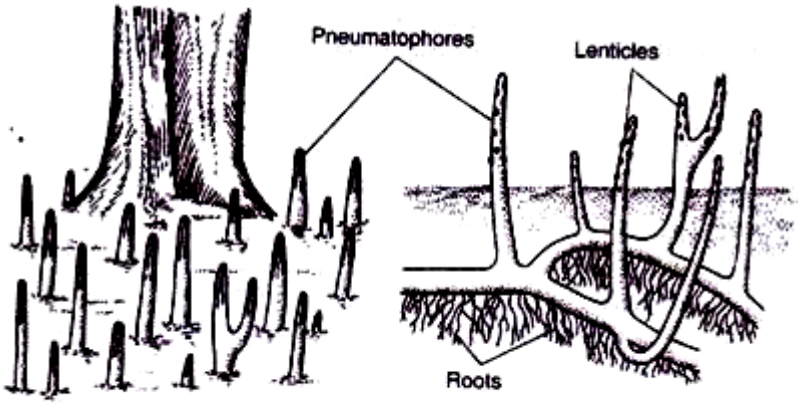


Fig. 10.1. Pneumatophores of mangrove plant.

Rhizophora is a halophytic plant with stilt roots to fix and with breathing roots (called **pneumatophores).**

They come above saline water logged soil and develop lenticular pores on the surface to exchange gases. The soil is amorphous in nature with lack of air. The T/S of pneumatophore shows several layered cork, aerenchymatous cortex with large air spaces. The collateral endarch vascular bundles are present instead of radial exarch vascular bundles.

Viviparous condition, weightlessness of seeds and seedlings are other adaptations.

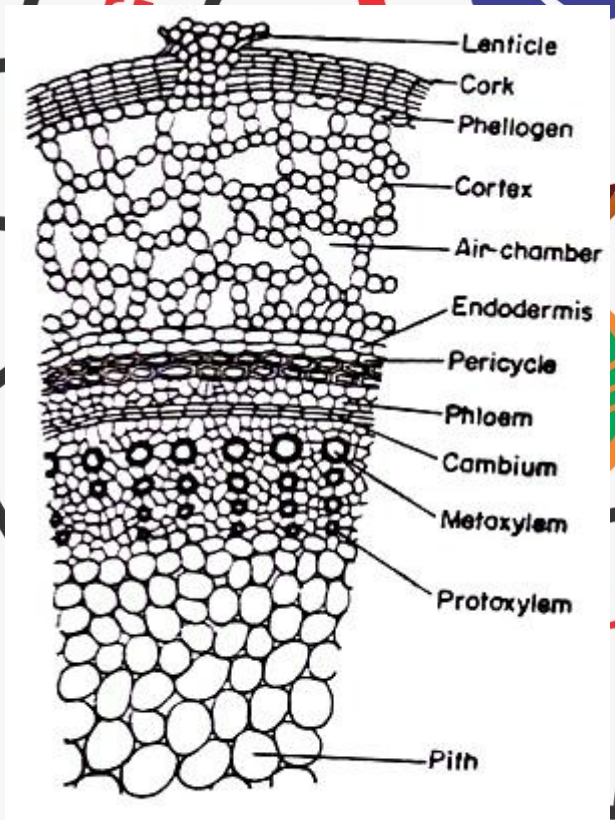


Fig. 8.6 : T.S. through Pneumatophore of *Rhizophora*

➢ **Epiphytic Adaptations (AEROPHYTES):**

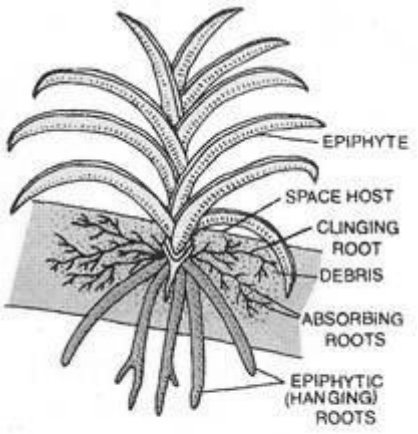
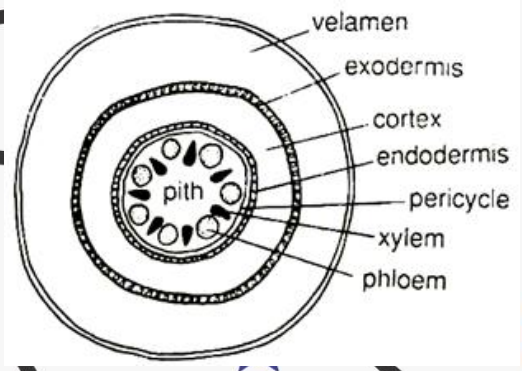


Fig. 5.21. *Vanda* showing thicker epiphytic roots, and narrow clinging and absorbing roots.

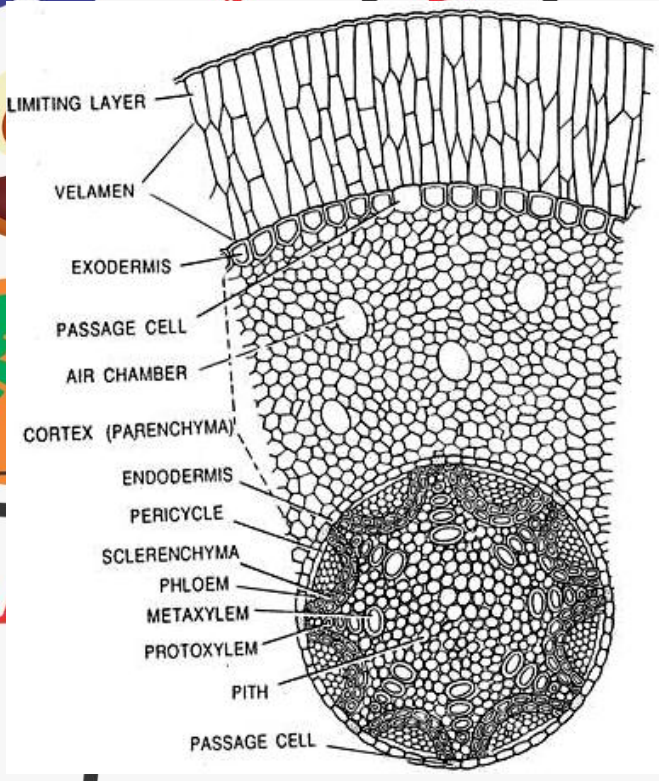
Plants which are growing on tree trunks of another plant without deriving nourishment from them are called epiphytes. They take support and shelter to get sunlight. Grows in places with regular rainfall and with more atmospheric humidity ex: Tropical rainforests.

Vanda is an epiphytic orchid plant. It shows the following epiphytic adaptations-

1. Roots and stem are well developed. The roots include two types hanging roots and clinging roots. Clinging roots help in fixing the plant body to the stem of host plant. The hanging roots or aerial roots help in absorption of moisture from atmosphere.
2. The internal structure of hanging roots show the multi layered water absorbing tissue called velamen.
3. Below epidermis is epiblema and it is single layered with thick walled cells. It is interrupted here and there by the presence of thin walled passage cells.
4. The cortex region consists of a number of small air chambers in between parenchyma tissue.
5. As these plants get less water, to avoid transpiration they will have leathery leaves.
6. These orchids are nest epiphytes where they form nest like structure in the crevices of the branches to collect humus and water.



T.S OF HANGING ROOT
(Ground Plan)



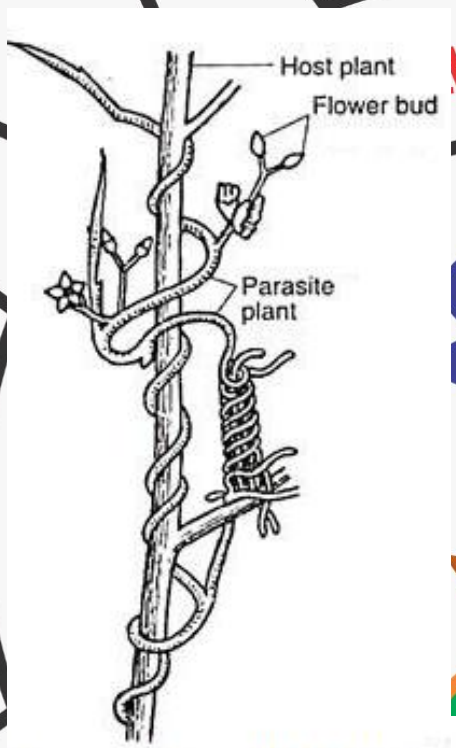
T.S OF HANGING ROOT
(A Portion Enlarged)

➢ **Parasitic Adaptations:**

The plants which capture their nutritional requirements and support (completely dependent) on the living host plant are called parasites.

Cuscuta is a total stem parasite. It has yellow thread like branched stem. It twines around the stem of host plants. It shows the following adaptations-

1. It has reduced leaves and no roots (growing into the soil).
2. The stem is yellow in colour and produces special kind of sucking roots into the host plant body called haustoria.
3. Haustoria are button like structures penetrating the host tissue and suck the nutrients from vascular tissue of the host plant.



Cuscuta reflexa **TWINING ON THE HOST**

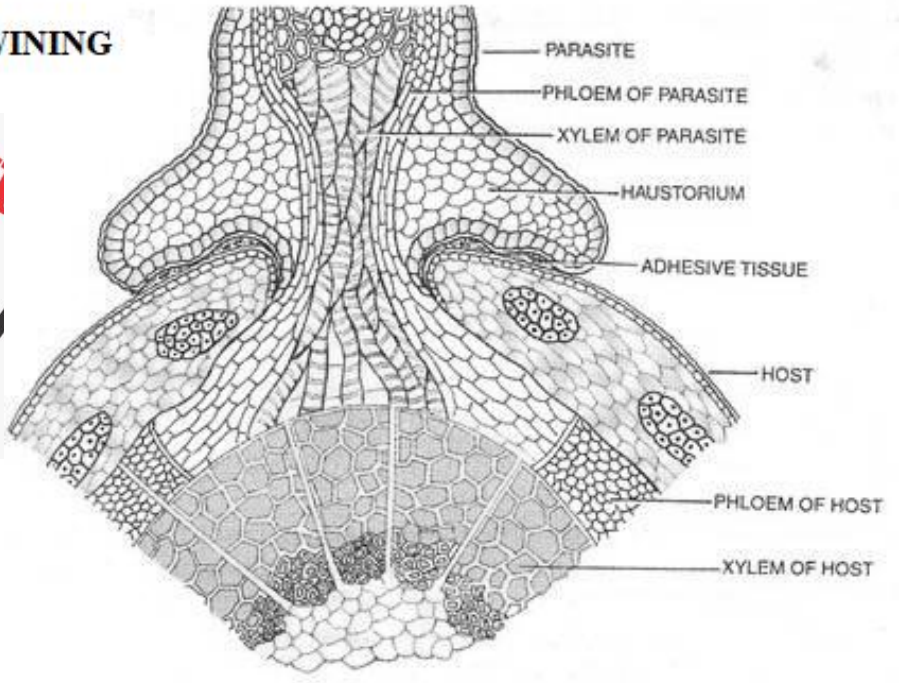


Fig. 5.20. Haustorial connection between *Cuscuta* and host.

ESTIMATION OF CHLORINITY OF WATER SAMPLE -BY HARVEY'S METHOD

AIM: To estimate the chloride content of water sample.

INTRODUCTION: Chlorides are widely distributed as salts of calcium, sodium and potassium in water and wastewater. Chlorides associated with sodium exert salty taste. Magnesium chloride in water generates hydrochloric acid which is highly corrosive and creates problems in boilers.

REQUIREMENTS: Pipette, Beaker, Conical Flask, Burette, Stand, Silver nitrate solution (0.005N), 2% Potassium Chromate indicator.

PRINCIPLE: The silver nitrate solution is titrated against water containing chloride. During the titration, chloride ion is precipitated as white silver chloride: $Ag^{+}+Cl^{-} <=> AgCl$

The indicator (potassium chromate) is added to visualize the endpoint, demonstrating presence of excess silver ions. In the presence of excess silver ions, solubility product of silver chromate exceeded and it forms a reddish-brown, brick red, orange or pale pink precipitate. This stage is taken as evidence that all chloride ions have been consumed and only excess silver ions have reacted with chromate ions:

$$2Ag^{+}+CrO_4^{2-} <=> Ag_2CrO_4$$

PROCEDURE:
Take 10 ml of water sample in a conical flask. Add 2 -3 drops of potassium chromate to this as indicator. Water sample in the conical flask turns yellow. Titrate this against standard silver nitrate solution in the burette till colour changes to orange red or pale pink.

TABULATION:
In Burette - Silver Nitrate (0.005N)
In Conical Flask - 10 ml of Water Sample
Indicator used - Potassium Dichromate (2%)
Colour changed - Yellow to Orange Red or Pale pink.

TRIAL NO		I	I I	I I I
BURETTE READING				
FINAL READING				
INITIAL READING				
□3				
AVERAGE				

CALCULATIONS:

□□□□□□□□□ □□ □□□□□ □ □□□. □□ □□□□□ (□□□□□□□ □□□□□)□□□□□□□ □□ □□□□□ □□□□□□

Preparation of 0.005 N $AgNO_3$ = Dissolve 0.8494 g of $AgNO_3$ in 1000ml distilled water and store in brown bottle (wt. / litre = normality x equivalent weight i.e. 0.005 x 169.88= 0.8494g)

Preparation of 2% $K_2Cr_2O_7$ = Dissolve 2gm of $K_2Cr_2O_7$ in 100ml distilled water.

ESTIMATION OF DISSOLVED OXYGEN IN A WATER SAMPLE

- BY MODIFIED WINKLER'S METHOD

AIM: To estimate the amount of dissolved oxygen in a given water sample.

INTRODUCTION:

Dissolved oxygen is the amount of gaseous oxygen (O_2) dissolved in the water. The presence of dissolved oxygen in water may be mainly attributed to two phenomena: Atmospheric diffusion and Photosynthetic activity of aquatic autotrophs. Dissolved oxygen in the water gets depleted by organic and inorganic enrichment from external source. Organic pollutants otherwise called as oxygen demanding waste and oxidizing inorganic substances, such as H_2S, NH_3 levels can cause the oxygen drop in due course of time. Since oxygen is the best requirement for biological oxidation, its continuously utilized by microorganisms and may soon get depleted and being anaerobic conditions.

REQUIREMENTS: Reagent bottles(100ml), Measuring cylinder, 1 ml and 10 ml pipettes, Burette stand, Conical flask, Light proof box (Dark Chamber), 10% Manganous sulphate, Alkaline Iodine Solution, Conc. H_2SO_4, 1% Starch Solution, Standard Sodium Thiosulphate Solution(0.01N)

□*4*) when added to water to be analysed followed by alkaline iodine solution (NaOH containing KI) forms a precipitate of manganous hydroxide. A part of manganous hydroxide is then converted into manganic hydroxide by oxygen dissolved in water sample. In a strong, acidic medium manganic hydroxide oxidises KI and releases free I_2. Number of I_2 molecules released is equal to oxygen molecules present in water sample.

□*4*+ KOH = $Mn(OH)_2$ + K_2SO_4

$3H_2SO_4 + 2Mn(OH)_2 + 2KI = 2MnSO_4 + K_2SO_4 + I_2 + 6H_2O$

PROCEDURE:

1. Take 100 ml of water sample in a reagent bottle add 1 ml $MnSO_4$ and 1 ml alkaline iodine into it. Close the mouth of reagent bottle with stopper and keep it in dark chamber for about 10 minutes or till the formation of white precipitate.
2. Remove the bottle from dark chamber, open the stopper and add 1ml conc. H_2SO_4 to dissolve the precipitate. Then solution in bottle turns into golden yellow colour.
3. Take 10 ml of golden yellow coloured solution in a conical flask. Add 1 drop of 1% freshly prepared starch solution as an indicator solution turns to blue colour. Titrate this against 0.01N sodium thiosulphate solution in a burette till colour changes from blue to colourless.

TABULATION:

TRIAL NO		I I	I I I
BURETTE READING			
FINALREADING			
INITIAL READING			
□*2*S□*3*			
AVERAGE			

CALCULATIONS:

1. 1 ml of $Na_2S_2O_3$is capable to absorb 8 mg of O_2 from the sample.
2. 1 ml of 0.1 N $Na_2S_2O_3$= 0.8 mg of O_2.
3. 1 ml of 0.01N $Na_2S_2O_3$= 0.08 mg of O_2.
   O*2.*
5. 10 ml of water sample contains y mg of O_2.

   Y x 1000*10* = Z mg of □*2.*

PREPARATION OF REAGENTS:

1. 10% $MnSO_4$ = Dissolve 10 g of $MnSO_4$ in 100 ml of water.
2. Alkaline iodide = Dissolve 150 g of KI and 500 g of NaOH in water and make up the volume to 1000ml.
3. 0.01 $Na_2S_2O_3$= Dissolve 24.83 g of $Na_2S_2O_3$ in 1000ml of distilled water.
   Wt / Ltr = Normality x Equivalent Weight of $Na_2S_2O_3$= 24.83g.
4. 1% starch = Dissolve 1g of soluble starch in 100 ml of warm water.

FORESTS OF KARNATAKA

□*2* (or 20% of Karnataka's geographic) area is covered by forests. The forests are classified as reserved □*2*), protected (3,932 k□*2),* unclosed (5,748 k□*2),* village*124*k□*2* and private (309 k□*2)* forests. The percentage of forests area to geographical area in the state is less than the all India average of about 23% and 33% prescribed in the National Forest Policy. The area under protected forests in the neighbouring □*2* (9% of the total area of the country), Maharashtra 54,000k□*2*(8%) , Tamil Nadu 22, 000k□*2*(3%) and □*2*(2%).

Karnataka is known for its valuable timbers from the evergreen forests in the Western Ghats region, notably Teak and Rosewood, the richly ornate panels of which adorn the beautiful chambers of the two houses of Karnataka Legislature.

Karnataka is one such state where it has magnificent forests in India. From the evergreen forests of Western Ghats to scrub or thorny forests in plain areas.

1. **EVERGREEN AND SEMI EVERGREEN FORESTS**:
   An evergreen forest is a forest consisting entirely or mainly of evergreen trees that retain green foliage all year round and semi evergreen forests are generally considered as a transitional stage between evergreen and moist deciduous forests. These forests are characterised by ever- green trees mixed with deciduous having typical features like less dense canopy, gregariousness, frequent buttressed trunks, thicker and rougher barks, and heavy climbers. Ex: *Dipterocarpus indicus, Hopea parivflora, Myristica fauna, Gymnacranthera canarica, Vateria indica* etc.,

   The evergreen forests are found along stretches of Western Ghats i.e. along Western slope of Malenadu region of Coorg through the western parts of Hassan, Chikkamagaluru, Shivamogga and North Kanara districts. The annual rainfall varies from 100 – 300 inches per annum (1 inch = 2.54 cms)

   The semi –evergreen forests are found in western parts of Mysore and Hassan, east part of Coorg, central parts of Chikkamagaluru, Shivamogga, South and North Kanara districts. The annual rainfall varies from 60 – 100 inches per annum.

2. **MOIST DECIDUOUS FORESTS:**
   Temperate deciduous forests are located in the areas that have moderate rainfall and temperature and with cold winters. These are the typical monsoon forests in areas where the amount of annual rainfall C, and humidity percentage of 60 to 80. They mostly occur along the eastern slopes of the Western Ghats, north eastern parts. Teak (*Tectona grandis*) are commercially the most significant species; occupying the relatively wetter north eastern parts of the peninsula Eg: *Terminalia*, *Lagerstroemia*, *Pterocarpus*, *Xylia*, *Tectona* and *Anogeissus* etc., These type of forests are found in Dharawada, Belgaum, Hassan, Tumkur and Bengaluru districts. Annual rainfall varies from 30 – 60 inches.

3. **DRY DECIDUOUS FORESTS:**

   The tropical deciduous forests shed leaves during December (in Northern Hemisphere) as water becomes scarce. This type is degraded version of the moist deciduous. It occupies a vast area of the country between moist deciduous (in the East) and tropical thorn (in the west) forests. Eg: *Acacia*, *Hardwickia*, Neem, *Pongamia*, *Soymida*, *Santalum album*, *Ficus* etc.,

4. **SCRUB AND THORNY FORESTS:**

   These forests are confined to areas where the rainfall is very low. Here due to paucity of rainfall the trees are stunted with large patches of coarse grasses. The typical vegetation consists of widely spaced

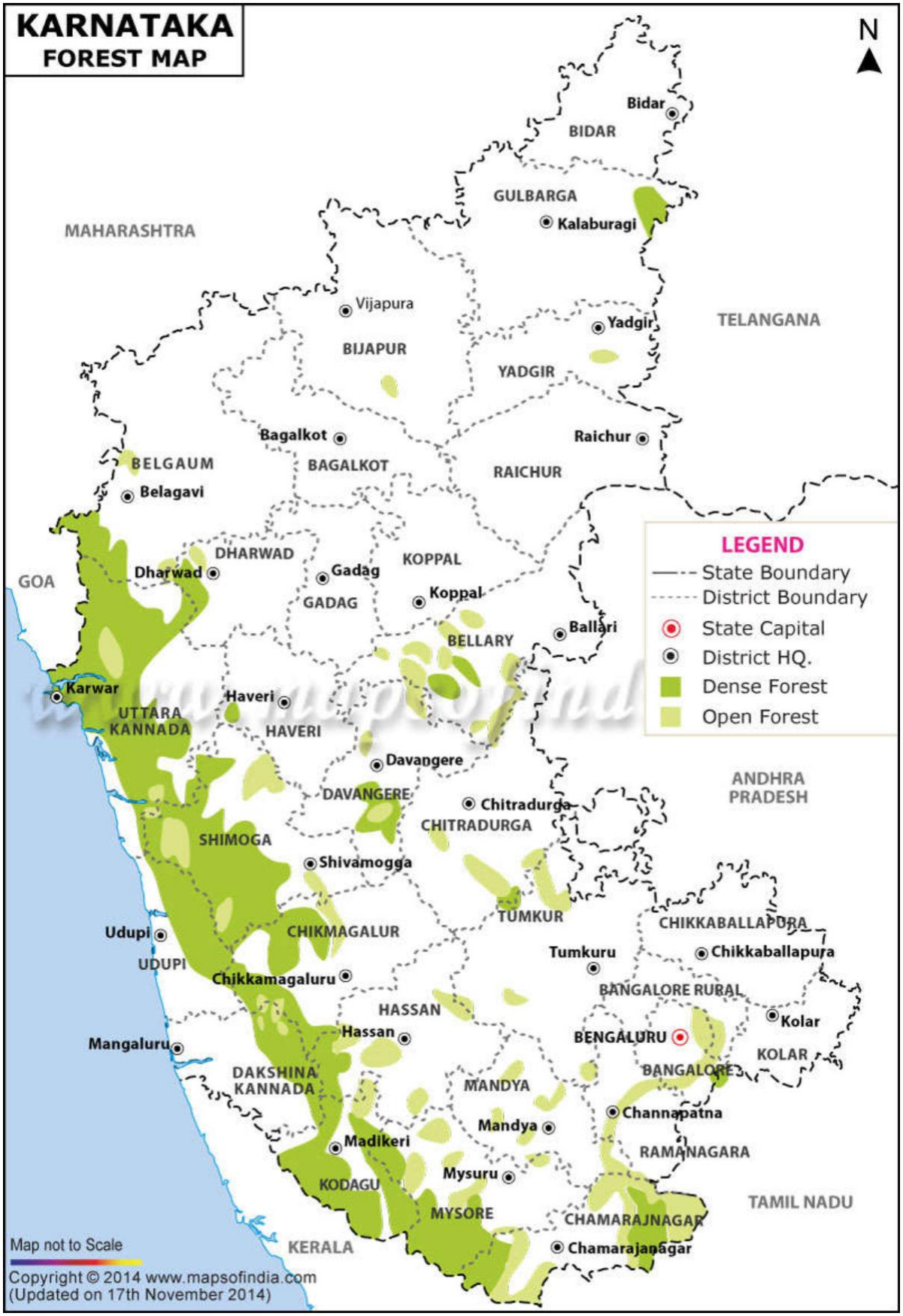
Acacias, Euphorbias including the typical spiny and thorny varieties and clumps of wild palms here and there. Eg: *Acacia* species, *Balanites roxburghii*, *Cordia myxa*, *Capparis* spp, *Prosopis* spp, *Azadirachta indica*, *Cassia fistula*, *Diospyros chloroxylon*, *Carissa carandas* and *Phoenix sylvestris* etc. This type of forest is found in Chitradurga, Bellary, Raichur, Gulbarga, Bijapura and Bidar district. Annual rainfall less than 25 inches.

5. GRASSLAND:

These forests are mainly grass lands and waste land. The favourable conditions for development of a stable grassland are frequent rainfall and sufficient warmth. The annual rainfall observed ranges between 25 to 80 cms.

6. SACRED GROVES:

They are community linked forest conservation activities. It varies in size and vegetation. They are locally called Devarakadu. 1476 such groves have been reported in Karnataka. These groves are very essential for conservation purposes often housing many medicinal and endemic species. Eg: Sage leaved *Alangium*, Neem, Peepal, *Garcinia* etc.


KARNATAKA
FOREST MAP
N
Bidar
BIDAR
GULBARGA
Kalaburagi
MAHARASHTRA
Vijapura
BIJAPUR
Yadgir
YADGIR
TELANGANA
Bagalkot
BAGALKOT
Raichur
RAICHUR
BELGAUM
Belagavi
LEGEND
State Boundary
District Boundary
State Capital
District HQ.
Dense Forest
Open Forest
DHARWAD
Dharwad
Gadag
KOPPAL
GOA
GADAG
Koppal
Ballari
BELLARY
Karwar
Haveri
UTTARA KANNADA
HAVERI
Davangere
DAVANGERE
ANDHRA PRADESH
Chitradurga
CHITRADURGA
SHIMOGA
Shivamogga
TUMKUR
CHIKKABALLAPURA
Udupi
CHIKMAGALUR
Tumkuru
Chikkaballapura
UDUPI
Chikkamagaluru
BANGALORE RURAL
HASSAN
Kolar
Hassan
BENGALURU
Mangaluru
KOLAR
DAKSHINA KANNADA
BANGALORE
MANDYA
Channapatna
Mandya
Madikeri
RAMANAGARA
Mysuru
KODAGU
TAMIL NADU
MYSORE
CHAMARAJNAGAR
Map not to Scale
KERALA
Chamarajanagar
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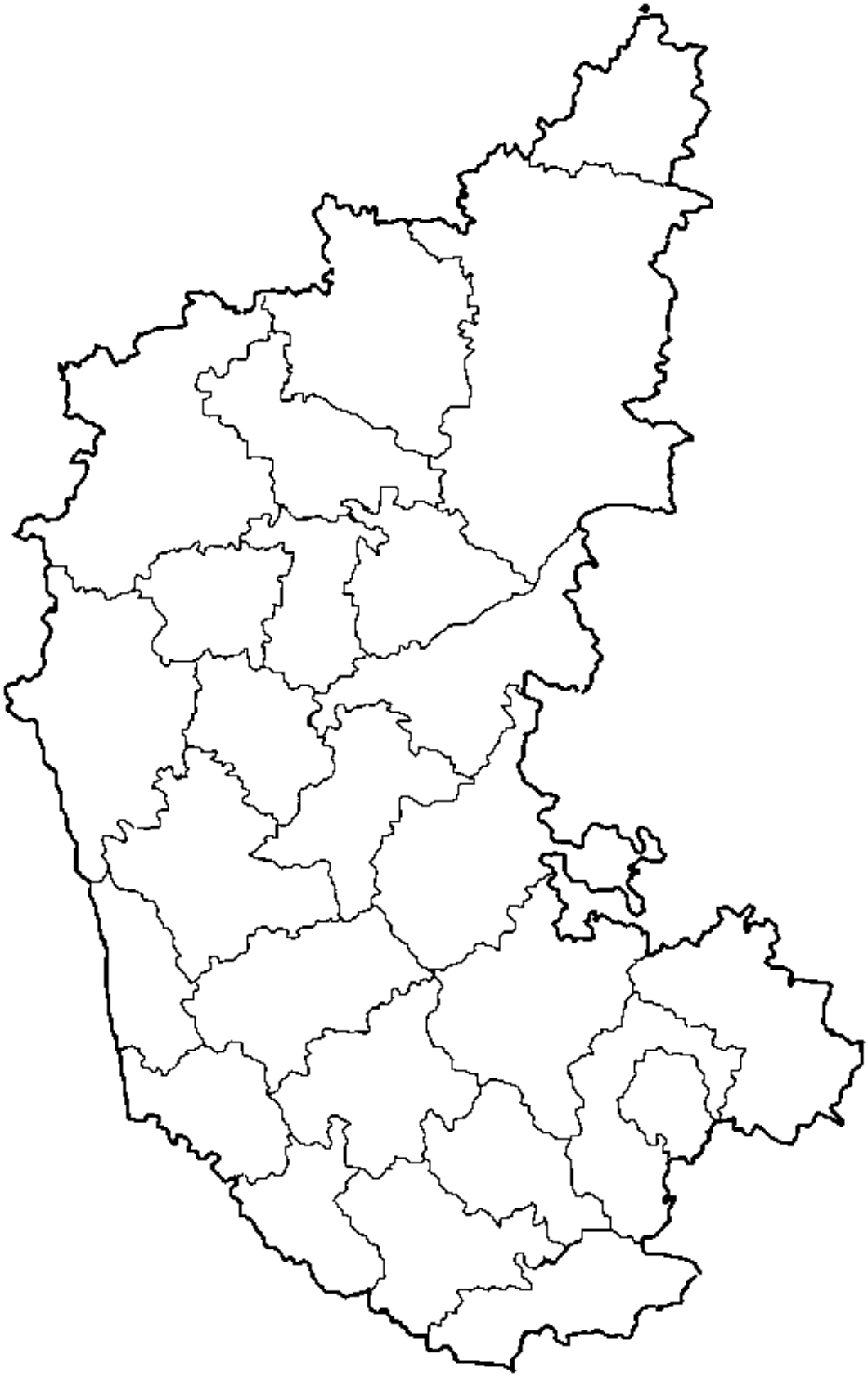
(Updated on 17th November 2014)


BIDAR
GULBARGA
BIJAPUR
BELGAUM
RAICHUR
DHARWAD
BELLARY
UTTARA KANNADA
CHITRADURGA
SHIMOGA
CHIKKAMAGALUR
TUMKUR
KOLAR
DAKSHINA KANNADA
HASSAN
BANGALORE
MANDYA
KODAGU
MYSORE
REFERENCES
EVERGREEN FOREST
SEMI EVERGREEN FOREST
MOIST DECIDUOUS FOREST
DRY DECIDUOUS FOREST
SCRUB FOREST



Phytogeography Regions of India

A phytogeographical region is defined as an area of uniform climatic conditions and having a distinctly recognisable type of vegetation. According to D. Chattarjee (1962), India can be divided into nine phytogeographical regions.

1. **Western Himalayas**

This region comprises north and south Kashmir, part of Punjab and Kumaon region of Uttaranchal. Average annual rainfall in the region is 100-200 cm. The region is wet in outer southern ranges and slightly dry in the inner areas. At high altitudes, snowfall occurs during winters. The region is subdivided into three zones.

1. **Submontane (lower, tropical and subtropical) zone:** This zone includes outer Himalayas i.e. regions of Siwalik Hills and adjoining areas from 300 to 1500 m altitude. Average annual rainfall of the zone is around 100 cm. The vegetation consists of subtropical dry evergreen, subtropical pine and tropical moist deciduous forests.
2. **Temperate (montane) zone:** This zone extends in the western Himalayas between the altitudes 1500 and 3500 m. The climate is wet between the altitudes 1500 and 1800 m and is drier at higher altitude. The vegetation consists of wet forests, Himalayan moist and Himalayan dry temperate forests.
3. **Alpine zone:** This zone extends between 3500 m and 5000 m altitudes. The rainfall is very scanty and climate is very cool and dry. The vegetation consists of alpine forests.

2. **Eastern Himalayas**

This region extends in the Himalayas from east of Nepal up to Arunachal. The climate is warmer and wetter than in western Himalayas. Tree line and snow line are higher by about 300 m than in the western Himalayas. The tropical temperature and rainfall conditions result in vegetation of the region having greater general species diversity, greater variety of oaks but lesser variety of conifers than in the western Himalayas. This region is also divided into three zones.

1. **Submontane (lower, tropical and subtropical) zone:** This zone extends from the foothills up to the 1850 m altitude. The climate is nearly tropical and subtropical. The vegetation consists of subtropical broad-leaved forests, pine forests and wet temperate forests.
2. **Temperate (montane) zone:** The zone extends from 1850 m to 4000 m altitude, about 500 m higher than in the western Himalayas. The vegetation consists of typical temperate forests with oaks and *Rhododendron* at lower and conifers at higher altitudes.
3. **Alpine zone:** This zone extends from 4000-5000 m altitude. The climate is very cool and dry. The vegetation consists of alpine forests.

3. **Indus plain**

This region comprises a part of Punjab, Delhi, Rajasthan, a part of Gujarat and Cutch. The climate has very dry and hot summers alternating with dry and cold winters. The annual rainfall is generally less than 70 cm and may be 10-15 cm in some areas. Most of the region is desert today though it had dense forests about 2000 years ago that were destroyed due to biotic factors particularly extensive cattle grazing. The vegetation today consists of tropical thorn forests and grasslands in some areas.

4. **Gangetic plain**

This region covers part of Delhi, Uttar Pradesh, Bihar, West Bengal and part of Orissa. Average annual rainfall ranges from 50 cm to 150 cm from east to west. The vegetation consists of tropical moist deciduous forests, dry deciduous forests, thorn forests and mangrove forests.

5. **Assam**

The region covers most of the Assam. The climate is characterized by very high temperature and rainfall. The vegetation consists of tropical evergreen and wet temperate forests in the lower plains while hilly tracts up to 1700 m altitude have subtropical pine forests.

6. **Central India**

This region comprises part of Orissa, Madhya Pradesh, Vindhyan region and Gujrat. The areas are mostly hilly with some places at 500-700 m altitude. The average annual rainfall is 100-170 cm. Biotic disturbances are very common in this region resulting in degradation of forests into thorny forests in the open area. The vegetation consists of tropical moist deciduous forests, chiefly Sal forests in areas of annual rainfall above 150 cm and mixed deciduous forest in areas of 125-150 cm annual rainfall. Tropical thorn forests are found in the areas of annual rainfall below 125 cm.

7. **Western coast of Malabar**

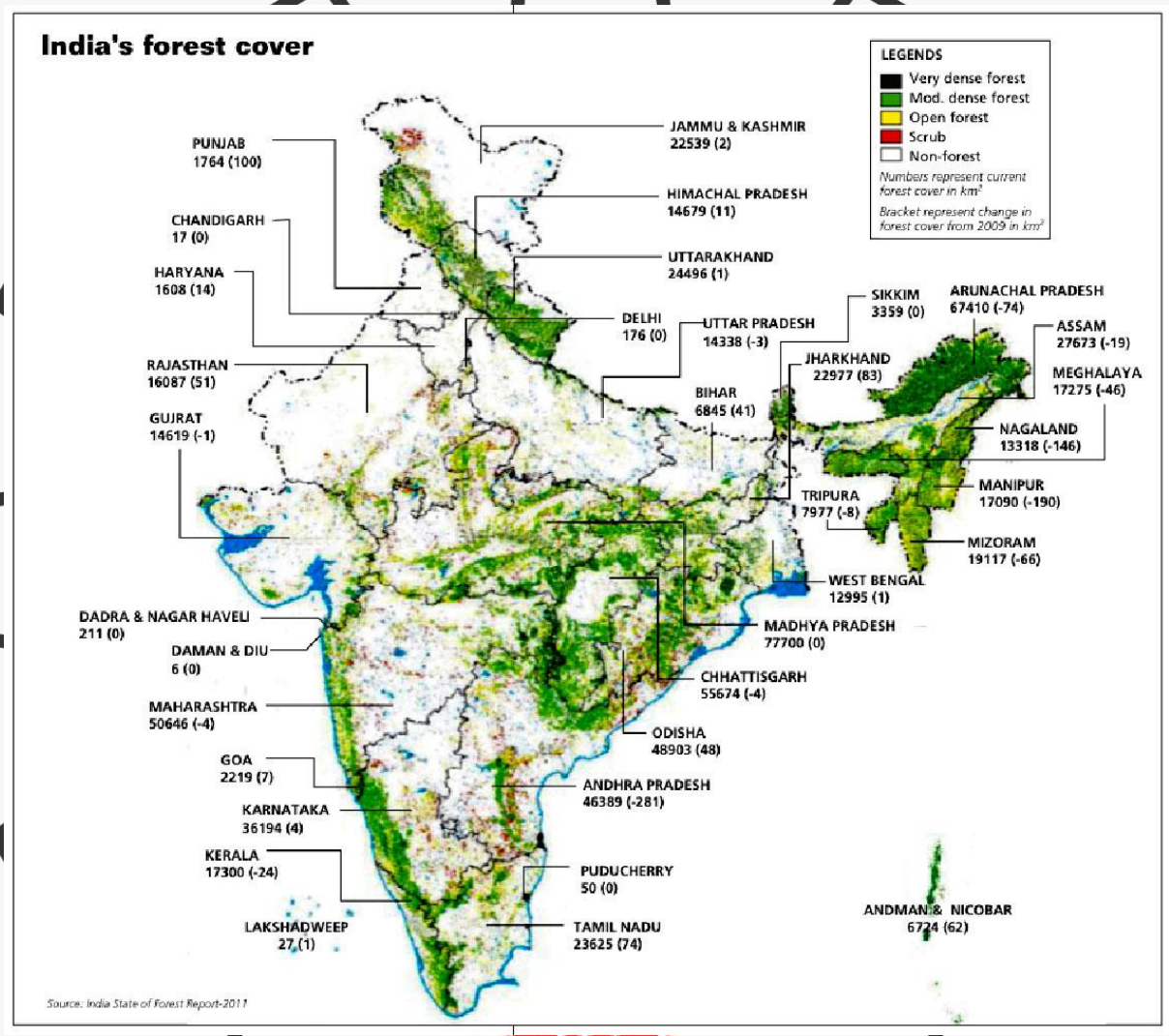
This is a small region extending from Gujrat to Kanyakumari along Western Ghats. The climate is warm humid having annual rainfall over 400 cm. The climate is tropical on the coasts and temperate in the hills. The vegetation consists of tropical wet evergreen, moist evergreen and moist deciduous forests. Wet temperate forests (Sholas) are present in Nilgiri while mangrove forests are found in the saline swamps on the coasts.

8. **Deccan**

The region comprises southern Peninsular India from southern Madhya Pradesh up to Kanyakumari excluding the Western Ghats. The average annual rainfall in the region is about 100 cm. The vegetation consists of tropical dry evergreen, dry deciduous and swamp forests.

9. **Andaman and Nicobar**

This region includes Andaman and Nicobar Islands. The climate of the region is warm and humid with very high temperature and annual rainfall. The vegetation consists of littoral mangrove, evergreen, semi-evergreen and deciduous forests.


India's forest cover
LEGENDS
Very dense forest
Mod. dense forest
Open forest
Scrub
Non-forest
Numbers represent current forest cover in km²
Bracket represent change in forest cover from 2009 in km²
PUNJAB 1764 (100)
CHANDIGARH 17 (0)
HARYANA 1608 (14)
RAJASTHAN 16087 (51)
GUJRAT 14619 (-1)
DADRA & NAGAR HAVELI 211 (0)
DAMAN & DIU 6 (0)
MAHARASHTRA 50646 (-4)
GOA 2219 (7)
KARNATAKA 36194 (4)
KERALA 17300 (-24)
LAKSHADWEEP 27 (1)
JAMMU & KASHMIR 22539 (2)
HIMACHAL PRADESH 14679 (11)
UTTARAKHAND 24496 (1)
DELHI 176 (0)
UTTAR PRADESH 14338 (-3)
BIHAR 6845 (41)
SIKKIM 3359 (0)
ARUNACHAL PRADESH 67410 (-74)
ASSAM 27673 (-19)
JHARKHAND 22977 (83)
MEGHALAYA 17275 (-46)
NAGALAND 13318 (-146)
MANIPUR 17090 (-190)
TRIPURA 7977 (-8)
MIZORAM 19117 (-66)
WEST BENGAL 12995 (1)
MADHYA PRADESH 77700 (0)
CHHATTISGARH 55674 (-4)
ODISHA 48903 (48)
ANDHRA PRADESH 46389 (-281)
PUDUCHERRY 50 (0)
TAMIL NADU 23625 (74)
ANDMAN & NICOBAR 6724 (62)
Source: India State of Forest Report-2011

SOIL ANALYSIS

Determination of pH of Soil

Aim: To Determine pH of Soil

Requirements: soil, pH paper, pH universal indicator, beaker, glass rod et.

Preparation of Soil:

- 20 g of soil was weighed and transferred into 100 mL beaker.
- 40 mL distilled water was added and stirred well with a glass rod.
- This was allowed to stand for half an hour with intermittent stirring.

pH Determination:

- Take a pH paper strip and place it on a white tile.
- Pour a drop of the sample on the pH paper using a clean dropper.
- Observe the colour of the pH paper.
- Now compare the colour obtained on the pH paper with the different colour shades of the standard colour pH chart and note down the pH value.
- Similarly, find the pH of the remaining samples using a fresh strip of pH paper and a separate dropper for each sample.

Using Universal Indicator Solution

- Take a small quantity of the given sample in a test tube using a dropper.
- Using a dropper pour a few drops of the universal indicator solution into the test tube containing the sample.
- Shake the test tube well and note the colour developed in the test tube.
- Now compare the colour produced in the test tube with the different colour shades of the standard colour pH chart and note down the pH value.
- Similarly, find the pH of the remaining samples.

Observations:

Record the observations in a tabular column.

SAMPLE NAME	For pH paper		For Universal Indicator Solution	
	Colour produced on the pH paper	Approximate pH	Colour produced in the Solution	Approximate pH

Precautions:

- Use only the standard colour pH chart supplied with the pH paper for assessing the pH value.
- Keep the pH strips away from chemical fumes.
- Either use fresh fine dropper or glass rod for each different sample, or wash the dropper or glass rod well with water every time.

- To correctly view the colour produced on the pH paper, keep the pH paper on a white tile while performing the experiment.

➢ **Determination of Porosity, Water Holding Capacity and Adsorptivity of soil:**

Experiment:

100g each of dry sand, dry silt (from river bed) and dry clay is taken. Three funnels having folded filter papers are separately filled with three types of soils. 100 ml of distilled water coloured with safranin are slowly poured in each type of soil and allowed to drain out through the stem of the funnel. The drainage is collected in beakers and their volumes are measured.

Observation:

It is seen that the collected volume of water is more in case of sandy, less in silty and least in case of clayey soils. The filtered water shows decrease in the intensity of colour upto different degrees maximum in sandy and minimum in clayey soil. The clay soil adsorbs maximum safranine colour and in sand it is minimum.

Inference:

The experiment shows that clay has maximum water holding capacity and adsorptivity but least porosity. Sand has the highest porosity but least water holding capacity and adsorptivity. Silt shows intermediate values between sand and clay.

➢ **Determination of capillary flow in soil:**

Experiment:
Three cylindrical glass tubes of the dimension 40 cm long and 2 cm diameter are taken and open end of each tube is plugged with cotton. Air dried soil samples (clay, silt and sand) are taken in each tube separately and uniformly packed upto certain height by moderate tapping. Tubes are allowed to stand vertically in beaker containing water so that the plugged end dips in water.

Observations:
Water gradually rises up through the soil in the tubes. It diffuses upward faster through sand followed by silt and clay.

Inference:
The capillary spaces between the colloidal particles of clay being narrower and find in dimension exert greater resistance to flow of water and maximum adhesive force. In case of sand the capillary spaces are wider offering lesser resistance to flow, and minimum adhesive force.

➢ **Determining soil texture by three methods**:

Objective:

The purpose of this lab activity is to determine the amount of clay, silt and sand particles in a given soil. Soil class will be determined, based on the USDA soil survey manual.

Introduction and background:

The amount of sand, silt and clay ultimately makes up the class of the soil. To determine the class type of an unknown soil we will have to determine the ratio of sand, silt and clay particles in a specific volume of soil. Soil particles are categorised into groups according to size.

Clay = less than 0.002mm, Silt = 0.002 to0.06mm

Sand = 0.06 to 2.0mm , Gravel = greater than 2.0mm

We will be using comparative volumes to determine the ratio of these particles, based upon the fact that different sizes of particles will fall out of solution at different rates.

Method i:

Materials-

- Plastic stand
- 3 – 50 ml graduated centrifuge tubes
- Tube rack
- Stopper to fit the centrifuge tube
- Soil dispersing agent – Calgon
- Soil

Procedure-

1. Label the centrifuge tubes A, B and C.
2. Break up the soil into individual particles and add soil to the level of the line marked 15 ml in centrifuge tube A. Tap the bottom of the tube gently against the table to pack the soil and eliminate any large air pockets. Add more soil, if necessary, to the 15ml mark.
3. Add 1 ml of the soil dispersing agent (Calgon) to the soil, and add tap water to the level of 45 ml.
4. Place the stopper firmly in the tube. Holding the stopper, shake the tube for 2 – 5 min. make sure all the soil is mixed with the water.
5. Remove the stopper and place the centrifuge tube in the stand for 30 seconds. The time is critical. If you allow more than 30 seconds to pass, shake the tube and allow the tube to stand for another 30 seconds.
6. Carefully pour all the solution from the centrifuge tube A into centrifuge tube B(leaving the soil particles that settled out). Gently tap tube A on the table to level the soil left in the tube and return to the stand.
7. Allow tube B to stand undisturbed for 30 mintes. At the end of the 30 minute standing time, carefully pour the solution from centrifuge tube B into centrifuge tube C (Again leaving the particles that settled).
8. Read the volume of soil particles, as accurately as possible, for tubes A and B. Record the data.

Data:
Volume of Soil sample: 15.0ml
Particles in tube A: ml

Particles in tube B: ml

Calculations:

The mineral particles in separation tube A are sand. They are the largest and heaviest particles. Therefore, they settle out first. The particles in separation tube B are silt. Since they are lighter than sand, they take longer to settle out.
The particles remaining in the final tube are clay. Clay particles swell when placed in water, and they tend to remain in water. This tube is not an accurate indication of the amount of clay in the sample. The amount of clay is more accurately determined mathematically.

9. Calculate the percent of sand in your soil sample:
   Volume in tube A (sand) divided by 15 ml (total sample) times 100= **%Sand.**
10. Calculate the percent of silt in your sample:
    Volume in tube B (silt) divided by 15 ml (total sample) times 100= **%Silt.**
11. Calculate the percent of Clay in your sample:
    Add the volumes of tubes A and B then subtract that answer from 15 ml (total sample). This is the volume of clay.
    Volume of clay divided by 15 ml times 100 =**% Clay.**
12. Now determine the soil type for your sample by comparing your answers in steps 9, 10 and 11 to the following table.

SOIL

Sands: soil that contains 85% to 90% or higher sand, with no more than 10% clay and with the rest silt.

Loamy sands: soil that contains between 70% to 85% sand and with clay being 14 % or below.

Sandy loams: soil with 52% or more sand and 20% or less clay.

Loam: soil with 7% to 27% clay, 28 % to 50% silt and less than 52% sand.

Silt loam: soil that contains 50% or more silt and 12% to 27% clay.

Clay loam: soil that contains 27% to 40% clay and 20% to 45% sand.

Clay: soil that contains 27% to 40% or more clay, and less than 45% sand and less than 40% silt.

Soil type for sample =

Method ii:

Materials –

- 100ml graduated cylinder
- Rubber stopper that fits the cylinder
- 5% Calgon solution
- Soil samples

Procedure:

1. Add approximately 50 ml of soil to the graduated cylinder, and fill with Calgon solution to the 100 ml mark. Mix well and allow to stand for 15 minutes.
2. Secure the stopper in the graduated cylinder and holding a finger over the stopper, shake by inverting for 5 to 10 minutes. Allow to stand undisturbed for 24 hours.

3. You will be able to see the lines that divide the sand, silt and clay columns. The sand will be at the bottom, the silt in the middle and the clay on top. Read and record as data: the top of the sand column(also the bottom of the silt column), the top of the silt column (also the bottom of the clay column), and the top of the clay column (also the total volume)

Data:

Volume at the top of sand column : ___ml
(Also represents the bottom of the silt column)
Volume at the top of the silt column : ___ml
(Also represents the bottom of the clay column)
Volume at the top of Clay column : ___ml
(Also represents the total volume of the sample)

Calculations:

4. Calculate the percent of sand in the sample.
   Volume of sand divided by the total volume times 100= %Sand.
   Percent of Sand = ___ %

5. Calculate the percent of Silt in the sample

   Volume at top of silt column minus volume of sand = volume of silt.
   Volume of silt divided by total volume times 100= % Silt
   Percent of Silt= ___ %

6. Calculate the percent of Clay in the sample
   Volume at top of Clay column minus volume at top of silt column = volume of Clay
   Volume of Clay divided by total volume times 100 = ___% Clay.
   Percent of Clay = ___%
7. Use the soil type table from method 1 to determine the texture of your soil sample
   Soil type for Sample = ___% .

Method iii:

Materials:

- Balance
- Weighing paper
- Soil sieves
- Dry soil samples

Procedure:

1. Place your weighing paper on the pan of the balance and find its mass. Record on the DATA TABLE.
2. Set the balance to 100 g plus the mass of the weighing paper, and weigh out that mass of soil that has been broken up into loose particles. This will give you 100 g as your total sample mass.
3. Place your soil sample into sieve number 1 and shake it into sieve number 2 for two minutes.
4. Place whatever soil is left in sieve number 1 onto the weighing paper. Find the mass and record it on the DATA TABLE as mass of sand particles and weighing paper.
5. Shake sieve number 2 into sieve number 3 for two minutes.
6. Place whatever soil is left in sieve number 2 onto the weighing paper. Find the mass and record it on the DATA TABLE as mass of silt particles and weighing paper.

7. Place whatever soil is left sieve number 3 onto the weighing paper. Find the mass and record it on the DATA TABLE as mass of clay particles and weighing paper.

   Data:

   Mass of weighing paper: ___g

   Total mass of sample: 100g

   Mass of sand particles and weighing paper: ___g

   Mass of silt particles and weighing paper: ___g

   Mass of clay particles and weighing paper: ___g

   Calculations:

8. Calculate the percent of sand

   Mass of the sand particles and weighing paper minus mass of weighing paper= mass of sand

   Mass of sand divided by total mass times 100= ____**%Sand.**

   Percent Sand= ____%

9. Calculate the percent of silt

   Mass of silt particles and weighing paper minus mass of weighing paper= mass of silt.

   Mass of silt divided by total mass times 100 = ____**% Silt.**

   Percent Silt= ____%

10. Calculate the percent of clay

    Mass of clay particles and weighing paper minus mass of weighing paper= mass of clay.

    Mass of clay divided by total mass times 100= ____**%Clay**

    Percent Clay= ____%

11. Use the soil type table from method 1 to determine the texture of your soil sample

    Soil type for sample=

STUDY OF PLANT POPULATION FREQUENCY BY QUADRAT METHOD

Aim:

Our aim is to study the plant population frequency by quadrat method.

Theory:

In ecology it is useful to know the frequency of certain plant species in a certain place, or at a certain time. Frequency can be defined as the degree of uniformity of the occurrence of individuals of a species within a plant community. However, finding the frequency of plant species is very difficult for a large populations or extensive habitats. A widely used method for plant frequency sampling is by quadrat method.

Quadrat Method:

Scientists usually calculate the plant population frequency using the quadrat method. A quadrat is a sample plot of a specific size used for the study of population or a community. Quadrats are used in many different scientific disciplines like vegetation assessment, including plant density, plant frequency and plant biomass. Frequency is highly influenced by the size and shape of the quadrats used. The area that is chosen for study must not be so big that it cannot be sampled adequately, or so small that the habitat is difficult for sampling. For herbaceous vegetation a metre square quadrat is normally used.

Variants in Plant Distribution:

Variation is distribution is caused by several factors like soil conditions, vegetative propagation, quantity and dispersal of seeds, grazing or other biotic activities and predation by insects or diseases. Some species abundantly spread all over the area have a chance of occurring in all the sampling quadrats and therefore its frequency will be 100. The plants with high frequency are wide in distribution.

Procedure:

- In the selected site of study, hammer the nails firmly in the soil without damaging the vegetation.
- Fix four nails to make a square.
- Tie each end of the nails using a thread, to make a 1m x 1m quadrat.
- Similarly, make nine more quadrats randomly in the site of study.
- Select the plant species for study of the population frequency.
- Observe the presence of species "A" in the first quadrat and mark it in the table.
- Similarly, check for the presence of species "A" in other quadrats respectively and record the data in the table.
- Observe the presence of species "B" in all quadrats and mark it in the table.
- Repeat the same procedure for species "C" and record the data in the table.
- We can calculate the frequency of plant population by this equation:

$$\frac{\text{(number of sampling units in which the species occurs)}}{\text{Total number of sampling units employed for the study}} \times 100$$

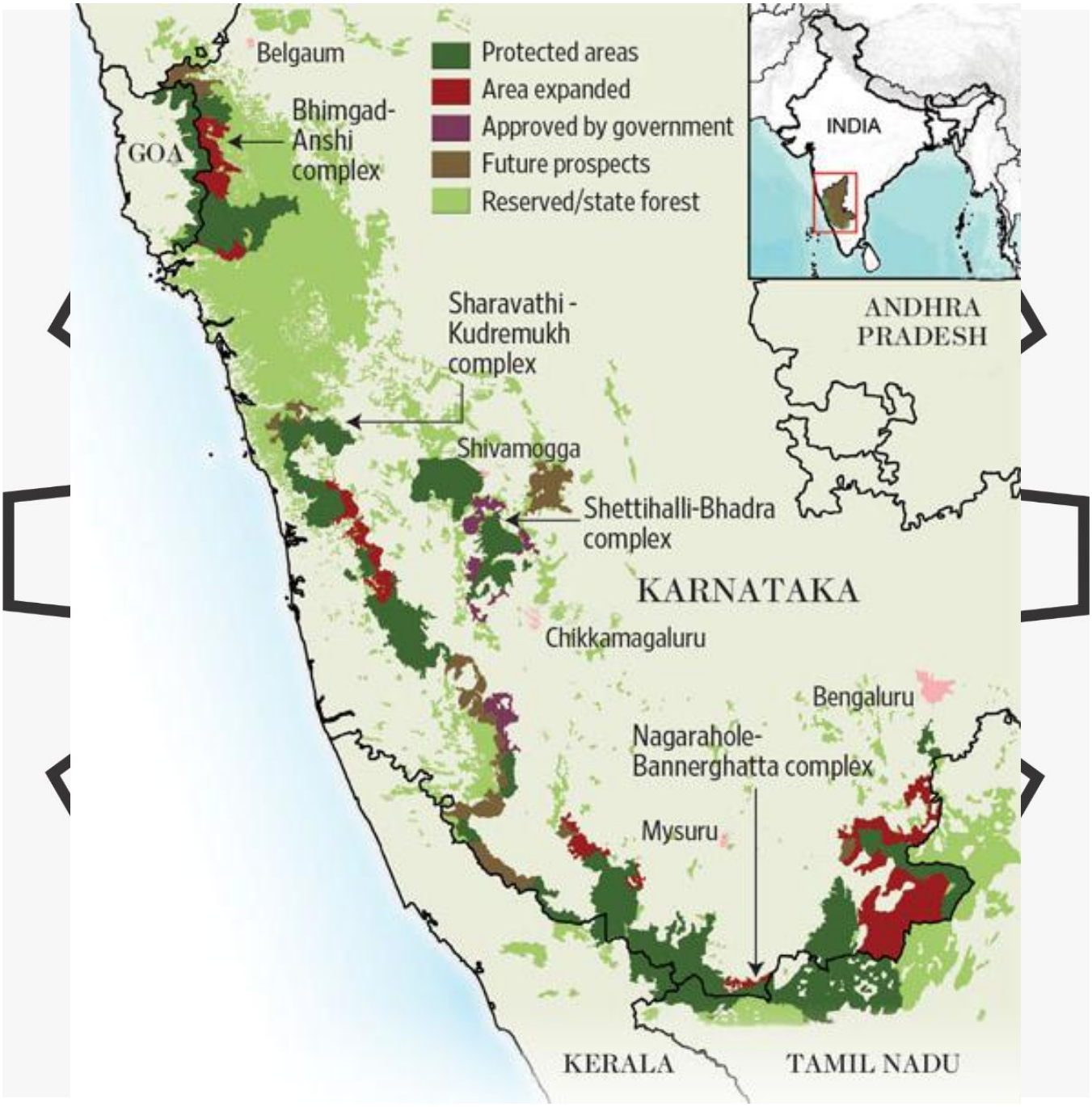
Observations:

Plant species	Quadrats employed in the study										Number of quadrats in which the species is present (N)	Percentage frequency F = N/Q ×100.
	I	II	III	IV	V	VI	VII	VIII	IX	X		
A	P	P		P			P		P		5	50%
B					P						1	10%
C		P		P		P				P	4	40%

Frequency value indicates the number of times a plant species is present within a given number of sample quadrats.

Discussion:

Plants growing together exhibit mutual relationships among themselves and also with the environment. Such groups of plants in an area represent a community. The number of individuals of species varies from place to place, making it necessary to take many random sample areas for reliable results. Density values are significant because they show relative importance of each species. With increasing density the competition stress increases and the same is reflected in poor growth and lower reproductive capacity of the species. Data on population density are often very essential in measuring the effects of reseeding, burning, spraying and successional changes. Discuss the vegetation composition of the area and comment on the dominant component species.


Belgaum
Protected areas
Area expanded
Approved by government
Future prospects
Reserved/state forest
Bhimgad-Anshi complex
GOA
INDIA
ANDHRA PRADESH
Sharavathi - Kudremukh complex
Shivamogga
Shettihalli-Bhadra complex
KARNATAKA
Chikkamagaluru
Bengaluru
Nagarahole-Bannerghatta complex
Mysuru
KERALA
TAMIL NADU